European Commission

LAB – FAB – APP

Investing in the European future we want

Report of the independent High Level Group on maximising the impact of EU Research & Innovation Programmes

Research and Innovation

LAB – FAB – APP — Investing in the European future we want

European Commission
Directorate-General for Research and Innovation
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EUROPEAN COMMISSION

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Investing in the European future we want

Report of the independent High Level Group
on maximising the impact of EU Research & Innovation Programmes

2017 Directorate-General for Research and Innovation

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PREFACE

The European Commission, through Carlos Moedas, Commissioner for research, science and innovation, invited us to draw up a vision and strategic recommendations to maximise the impact of future European Union (EU) research and innovation (R&I) programmes (Annex 1 contains the Group's mandate).

This report is the result of the Group's deliberations. The twelve of us brought different but complementary perspectives to research, innovation and education. These perspectives were grounded in personal experience with the policy, the practice or in many cases both.

The Group has built on the results of the interim evaluation of Horizon 2020, on a collection of documents (referred to in the report) and on issue papers prepared by the Commission services at our request. We took into account the stakeholder input received as part of the Horizon 2020 interim evaluation, consulted with a range of predominantly European-level stakeholder organisations and received feedback from others (see Annexes 2 and 3 for further details).

We agreed without difficulty on a number of core messages. Our main message, and vision, is that investing in research and innovation is increasingly crucial for shaping a better European future in a rapidly globalising world, where success depends ever more on the production and conversion of knowledge into innovation.

Our report focuses on proposing guiding principles for designing a post-2020 EU programme for research and innovation. It does not propose priority themes or subjects such as health, energy, security, space or oceans. We believe, nevertheless, that our recommendations, together with other inputs such as the ongoing foresight study (see Annex 3), should influence their choice and especially the participatory process for determining them.

Our recommendations are addressed to the European institutions, national governments as well as to other stakeholders: companies, universities, research institutes, non-governmental organisations and all others engaged in research and innovation within the EU and beyond.

We also wish to reach out to a wider public. Our society should increasingly become a living laboratory for innovative solutions to the many challenges we face in Europe – be they economic, environmental or social. Through broad-based, impact-focused research and innovation policy and investments, we can turn these challenges into innovation opportunities. This requires action and participation by many, if not all of us.

We need to get rid of the notion that research and innovation is not relevant to society. To shape our future together, we need to imagine, invent and create. We need research ("Labs"), innovation (competitive fabrication ("Fabs") and applications for the benefit of all ("Apps"). Hence the title of our report: Lab, Fab, App: investing in the future we want.

I hope we will succeed in convincing public opinion and decision-makers that further EU investment in research and innovation and maximising its impact is probably the best option that Europe has to deliver solutions and future well-being for its citizens.

Let me wholeheartedly thank my colleagues and the Secretariat team for their engagement in and dedication to this collective endeavour. I really enjoyed working with them.

Pascal Lamy, Chair of the High Level Group

Summary of recommendations

The following recommendations are aimed at maximising the impact of future EU research and innovation programmes. Each of them is exemplified by a key action.

1. Prioritise research and innovation in EU and national budgets
   Action: double the budget of the post-2020 EU research and innovation programme.
2. Build a true EU innovation policy that creates future markets
   Action: Foster ecosystems for researchers, innovators, industries and governments; promote and invest in innovative ideas with rapid scale-up potential through a European Innovation Council.
3. Educate for the future and invest in people who will make the change
   Action: modernise, reward and resource the education and training of people for a creative and innovative Europe.
4. Design the EU R&I programme for greater impact
   Action: make the future programme's pillars driven by purpose and impact, fine-tune the proposal evaluation system and increase flexibility.
5. Adopt a mission-oriented, impact-focused approach to address global challenges
   Action: set research and innovation missions that address global challenges and mobilise researchers, innovators and other stakeholders to realise them.
6. Rationalise the EU funding landscape and achieve synergy with structural funds
   Action: cut the number of R&I funding schemes and instruments, make those remaining reinforce each other and make synergy with other programmes work.
7. Simplify further
   Action: become the most attractive R&I funder in the world, privileging impact over process.
8. Mobilise and involve citizens
   Action: stimulate co-design and co-creation through citizen involvement.
9. Better align EU and national R&I investment
   Action: ensure EU and national alignment where it adds value to the EU's R&I ambitions and missions.
10. Make international R&I cooperation a trademark of EU research and innovation
    Action: open up the R&I programme to association by the best and participation by all, based on reciprocal co-funding or access to co-funding in the partner country.
11. Capture and better communicate impact
    Action: brand EU research and innovation and ensure wide communication of its results and impacts.

INTRODUCTION

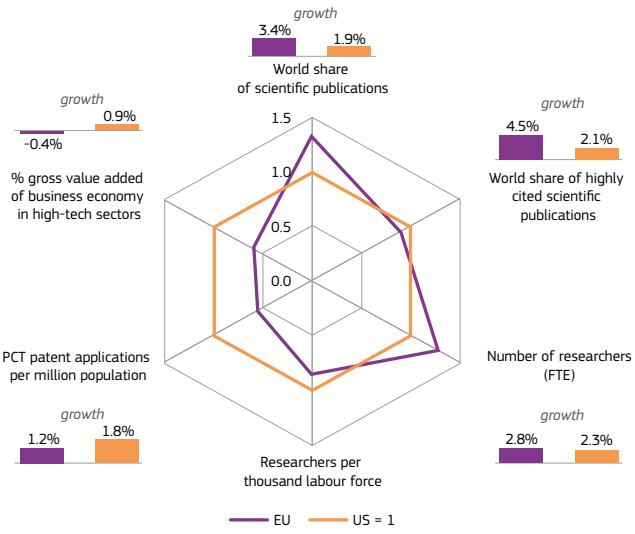
When looking ahead to the future of Europe in a globalising world, the contrast is striking between Europe's comparative advantage in producing knowledge and its comparative disadvantage in turning that knowledge into innovation and growth.

Europe is a global scientific powerhouse. It has all the necessary ingredients to shape a prosperous and safe future: 1.8 million researchers working in thousands of universities and research centres as well as in world-leading manufacturing industries[1], a suite of increasingly inter-connected research infrastructures, a thriving ecosystem of small and medium-sized enterprises and an increasing number of hotspots for start-ups[2]. With just 7 % of the world's population and 24 % of global GDP, it produces around 30 % of the world's scientific publications[3].

But compared to other major economies, Europe suffers from a growth deficit which, together with the experience of uneven progress, fuels social disenchantment and political divisions across the continent. At the heart of Europe's slow growth lies its innovation deficit. Europe does not capitalise enough on the knowledge it has and produces.

The EU trails well behind many trading partners when it comes to innovation. It spends less than half as much on business R&D as a share of GDP compared to South Korea and the share of value added in high-tech manufacturing is half the South Korean average. The EU produces three times less quality patent applications than Japan[4]. The amount of venture capital available in the EU is at least five times lower than in the US; the number of fast-growing start-ups, so-called unicorns, is equally five times lower. The EU lags behind in investing in intangibles (40 % compared to 60 % in the US).[5]

Figure 1: Comparative and growth rates of scientific publications, highly-cited scientific publications, researchers, patent applications and valued-added of high-tech sectors in the EU and the USA. Source: European Commission, DG Research and Innovation. Data: Eurostat, OECD, CWTS based on Web of Science database.



1) Source: Eurostat

2) https://startupgenome.com

3) Source: CWTS Web of Science

4) Patent Cooperation Treaty (http://www.wipo.int/pct) patents are a recognised proxy for the ability of the economy to transform knowledge into marketable innovations.

5) Intangible Investment in the EU and US before and since the Great Recession and its contribution to productivity growth. European Investment Bank Working Paper 2016/08. Available at: http://www.eib.org/attachments/efs/economics_working_paper_2016_08_en.pdf

The rich diversity of the EU and its Member States is a strength, but it also makes the articulation of common European research and innovation (R&I) strategies and projects more complex than in countries such as the USA or South Korea. Contrary to the USA, investment in R&I at central EU level is minimal compared to decentralised public investment at national level.

This is nothing new; we have known this for decades. But the rate of technological and economic change and the urgency of global challenges continue to outpace Europe's response and reforms.

It is imperative for Europe to act, to act now and to act decisively.

Addressing the EU's innovation deficit requires action by the EU and its Member States – this is a collective responsibility. Universities need to modernise; industry and start-ups need to work more intensively with academia; the key innovators need to get support to succeed; society at large needs to be an integral R&I actor.

Research and innovation matter for our future. Especially for advanced economies like Europe's, science and innovation – and education – are what make the difference in enhancing productivity and boosting competitiveness. In the last twenty years, two-thirds of economic growth in industrialised countries is attributed to science and innovation (see the economic rationale for public R&I funding study, referenced in Annex 3).

Investing in intangible assets makes vital contributions to productivity and is at the core of what makes firms competitive. In the older Member States (so-called EU-15), the contribution of total intangible assets to output growth is between one and three times as high as the contribution from tangible assets[6].

6) Unlocking Investment in Intangible Assets. European Commission, Directorate-General for Economic and Financial Affairs, May 2017. Available at: https://ec.europa.eu/info/sites/info/files/dp047_en.pdf

Science and innovation are also key to preserving the values of enlightenment and democracy and to tackling the societal challenges of our time: building a digitally-smart, low-carbon, energy-efficient and circular economy that offers rewarding work and brings good quality of life for all in liveable cities and countryside; ensuring a safe climate, building a fair society; keeping our oceans clean and productive. Over time, performance in science and innovation will determine Europe's place in the world and its capacity to boost the kind of growth that is exemplified by the world's 2030 agenda for sustainable development.

Europe's challenge and ambition are straightforward: step up investment in its knowledge assets and turn the high volume and quality of its science and research results faster and deeper into innovations which generate value for economy and society. Transform knowledge into economic and societal innovation – resulting in a competitive economy that derives prosperity from higher value-added goods and services, as well as benefiting society.

Europe must embrace the transformative power of open science, allowing for a faster circulation of increasing amounts of knowledge, and seize the potential of open innovation to trigger faster and fairer growth, building a knowledge economy that is open to the world.

We have an asset for achieving these ambitions: Horizon 2020, the EU's main funding programme for research and innovation up to 2020. The interim evaluation of Horizon 2020 and the input from many stakeholders demonstrate that its success is creating momentum. Non-EU countries seek to be part of it. Horizon 2020's continental reach, its focus on excellence and its track record in fostering cross-border collaboration is unique in the world. It strengthens Europe's scientific excellence and industrial competitiveness through competitive funding and cross-border, cross-disciplinary and cross-sectorial

works. It pools resources and ingenuity for tackling global challenges. It develops the evidence base for policy-making. It grows Europe together.

The Group is convinced of the crucial role of research and innovation in shaping the future we want to see in Europe and beyond. Investing in research, innovation and education is an economic necessity, a social obligation as well as a political opportunity for a shared project that makes Europe a pole of attraction in an increasingly connected world. The post-2020 budget discussion is the right moment to illustrate with clear determination the Europe we want.

It is in this light that the Group has formulated 11 recommendations designed to maximise the impact of future EU R&I programmes and further increase their return on investment for Europe and Europeans. The recommendations should further sharpen Europe's innovative edge by making purpose drive process, form follow function and instruments stimulate innovation. Each recommendation is exemplified by a key action.

1. Prioritise research and innovation in EU and national budgets

There is abundant evidence of Horizon 2020's European added value compared to what can be done at national level; there is no evidence, on the other hand, of significant substitution effects between EU and national R&I investment[7].

EU investment in research and innovation projects is distinctive in the way that it fosters **transnational collaboration and competition** of a scale, scope and speed that no single country can match. Horizon 2020 resources are invested following continent-wide competition and independent expert evaluation. It supports transnational and multidisciplinary collaboration, pulls additional investment by the public and private sectors and leverages and structures national R&I. According to its interim evaluation, 83 % of Horizon 2020-funded projects would not have gone ahead without EU-level support.

The recent Monti report on future financing of the EU states that research and innovation should be "**one of the essential policy priorities in the future**". R&I is foremost a budgetary policy: the volume of resources allocated is an expression of the policy ambition. Given that R&I is one of the main factors of global competitiveness, the EU's ambition must be to at least **align its investment with that of its main competitors**, such as USA, Japan, South Korea or China.

Doubling the overall budget of the post-2020 EU research and innovation programme is the best investment the EU can make.

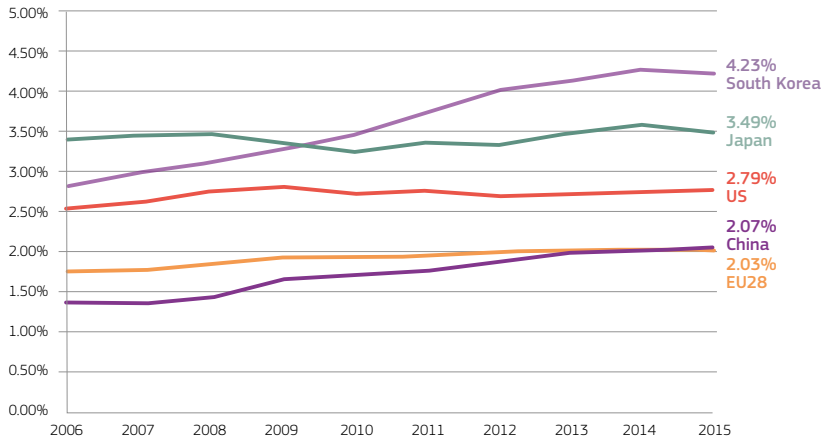
Reducing the overall level of R&I investment would be a mistake and a clear reversal of progress. At a minimum, the budget should maintain the average annual growth rate of Horizon 2020, taking the budget foreseen for the programme's final year as a starting point. This would lead to a seven-year budget of at least €120 billion in current prices[8]. Anything below that would break momentum and call into question the EU's commitment to deliver on its political priorities, as embodied in the Rome declaration[9] of March 2017 in which innovation is considered crucial.

7) See annex 4 for an overview of the EU added value of Horizon 2020, and annex 5 for a summary of an analysis on the substitution effects between EU and national R&I investment.

8) The compound annual growth rate for the Horizon 2020 budget is around 6.5 % in current prices, while the annual budget for Horizon 2020's final year in 2020 is projected to be just over €13 billion.

9) For further details, see: http://www.consilium.europa.eu/en/press/press-releases/2017/03/25-rome-declaration/

Figure 2: Comparative evolution of gross domestic expenditure on R&D as a percentage of GDP in the EU, China, South Korea, USA. Source: European Commission, DG Research and Innovation. Data: Eurostat and OECD.



Increasing the budget will help address the **severe problem of underfunding**. Doubling the R&I budget will not generate any concern about absorption capacity. Horizon 2020 can currently only fund 1 in 4 of the proposals evaluated as high-quality through independent peer-review. To be efficient and avoid the excessive costs of high-quality but unfunded proposals, the post-2020 programme must ensure a success rate in the range of 15 to 20%, as was the case for Horizon 2020's predecessor. Funding should be secured for at least 30% of high quality proposals.

The Group welcomes the recent decision to finance **defence research at EU level**, as long as its budget is additional to the recommended doubling of the civil R&I programme. We see great benefit in defence research being executed along the lines of the DARPA model[10], exploiting the advantages of excellence-driven transnational competition and collaboration. However, given the different conditions and rules that govern defence research, its implementation should be clearly separate from the civil R&I supported by the EU.

The EU R&I programme represents only a small proportion of total public investment in research and innovation in the EU, about 10% of public R&D investment. At the same time, success in the EU programme often correlates with the level and performance of national investment in R&I[11]. An **increase in EU funding must therefore be matched by an increase in national investments in R&I**. The trends in national R&I investments should be monitored and encouraged, notably through the European Semester and encouraged through the EU budget – for example, by rewarding certain reforms or establishing a performance reserve. This does not necessarily mean extra reporting by Member States, as existing EU data sets could be used.

It is essential – also as a strong signal to the rest of the world – that both the EU and its Member States finally undertake to reach the **3% target** of GDP invested in R&I[12]. This should be made a core part of any European or national investment plan and a renewed agenda for economic convergence – especially, but not only, in the euro area.

10) The Defense Advanced Research Projects Agency (DARPA) is an agency of the US Department of Defense that finances research projects on emerging technologies for military use.

11) See annex 5 for an analysis of this.

12) This target, set by the European Commission and endorsed by the European Parliament and Member States through the Council of the EU, was first established as part of the Lisbon Strategy in 2000. In 2010, it was reaffirmed as one of the five headline targets of the Europe 2020 Strategy.

Recent estimates indicate that achieving the 3% target requires an additional public and private R&I investment of €150 billion per year[13]. The biggest gap to reaching the 3% is the lack of private sector R&I investment. Private sector investment should therefore be leveraged as much as possible, with Member States exploiting measures that fit their national policy toolbox, such as tax credits and innovative public procurement. **Co-funding mechanisms** with industry, countries, foundations and other sources of funding should be promoted, both at EU and national levels.

Only if EU and national programmes and budgets work better together in increasing R&I investments will we see innovation-led growth that builds a prosperous and cohesive Europe.

Action: double the budget of the post-2020 EU research and innovation programme.

2. Build a true EU innovation policy that creates future markets

The EU's innovation deficit is not due to a lack of knowledge or ideas, but because we do not capitalise on them. We need rapid European or international scale-up of innovative solutions.

Addressing this deficit requires more than public money and more than awarding grants. Much but not all innovation stems from research; not all research leads to innovation. Research needs time to generate results, while speed is essential for successful innovation. Even so, research and innovation need to be integrated as much as possible in policy and programmes. Research is necessary, but not sufficient, to fuel innovation.

Innovation needs fertile ecosystems – such as industrial, agriculture, competition and trade policies – for researchers and innovators, companies and public authorities, stimulated by a coherent EU innovation policy that cuts across all EU policy domains, thus providing a common regulatory framework that fosters entrepreneurship. Innovation policy should provide stable and consistent incentives to innovators and markets. Other policy areas such as industry, competition, trade, agriculture, energy and transport should help create the right framework conditions for innovation to flourish. A consistent and clear definition of strategy, targets, implementation levers and measures and evaluation of budgets as well as evidence-based policy-making are conditions for success.

In this way, EU innovation policy can boost the growth of companies, which underpins the competitiveness of our industry. To ensure European industry's success in the global market and its leadership in the current industrial revolution with its blurring of physical, digital and biological spheres, innovation policy should aim at promoting faster and better development, production and use of new products, and industrial processes and services. This in turn will entice higher private investment in R&D; currently, half of the EU's investment gap in private R&D compared to our main competitors stems from the smaller share of high-tech companies.

The EU's substantial knowledge assets, based on science and research, need to be faster and more intensively turned into innovations, in the form of new products, processes, services and business models, which generate value for economy and society. Industry plays a fundamental role in this transformation. Academia and industry are no rivals in this – they are allies. The vocation of the R&I programme must be to make their alliance productive. The participation of academia is natural, that of industry is to be encouraged.

The promotion of innovation should play a key role in **delivering on all EU policy priorities**. As part

13) Staff Working Document for Horizon 2020 Interim Evaluation. European Commission, May 2017. Available at: https://ec.europa.eu/research/evaluations/index_en.cfm?pg=h2020evaluation

of a coherent innovation policy, EU policy-makers should be required to regularly identify, in dialogue with stakeholders and citizens, how and what innovation can help them more easily achieve their objectives. Every EU funding programme and each instrument should have innovation objectives and reserve budget for promoting innovation.

Innovation is more than technology. EU innovation policy must be based on a **definition of innovation** that acknowledges and values all forms of new knowledge – technological, but also business model, financing, governance, regulatory and social – which help generate value for the economy and society and drive systemic transformation.

It should **rigorously assess the potential innovation impact** of new policy initiatives. Particularly when deployed in accordance with the EU innovation principle, regulation can be a powerful way to stimulate innovation that is driven by demand. This would also address the challenge of fragmented regulation within the EU, which hampers the uptake of new solutions that are for example made possible by progress in nanotechnology or new materials. Public procurement is also key in designing demand-side innovation policies that help reduce market uncertainty for innovative solutions, shape future markets and open new opportunities for European companies.

A true EU innovation policy should allow for **policy experimentation**, for example through bringing together regulators and innovators to overcome possible regulatory bottlenecks to innovative solutions, as pioneered in the EU innovation deals for the circular economy.[14]

Furthermore, it should **anticipate the effects of the expected labour market transition** over the next decades, due to digitalisation, automation and demographic trends.

Breakthrough innovation, the type that creates new markets, is rare in Europe. This is due to a range of factors, including lack of venture capital, a deep-rooted aversion to risk and an inability to exploit the scale that an economy of half a billion people represents. EU R&I programmes should therefore put a stronger focus on breakthrough rather than incremental innovation.

Modern R&I policies and programmes with the highest potential for promoting breakthroughs are those that resolutely push and pull **cross-disciplinary, cross-sectorial, cross-institutional and cross-border collaboration**, responsive to market opportunities and societal expectations. The EU level is uniquely placed to remove borders of all kinds.

A **European Innovation Council** should be installed as a permanent, high-level strategic body empowered to invest in entrepreneurs and businesses, irrespective of size, sector or maturity, with risky innovations that have rapid scale-up potential at the cross-roads of different technologies and disciplines. This will give renewed impetus for improving framework conditions. The EIC should achieve the same high standard for innovation as the European Research Council has created for frontier research.

Action: Foster ecosystems for researchers, innovators, industries and governments; promote and invest in innovative ideas with rapid scale-up potential through a European Innovation Council.

14) For further details, see: https://ec.europa.eu/research/innovation-deals/index.cfm?pg=home

3. Educate for the future and invest in people who will make the change

Europe can have the most impressive talent pool on earth, but it will fail to capitalise on this if the education system does not foster a more innovative and risk-friendly culture. There will likely be no excellent research and innovation without excellent education.

A **fundamental reform of the role of education** should systematically embed innovation and entrepreneurship in education across Europe, starting from early stage school curricula. Schools should foster a culture that boosts self-confidence; society should build an environment that allows for failure of new ventures and continuous life-long-learning. In the future, everybody in society should be stimulated to be creative, from children to elderly, from employees to employers, from civil servants to start-ups.

Europe's universities need urgent renewal, to stimulate entrepreneurship and tear down disciplinary borders. Strong non-disciplinary collaborations between universities and industry should become the rule and not the exception. The post-2020 EU R&I programme needs to **provide incentives for the modernisation of universities**. A clearly-defined 'European university' label could reward research and higher education institutions which actively and successfully promote open science, open innovation and openness to the world, i.e. through new ways of teaching, promoting cross-disciplinarity and entrepreneurship whilst attracting researchers and students from around the world. The EU could, in return, offer top-up funding for certain institutional costs at those universities.

For its part, the post-2020 EU R&I programme should **reinforce support for skills and competence development in EU-funded projects**. Collaborative R&I projects should include training activities for the next generation of researchers and innovators, particularly skills needed for data-driven open science. Development of curricula for the next generation workforce should be taken forward in synergy with the European Social Fund. High-level objectives between the EU's R&I and Erasmus programmes should be aligned and their progress jointly monitored.

Increasing the budget of the post-2020 EU R&I programme will provide more resources for the **European Research Council** (ERC), which finances projects defined and driven by researchers on the sole criterion of excellence. As shown by the interim evaluation of Horizon 2020, the ERC has become a global beacon of scientific excellence and provides those that do the science of the future with the skills and competences that Europe needs to stay at the forefront of development. The ERC's synergy grant scheme has great potential to stimulate multidisciplinarity, while the ERC proof of concept scheme holds great promise to help bridge the valley of death between fundamental research and commercialising a new product or service.

The post-2020 EU R&I programme should also increase the resources for **Marie Skłodowska-Curie Actions** which support researchers' career development and training. New training and career development schemes are needed. A well-endowed EU Industry Research Fellowship scheme will help break down barriers between sectorial and disciplinary silos. It should be open to talent from everywhere, supporting innovators returning to an EU country from elsewhere, as well as providing entrepreneurial training schemes for refugees.

Education plays a central role in **Knowledge and Innovation Communities** (KICs) established by the European Institute of Innovation and Technology (EIT). They bring together businesses, research centres and universities in areas like climate, raw materials and digital technologies. Operating at the

intersection of research, education and innovation, the KICs support the development of innovative products and services, the creation of new companies and the training of a new generation of entrepreneurs. To maximise their impact and as part of rationalising the EU funding landscape, they should be better deployed to deliver on the global challenges (see recommendations 5 and 6). KICs could be directly incorporated in the post-2020 EU R&I programme.

Action: modernise, reward and resource the education and training of people for a creative and innovative Europe.

4. Design the EU R&I programme for greater impact

One of Horizon 2020's novelties was its three-pillar structure corresponding to who sets the agenda: the scientific community for excellent science, industry for industrial leadership and society for addressing societal challenges. The three pillars and the core principle of excellence across the entire programme have attracted large support from stakeholders who call for an evolution rather than a revolution: fine-tuning the pillars, improving their internal coherence and maximising their mutually reinforcing impact.

To maximise impact, the post-2020 EU R&I programme must act as a true investment programme. It should **focus on purpose and impact** of R&I instead of instruments, technological-readiness levels, disciplines, prescriptive topics or industry sectors.

The **future three pillars** should feature a clearly-defined and complementary rationale for their interventions. This will enhance their interconnection and combined benefit for economy, including industry, and society. They should lay out results and impacts that are expected to be achieved within specified timescales (for example, via 'top down' calls for proposals that have thematic objectives; or via 'bottom-up' calls which are completely open to researchers and innovators, academia and all industry, irrespective of size, to define the area they would like to address).

These pillars should focus on "science and skills", "innovation and competitiveness" and "global challenges". Driven by complementary goals, they should be better connected than in the current situation, with open science and open innovation being common threads.

The European Research Council should be central to the science pillar, the proposed European Innovation Council central to the innovation pillar, and large-scale missions central to the global challenges pillar. Innovation should be promoted across all pillars, with a consistent priority attached to interdisciplinarity as a source of technological and other innovation (such as educational, business or social innovation).

The post-2020 EU R&I programme should be **open to experiment** with new ways of calling for and evaluating proposals and supporting projects, for example through innovative blending of grant, loan and equity-based forms of investment.

Calls for proposals for funding under the post-2020 EU R&I programme should become more flexible, overarching and, when top-down, **non-prescriptive**. Applicants should be allowed to choose, from a portfolio of instruments provided, the one that best matches the R&I purpose, its potential impact and the risk involved.

With excellence at its core, **the evaluation process** for proposals submitted to the post-2020 EU R&I programme **should be customised** in line with each pillar's objectives. All proposals across the programme should be evaluated on the basis of excellence, i.e. based on quality without geographic or other criteria involved, while recalling that a certain part of

the programme should contain measures targeted at lower-performing countries (see recommendation 6). However, excellence should be assessed on the basis of the pillar's objectives, such as the potential for breakthrough innovation in the second pillar or the societal relevance in the third.

A modernised proposal evaluation system should also attract **different types of evaluators**. Evaluation teams should consist of top people with broad experience well-matched to the call or mission and different competences to evaluate excellence and impact. Resources should be invested in providing meaningful evaluation feedback to applicants, including on the choice of funding instrument.

Larger projects should be subject to a **mid-term evaluation**, possibly leading to adjustment or even discontinuation. In line with open access, all initial and mid-term project evaluation reports should be made public. In turn, consortia should be allowed to quickly and easily adapt their project in line with evolving needs and opportunities.

The proposed European Innovation Council should be a driver for designing new proposal evaluation and selection processes to better capture high-risk, high-return projects, introduce greater flexibility in grant management (stop-go decisions) and tolerate failure. Elements of the ERC's process for proposal evaluation could provide a source of inspiration.

Action: make pillars driven by purpose and impact, fine-tune the proposal evaluation system and increase flexibility.

5. Adopt a mission-oriented, impact-focused approach to address global challenges

Innovation leaders do not limit themselves to studying challenges or solving 'market failures'. They develop strategic missions where they see societal and market potential and actively direct public investment accordingly. To become an innovation leader and maximise the impact of its intervention, the EU should however not spread its investments in R&I too thinly. Instead, it should prioritise investing in areas where the EU added value is greatest in terms of the degree of risk involved and where the benefits of economies of speed, scale and scope can be reaped. Those responsible for other sectorial policies – such as industry, agriculture, energy, transport, ICT, culture – should be fully engaged with innovation policy-making, both helping to programme research and innovation and unlocking the innovation potential of structural funds (see recommendation 6).

The post-2020 EU R&I programme should thus translate global societal challenges (social, economic, environmental) into a limited number of large-scale research and innovation '**missions**'. These would define expected impacts across an entire portfolio of activities, rather than at the level of individual call topics. The UN Sustainable Development Goals should serve as a global reference framework for defining Europe's R&I missions.

R&I missions should foremost be **easy to communicate** and capture public imagination and involvement, thus allowing for better communication of the benefits of the future programme (see recommendation 11). They should mobilise many actors and investors, including at national level, and induce action **across disciplines, sectors and institutional silos**.

Missions should be **open to all actors** in the research and innovation cycle, in particular new actors of innovation and change such as cities and regions, which could act as "innovation laboratories of change" in piloting new ideas and concepts.

Missions, or "moon shots", should have a **breakthrough or transformative potential** for science, technology, industry or society. It should be possible, within the appropriate timeframe, to ascertain to what extent the mission has been accomplished. Failure should be allowed, and unexpected spill-over benefits should be encouraged.

Missions defined in this way will, by design, fully **integrate social sciences and humanities (SSH)**. Where missions concern the big social questions of our time, for example having rewarding work in an era of robotics, living and working well together in culturally diverse cities or ensuring equal opportunities in and fair benefits from an innovative society, SSH researchers will initiate and lead them. Design-thinking should also be included to the greatest extent.

Having set the direction and expected impact, missions should be underpinned by **non-prescriptive calls** for proposals that allow applicants to choose the funding instrument they need; for instance research projects, co-funded activities, prizes, financial instruments or public procurement. Instruments should support missions, not the other way around.

Partnerships (public-private and public-public) with industry, foundations and public authorities should be taken forward in as far as they mobilise joint investment in established missions, through a simple and flexible co-fund mechanism. The additionality of other sources of funding and capabilities in order to realise a mission along with bringing together the required partners and stakeholders (from industry, SMEs, universities, research centres, civil society etc.) should be a key guiding criterion.

The Group's remit was not to prescribe Europe's moon shots. By way of illustration, it has identified some potential missions for the post-2020 EU R&I programme: achieving a plastic litter-free Europe by 2030; understanding and enhancing the brain by 2030; producing steel with zero carbon in Europe by 2030; making 3 out of 4 patients survive cancer by 2034[15]; building and operating the first quantum computer in Europe. The Group calls on the European Commission to launch a wide stakeholder debate among citizens, scientists and innovators on potential future R&I missions for Europe.

Action: set research and innovation missions that address global challenges and mobilise researchers, innovators and other stakeholders to realise them.

6. Rationalise the EU funding landscape and achieve synergy with structural funds

The range of funding schemes for R&I across the EU budget is numerous, complex and not accessible enough. As a result, companies and innovators do not easily know where to look. This risks increasing transaction costs and diluting excellence by favouring a "competition among those in the know", excluding those who may be excellent but unfamiliar with the system. Today's set of EU funding schemes also illustrates the lack of a systemic and coordinated R&I policy at EU level.

The Group supports a **modernised and user-friendly EU budget** which maximises European added value by privileging transnational collaboration and competition.

15) Target put forward by Cancer Research UK.

Access to EU funding for the user should be facilitated by having harmonised rules for participation across the EU budget and a **one-stop-shop for research and innovation** funding.

A **coherent execution of the R&I programme** will foster excellence, openness, collaboration and inter-disciplinarity, avoiding capture by incumbents or silo mentality.

EU funding schemes with similar intervention logic should be combined. For example, the post-2020 EU R&I programme could incorporate the successor of the SME programme COSME[16]. A minimum objective should be to eliminate one third of R&I funding schemes, instruments and acronyms across the landscape. Sunset or exit clauses should be introduced in major structuring initiatives. As already recommended, the various innovation support schemes should be streamlined with a European Innovation Council.

While the EU R&I programme is about boosting and networking excellence at European level, the **structural funds are essential for R&I capacity-building** in regions that are catching up in terms of their R&I performance and their participation in the EU R&I programme. It is crucial that the post-2020 EU R&I programme and future structural funds are designed from the beginning with complementary, mutually reinforcing and interoperable intervention logics.

A substantial proportion of the future structural and agricultural funds should focus on financing R&I infrastructures and their sustainability, universities, research centres, incubators, science parks and innovation diffusion activities that are aligned with and support the post-2020 EU R&I programme's objectives and pillars. This approach should take into consideration increasingly transnational smart specialisation strategies[17]. The EU R&I programme should set the agenda for R&I investments within the structural funds.

The budget for such investment could flow from the future structural funds to the post-2020 EU R&I programme, to be implemented according to the latter's main principles but with a geographical rationale. The option of using structural funds for participating in transnational R&I co-funded activities should be made easy.

At the same time, building on the Horizon 2020 experience, the future EU R&I programme should have a **ring-fenced amount** to "spread excellence and widen participation". The resources, in this ring-fenced amount of the post-2020 EU R&I programme, should be used to assist regions in setting up transnational, mission-like smart specialisation strategies that complement or support the R&I programme's objectives.

Structural Funds should also be deployed in a much more flexible and simple way in order to fund – under the Seal of Excellence scheme[18] – proposals evaluated under the R&I programme calls but not funded due to a lack of resources.

None of this will work without conducive EU State Aid rules. The current State Aid rules are perceived as insufficiently innovation-friendly. While designed to avoid unfair competition within the single market, they should not act as a barrier to strategic investments which correspond to EU priorities and are carried out through projects selected through

16) COSME (Competitiveness of Enterprises and Small and Medium-sized Enterprises) is the EU programme running from 2014 to 2020 which provides funding for a range of support services to SMEs in particular. It has an overall budget of €2.3 billion.

17) A policy process that aims to boost innovation within EU regions and promote efficient public investment in R&I. EU regions focus on their strengths in research and innovation by establishing a strategy for smart specialisation, which is a condition to receive Structural Funds support via the European Regional Development Fund. For further information, see: https://ec.europa.eu/jrc/en/research-topic/smart-specialisation.

18) The Seal of Excellence scheme, launched in 2015, is a quality label recognising proposals submitted to Horizon 2020 calls which were evaluated as high-quality but were not funded due to lack of available budget. The holder of a Seal of Excellence can approach other sources of funding (regional, national, private, public) with this quality label.

EU-level competition. **State aid exemptions** should – under pre-defined conditions – be extended to transnational smart specialisation strategies which act as R&I missions of common European interest.

At the same time, the EU should work with international partners to create **a global level playing field with regard to public support to private sector R&I**. The EU should aim at building converging and open state aid regimes with our main trading partners that stimulate R&I investment without distorting competition. A well-resourced post-2020 EU R&I programme entirely open to international participation will increase the strength of this argument.

Action: cut the number of R&I funding schemes and instruments, make those remaining reinforce each other and make synergy with other programmes work.

7. Simplify further

Within the EU funding programmes landscape, Horizon 2020 has achieved remarkable simplification. It has made access to the programme easier, reduced costs for applicants and made the programme more attractive.

The drive for simplification should continue: for the EU budget overall, for the EU R&I programme, as well as for programmes at national level.

Call documents should become much simpler, easy to find, easy to read and easy to respond to. The **Participant Portal** website should function as a one-stop-shop for all steps from application to final reporting, covering all R&I initiatives across the EU budget. Documentation (including grant agreements) should be kept to a minimum; their simplification should result from co-design with researchers and innovators.

Priority should be given to increasing flexibility within the calls for proposals. In those calls, applicants should not only be given the choice of the instrument for their proposal but also a **choice between cost-based or lump-sum funding for their project**, with payment against fulfilment of activities. The latter will eliminate the need for cost reporting, timesheets, financial audits and deliver on the objectives of an EU Budget Focused on Results[19]. Novel ways of proposal evaluation and selection should be explored that accelerate the process and that take better account of off-mainstream ideas and of less well-known actors.

Administrative processes along the entire project life-cycle, including amendments, should be simplified and streamlined across the programme. Consortia should have the flexibility, within the existing project budget, to easily adapt work plans and composition of research teams to new developments and opportunities. Non-performing projects should be stopped.

To further reduce the burden for beneficiaries of EU-funded R&I projects, the Commission should **accept usual accounting practices of the beneficiaries. Reporting obligations** should be kept to a minimum, and be weighed against the need to have continuous and real-time data on the results and impacts of projects.

In order to **reduce the audit burden**, the obligation to provide representative 'error rates' for the programme should be dropped. Audits should only be carried out when there is a suspicion of fraud or serious financial wrongdoing on a project.

Further simplification can be achieved through **better alignment of national programmes among each other and with the EU programme**, in line with recommendation 9. Member States should be

19) Launched in 2015, this is an initiative designed to maximise the EU's investments in support of growth, jobs and stability in Europe and beyond. For further details, see: http://ec.europa.eu/budget/budget4results/index_en.cfm.

encouraged to use the same evaluation processes and implementation rules for national funding programmes, progressively leading to similar procedures governing R&I programmes across Europe.

Action: be the most attractive R&I funder in the world, privileging impact over process.

8. Mobilise and involve citizens

Investing in R&I is crucial for shaping our future. EU R&I programmes stimulate co-creation through cross-border collaborations and collaborations between different sectors.

Drawing on national examples such as Nesta[20], the future EU R&I programme should aim to become the **biggest co-created and co-creation programme in the world**. Countries like the Netherlands and Denmark have carried out successful initiatives of involving citizens in the R&I agenda-setting, which can serve as sources of inspiration[21].

Fully mobilising and involving stakeholders, end-users and citizens in the post-2020 EU R&I programme, for instance in defining its missions, will not only increase the degree of co-creation, it will also maximise its impact and stimulate a **stronger demand for innovative products and services** as well as a better grasp of social changes. This will bring open science and open innovation to the next level and turn Europe into a continental living innovation lab.

The EU R&I programme should provide incentives for stakeholders and end-users to participate more widely in its multi-annual programming, for example through identifying, debating and possibly even deciding which EU-level missions to choose. The same goes for the programme's implementation through co-designing research and innovation agendas and taking part in developing and testing new solutions.

Citizens should also be actively involved in measuring progress towards the fulfilment of missions, including stirring public debate on how to interpret, value and share progress.

Crowdsourcing of ideas and funds for all types of innovation should become an integral part of the future EU R&I programme, particularly in the context of missions that have a societal vocation.

Maximum use should be made of **social media**. Virtual 'Groups of 1000 citizens' (G1000)[22], for example, could give an opinion on new missions, even going as far as allowing for an open process of defining certain parts of the calls for proposals. Potential users or beneficiaries of envisaged new solutions could be encouraged to provide real-time feedback and suggestions.

Whenever possible, **citizen science** should be encouraged, where citizens become providers and users of data. This will reinforce and give new meaning to the policy of open access to publications and data; this openness should enable citizens and citizen groups to participate in evidence-based policy and decision-making. This could give rise to new types of partnerships, such a "P4P"s or "P4.0s" where "people" are working together with the public and private sector. This could be systemically implemented on European, national and regional levels.

Action: stimulate co-design and co-creation through citizen involvement.

20) See: http://www.nesta.org.uk.

21) See: http://www.wetenschapsagenda.nl/national-science-agenda/?lang=en and: www.cimulact.eu.

22) http://www.g1000.org/en/.

9. Better align EU and national R&I investment

The achievement of a **European Research Area** – a unified area in which researchers and innovators, scientific knowledge and technology circulate freely – is enshrined in the EU's Treaty as part of the EU's objective to strengthen its scientific and technological bases. It is fundamental to the EU's research and innovation ambitions.

The European Research Area does not mean that EU and Member States do the same thing. **Complementarity** should prevail.

Member States should invest smartly and sustainably in R&I at national level, focusing investments on building human capital and infrastructures for R&I and prioritising those areas where they are strongest. They should contribute to the European Research Area by continuously increasing the performance of their funding and by promoting open science and open innovation. The EU's regulatory and policy framework should contribute to making the Area open, effective and efficient.

The post-2020 EU R&I programme should act as a **common strategic reference agenda** for all R&I investments in Europe. It should concentrate its resources on where its added value is greatest, mainly through fostering transnational collaboration and competition and taking advantage of economies of scale, speed and scope to achieve breakthrough, disruptive innovation.

The alignment of national and EU R&I investments has, for many years, been a cornerstone of the European Research Area. Yet it is increasingly clear that the complex set of funding schemes and instruments designed to provide R&I support creates a substantial cost for coordination. It risks making alignment a goal in itself rather than a means to an end. The Group proposes a **new and simpler vision on alignment**, one based on clear direction of the missions the EU wants to accomplish and on a clear division of labour between the EU and national policy levels – where each focuses on its core tasks and where it can add most value. EU R&I programmes should focus on topics and objectives with high EU added value, beyond specific national priorities and interests.

EU Member States should develop multi-annual **national R&I strategies** outlining priorities for national R&I investments and their alignment with the EU R&I programme. These should also be aligned to broader EU socio-economic goals, as laid out in the EU Annual Growth Survey. These national R&I strategies should be subject to EU-supported international peer review.

The EU should limit its co-investment in partnerships with Member States to those which help achieve the EU's missions and have a high degree of EU added value. A **simplified and flexible co-funding mechanism** should be established to this end, with lead agencies specialising in their implementation. The EU contribution should maximise the leverage of national and private investments. The proportion of national and EU contributions should be defined according to the mission in question. Conditions and rules for launching joint calls for proposals should be light-touch and not defined in advance by the EU.

Action: ensure EU and national alignment where it adds value to the EU's R&I ambitions and missions.

10. Make international R&I co-operation a trademark of EU research and innovation

Access to talent, knowledge, ideas and markets across the globe is one of the positive sides of globalisation[23]. Europe should organise itself better to benefit from this.

International cooperation in R&I is fundamental to make this a reality. Using the **Sustainable Development Goals to frame large-scale R&I missions** will stimulate and steer international R&I cooperation on common global challenges. Europe should continuously invite the rest of the world to collaborate in research and innovation; and dedicate the means to this end.

Horizon 2020 mainstreams funding for international cooperation throughout the programme. Contrary to its predecessor programme, it excludes a number of third countries[24] such as Brazil, Russia, India and China from its funding. Participation by such partners has dropped noticeably compared to the past.

In the post-2020 EU R&I programme, international cooperation should be stimulated through **one centralised fund**, acting as a reserve which can be mobilised in order to undertake international cooperation activities within its different pillars.

To become even more open to the world, the post-2020 R&I programme should **encourage and support all international partners in as far as they help realise its missions**, on the condition of reciprocal co-funding or access to funding in the partner country.

A step-change would be to open the **EU R&I programme to association by trading partners** of a similar level of excellence, such as Canada or Australia. Association of non-EU countries to future EU R&I programmes should be governed by excellence in R&I, not confined to a particular part of the world. This will make the EU programme the potential nucleus of a global programme for open science and open innovation, exporting good regulatory practices and improving international trading and investment conditions. It will be an expression of the EU's ambition to harness globalisation through collaboration in science and innovation, thus helping to address the negative aspects of globalisation.

Whatever Brexit modalities are agreed between the UK and the EU by 2019, **full and continued engagement with the UK** within the post-2020 EU R&I programme remains an obvious win-win for the UK and the EU. The UK has one of the strongest science bases of all European countries. A positive cooperation model (e.g., based on mutual investment) should be established, so that the UK remains part of the European Research Area.

Action: open up the R&I programme to association by the best and participation by all, based on reciprocal co-funding or access to funding in the partner country.

23) See the recent European Commission reflection paper on Harnessing Globalisation – one of the five papers that follow the White Paper on the Future of Europe.

24) Countries which are not EU Member States, nor associated to the Horizon 2020 programme. See the current list of associated countries here: http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/3cpart/h2020-hi-list-ac_en.pdf.

11. Better capture and communicate impacts

The post-2020 EU R&I programme needs a **definition of impact** beyond GDP that captures for instance impact on science, skills and competences, competitiveness of European industry, innovation practices, performance of Member States, and on policy-making.

At the design stage of the post-2020 EU R&I programme, a **comprehensive and centralised monitoring and programme evaluation system** is needed, based on a streamlined set of indicators differentiating between the different pillars and specifying what can be captured short, medium and long term.

In order to minimise reporting burdens for beneficiaries, the Commission should rely as much as possible on **automated data collection systems** and seek innovative ways for tracking project results and the mobility and career development of EU-funded researchers and innovators.

The EU R&I programme should be **big on big data**. Data will be the fuel of science and innovation in the 21st century. Data from publicly-funded research should be easily accessible and re-usable across disciplines with due protection of partners' legitimate interests, especially intellectual property. The European Open Science Cloud should foster the emergence of an ecosystem of new data services and technologies.

The Commission should **work with Member States to develop a system to measure the impacts** of EU R&I programmes at national level in a comparable way, with an agreed core set of impact indicators that everybody will use. The EU and Member States should aim to deploy commonly accepted econometric models to measure the macro-economic impact of both EU and national R&I programmes.

Communication on relevance and impacts to citizens will be improved by moving from individual success stories to **portfolio analysis**, reporting on mission achievement rather than on only individual project successes. The Commission should develop ways and means to derive intelligence and results in real time from EU-funded research in response to EU policy needs.

A **consistent and unique branding of the programme** should ensure the wide and global visibility of EU investment and activity in research and innovation.

Beneficiaries of EU R&I funding should become principal communicators on impact – they must be sure that what they do is responsive and responsible to society at large. Communicating on science should become part of researchers' career and their reward system. A communication strategy should be part of the proposal requirements and followed through at each milestone. Stories to be told should be accessible to non-scientists. Beneficiaries should be incentivised to report on impacts, for instance by making the reports of the beneficiaries publicly available and showcasing the most impactful.

The Commission, in cooperation with Member States, should develop a common action plan and **exchange of best practices on how to make science and citizens talk**. An on-line "EU University" can provide a platform for top EU-supported researchers or innovators to give brief lectures, responding to R&I-related questions from citizens.

Action: brand EU research and innovation and ensure wide communication of its results and impacts.

ANNEX 1

Mandate of the High Level Group

The High Level Group (HLG) shall formulate a vision for future EU Research and Innovation (R&I) and draw strategic recommendations on maximising the impact of EU R&I programmes in the future, i.e. how to fulfil that vision. It will produce to this effect a report of 15 to 20 pages by end of June 2017.

The Group is set up in the context of the Interim Evaluation of Horizon 2020, which is currently carried out by Commission Services. The HLG's work will be grounded in the results of the evaluation (i.e. relevance, coherence, efficiency, effectiveness and EU added value) as they become available. It will also be informed by the economic rationale for investments in R&I, as well as by R&I foresight. It may take into account other input it considers appropriate.

The focus of the HLG's vision and recommendations for future EU investments in R&I will be excellence, openness and impact and how to maximise their impact as part of future R&I policy and programming at EU level.

The HLG report will influence the programming of the 2018 – 2020 work programme of Horizon 2020 (with more than €30 billion to programme) and will set the scene for a public and political debate on R&I in the Multiannual Financial Framework post-2020.

While the HLG's report will be addressed to the European Commission, the wider audience for the report will be the EU institutions as well as the broad range of stakeholders involved in current and future EU R&I as part of the European Research Area and beyond.

The full mandate of the HLG is contained in Commission Decision C(2016) 5871 final of 21 September 2016, which can be found online here:

http://ec.europa.eu/research/evaluations/pdf/archive/h2020_evaluations/tor_hlg_h2020_interim_evaluation.pdf#view=fit&pagemode=none

ANNEX 2

Consultations with stakeholders

The following European stakeholder organisations participated in meetings of the High Level Group:

- Business Europe
- Committee of the Regions
- European Alliance for Social Sciences and Humanities Research
- European Association of Craft, Small and Medium-Sized Enterprises
- European Association of Research & Technology Organisations
- European Climate Foundation, Industrial Innovation for Competitiveness Initiative
- European Economic and Social Committee
- European Industrial Research Management Association
- European Network of Innovation Agencies
- European Regions Research and Innovation Network
- European Start-up Network
- European Trade Union Confederation
- European University Association
- Science Europe

The following individuals participated in meetings of the High Level Group:

- Patrick Aebischer, President Emeritus, École Polytechnique Fédérale de Lausanne
- Jean-Pierre Bourguignon, President, European Research Council
- Koenraad Debackere, Executive Director for Research and Development, Katholieke Universiteit Leuven
- Marjolein Helder, Founder and Chief Executive Officer of Plant-e, and Member of the High Level Group of Innovators
- Peter Olesen, Chairman of the Governing Board, European Institute of Innovation and Technology
- Kinga Stanisławska, Managing Director and Founder of Experior Venture Fund, and Member of the High Level Group of Innovators

The High Level Group received written input from a number of organisations, such as:

- Academia Europaea
- Association of European Research Establishments in Aeronautics
- Bill and Melinda Gates Foundation
- Cancer Research UK
- ETH Zurich and University of Zurich
- European Brain Council
- European Research Council Scientific Council
- The European Organisation for Nuclear Research (CERN)
- Government of Portugal
- Jožef Stefan Institute, Ljubljana
- Norwegian University Rectors

The High Level Group interacted with the following EU institutional actors:

European Parliament – Members of the European Parliament Soledad Cabezon Ruiz, Christian Ehler, Barbara Kudrycka and Lieve Wierinck attended part of a High Level Group meeting.

Council of the EU – Pascal Lamy visited the COREPER I committee, consisting of the Deputy Permanent Representatives of EU Member States.

European Commission – the High Level Group and its members interacted, within a number of different meetings, with Vice President Jyrki Katainen (Jobs, Growth, Investment and Competitiveness) and Commissioners Violeta Bulc (Transport), Miguel Arias Cañete (Climate Action & Energy), Corina Crețu (Regional Policy), Phil Hogan (Agriculture & Rural Development), Julian King (Security Union), Günther H. Oettinger (Budget and Human Resources) and Margrethe Vestager (Competition). Carlos Moedas (Commissioner for Research, Science and Innovation) attended a part of the meetings of the Group.

ANNEX 3

Summary of 3 building blocks for High Level Group report

1) Interim Evaluation of Horizon 2020

Commission Staff Working Document – Executive Summary of the Interim Evaluation of Horizon 2020, 30 May 2017

Horizon 2020 was designed to drive economic growth and create jobs by coupling research and innovation (R&I), with an emphasis on excellent science, industrial leadership and tackling societal challenges. The general objective is to contribute to the EU's overarching jobs and growth strategy by: helping to build a society and an economy based on knowledge and innovation across the Union; by leveraging additional research, development and innovation funding; and by contributing to attaining R&I targets, including the target of 3 % of GDP for R&I across the Union by 2020.

This evaluation assesses Horizon 2020's current progress towards its objectives. The findings will contribute to the last Work Programme for 2018 – 2020, will provide the evidence-base for the report of the High Level Expert Group on maximizing the impact of EU Research and Innovation programmes and will inform the design of future Framework Programmes. An interim evaluation, when the first projects have only started three years ago, has obvious limitations. Science and innovation are long term and risky endeavours creating impact that can only very partially be captured after such a short period. A monitoring system with indicators to systematically track impact (in particular for societal challenges) is found to be wanting. No similar programmes exist to benchmark progress.

Nevertheless, the interim evaluation finds that the Programme's original rationale for intervention and its objectives and challenges identified at the programme launch are still highly **relevant** also in light of new political priorities. The EU still spends too little on R&I (the 3 % R&D expenditure target has not been met and Horizon 2020 only represents a small proportion of the total public R&D spending in the EU) and the innovation gap with key competitors still exists, even though performance is improving. Horizon 2020 supports cutting edge research and technological developments and has allowed for fast reactions to important developments like the Ebola outbreak and the migration surge. But the right balance still has to be found between being too prescriptive or not prescriptive enough to be able to swiftly capture disruptive technologies and business innovations. The relevance of the programme is shown by the sustained interest in its highly competitive calls: more than 30 000 proposals were submitted per year (compared to 20 000 for FP7), a third of which from newcomers. Still, more can be done to bring R&I closer to the public and further improve relevance and impact. The translation and linking of the high-level objectives into work programmes, calls, and projects could be made more systematic, transparent and participatory.

The externalisation of the most resource-intensive parts of the programme to Executive Agencies increased **efficiency** compared to FP7. It helped keep the administrative expenditure below the target of 5 % of the budget. Simplification measures have greatly improved operations, notably on the time-to-grant (on average 192 days, 100 days faster than in FP7). More specific feedback to applicants would further improve the evaluation procedure. The attractiveness of the Programme led to very low success rates (11.6 % compared to 18.5 % in FP7), leaving some parts strongly underfunded. An additional EUR 62.4 billion would have been needed to fund all the high-quality proposals evaluated. Horizon 2020's

focus on excellence leads to a high concentration of funding (both in terms of participants and geographical representation). Even though Horizon 2020 is open to world and has a broad international outreach through a number of multilateral initiatives the level of funding of participants from third countries has decreased compared to FP7.

Looking at **effectiveness**, early evidence at this very early stage of implementation indicates that progress is being made towards delivering on all Horizon 2020 objectives. Horizon 2020 is producing world-class excellence in science through for example the creation of multi-disciplinary international networks, training and mobility of researchers and the creation of research infrastructures. Support to innovation and industrial leadership has been effective with some early results on company growth, additional funding leveraged and innovations brought to the market. Horizon 2020 is already generating outputs that contribute to tackling societal challenges. However, the programme falls behind the expenditure target for sustainable development and climate change. Horizon 2020 is making progress, albeit slowly, in spreading excellence and widening participation and is making slight progress compared to FP7 in generating science with and for society.

Even though Horizon 2020 only represents a small proportion of total public R&D spending in the EU, macroeconomic models estimate significant socio-economic impact from Horizon 2020 (in the order of over EUR 400 billion gained by 2030).

However, a number of factors may impede full effectiveness in terms of market uptake: technological and regulatory obstacles, lack of standards and access to finance, as well as lack of customer acceptance of new solutions. Also, while supporting established innovators, the programme has not yet been able to reach out to young, fast-growing companies. As currently designed, it is not able to identify and support new innovators that are developing breakthrough solutions at the intersection of different sectors and technologies, or that are capable of creating new markets and have the potential to scale up rapidly.

Horizon 2020, with its three pillars, has a more **coherent** structure than FP7; the use of focus areas to promote interdisciplinary solutions to multiple societal challenges is particularly supported by stakeholders. However, a large number of instruments make the landscape for EU R&I support difficult to navigate and may lead to less coherent interventions. A stronger focus on higher Technology Readiness Levels in some parts of the Programme creates concerns of diverting resources away from preparing future breakthrough innovations, albeit longer-termed ones. Despite initiatives being taken to reinforce synergies with other EU funds, notably the European Structural and Innovation Funds, further coherence is hampered by the different intervention logics and complexity of the different funding and other rules such as State Aid rules. The Public-to-Public Partnerships supported by Horizon 2020 co-funding are building lasting collaborations but appear not to have been influential on Member States' policies and strategies.

Horizon 2020 produces demonstrable benefits compared to national and regional-level support to R&I in terms of scale, speed and scope, notably through the creation of cross-border, multidisciplinary networks; pooling of resources and creating critical mass to tackle global challenges. It thus increases the EU's attractiveness as a place to carry out research. Stakeholders find that Horizon 2020 has higher **added value** than other programmes. The programme's additionality (i.e. not displacing or replacing national funding) is very strong (83 % of projects would not have gone ahead without Horizon 2020 funding). The strong and direct pan-European competition guarantees the EU added value

of single beneficiary programme parts, like the SME Instrument and the European Research Council. The latter is now a beacon of scientific excellence across the world.

2) The Economic Rationale for Public R&I Funding and its Impact

Paper published by the European Commission's Directorate-General for Research and Innovation, January 2017. Available at: https://bookshop.europa.eu/en/the-economic-rationale-for-public-r-i-funding-and-its-impact-pbKI0117050/.

Research and Innovation (R&I) are key drivers of productivity and economic growth as demonstrated by ample empirical evidence. Firms and economies achieve large and significant returns on these investments, which also create new and better jobs. The importance of R&I increases even further as our economies become more knowledge-based and intensive in intangible assets.

R&I investments are of course also crucial to address key societal challenges and improve well-being. They contribute to better health outcomes, the fight against climate change, and more inclusive and resilient societies. Therefore, a full understanding the impacts of R&I needs to consider both the economic impacts and the social impacts that support higher levels of well-being. A number of market failures are directly linked to investment decisions in R&I. High risks, sunk costs, market uncertainty, lack of full appropriability of results, or unavailability of funding, all induce underinvestment in R&I below what is socially desirable. To maximise the spillovers that the creation and diffusion of knowledge generates, public funding for R&I is needed.

At the same time, we should not lose sight of the fact that the rationale for public R&I funding is evolving. Innovation dynamics are changing big time. Digitalisation, artificial intelligence and robotics grow exponentially, big data analytics changes our approach to business, science is more and more open and inter-disciplinary, and "winner takes most" competition can make a small number of highly profitable firms drive market shares to a considerable extent.

Celerity of change, increased complexity and higher concentration of benefits in key innovators radically influence the impacts of R&I investments and can lead to "negative externalities" in the form of extraordinary network and scale effects, erosion of human capital, and fast and creative destruction. All these phenomena affect -and are affected by- the impact of R&I investments.

Public R&I funding should therefore address the needs of fundamental research while equally support market-creating disruptive innovation, and strike a balance between cooperation and competition. Increasingly, well-functioning markets and smart regulations that avoid market fragmentation and the production of skilled human capital and appropriate financing affect R&I decisions and their capacity to impact on productivity and economic growth.

The benefits of public R&I funding have been extensively researched and are generally positive according to a number of meta-analyses. Nonetheless, capturing the whole breadth of R&I benefits is a complex operation and significant challenges to that measurement are linked to the intangible and changing nature of innovation. More robust evidence is therefore needed.

As regards EU public R&I funding, the economic impacts of FP7 have been estimated to be very large and significant. Further work is needed to measure the impact of public supranational R&I investments. The interim evaluation of Horizon 2020, the EU R&I funding programme 2014-2020, and the ex-ante evaluation of the successor to Horizon 2020, will shed additional light on this issue.

To sum up, the economic impacts of public R&I funding are large and significant. Public R&I policy is justified by market failures, positive spill-overs and negative externalities. These impacts are directly affected by: (1) Adequate investments from fundamental research to market-creating and disruptive innovation, (2) Improved framework conditions in support of innovation, including more accessible and cost-efficient business support, (3) Responsive public R&I policy that adapts to the changing landscape of innovation creation and diffusion.

3) BOHEMIA, New Horizons: Foresight in Support of the Preparation of the European Union's Future Policies in Research and Innovation

Study carried out for the European Commission's Directorate-General for Research and Innovation, to be published in the second half of 2017.

The BOHEMIA study, a foresight exercise launched by the European Commission in 2016, is developing future scenarios for the different contexts of EU R&I policy. It is gathering views of experts on future technologies, societal issues, R&I practices and their likely evolution and will develop policy recommendations.

The project is divided into three phases:

- Phase 1: Extensive review of available foresight to produce meta-scenarios relevant for Europe and deeper insights in topical fields (published in June 2017 and available at: https://ec.europa.eu/research/foresight/index.cfm?pg=strategic#bohemia)
- Phase 2: Delphi survey to gain insights on future technologies, societal issues, and R&I practices based on the scenarios (survey May June 2017, analysis of results ongoing)
- Phase 3: Analysis and policy recommendations (to be published in the last part of 2017)

The meta-scenarios look at the context of EU R&I interventions, as it is shaped by global megatrends and the transitions required for sustainability, in particular in relation to the Sustainable Development Goals of Agenda 2030.

Two types of scenario are used to illustrate these transitions:

- 'perseverance scenarios' where current trends persevere leading to crises;
- 'change scenarios', in which Europe leads the transition to 'the future we want'.

A number of key messages emerge from the scenarios report:

- R&I investment is key for a strong Europe in turbulent times. Investment in R&I enables us to be in charge of our future.
- The acceleration of change and the systemic nature of the challenges require flexibility for experimentation and learning from the best as well as connecting disciplines and connecting policies.
- Options are needed before crises strike. To best develop options, R&I needs direction (to create the conditions for future markets), but also openness and flexibility (for the markets to emerge) and global cooperation in order to help solve global problems through global markets.
- Getting the governance and regulation right is paramount. Appropriate governance involves openness, inclusiveness and fairness as guiding principles. Cities are a key level of governance; R&I policy should make them play an active role. Public engagement and innovation-conducive regulation will make the difference.

ANNEX 4

European added value of EU support to research and innovation

Without replacing national research and innovation (R&I) activities, EU funded R&I activities through the Framework Programmes produce demonstrable benefits compared to national and regional-level support to research and innovation in terms of scale, speed and scope. The added value comes through – *inter alia* – strengthening the EU's scientific excellence through competitive funding; the creation of cross-border, multidisciplinary networks; the pooling of resources to achieve critical mass for tackling global challenges, and developing the evidence-base to underpin policymaking.

Overall, this increases the EU's global attractiveness as a place to carry out research and innovation, strengthens the EU's competitiveness, contributes to growth and jobs[25] and makes the EU a world leader in tackling global challenges. Therefore, EU research and innovation should be "one of the essential policy priorities in the future"[26].

EU support to research and innovation:

- Strengthens the EU's scientific excellence through competitive funding – Excellence-based EU-wide competition increases the quality and visibility of the research and innovation output beyond what is possible with national or regional level competition. This is shown by the fact that EU-funded peer-reviewed research publications are cited more than twice the world average. Publications from EU funded R&I activities are almost four times more represented in the world's top 1 % of cited research compared with the overall publication output of the 28 EU Member States.[27] Compared to 1.7 % of national publications, 7 % of European Research Council publications (973, since its creation in 2007) are among the top 1 % highly cited in the world by field, year of publication and type of publication[28].
- Creates critical mass to address global challenges – Collaborative projects funded at EU level will help to achieve the "critical mass" required for breakthroughs when research activities are of such a scale and complexity that no single Member State can provide the necessary financial or personnel resources". This occurs where a large research capacity is needed and resources must be pooled to be effective, or where there is a strong requirement for complementary knowledge and skills (e.g. in highly inter-disciplinary fields). Investing in research and innovation at EU level will address global challenges (e.g. migration,

25) Macro-economic modelling suggests that by 2030, the extra impacts of investing EUR 70 billion in R&I at EU level is expected to generate between 0.27 % and 0.35 % more GDP, to increase EU net exports by between EUR 18 and 23 billion and to increase employment by between 110 000 and 179 000 units compared to the reference scenario. Source: PPMI study, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming.

26) High Level Group Own Resources report, http://ec.europa.eu/budget/mff/hlgor/library/reports-communication/hlgor-report_20170104.pdf

27) Elsevier based on Field Weighted Citation Index.

28) The European Research Council is recognised as a global brand synonymous with research excellence, with substantial structuring effects in the Member States. Four ERC grantees have been awarded the Fields Medal after being funded by the ERC. The ERC, MSCA and FET, together with collaborative research themes, have supported at least 17 Nobel Prize winners prior or after the award of their prize and Horizon 2020 beneficiaries have also contributed to major scientific discoveries including the Higgs Boson at CERN, the detection of gravitational waves and the discovery of a planetary system composed of seven Earth-like worlds (exo-planets) located relatively close to Earth in 2017.

security, climate change, health) which facilitates finding solutions much faster and more efficiently compared to what can be done at national level.

- Reinforces the EU's human capital – EU-funded R&I activities support human capital reinforcement through mobility and training which provide access to complementary knowledge[29]. 300 000-340 000 researchers in the EU Framework Programmes teams are fully or at least partly involved in EU-funded research activities[30]. In the case of the Marie Skłodowska-Curie Actions, evidence shows that the research impact of internationally mobile researchers is up to 20 % higher than the impact of those who opt to stay in their home country[31].
- Builds multidisciplinary transnational networks for more impact – EU R&I activities build cross-sectorial, inter-disciplinary, intra- and extra-European research and innovation networks which is key for bringing knowledge quickly to market and gaining industrial leadership. Based on a counterfactual analysis, EU-funded R&I teams had, on average, 13.3 collaborations versus six collaborations in the control group. The beneficiary teams also established almost twice as many collaborations with partners from outside the EU (on average, 3.6 partners from third countries versus 2.1 partners in the control group).[32] This leads to more impact: for example, Horizon 2020 publications including authors from associated and third countries score up to more than three times as much as the world average.[33]
- Increasing the EU's competitive advantage – EU R&I activities increase the competitive advantage of participants, for example through international multi-disciplinary networks, the sharing of knowledge and technology transfer and access to new markets. According to a counterfactual analysis, EU funded R&I teams grow faster (11.8 % more)[34]. EU-funded R&I teams are around 40 % more likely to be granted patents or produce patent applications compared with non-funded teams.[35] Furthermore, patents produced in the context of EU Framework Programmes are of higher quality and higher likely commercial value than similar patents produced elsewhere.
- Creates new market opportunities through collaborative multi-disciplinary teams and dissemination of results – Compared to the national level, EU R&I activities involve key industrial players, SMEs and end-users, which reduces commercial risks, for example through the development of common standards and interoperable solutions and by defragmenting existing markets. EU funded collaborative R&I activities with open access policies enable a more rapid and wide dissemination of results to users, industries, firms (SMEs in particular), citizens, etc. – leading to a better exploitation and larger impact than would be possible only at Member State level.

29) Study on assessing the contribution of the Framework Programmes to the development of human research capacity: http://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/fp_hrc_study_final_report.pdf

30) PPMI study, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming.

31) http://www.oecd.org/sti/Science-brief-scoreboard.pdf "Outflows tend to be associated with higher rated publications than their staying or returning counterparts. Assuming one could raise the performance of "stayers" to the level of their internationally mobile researchers [...] this would help countries catch up with leading research nations."

32) PPMI study, based on survey data.

33) Elsevier based on Field Weighted Citation Index.

34) Average growth rate of 24.4 % in EU-funded teams compared with 12.6 % in the control group.

35) PPMI study, based on survey data.

- Strengthens the evidence-base for policy-making – EU-funded R&I activities have an important role of supporting policy-making, which is for example illustrated by the results of EU funded projects related to antimicrobial resistance[36] and EU-funded projects in the field of climate change which played a key role in developing and aggregation climate change models, with a strong impact at the International Panel on Climate Change (IPCC).
- Leverages private investment: EU-funded R&I activities induce the private sector to invest more of their own funds. A counterfactual analysis shows a 24.6 % difference in the budget leverage.[37] Involving key EU industry players helps ensure that research results and solutions are applicable across Europe and beyond, enables the development of EU- and worldwide standards and interoperable solutions, and offers the potential for exploitation in a market of 450 million people: based on preliminary data, public-private partnerships are expected to attract between EUR 0.90 and 2.17 from private actors per each EUR of EU funding invested[38]. Thanks to its leverage effect, it is estimated through macro-econometric modelling that each EUR of EU investment in R&I would bring a GDP increase of between EUR 6 and 8.5 between 2014 and 2030.
- Has a high additionality – The EU invests in distinctive research and innovation projects, which are unlike those funded at national or regional level: the programme's additionality (i.e. not displacing or replacing national funding) is very strong with, on average, 83 % of projects that would not have gone ahead without Horizon 2020 funding[39].

36) Several of these projects have allowed collaboration with policy makers, such as the European Medicines Agency and their results have had an effect on antibiotic stewardship policies and infection control policies.

37) Beneficiary teams increased their R&D budgets by 22.4 %. The corresponding value for the non-FP teams was -2.2 %. PPMI study, based on survey data.

38) Data provided by the Thematic Units responsible for the seven JUs.

39) PPMI study, study based on survey data.

ANNEX 5

Comparison of trends between national government budget allocations for R&D and EU contribution in FP7 and Horizon 2020 by EU Member State

Objective

This exercise aims at assessing the extent to which statistical evidence potentially illustrates that EU funding in the context of the Framework Programmes is substituting public funding for research at national and regional level.

Methodology

The two indicators that are examined are:

- **The government budget allocations for research and development** (GBARD, previously called GBAORD)[40], which include budget from central and regional governments.
- The **amounts of EU contribution in FP7 and Horizon 2020** (annualised)[41].

The idea is to examine the extent to which budget increase or decrease by national governments correlates with increase or decrease of EU contribution over the same period. Two time periods are considered: 2007-2013 (the duration of the FP7 programme) and 2014-2016 (Horizon 2020 to date).

To measure the change in GBARD between both periods, the yearly average GBARD is calculated over 2007-2014 and over 2014-2015 for each Member State (2016 is not yet available for most Member States).

The growth rate between both averages is then computed. Similarly, the change in EU contribution between FP7 and Horizon 2020 is the growth rate between the yearly average EU contribution under FP7 and the yearly average under Horizon 2020.

Findings

All EU Member States are positioned in terms of change in GBARD and EU contribution between the Framework Programmes. Countries that are located on the left side of the graph have experienced budget cuts between the two periods, while countries on the right side have seen their national R&D budget increased. Countries in the upper part of the graph receive more funding from the EU in Horizon 2020 than in FP7, while countries in the lower part receive less.

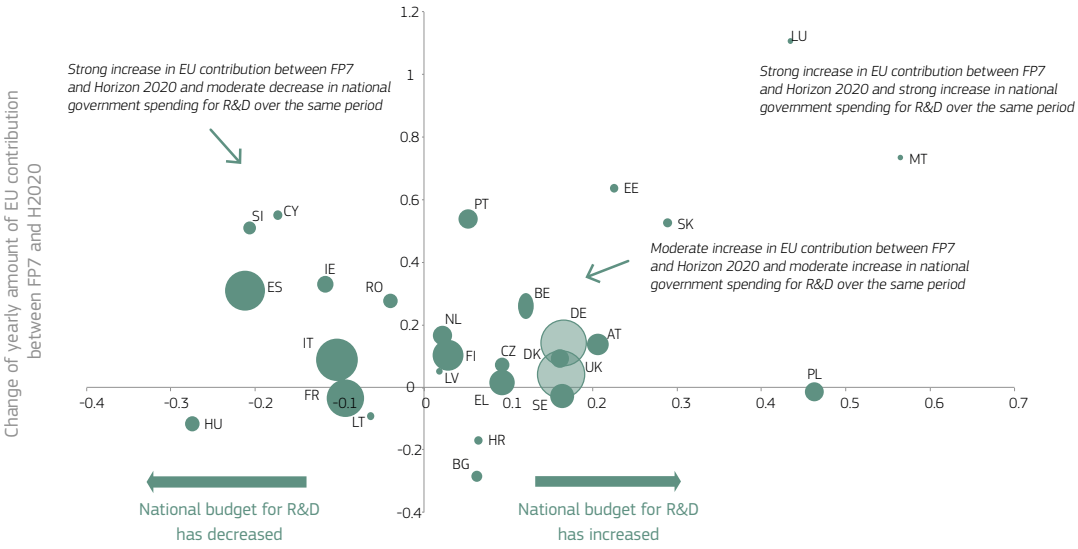
While some countries present simultaneously a decrease in national budget for R&D and an increase in EU contribution from the Framework Programmes, this result is **not systematic for all countries**.

Figure 1 shows a cluster of several countries that have experienced a moderate increase of both indicators, and even countries that have seen both funding measures increase strongly over the period.

Overall, there is no direct evidence of overall crowding-out effect (i.e. many countries are not located in the upper left part of the graph).

40) Source : Eurostat.
41) Source : Corda.

Figure 1: Change in GBARD and change in EU contribution between FP7 and H2020 (size of circles: number of applications in Horizon 2020)



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The European Commission, through Carlos Moedas, Commissioner for research, science and innovation, invited us to draw up a vision and strategic recommendations to maximise the impact of future European Union (EU) research and innovation programme.

This report is the result of the Group's deliberations. The twelve of us brought different but complementary perspectives to research, innovation and education. These perspectives were grounded in personal experience with the policy, the practice or in many cases both.

The Group agreed without difficulty on a number of core messages. Our main message, and vision, is that investing in research and innovation is increasingly crucial for shaping a better European future in a rapidly globalising world, where success depends ever more on the production and use of knowledge.

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