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COMMISSION STAFF WORKING DOCUMENT

IN-DEPTH INTERIM EVALUATION
of
HORIZON 2020

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1. EXECUTIVE SUMMARY

This Staff Working Document represents the interim evaluation of Horizon 2020, the EU Framework Programme for Research and Innovation 2014-2020. 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.

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 but 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). Horizon 2020 is open to the world and has a broad international outreach, in particular through a number of multilateral initiatives; however the number of participations from third countries in Horizon 2020 projects 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; still, this expenditure represents a considerable increase compared to FP7. 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, new 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 Investment 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 trans-national, 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 national and/or regional 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. KEY DEFINITIONS, ACRONYMS AND GLOSSARY

Name or abbreviation	Description
Applicant	Legal entity submitting an application for a call for proposals.
Application	The act of involvement of a legal entity in a Proposal. A single Applicant can apply in different proposals.
ARF	Access to Risk Finance
Associated Country	Third Countries that are party to an association agreement with the European Union. They participate in Horizon 2020 under the same conditions as EU Member States. As of 1 January 2017 16 countries were Associated.[1]
CEF	Connecting Europe Facility
COFUND-EJP	European Joint Programme Cofund
COSME	European Union Programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises
COST	European Cooperation On Science and Technology
cPPP	Contractual Public-Private Partnership
CSA	Coordination and Support Action
DG CONNECT	European Commission's Directorate-General for Communication Networks, Content and Technology
DG REGIO	European Commission's Directorate-General for Regional and Urban Policy (DG RE-GIO)
DG RTD	European Commission's Directorate-General for Research and Innovation
EASME	Executive Agency for Small and Medium-sized Enterprises
EESC	European Economic and Social Committee
EFSI	European Fund for Strategic Investments
EIP	European Innovation Partnership
EIT	European Institute for Innovation and Technology
ERC	European Research Council
ERCEA	European Research Council Executive Agency
ESIF	European Structural and Investment Funds
ETP	European Technology Platform
EU-13	BG - Bulgaria, LT - Lithuania, SK - Slovakia, CY - Cyprus, LV - Latvia, CZ - Czech Republic, MT - Malta, EE - Estonia, PL - Poland, HR - Croatia, RO - Romania, HU - Hungary and SI - Slovenia
EU-15	AT- Austria, BE - Belgium, DE - Germany, DK - Denmark, EL - Greece, ES - Spain, FI-Finland, FR - France, IE - Ireland, IT - Italy, LU - Luxembourg, NL - Netherlands, PT - Portugal, SE - Sweden and UK - United Kingdom
FET	Future and Emerging Technologies
FTI	Fast Track to Innovation
High Quality Pro-posal	A proposal that scores above set evaluation threshold, making it eligible for funding.
IA	Innovation Action
ICT	Information and Communication Technologies
INEA	Innovation and Network Executive Agency
JPI	Joint Programming Initiative
JRC	Joint Research Centre
JTI	Joint Technology Initiative
JU	Joint Undertaking
KIC	Knowledge and Innovation Community
KPI	Key Performance Indicators in the legal basis of Horizon 2020.
LEIT	Leadership in Enabling and Industrial Technologies

[1] See list here http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/3cpart/h2020-hi-list-ac_en.pdf

MSCA	Marie-Skłodowska-Curie Actions
Newcomer	A Horizon 2020 Participant who was not involved in a FP7 Project (not a FP7 participant).
NMBP	Nanotechnologies, Advanced materials, Biotechnology and Advanced manufacturing and processing
P2P	Public to Public Partnership
Participant	Any legal entity carrying out an action or part of an action under Horizon 2020.
Participation	The act of involvement of a legal entity in a Project. A single Participant can be involved in multiple Projects.
PCP	Pre-Commercial Procurement
PPI	Public Procurement of Innovative Solutions
PPP	Public-Private Partnerships
Project	Successful proposals for which a Grant Agreement is "signed".
PSF	Policy Support Facility
PSF	Policy Support Facility
REA	Research Executive Agency
RI	Research Infrastructures
RIA	Research and Innovation Actions
SC1	Societal Challenge 1: Health, demographic change and wellbeing
SC2	Societal Challenge 2: Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy
SC3	Societal Challenge 3: Secure, clean and efficient energy
SC4	Societal Challenge 4: Smart, green and integrated transport
SC5	Societal Challenge 5: Climate action, environment, resource efficiency and raw materials
SC6	Societal Challenge 6: Europe in a changing world - inclusive, innovative and reflective societies
SC7	Societal Challenge 7: Secure societies protecting freedom and security of Europe and its citizens
SDG	Sustainable Development Goals
SEWP	Spreading Excellence and Widening Participation
SGA	Specific Grant Agreement
SME	Small or Medium-Sized Enterprise
SME-1 and SME-2	SME instrument phase 1 and 2
Success rate	The share of proposals that are retained for funding out of the total number of eligible proposals.
SWAFS	Science with and for Society
Third Country	A state that is not a Member State of the EU. “Third Countries” does not include Associated Countries.
Time to grant	The elapsed time between the call closing date and the signing of the grant agreement, which marks the official start of the project.
TRL	Technology Readiness Levels are indicators of the maturity level of particular technologies. This measurement system provides a common understanding of technology status and addresses the entire innovation chain: TRL 1 – basic principles observed; TRL 2 – technology concept formulate; TRL 3 – experimental proof of concept; TRL 4 – technology validated in lab; TRL 5 – technology validated in relevant environment; TRL 6 – technology demonstrated in relevant environment; TRL 7 – system prototype demonstration in operational environment; TRL 8 – system complete and qualified; TRL 9 – actual system proven in operational environment

3. INTRODUCTION

3.1. Purpose of the evaluation

This Commission Staff Working Document presents the interim evaluation of Horizon 2020 - the Framework Programme for Research and Innovation 2014-2020 -, in line with Article 32 of the Regulation 1291/2013[2] and the Commission's Better Regulation Guidelines[3]. The interim evaluation aims to contribute to improving the implementation of Horizon 2020 in its last Work Programme 2018 – 2020, to provide the evidence-base for the report of the High Level Expert Group on maximizing the impact of European Research and Innovation Framework programmes and to inform the design of future Framework Programmes. It assesses progress made towards achieving the objectives of Horizon 2020, the efficiency and use of resources, its continued relevance; the coherence within the Horizon 2020 and with other instruments and its EU added-value.

3.2. Scope of the evaluation

The interim evaluation of Horizon 2020 covers the entire Horizon 2020 programme and its specific programme, including the European Research Council (ERC) and activities of the European Institute of Innovation and Technology (EIT) with the exception of public-public partnerships (initiatives based on Article 185 of the Treaty), public-private partnerships (initiatives based on Article 187 of the Treaty), activities of the European Institute of Innovation and Technology, and the Euratom Framework Programme. While references are made to those initiatives in this evaluation, this is done without prejudice to the forthcoming separate dedicated interim evaluations of those initiatives.[4] Joint Research Centre (JRC) direct actions are part of the EC and Euratom Framework Programmes, but are evaluated separately. The interim evaluation covers the first half period of Horizon 2020 implementation (2014 - 2016 included). Furthermore, it reports on the wider impacts of the previous European Framework Programmes, with a longer-term perspective.

4. BACKGROUND TO THE INITIATIVE

4.1. Description of the initiative and its objectives

Summary box: Key features of Horizon 2020

- An EU research and innovation Framework Programme that is unique in the world in terms of budget (about EUR 80 billion, the largest Framework Programme budget ever), duration (7 years), budgetary framework stability, and scope (research plus innovation; grants as well as loans, equity, and procurement; broad top-down thematic coverage as well as bottom-up blue sky research; trans-national, cross-sectoral, inter-disciplinary collaboration, mobility, coordination).
- Pursuing an ambitious general objective of 'building a society and economy based on knowledge and innovation'.
- A simple structure, aligned with the specific objectives, comprising three pillars: 'Excellent science'; 'Industrial leadership'; 'Societal challenges' and two additional priorities

[2] See Annex 2 for an overview of the elements covered by this provision.
[3] More information here: http://ec.europa.eu/smart-regulation/guidelines/toc_guide_en.htm
[4] The European Institute of Innovation and Technology, the Euratom Framework Programme and the Article 185 and 187 initiatives have a separate legal base and will be covered by self-standing interim evaluations in separate Staff Working Documents to be published in the second half of 2017.

- With a built-in innovation and impact orientation (challenge-based approach; funding all the way from lab to market; enhanced business and SME involvement; impact-oriented call texts; expected impact to be spelled out in proposals; impact looked at in evaluation; regular reporting and monitoring).
- Excellence as guiding principle and main evaluation and selection criterion.
- Allocation of funding through a strategic programming process and two-year work programmes.
- Wide range of instruments and actions.

Research is a shared competence between the European Union (EU) and Member States[5]. The Framework Programmes are the EU's main instruments for the funding of research and innovation (R&I) in Europe. Horizon 2020 is the eighth EU's Framework Programme for research and innovation for the period 2014 – 2020 with a budget of nearly EUR 80 billion, bringing together EU level research and innovation funding into a single programme, covering the scope of the 7th Framework Programme (FP7), the innovation activities from the former Competitiveness and Innovation Framework Programme (CIP), as well as EU funding to the European Institute of Innovation and Technology.

Its general objective is "to contribute to building a society and economy based on knowledge and innovation across the Union by leveraging additional research, development and innovation funding and by contributing to attaining research and development targets, including the target of 3% of Gross Domestic Product (GDP) for research and development (R&D) across the Union by 2020. It shall thereby support the implementation of the Europe 2020 strategy and other Union policies, as well as the achievement and functioning of the European Research Area (ERA)". [6]

It is structured around three pillars ('mutually reinforcing priorities'): excellent science, industrial leadership and societal challenges, each having their own specific objectives and broad lines of actions. It has two additional priorities 'Spreading excellence and widening participation' and 'Science with and for society' with their own broad lines of actions. Furthermore, the JRC and EIT are expected to contribute to the general objectives and priorities.

When Horizon 2020 was adopted, this single framework integrating research, education[7] and innovation aspects was expected to deliver enhanced scientific, technological and innovation impacts which would translate into larger downstream economic, competiveness and social impacts as well as environmental and EU policy impacts.

Figure 1 Structure of Horizon 2020

Source : European Commission

[5] Article 4(3) Treaty on the Functioning of the European Union
[6] Article 5, Regulation 1291/2013/EC establishing Horizon 2020.
[7] A big part of the European action related to education is covered by ERASMUS+ and is thus outside Horizon 2020.

SMEs were expected to benefit in particular from administrative simplification and closer knowledge triangle coordination particularly concerning research and innovation finance. Horizon 2020 also integrates a major simplification and standardisation of funding schemes and implementing modalities across all areas. Its far-reaching integration, simplification and harmonisation were expected to reduce costs for the European Commission and for applicants. A set of cross-cutting issues (such as gender equality, social sciences and humanities, international cooperation, responsible research and innovation, widening participation, sustainable development, biodiversity and climate action, digital agenda, SME and broader private sector participation) are promoted across Horizon 2020 to develop new knowledge, key competences and major technological breakthroughs as well as to improve the conduct and openness of R&I and translate knowledge into economic and societal value.[8]

The following five specific objectives of Horizon 2020 were identified in its impact assessment:

- Strengthen Europe's science base by improving its performance in frontier research, stimulating future and emerging technologies, encouraging trans-national training and career development, and supporting research infrastructures;
- Boost Europe's industrial leadership and competitiveness through stimulating leadership in enabling and industrial technologies, improving access to risk finance, and stimulating innovation in SMEs;
- Increase the contribution of research and innovation to the resolution of key societal challenges;
- Provide customer-driven scientific and technical support to EU policies;
- Help to better integrate the knowledge triangle — research, researcher training and innovation.

To reach the specific objectives, the following operational objectives have been set in its impact assessment:

- Increase the efficiency of delivery and reduce administrative costs through simplified rules and procedures adapted to the needs of participants and projects;
- Create transnational research and innovation networks (knowledge triangle players, enabling and industrial technologies, in areas of key societal challenges);
- Support the development and implementation of research and innovation agendas through public-private partnerships;
- Strengthen public-public partnerships in research and innovation;
- Support market uptake and provide innovative public procurement mechanisms;
- Provide attractive and flexible funding to enable talented and creative individual researchers and their teams to pursue the most promising avenues at the frontier of science;
- Increase the transnational training and mobility of researchers;
- Provide EU debt and equity finance for research and innovation;
- Promote world-class research infrastructures and ensure EU-wide access for researchers;
- Ensure adequate participation of SMEs;
- Promote international cooperation with non-EU countries.

[8] Annex 1 Regulation (EU) No 1291/2013

For the purpose of the evaluation, the intervention logic of Horizon 2020 was reconstructed based on programming documentation (see Figure 2). It describes the links between the problems to be tackled, the objectives to be achieved, the activities and the expected impacts[9]. It distinguishes between outputs (the direct products from the actions, such as reports, trained researchers, demonstrators, prototypes, new infrastructures), results (that relate to benefits for direct beneficiaries from their participation) and impacts (the wider effects of Horizon 2020), which are categorised into three main categories: scientific impact, innovation/economic impact and societal impact. The analysis of progress performed for this interim evaluation is made according to these main strands of impacts based on the information available so far.

In addition detailed intervention logics were developed for each specific objective of Horizon 2020 to support the in-depth 'thematic' assessments of each programme part that are available in Annex 2. All references in this document to "Annex 1" or "Annex 2" refer to the Annexes of the Interim Evaluation of Horizon 2020 Staff Working Document.

Box: Expected impacts of Horizon 2020

Scientific impact:

- The '*EU world-class excellence in science'* and the '*Emergence of new technologies or fields of science in the EU*' are both long-term impacts in the sphere of R&I, building typically upon long-term research efforts and consolidated - while sufficiently open - long-term partnerships in research.
- *'Better trans-national and cross-sector coordination and integration of R&I efforts*' refers to impacts in the sphere of R&I deriving from the creation of effective and long-lasting knowledge networks and linkages between the various stakeholders in research, education, and industry at European level as well as the creation of synergies and complementarities between R&I policies at the European, national and regional levels.

Innovation/ economic impact:

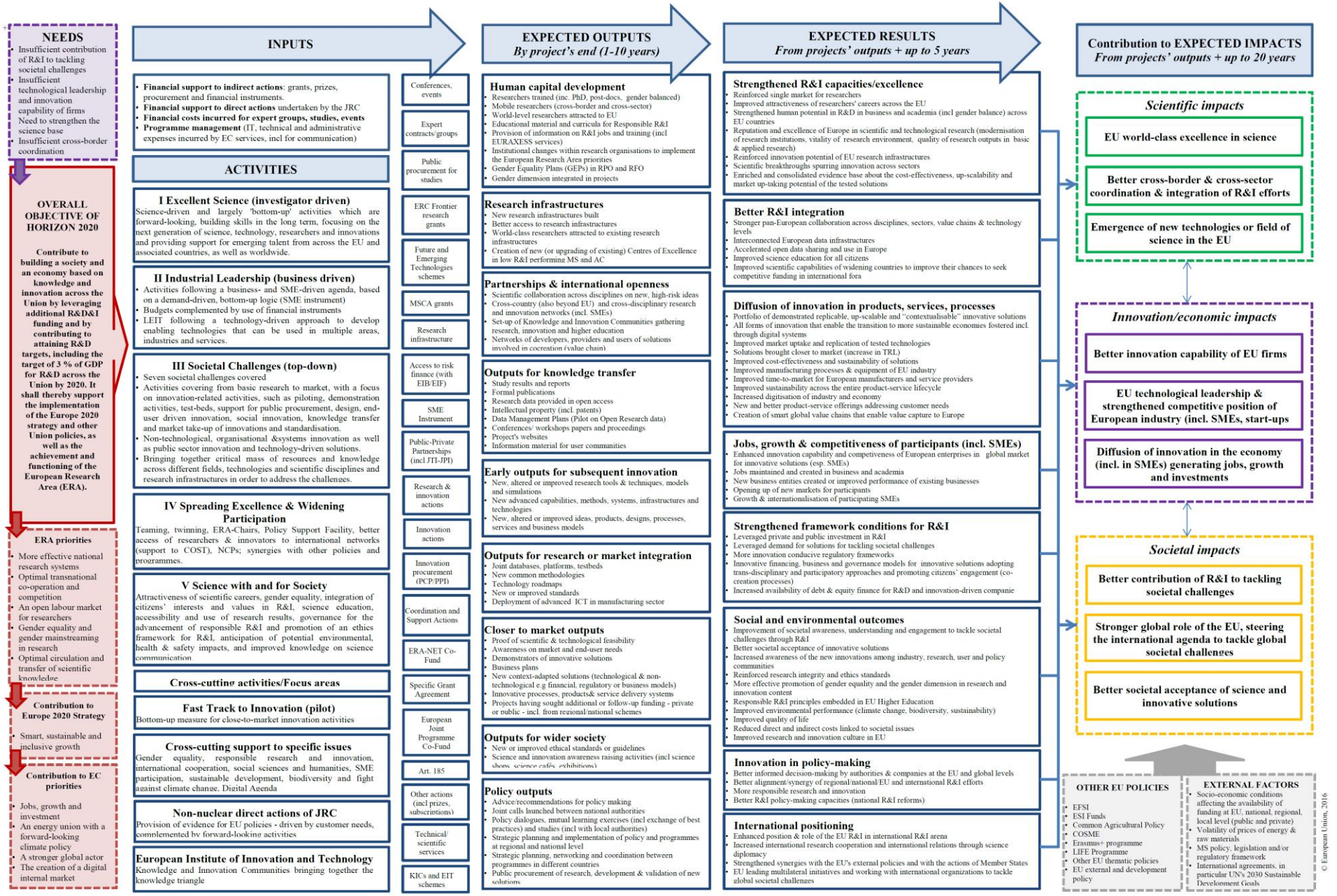
- '*Diffusion of innovation in the economy generating jobs, growth and investments'* and '*Strengthened competitive position of European industry'* cover the 'innovation' impacts in the economic sphere. The diffusion of innovation should strengthen the competitive positioning of industry; from a longer-term perspective, a critical factor is also the relevant knowledge capital in society (absorptive capacities) reflected in the "*Better innovation capabilities of EU firms*"., deriving also from, for example, standardisation efforts and the strengthening of the Single Market or the development of policies and regulations that are coherent at European level.

Societal impact:

- *'Better contribution of R&I to tackle societal challenges'* focuses on the impacts of R&I on issues such as quality of life, health, environmental protection, social inclusion, etc.
- '*Stronger global role of the EU, steering the international agenda to tackle global societal challenges'* focuses on the international positioning and influence of EU R&I on issues of global societal relevance.
- '*Better societal acceptance of science and innovative solutions'* refers to the role of R&I for supporting policy-making in line with citizen needs and the acceptance and take-up of R&I results by society (also based on broader involvement of society in R&I).

[9] The intervention logic is based on the following documents: The Horizon 2020 Regulation that defines the general and specific objectives, priorities, budget and principles for the management of the programme; The Council Decision establishing the specific programme implementing Horizon 2020 ('Specific Programme'); The Horizon 2020 Impact Assessment that establishes and assesses the problem definition, objectives and options of the programme; The Work Programmes 2014-2015 and 2016-2017, which detail the activities undertaken so far.

Figure 2 Horizon 2020 Intervention Logic



Needs coming from H2020 Impact Assessment, **Overall objective** of H2020 coming from Horizon 2020 establishment act Regulation (EU) No 1291/201; **Inputs** coming from Horizon 2020 establishment act Regulation (EU) No 1291/2013 (Article 10); **Activities** coming from Horizon 2020 establishment act Regulation (EU) No 1291/2013 (Annex 1, page 123 and following); **Types of outputs, results and impacts expected** regrouped based on Horizon 2020 establishment act Regulation (EU) No 1291/2013 (Annex 1, page 123 and following), Horizon 2020 specific programme Council Decision (2013/743/EU) + Annexes and Work Programmes 2014-2015 and 2016-2017

4.2. Baseline

When Horizon 2020 was conceived, Europe was facing a series of major challenges that centred on low growth rates, a diverse set of environmental, social and technological challenges, decreasing industrial competitiveness and persistent structural weaknesses hampering innovation. Science and innovation were identified as the key factors in helping Europe move towards smart, sustainable and inclusive growth, while also helping to tackle major societal challenges.[10]

The three pillars structure of Horizon 2020 reflects the set of issues identified as underlying the Europe's innovation gap: the insufficient contribution of research and innovation to tackling societal challenges; the insufficient technological leadership and innovation capability in the private sector; the need to strengthen the science base and insufficient trans-national coordination. A detailed analysis of the situation at the programme launch is provided under the Relevance section.

In many respects, Horizon 2020 constitutes a decisive break with the past. Before Horizon 2020, EU funding for research, education and innovation was covered by separate EU programmes (FP7, the innovation-related part of the Competitiveness and Innovation Programme (CIP), and the European Institute of Innovation and Technology (EIT)), with different rules and implementation modalities. The following box provides an overview of the main changes from FP7 to Horizon 2020 as well as the key expectations resulting from the changes of focus between FP7 and Horizon 2020. Where relevant and possible, the performance of FP7 and these expectations are used as a baseline in this evaluation. An overview of the results and impacts generated through FP7 is provided in Section 11.

Summary box: From FP7 to Horizon 2020

Recommendations from FP7 ex-post evaluation[11]	Horizon 2020
Focus on critical challenges and opportunities in the global context	➢ focuses on society's major challenges ➢ boosts private sector participation, including SMEs ➢ maximises synergies between different areas of research and innovation and new digital technologies
Align research and innovation instruments and agendas in Europe	➢ seeks to support the alignment of national research strategies ➢ better coordinates with EU regional funding ➢ helps EU countries reform their research and in-novation strategies ➢ identifies obstacles to research and innovation ➢ ensures that research proposals support innovation
Integrate different sections of research funding programmes more effectively	➢ focuses on better consistency across the funding programme ➢ ensures cross-cutting issues are considered ➢ simplifies access to research and innovation funding ➢ applies single set of rules consistently ➢ coordinates effectively across the Commission in managing funding
Bring science closer to citizens	➢ better communicates to the general public on science issues in general and on Horizon 2020 in particular ➢ strengthens open access to research publications and data ➢ involves citizens in research strategy and topics
Establish strategic programme monitoring and evaluation	➢ better monitors and evaluates funding and socioeconomic impacts ➢ improves feedback loop from project results to policy making

[10] Introduction to Horizon 2020 Ex-Ante Impact Assessment Report (COM/2011/808)
[11] European Commission, Commitment and Coherence – Ex-Post Evaluation of the 7th EU Framework Programme, Report from the high-level Expert Group, 2016, https://ec.europa.eu/research/evaluations/index_en.cfm

Main novelties of Horizon 2020 compared to FP7

- A single programme for all EU managed research and innovation funding, with a single set of participation rules.
- Full integration of innovation in the programme, meaning more support that is closer to market application (e.g. demonstration, support for SMEs, innovation services, venture capital)
- A focus on the major societal challenges Europe and the world face. This means bringing together different technologies, sectors, scientific disciplines, social sciences and humanities, and innovation actors to find new solutions to these challenges.
- Radically simplified access for participants, including a single web portal for all information and projects, less paper work to make applications, and fewer controls and audits.
- A more inclusive approach with specific actions to ensure excellent researchers and innovators from all European regions can participate, and reinforced support for partnerships with the private sector and with the public sector in order to pool resources and build more effective programmes.
- At the same time, successful elements from FP7 are being scaled up, such as the European Research Council and trans-national collaborative projects.

Main elements of continuity/strengthening of successful elements from FP7

- The *European Research Council,* which had in a few years' time become the point of reference for excellent frontier research in Europe and which has therefore been significantly strengthened;
- The *Marie Curie actions* for training, mobility and career development of researchers and the research infrastructure actions;
- The *collaborative research actions* which have been at the heart of the successive Framework Programmes for Research and are under Horizon 2020 extended to innovation aspects such as market-replication, demonstration, involvement of users, design, intellectual property and standardisation issues;
- The *financial instruments* of both FP7 and the CIP which have been met with great demand and which have been shown to be particular valuable in a time in which debt and equity financing have been severely constrained;
- *Demand side measures* to stimulate innovation (in particular public procurement of innovative solutions), support through clusters, IPR management and exploitation, SME innovation capacity support, stemming from the CIP.
- While aligning with the strategy of Horizon 2020, the *European Institute of Innovation and Technology* maintains its mission: integrating the knowledge triangle and experimenting with new approaches for innovation, notably involving the business community.

Main expectations from Horizon 2020 compared to a continuation as in FP7 (based on the Impact Assessment of Horizon 2020 performed in 2012)

- As under FP7, Horizon 2020 is expected to achieve critical mass at programme and project level. At the same time, it is expected to enhance the promotion of scientific and technological excellence and allow for more flexibility.
- Administrative costs for applicants and participants are expected to reduce drastically, which is expected to significantly improve accessibility, in particular for SMEs, and increase levels of support from all types of stakeholders.
- Knowledge triangle and broader horizontal policy coordination is expected to be enhanced through a single framework integrating, research, innovation, and researcher training and skills development, and explicitly defining links with other policies.
- Scientific, technological and innovation impacts are expected to be enhanced through the provision of seamless support from scientific idea to marketable product, stronger output orientation, better dissemination of research results, clearer technological objectives, enhanced industrial and SME participation and, thus, enhanced leverage, funding of demonstration activities, and provision of innovation financing and support.
- In combination with clarity of focus and high-quality intervention logic, enhanced scientific, technological and innovation impacts are expected to translate into larger downstream economic and competiveness, social, environmental and EU policy impacts.

4.3. Evaluation questions

In line with the 'Better Regulation' guidelines, this interim evaluation addresses evaluation questions under each of the sections, which are structured around the five evaluation criteria of relevance, efficiency, effectiveness, coherence and EU added value.

- **Relevance:** assessment of whether the original objectives of Horizon 2020 are still relevant and how well they still match the current needs and problems;
- **Efficiency:** the relationship between the resources used by Horizon 2020 and the changes it is generating;
- **Effectiveness:** how successful Horizon 2020 has been in achieving or progressing towards its objectives;
- **Coherence:** how well or not the different actions work together, internally and with other EU interventions/policies;
- **EU added value:** assessment of the value resulting from Horizon 2020 that is additional to the value that could result from interventions which would be carried out at regional or national levels.

Figure 3 Evaluation questions and sub-questions

Main evaluation questions	Sub-questions per evaluation criteria
How relevant has Horizon 2020 been so far?	➢ Is Horizon 2020 tackling the right issues? ➢ Does Horizon 2020 allow adapting to new scientific and socio-economic developments? ➢ Is Horizon 2020 responding to stakeholder needs?
How efficient has Horizon 2020 been so far?	➢ How efficient are the programme management structures? ➢ How efficient are the communication and application processes? ➢ How efficient is the distribution of funding? ➢ To what extent is Horizon 2020 cost-effective?
How effective has Horizon 2020 been so far?	➢ What is the progress made towards achieving scientific impact? - What is the progress made on strengthening R&I capacities, reputation and scientific excellence? - What is the progress made on improving R&I integration? - What is the contribution of Horizon 2020 to the achievement and functioning of the European Research Area ➢ What is the progress made towards achieving innovation and economic impact? - What is the progress made on advancing knowledge, IPR and knowledge transfer? - What is the progress made on reinforcing framework conditions for R&I? - What is the progress made on delivering close to market outputs and diffusing innovation in products, services and processes? ➢ What is the progress made towards achieving societal impact? - What is the progress made on tackling societal challenges? - What is the progress made on generating science with and for society? - What is the progress made on generating science for policy? ➢ What is the overall progress of Horizon 2020 towards its general objective?
How coherent has Horizon 2020 been so far?	➢ To what extent is Horizon 2020 coherent internally? ➢ To what extent is Horizon 2020 coherent with other EU initiatives, in particular the European Structural and Investment Funds (ESIF) and the European Fund for strategic Investment (EFSI)? ➢ To what extent is Horizon 2020 coherent with other initiatives at national, regional and international level?
What is the European added value of Horizon 2020 so far?	➢ What is the European added value of Horizon 2020 compared to national and/or regional levels?

4.4. Method

Contrary to the ex-post evaluation of FP7, the predecessor programme, the interim evaluation has not been carried out by one external expert group, but has been coordinated by the Evaluation Unit of the Commission's Directorate-General for Research & Innovation, with the support of a Working Group and an Inter-Service Group comprising other Commission services. The interim evaluation started in April 2016 and has been guided by Terms of Reference adopted by the Commission after a vote by the Member States' Programme Committee. It has been based on the following data sources: [12]

- Monitoring reports of Horizon 2020 and statistical data mainly from the Commission's internal IT Tools as well as Eurostat/OECD data;
- Extensive analysis carried out by the responsible Commission services on the different programme parts of Horizon 2020 ('thematic assessments'[13]), on the 15 cross-cutting issues, on the Horizon 2020funding model and various Horizon 2020 instruments/actions (Article 185/187 initiatives, Fast Track to Innovation, SME Instrument EIT), on participating companies' profiles (ORBIS data), on the New Management modes (based on external evaluations of agencies and internal data), on participations' networks (with the JRC). Most internal assessments benefitted from the support from external expert groups/studies as well as dedicated surveys of beneficiaries.
- External horizontal studies covering the entire Horizon 2020 programme on publications and networking based on Scopus data (Elsevier, forthcoming), the financing of participating companies (Grimpe et al, 2017); on the EU Added Value and economic impact of the Framework Programme (PPMI, forthcoming) - which included a representative survey of Horizon 2020 project coordinators, counterfactual analysis and macro-economic modelling -; and the work of an Expert Group on Evaluation Methodologies using text- and data mining tools to investigate the relevance and impact of the Framework Programme[14];
- Data from other EU Institutions such as the Conclusions on the Interim Evaluation of the Council, work of the ITRE committee of the European Parliament, relevant Court of Auditors' reports and reports/evaluations of the European Economic and Social Committee.

Input from various stakeholder consultations was used to contextualise the findings, in particular the NCP surveys launched in the context of the Horizon 2020 Annual Monitoring reports, the Simplification Survey, the Call for Ideas on the European Innovation Council and the stakeholder consultation on the Interim Evaluation of Horizon 2020 to which more than 3,500 stakeholders replied and more than 300 stakeholder position papers were submitted.[15]

Limitations – robustness of findings

[12] Further details on the methodologies adopted for this interim assessment and results are provided in Annex 1.

[13] Methods used for the 18 in-depth 'thematic assessments' include: expert groups, case studies, surveys, interviews, text mining, statistical analysis, documentary reviews, internal assessments, bibliometric analysis, patent analysis, Social Network Analysis. All 'thematic assessments' are available in Annex 2.

[14] European Commission Expert group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020, Applying relevance-assessement methodologies to Horizon 2020 (forthcoming report)

[15] A full analysis of the stakeholder consultation (both the questionnaire and the position papers) is provided in Annex – Part 2. The SWD summarises key stakeholder input to dedicated topics. Input received from stakeholders in position papers is highlighted in blue boxes throughout the SWD.

The main limitation of this interim evaluation concerns its timing: it is taking place only three years after the beginning of Horizon 2020, while most projects have only just started (projects completed at time of this evaluation represent 0.6% of funding allocated so far). Whereas for some actions effects may be expected within a short-term period, such as an increase in private R&D investment, this period is too short for many results and wider impacts to emerge. Some lower risk actions have many incremental and short term effects – easier to capture and to report on - whereas long term or high risk actions (such as fundamental research) might bear more radical effects in the longer term (e.g. 20-30 years) and have effects more difficult to capture through usual indicator systems (e.g. the general advancement of knowledge).

Limitations include issues related to data availability and measurability of outcomes (for example, most Horizon 2020 indicators focus on input/outputs but not on results and impact in particular the indicators to track progress on the societal challenges are not challenge specific, i.e. they relate to classical outputs from R&I projects - publications, patents, prototypes - but not to their impacts on e.g. decreasing CO2 emissions, improving health of citizen, or their security, often on the longer term), aggregation (for example monitoring data covering the entire programme comes from various data sources, which are difficult to aggregate) and reliability of certain data (for example data on patents and publications are for many parts of the programme based on self-reporting by project coordinators; data on the cross-cutting issues like gender and social sciences and humanities is based on flagging by project officers). It has also not always been possible to validate findings from external studies/expert groups, for example with respect to macro-econometric modelling results.

Another limitation is the lack of benchmarks to compare performance. Worldwide there is no programme similar to Horizon 2020 in terms of size, thematic coverage and depth: the EU Framework Programmes are rather unique in their form, covering R&I aspects from fundamental research to close-to-market innovation, from programmed topics in specific thematic areas to fully bottom-up blue-sky science. Also, the R&I performance of countries is influenced by many other factors than Horizon 2020 only. The performance of Horizon 2020 should thus be seen in the context of its role in the wider R&I support system in particular as regards its positioning against (and impact on) the national and regional policy initiatives.

To overcome/mitigate these limitations, the interim evaluation is transparent in indicating its data sources and all underlying data sources are made publicly available. The analysis of the evidence by Commission services has allowed identifying data availability/quality problems that could already be overcome over the course of the evaluation. Conclusions are drawn based on the systematic triangulation of evidence from various data sources. All evaluation results have been systematically checked against input from stakeholders. Whenever possible (i.e. in the case of the analysis of participation patterns), FP7 was used as a benchmark.

5. IMPLEMENTATION STATE OF PLAY

5.1. Overview of implementation processes, inputs and activities

The Commission is responsible for programming R&I policy, and in particular the content of the Work Programmes. While the Horizon 2020 legislation sets out the broad lines of action and the budget envelope, the Work Programmes define the priorities for each year as well as the details of the calls for proposals. The priority-setting process and the topics covered under the Work Programmes for each programme part are discussed in depth in Annex 2.

Compared to FP7, the Commission took a **new approach to implementing Horizon 2020.** The strategic programming is the process to shape Horizon 2020's work programmes so that they are forward-looking, responds to new developments, covers the full research and innovation cycle, and contributes significantly towards the EU's overall policy objectives.[16] It also sequences the specific objectives of the Horizon 2020 parts into two-year work programmes and aims to provide for a coherent implementation of the multi-annual approach and strategic orientations.

Following the opinion of the Programme Committee, consisting of Member State representatives, the Work Programme is formally adopted by the Commission. Reacting to calls for proposals, applicants from industry, academia and other players submit project ideas that are evaluated by panels of independent experts. The two-year work programmes is expected to give researchers and businesses more certainty on the direction of EU research and innovation policy. At the same time the strategic programming is expected to allow flexibility in the redefinition of priorities and the response to pressing needs. To make funding flexible and to counterbalance the possible rigidity of the two-year work programmes there is room for Work Programme updates to be issued if necessary and as in this case to activate an emergency procedure to swiftly allocate funds to a particular purpose. [17]

On the implementation side, continuing the trend for **externalising implementation** to Executive Agencies, which began under FP7, four Agencies are responsible for the operational and programme management tasks across most of the programme[18]. For specific parts of the programme, management is carried out through different forms of partnership (Public-Private Partnerships (PPP) and Public To Public Partnerships (P2P)), where the Commission's involvement is at arm's length.

As an evolution to FP7, Horizon 2020 is based on a **broad innovation and impact orientation**, which is not limited to the development of new products and services based on scientific and technological results, but which also incorporates the use of existing technologies in novel applications, continuous improvement, non-technological and social innovation. It includes activities closer to the market and to end-users (e.g. prototyping, testing, demonstrating, piloting, product validation, and market replication) and demand-side approaches. To this purpose, it deploys new types of action: the SME Instrument, innovation actions, innovation procurement and inducement prizes.

Figure 3 provides an illustration of the **different types of actions** used under Horizon 2020. Whereas the bulk of the budget is granted to collaborative R&I projects (most specifically through Research and Innovation Actions and Innovation Actions) support to individual applicants is provided under the European Research Council (ERC) grants, Future and Emerging Technologies (FET) schemes, Marie Skłodowska-Curie Actions (MSCA) and under the SME instrument. Other types of actions include the procurement of innovative solutions (Pre-commercial procurement for innovation (PCP), Public Procurement of Innovative solutions (PPI)), public-public partnerships (including ERA-NET Co-funds, Article 185), public-private partnerships (including Joint Technology Initiatives, contractual Public-Private Partnerships), inducement prizes and financial instruments. Coordination, support and other actions are used

[16] OJ, L 347, p. 974.
[17] As it happened during the Ebola crisis, see section 6.2
[18] Four Executive Agencies are part of the Research family: the Executive Agency for Small and Medium-sized Enterprises (EASME), the European Research Council Executive Agency (ERCEA), the Innovation and Networks Executive Agency (INEA) and the Research Executive Agency (REA).

for studies, expert groups, conferences, as wells as for disseminating and exploiting results. Such grants are also used to underpin R&I policy initiatives (e.g. Policy Support Facility, Belmont Forum, and Innovation Deals). There is also support to communication measures, including to the public at large. A special form of collaborative projects is also piloted, the Fast Track to Innovation, focusing on industrial actors, and rapid turn-around. Also, the Commission undertakes direct actions in the form of R&I activities through its Joint Research Centre.

Figure 4 Types of actions in Horizon 2020

Type of action and objectives pursued	Target Groups	Changes to FP7
COLLABORATION-BASED GRANTS		
Research and Innovation Actions (RIA): Action primarily consisting of activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution. It may include basic and applied research, technology development and integration, testing and validation on a small-scale prototype in a laboratory or simulated environment **TRL covered[20]: Defined in the Work Programme where appropriate (normally 3-6 in RIAs)**	Consortia of partners from different countries, industry and academia	Changes to funding model and further focus on innovation
Innovation Actions (IA): Actions primarily consisting of activities directly aiming at producing plans and arrangements or designs for new, altered or improved products, processes or services. For this purpose they may include prototyping, testing, demonstrating, piloting, large-scale product validation and market replication. They are used for areas where the scientific and technology insights are available and the focus shifts to turning these into applications. **TRL covered: Defined in the Work Programme where appropriate (normally 6-8 in IAs)**	Consortia of partners from different countries, industry and academia	New action and changes to funding model
Fast track to innovation (IA): Continuously open, innovator-driven calls will target innovation projects addressing any technology or societal challenge field	Consortia of partners from different countries	New action
European Joint Programme Cofund (**COFUND-EJP):** Support to coordinated national research and innovation programmes in implementing a joint programme of activities (ranging from research and innovation activities to coordination activities, training activities, dissemination activities and financial support to third parties)	Independent legal entities from Member States or Associated Countries owning or managing national research and innovation programmes	New action
ERA-NET-Cofund: Support public-public partnerships in their preparation, establishment of networking structures, design, implementation and coordination of joint activities as well as Union topping-up of a trans-national call for proposals	Independent legal entities from Member States or Associated Countries owning or managing national R&I programmes	-
Pre-Commercial Procurements (PCP): PCP actions aim to encourage public procurement of research, development and validation of new solutions that can bring significant quality and efficiency improvements in areas of public interest, whilst opening market opportunities for industry and researchers active in Europe	EU funding for a group of procurers ('byers group') to undertake together one joint PCP / PPI procurement	-

[19] The forms of funding provided in the Financial Regulation are grants, prizes, procurement and financial instruments (debt and equity). Horizon 2020 grants may reach a maximum of 100% of the total eligible costs, without prejudice to the co-financing principle; the grant shall be limited to a maximum of 70% for innovation actions and programme co-fund actions (except for non-profit legal entities where 100% rate applies). Indirect eligible costs shall be determined by applying a flat rate of 25%.

[20] The definition of TRL levels is not a precondition for most of the actions, except if mentioned in the Work Programme (only for RIA and IA).

Type of action and objectives pursued	Target Groups	Changes to FP7
Public Procurement of Innovative solutions (PPI): PPI actions enable groups of procurers to share the risks of acting as early adopters of innovative solutions, whilst opening market opportunities for industry	EU funding for a group of procurers ('buyers group') to undertake together one joint PCP/PPI procurement	-
Coordination and Support Actions: Actions consisting primarily of accompanying measures such as standardisation, dissemination, awareness-raising and communication, networking, coordination or support services, policy dialogues and mutual learning exercises and studies, including design studies for new infrastructure and may also include complementary activities of networking and coordination between programmes in different countries	Single entities or consortia of partners from different countries	-
MSCA ITN: ITN supports competitively selected doctoral(-level) programmes, implemented by partnerships of universities, business and other RPOs across Europe and beyond. Partnerships take the form of collaborative European Training Networks (ETN), European Industrial Doctorates (EID) or European Joint Doctorates (EJD).	Consortia of partners from different countries who recruit early stage researchers (of any nationality), i.e. PhD candidates	
MSCA RISE: The Research and Innovation Staff Exchanges (RISE) support international and inter-sectoral collaboration through research and innovation staff exchanges, and sharing of knowledge and ideas from research to market (and vice-versa).	Consortia of partners from different countries who exchange staff (early stage and experienced researchers, technical staff)	
MONOBENENEFICIARY GRANTS		
Marie Skłodowska-Curie Actions (MSCA) Individual Fellowships (IF)**):** support experienced researchers undertaking mobility between countries, and where possible to the non-academic sector.	Experienced researchers (of any nationality)	-
MSCA COFUND: Aims at stimulating regional, national or international programmes (fellowship or doctoral programmes) to foster excellence in researchers' training, mobility and career development, spreading the best practices of MSCA	Independent legal entities from Member States or Associated Countries owning or managing national R&I programmes	-
ERC Frontier Research: Funding for projects evaluated on the sole criterion of scientific excellence in any field of research, carried out by a single national or multinational research team led by a 'principal investigator'	Excellent young, early-career researchers, already independent researchers and senior research leaders. Researchers can be of any nationality and their project in any research field	-
SME Instrument Phase 1 (IA): The SME Instrument is targeted at all types of innovative SMEs showing a strong ambition to develop, grow and internationalise. It provides staged support covering the whole innovation cycle in three phases complemented by a mentoring and coaching service. Phase 1 – feasibility study verifying the technological/practical as well as economic viability of an innovation idea/concept	Only SMEs can participate. Either a single SME or a consortium of SMEs established in an EU or Associated Country	New action
SME Instrument Phase 2 (IA): Phase 2 – innovation projects that address a specific challenge and demonstrate high potential in terms of company competitiveness and growth underpinned by a strategic business plan	Only SMEs can participate. Either a single SME or a consortium of SMEs established in an EU or Associated Country	New action
Specific Grant Agreement (SGA): The Financial Regulation provides the possibility of *Framework Partnership Agreements* for long term partnerships and associated specific grant agreements. Framework Partnership Agreements and Specific Grant Agreements have been used in a limited way when in line with the objectives of the programme parts		-
NON-GRANT ACTIONS		
Prizes: Financial contribution (lump-sum) given as reward following a contest. Prizes are a 'test-validate-scale' open innovation approach that brings together new-to-industry players and small players that	Whoever can most effectively meet a defined challenge	New action

Type of action and objectives pursued	Target Groups	Changes to FP7
may pursue more radically new concepts than large, institutionalized contestants. Inducement prizes offer an incentive by mobilising new talents and engaging new solver communities around a specific challenge. They are only awarded based on the achievement of the target set, solving the challenge defined.		
Public-Public Partnerships also provided via the Article 185 initiatives: Article 185 of the TFEU allows the integration of national efforts into a programme undertaken jointly by several Member States, with the participation of the EU, including participation in the structures created for the execution of the joint programme.	EU Member States	-
Public-Private Partnerships: Support the development and implementation of research and innovation activities of strategic importance to the Union's competitiveness and industrial leadership or to address specific societal challenges. They take the form of Joint Undertakings under Article 187 of the TFEU and organise their own research agenda. **Also c**ontractual PPPs are supported.	Partnerships between public and private sector	-
Public Procurement: Supply of assets, execution of works or provision of services against payment	By means of tenders and subject to special procurement procedures	
Financial instruments: Equity or quasi-equity investments; loans; guarantees; other risk-sharing instruments. Horizon 2020's financial instruments operate in conjunction with those of COSME. Strong synergies shall be ensured with the European Fund for Strategic Investments (EFSI) to create the maximum possible impact. Shall be the main form of funding for activities close to market under Horizon 2020.	FI are not directly implemented by the Commission (nor via the WP), but via EIB/EIF.	Replacing RSFF

Source: European Commission

5.2. Overview of implementation status after three years

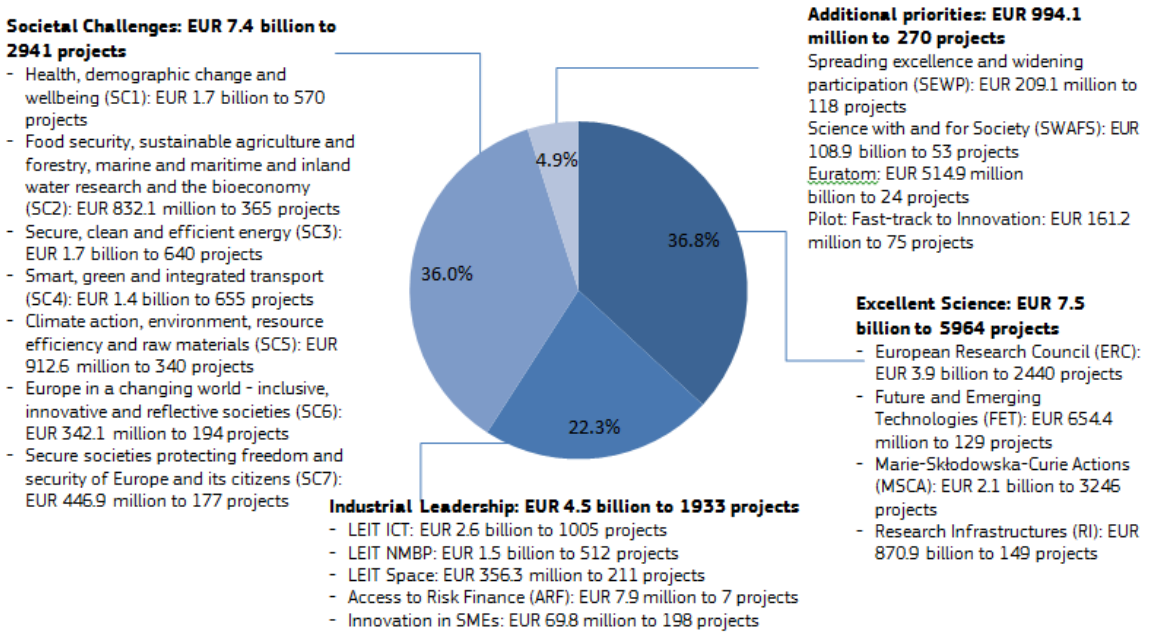
The Commission monitors the implementation of Horizon 2020 through annual monitoring reports[21], based on Horizon 2020 Key Performance Indicators (KPI).[22] The overall budget of Horizon 2020 is EUR 74.8 billion[23]. As of 1 January 2017, EUR 20.4 billion has been allocated to 11,108 signed grants.[24] As shown in the following Figure EUR 7.5 billion was allocated in Pillar 1: Excellent Science (36.8%), EUR 4.5 billion to Pillar 2: Industrial Leadership, EUR 7.4 billion to Pillar 3: Societal Challenges and EUR 944.1 million to additional priorities[25].

Most of the EC funding has been allocated through Research and Innovation Actions (RIA, 39.3% of the funding), followed by frontier research grants awarded by the ERC (19.0%), Innovation Actions (17.2%) and MSCA (10.3%). MSCA accounts for the highest number of grants signed (3,246) followed by ERC (2,440) and RIA (1,680). The programme surpassed the 20% SME target (almost 24% of the total budget for LEIT and Societal Challenges going to SMEs) and is in line with the minimum target of earmarking 7% of the budget for LEIT and Societal Challenges to the SME instrument. However, both the expenditure targets for climate action (35% of the EU financial contribution that is climate-related) and for sustainable development (60% of the EU financial contribution that is sustainability-related) are not met so far (27.0% and 53.3% respectively).

[21] Available at: https://ec.europa.eu/research/evaluations/index_en.cfm?pg=monitoring
[22] https://ec.europa.eu/programmes/horizon2020/en/news/horizon-2020-indicators-assessing-results-and-impact-horizon
[23] Regulation (EU) 2015/1017 of The European Parliament and of the Council of 25 June 2015
[24] Including EUR 0.5 billion in grants under Euratom
[25] Detailed implementation data can be found in Annex 1.

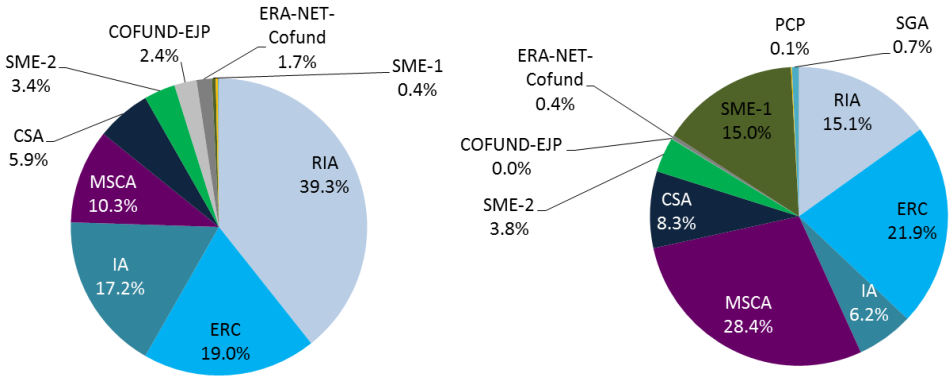
A detailed analysis of the current implementation status and processes is provided under the Efficiency assessment, whereas early results are discussed under Effectiveness and the complementarity of the set of actions is analysed under the Coherence section.

Figure 5 Funding allocation and number of projects per programme part



Source: CORDA, cut-off date by 1/1/2017

Figure 6 Funding allocation (left) and number of grants (right) by type of action



Source: Corda, calls until end 2016, Signed Grants cut-off date by 1/1/2017.

Figure 7 Overview of key programme targets and progress so far (1 January 2017)

Horizon 2020 targets	Current status
Climate action target: 35% of EC financial contribution that is climate-related (RIO-Markers methodology)	27.0%
Sustainable development target: 60% of EC financial contribution that is sustainability-related (RIO-Markers methodology)	53.3%
SME target: 20% of EC financial contribution going to SMEs (only LEIT and Societal Challenges)	**23.9%**
SME Instrument target: 7% of EC financial contribution committed through the SME instrument (only LEIT and Societal Challenges)	5.6%

Source: CORDA, cut-off date 1/1/2017

Figure 8 lists key indicators for FP7 and Horizon 2020 used for benchmarking purposes.

Figure 8 FP7 vs Horizon 2020 benchmarking

		FP7 2007-2013, € 55 billion	**Horizon 2020** 2014-2020, € 74.8 billion **Status as of 01/01/2017**	**Difference**
Eligible proposals submitted (number)		134 535	102 076	-
EC Contribution requested in eligible proposals (EUR million)		216 358	172 748	-
High Quality Proposals submitted (number)		No info	45 632	-
EC Contribution requested in High Quality Proposals (EUR million)		No info	85 006.1	-
Signed grants (number)		25 781	11 108	-
EC Contribution to signed grants (EUR million)		45 452	20 400.1	-
Applications in proposals (number)		563 079	379 169	-
Open Access (share of peer-review publications provided in open access)		61.8%	60.8% to 68.7%	↓1 pps
Peer reviewed publications (number)		219 620	4 043	-
Patent applications (number)		2 669	153	-
Newcomers (share of participants)		Above 70%	52.1%	↓19.9 pp
Collaborative projects (% of total EC contribution)		72%	76%	↑4pps
Time to grant in number of days (excl. ERC)		303 days	192.2 days	↓110.8
Funding rate (EC contribution as % of total project costs)		70%	70%	stable
Concentration of funding to top 100 beneficiaries (% of EC contribution)		34.6%	32.9%	↓1.7 pps
Yearly (2007-2013 for FP7; 2014-2016 for Horizon 2020)	**.. EU contribution to signed grants (EUR million)**	6 493.1	6 800.0	↑4.7%
	.. EU contribution requested in eligible proposals (EUR million)	31 111.1	57 582.7	↑85.1%
	.. eligible proposals submitted	19 219	34 025	↑77.0%
	.. participations supported	19 736	16 363.3	↓17.1%
	.. signed grants	3 683	3 703	↑0.5%
	.. participants supported	4332	5 559.6	↑28.3%
	.. applications submitted	80 440	126 390	↑57.1%
	.. applications submitted from private sector	20 443	47 293	↑131.3%
	.. applications submitted from SMEs	19 027	33 145	↑74.2%
Private sector (PRC)	**.. share of applications**	25.4%	37.4%	↑12.0 pps
	.. share of participations	30.4%	33.2%	↑2.4 pps
	.. share of EU contribution	24.2%	27.7%	↑3.5 pps
SME	**.. share of applications**	23.7%	26.2%	↑2.5 pps
	.. share of participations	18.4%	20.7%	↑2.3 pps
	.. share of EU contribution	14.4%	16.0%	↑1.6 pps
EU-13	**.. share of applications**	9.6%	10.3%	↑0.7 pps
	.. share of participations	7.9%	8.5%	↑0.6 pps
	.. share of EU contribution	4.2%	4.4%	↑0.2 pps
Associated countries	**.. share of applications**	8.4%	7.1%	↓1.3 pps
	.. share of participations	8.2%	7.0%	↓1.2 pps
	.. share of EU contribution	9.0%	6.5%	↓2.5 pps
Third countries	**.. share of applications**	5.6%	3.1%	↓2.5 pps
	.. share of participations	3.6%	1.9%	↓1.7 pps
	.. share of EU contribution	1.3%	0.6%	↓0.7 pps
Success rate	**.. of projects' proposals**	18.4%	11.6%	↓6.8 pps
	.. of total funding requested	19.9%	12.7%	↓7.2 pps
	.. of total applications	21.8%	14.1%	↓7.7 pps
	.. for private sector (applications)	23.3%	13.0%	↓10.3 pps
	.. for SMEs (applications)	20.2%	12.0%	↓8.2 pps
	.. of EU-13 countries (applications)	18.0%	11.1%	↓6.9 pps
	.. of Third Countries (applications)	23.8%	18.3%	↓5.5 pps
	.. of Associated Countries (applications)	21.7%	13.4%	↓8.3 pps
Proposals' evaluation	**Number of proposals evaluated per year**	~20 000	~33000	↑65%
	Time spent per evaluator per proposal	0.8 day	0.7 day	↓0.1 day

Source: CORDA, cut-off date 1/1/2017 and EMM2

6. HOW RELEVANT HAS HORIZON 2020 BEEN SO FAR?

This question aims to determine whether the original objectives of Horizon 2020 as defined in its impact assessment are still relevant and how well they still match the current needs and problems of stakeholders. It also addresses the question of the flexibility of the programme against new scientific and socio-economic developments.

Expectations from Horizon 2020 in terms of relevance

Based on the Horizon 2020 impact assessment - compared to FP7 - Horizon 2020 is expected to focus on a limited number of mutually consistent and concrete higher-level objectives that are closely related to Europe 2020 (i.e. on growth and the resolution of six societal challenges through research, innovation, and the training and skills development of researchers). Horizon 2020 is expected to have the support of all types of stakeholders, who agree on the need to orient EU research and innovation funding towards the resolution of societal challenges and the achievement of ambitious EU policy objectives in areas such as climate change, resource efficiency, energy security and efficiency, demographic ageing, etc., and who support the centring of EU research and innovation funding around three objectives: tackling societal challenges, strengthening competitiveness, and raising the excellence of the science base. By strengthening bottom-up schemes and making work programmes less prescriptive Horizon 2020 is also expected to provide for more programme flexibility than FP7, being also more open with both curiosity-driven and agenda-driven activities working in tandem.

Summary box: Key findings on the relevance of Horizon 2020

- ✓ Horizon 2020's original rationale for intervention and objectives remain largely valid.
- ✓ Further strengthening the EU's science base is as necessary as ever and remains a valid Horizon 2020 objective.
- ✓ Closing the innovation gap and boosting industrial leadership remains a valid key objective for the EU and Horizon 2020, although the importance of supporting breakthrough, market-creating innovation is now more clearly recognised than when designing Horizon 2020.
- ✓ The societal challenges identified when conceiving Horizon 2020 still exist and are valid continued priorities for the EU and Horizon 2020.
- ✓ The continued relevance of Horizon 2020 also lies in its contribution to the achievement of a wide range of EU and global objectives such as the Sustainable Development Goals.
- ✓ Horizon 2020 has been flexible enough to support research on urgent new needs (e.g. Ebola and Zika outbreaks, migration) as well as new, promising science and research.
- ✓ Emerging priorities and new developments need to be scouted continuously and the right balance has to be found between being too prescriptive or not prescriptive enough.
- ✓ The strategic programming process improved the intelligence-base underpinning programming choices and helped better define the focus in line with stakeholder needs.
- ✓ Horizon 2020 is broadly in line with stakeholders' needs and is attractive for newcomers.
- ✓ The 2-year programming is at times seen as too rigid to swiftly respond to emerging needs dictated by disruptive and counter-intuitive technologies and business models.
- ✓ The translation of high level challenges and objectives into specific calls and topics is not always clear.
- ✓ The wider public's understanding of the benefits of publicly supported research and innovation and the involvement of civil society in Horizon 2020 can be further improved.

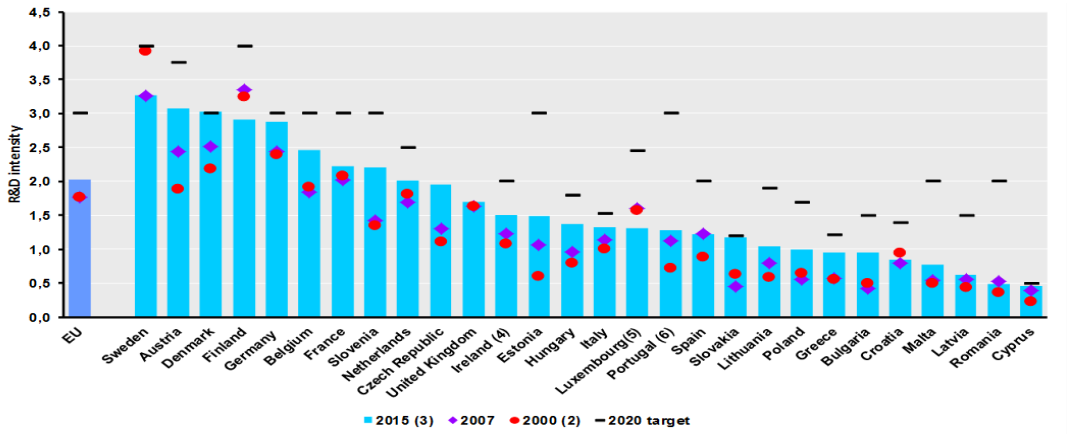
6.1. Is Horizon 2020 tackling the right issues?

6.1.1. The relevance of Horizon 2020 given the challenges to address

When Horizon 2020 was conceived Europe suffered from a number of critical weaknesses in its R&I system, which contributed to the problems of low productivity, declining competitiveness, inadequate response to societal challenges and the inability to move to a new sustainable economic model[26]. Europe's innovation gap was identified as the key problem driver, with the following structural problem drivers underpinning it: the need to strengthen the science base; insufficient technological leadership and innovation capability in the private sector; insufficient contribution of research and innovation to tackling societal challenges; and insufficient trans-national coordination. Horizon 2020 was adopted to tackle those problem drivers and improve Europe's competitiveness.

These (structural) problems still persist. The EU has not yet overcome the effects of the economic crisis – for the first time in almost a decade, all 28 EU economies are expected to grow over the next two years. High unemployment, especially amongst young people, remains the biggest socioeconomic concern and challenge in many Member States in 2016. At the same time, **the EU has to respond to new emerging challenges**, such as armed conflicts, rising migration flows or global health emergencies. The EU still faces strong productivity and innovation challenges, as emerging from the most recent economic forecasts.[27] Actions in the area of research and innovation are a central element in a coherent response to these overarching challenges.[28] In terms of investments in research and development (R&D), **overall EU-28 progress towards the Europe 2020 target (gross expenditures on R&D representing 3% of GDP by 2020) has so far been limited, reaching 2.03% in 2015** (Figure 9).

Figure 9 R&D intensity, 2000, 2007, 2015 and 2020 target



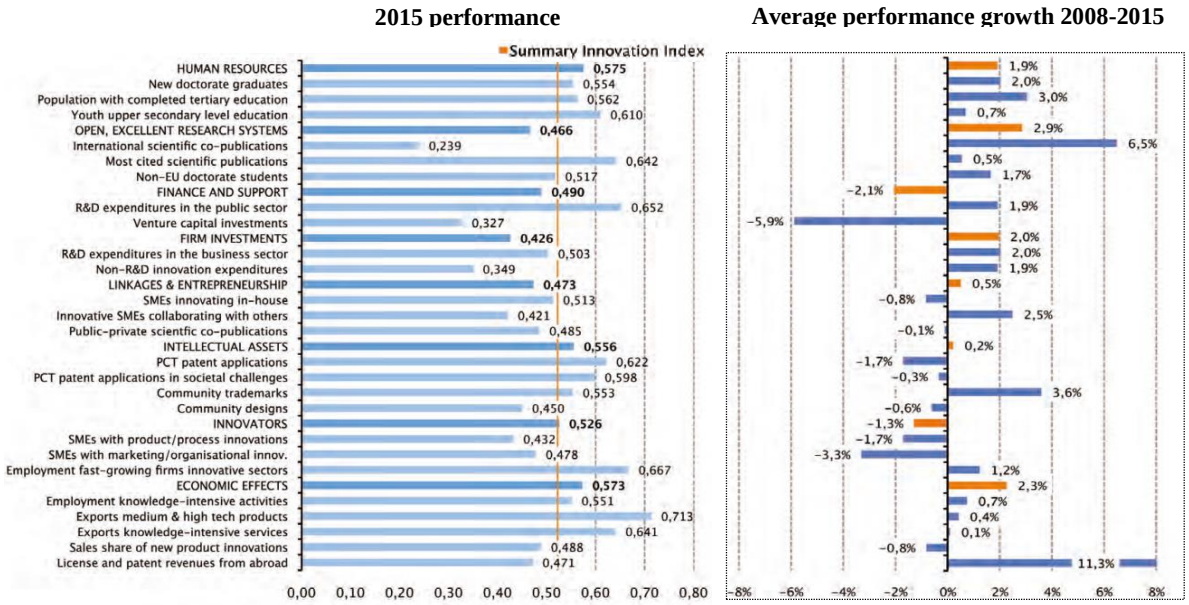
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat
Notes: (1)CZ, UK: R&D intensity targets are not available. (2)EL, SE: 2001; HR: 2002; MT: 2004. (3)IE: 2014. (4)IE: The R&D intensity target is 2.5% of GNP which is estimated to be equivalent to 2.0% of GDP. (5)LU: The R&D intensity target is between 2.30% and 2.60% (2.45% was assumed). (6)PT: The R&D intensity target is between 2.70% and 3.30% (3.00% was assumed). (7)DK, EL, FR, HU, NL, PT, RO, SI, SE, UK: Breaks in series occur between 2000 and 2015.

Figure 10 provides a snapshot of the European research and innovation performance in 2015 as well as the evolution over 2008-2015. Overall **EU research and innovation performance has been increasing** at an average annual rate of 0.7% between 2008 and 2015, but growth

[26] European Commission, SEC(2011) 1427, Impact Assessment Accompanying the Communication from the Commission 'Horizon 2020 - The Framework Programme for Research and Innovation' (COM(2011) 808)
[27] European Commission (2016), European Economic Forecast Autumn 2016. Institutional Paper 038
[28] European Commission (2016), European Economic Forecast Autumn 2016. Institutional Paper 038

has not been equally strong across all R&I performance dimensions and indicators. In spite of some improvement, the EU is still lagging behind main international competitors, such as the USA, Canada and Australia.[29] The EU has been strengthening its educational knowledge base turning Europe into a more knowledge-based economy whereas the EU innovation system has become more networked both between Member States and at the global scale. However despite improvements the EU still displays **weaknesses in terms of firm-level investments and the share of innovative SMEs collaborating with others, international scientific co-publications and public-private co-publications**. Noteworthy is the negative growth of the average EU performance in the 'Finance and support' dimension which is due to a **strong decline in Venture capital investments** from an already low level (-5.9%), a declining performance in SMEs that introduced product or process innovations, and SMEs that introduced marketing or organisational innovations.

Figure 10 EU-28 research and innovation performance per dimension, 2015 and average performance growth over 2008-2015



Source: European Innovation Scoreboard 2016, European Commission

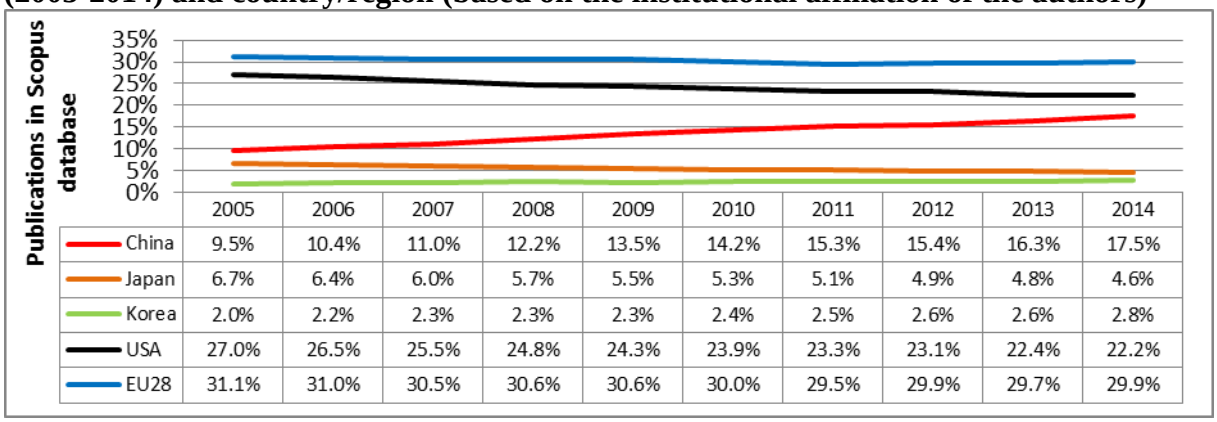
Furthermore, within the EU, there is substantially **unequal R&I performance amongst European Member States**[30]. The need for trans-national coordination was identified as a need to be addressed through Horizon 2020. Optimal circulation and transfer of knowledge (across countries, sectors and disciplines) is one of the key prerequisites for relevant research with societal or economic impact[31] and is addressed throughout Horizon 2020 through trans-national activities. Also, the specific programme Spreading Excellence and Widening Participation (SEWP) aims specifically to fully exploit the potential of Europe's talent pool and to ensure that the benefits of an innovation-led economy are both maximised and widely distributed across the Union in accordance with the principle of excellence. The thematic assessment validates the objectives of the SEWP programme highlighting however that widening countries are not all affected by the same problems and to different extents showing that the current dichotomy widening-non-widening and EU-13 versus EU-15, can be considered as a simplification of the reality.

[29] European Commission (2016), European Innovation Scoreboard 2016
[30] European Commission (2016), European Innovation Scoreboard 2016
[31] European Commission (2016), Science, Research and Innovation Performance of the EU, 2016

The need to strengthen the science base

In terms of scientific publications, the **EU is a world leader in terms of quantity, but still lags behind the USA in top quality output** as measured by bibliometric indicators[32] - even if improving in recent years - or by tracking major scientific recognitions such as the Nobel Prize awards. Other regions have been expanding their scientific profile, and emerging countries such as China have become large producers of scientific knowledge. However looking at the share of top 1% most highly cited publications (Figure 11) **the EU-28 has caught up with the USA in 2014, each accounting for about 40% of the world's top-cited publications**. In 2014 EU –based authors appeared on more top 1% cited publications (14,172) than USA-based authors based (14,093) in absolute numbers for the first time.

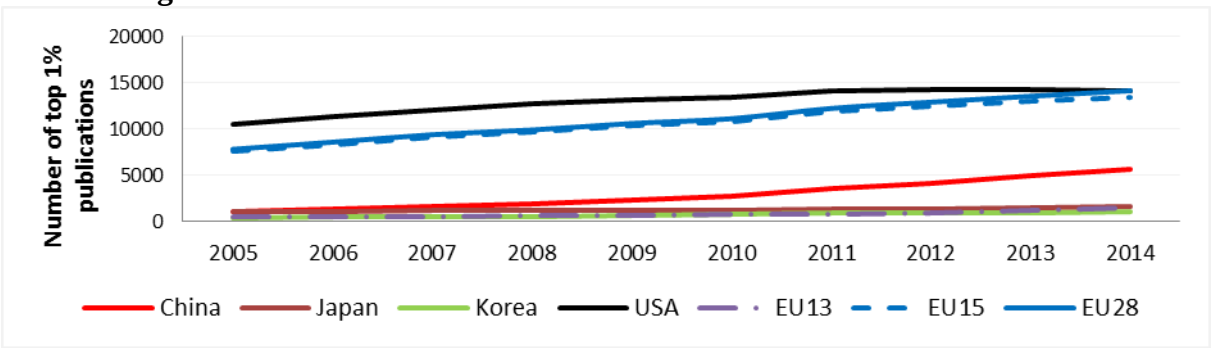
Figure 11 Percentage of publications indexed in Elsevier's Scopus database by year (2005-2014) and country/region (based on the institutional affiliation of the authors)



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
China	9.5%	10.4%	11.0%	12.2%	13.5%	14.2%	15.3%	15.4%	16.3%	17.5%
Japan	6.7%	6.4%	6.0%	5.7%	5.5%	5.3%	5.1%	4.9%	4.8%	4.6%
Korea	2.0%	2.2%	2.3%	2.3%	2.3%	2.4%	2.5%	2.6%	2.6%	2.8%
USA	27.0%	26.5%	25.5%	24.8%	24.3%	23.9%	23.3%	23.1%	22.4%	22.2%
EU28	31.1%	31.0%	30.5%	30.6%	30.6%	30.0%	29.5%	29.9%	29.7%	29.9%

Source: Scopus database, ERCEA elaboration

Figure 12 Evolution of number of top 1% most highly cited publications, selected countries and regions



Source: Scopus database, ERCEA elaboration

Worldwide, the EU is however lagging behind in university rankings. In the 2016 Leiden rankings,[33] only two EU universities are in the top 25 (US has 19) and seven in the top 50 (all from the UK, US has 38).[34] Within the EU, **scientific quality is concentrated in a group of leading countries** predominantly in North-West Europe while Southern, Eastern and Baltic

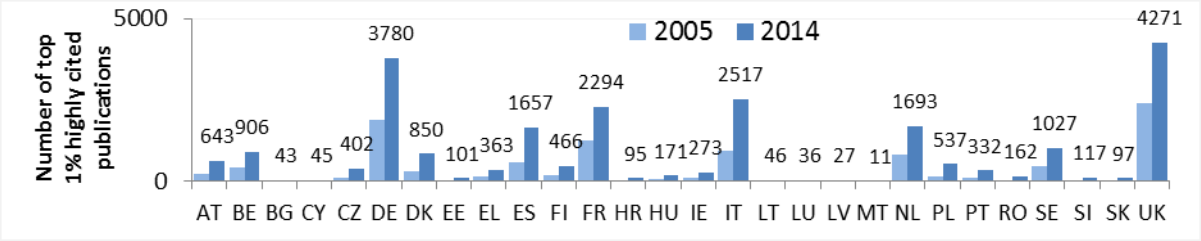
[32] OECD (2015), Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society

[33] http://www.leidenranking.com/, based on proportion of a university's publications that, compared with other publications in the same field and in the same year belong to the top 10% most frequently cited

[34] The US has 58 universities in the top 100 while the EU has 30 (including 17 from the UK, 7 from the Netherlands) with another seven from Switzerland and Israel combined

countries still rank at the bottom despite progress in recent years. Figure 10 shows the evolution of the number of top 1% highly cited publications by EU country.

Figure 13 Number of top 1% highly cited publications, 2005 and 2014, EU countries



Source: Scopus database, ERCEA elaboration

Evidence also shows a positive correlation between the level of science-business collaboration and the quality of research and frequency of innovation. Public-private co-publications per million-population stand at 50.03 in the EU, around 5 points lower than in Japan and over 35 points lower than in the USA.[35] The number or researchers increased in the EU in the last decade (from 1.4 million in 2005, to 1.7 million in 2013 and 1.8 million in 2015 in full time equivalents), but there are still large differences between EU Member States in how researcher careers are structured and how professional development and career planning is supported at the institutional level[36]. A growing share of PhD candidates in the EU is finding career opportunities outside traditional academic research careers[37].

Overall, the EU's public sector research system is large and diverse and remains the largest producer of knowledge in the world. However, it is essentially a "mass producer" with, relative to its size, comparatively few centres of excellence that standout at the world level and with large differences between European countries. Underlying the Horizon 2020 Excellent Science pillar, **the need to strengthen the EU's science base and support excellent research to improve the quality, relevance and impact of its scientific output remains valid** at a time when non-EU countries are investing massively in science and engaging in strategies to attract the top researchers.[38] Horizon 2020 allocates a budget of EUR 24.4 billion (31% of Horizon 2020 budget) for actions to raise the excellence of Europe's science base, in particular through actions which proven to be a massive success, including the European Research Council, with the view to generate the ground breaking research and innovation needed to sustain Europe's competitiveness in the long term.

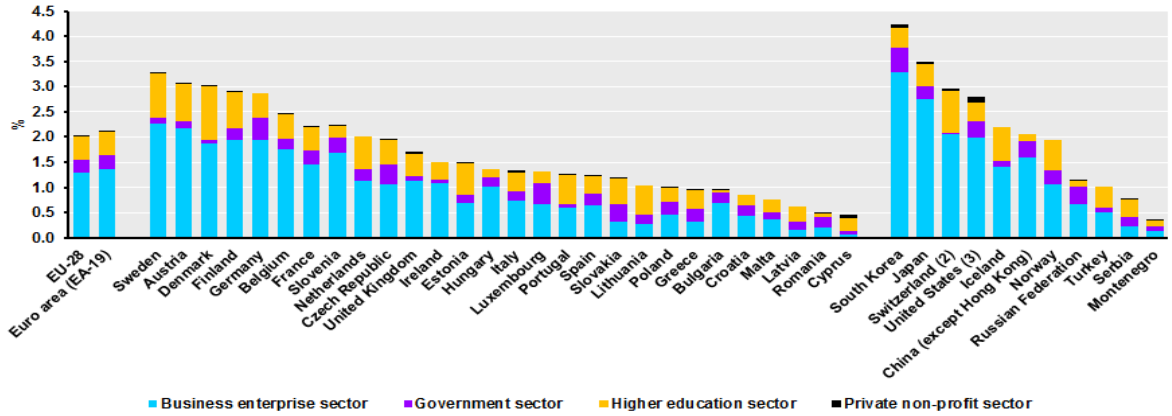
The need for a reinforced technological leadership and innovation capability in the private sector

Low consumer demand in Europe, uncertainties about the economic outlook, relatively high prices of raw materials and energy prices, as well as difficulties in access to finance for SMEs, were weighing down on business confidence when Horizon 2020 was designed[39] [40]. **Europe still shows a structural gap in private R&D investments, compared for instance to the USA, together with lower productivity growth**, which puts competitiveness at risk.

[35] European Commission (2016), Science, Research and Innovation Performance of the EU, 2016
[36] IDEA Consult (2013), MORE2 study final report
[37] The non-academic sector here does not necessarily focus on industry, but could encompass public sector organisations, the voluntary sector and non-profit organisations.
[38] See Annexes Part 3 for in-depth assessments of each Horizon 2020 specific objective.
[39] European Commission, Industrial Policy Communication and Staff Working Document No 297, 2012
[40] Impact Assessment. Commission Staff Working Paper. SEC(2011) 1427 final

In 2015, just under 23 million SMEs generated EUR 3.9 trillion in value added (slightly less than three fifths of EU value added in the non-financial business sector) and employed 90 million people in Europe (two thirds of EU business sector employment). While business expenditure on R&D (BERD) in the EU-28 increased from 1.13% GDP in 2007 to 1.30% GDP in 2014[41], the EU is not on track to meet its 2% business R&D expenditure target by 2020. The gap in business R&D expenditure between the EU and some of its main competitors is mainly caused by a **lower weight of high-tech sectors in the EU's economy**. One source of Europe's lagging business innovation deficit relative to the US is seen in the **lack of "yollies**", i.e. young companies that have grown into world-leading innovators, in new innovation-based growth sectors.[42] It has been estimated that there could be up to 1 million new jobs created and up to EUR 2,000 billion added to GDP in the EU over the next 20 years if the share of scale-ups would match that of the USA.[43] Access to finance, in particular **venture capital availability**, for SMEs, seed and start-up companies is crucial for innovative firms to grow, increasing their revenue levels, market shares, and employment opportunities.[44] [45] Whereas the volumes of venture capital investment in the USA have suffered a slight decrease of around 3% in terms of GDP from 2007 to 2013, **the drop in the EU reached nearly 10% in the same period**. The size of the gap between the USA and the EU is 6:1, in terms of GDP.

Figure 14 Gross domestic expenditure on R&D by sector, 2015 (% of GDP)



Source: European Commission, Data: Eurostat, OECD. Notes: (1)Switzerland: 2012; Ireland, Turkey, Serbia, Montenegro: 2014. (2) Switzerland: Government expenditure on R&D refers to federal or central government only.(3)United States: Most or all capital expenditure is not included.

In comparison to the USA, the EU is strongly specialised in medium-high-tech sectors such as automobiles and parts as well as in electronics and electrical equipment. However, **the EU is lagging far behind the USA in high tech sectors** such as software and technical hardware and equipment, and has a similar share of companies in pharmaceuticals and biotech, while aerospace and defence are more present in the EU (Figure 15).

[41] The group of EU companies within the World's top 2500 increased their R&D in last year by 7.5%, above the rate of the US companies at 5.9% and the Japanese companies at 3.3%.

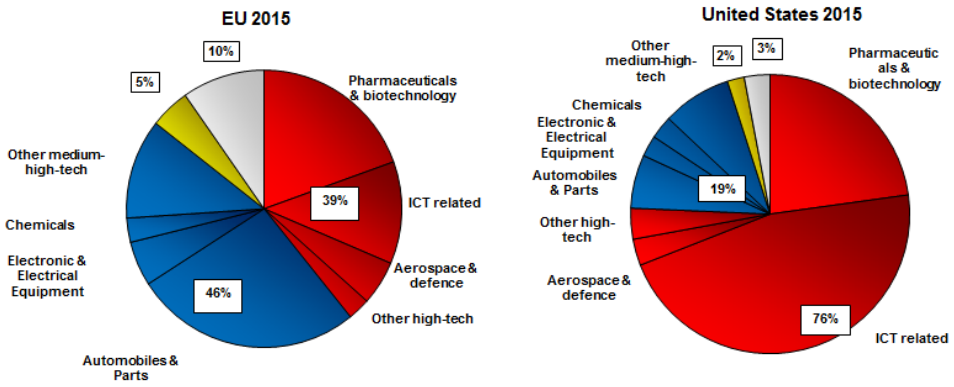
[42] High growth enterprises tend to be younger than the average enterprises (Innova, TNO, Framework Conditions for High Growth Innovative Enterprises, 2016). Among the USA leading innovators in the Industrial R&D Scoreboard, more than half are "young" (i.e. born after 1975), qualifying them as yollies whereas in the EU this share is one out of five. Yollies account for 35 % of total business R&D in the USA, while in Europe they represent 7%, (Veugelers R. Cincera M., How to Turn on the Innovation Growth Machine in Europe, 2015). High growth enterprises in the USA have on average twice as many employees as the European ones. The OECD concludes that 'a small set of high-growth enterprises drives a disproportionate large amount of employment creation'(OECD, Entrepreneurship at a glance 2016).

[43] Europe's next leaders: the Start-up and Scale-up Initiative, COM(2016) 733 final

[44] EIB (2015). Investment and Investment Finance in Europe 2015: Investing in Competitiveness

[45] European Commission (2016), Science Research and Innovation Performance of the EU, 2016

Figure 15 Sectoral composition of R&D intensive enterprises in the EU and United States, 2015



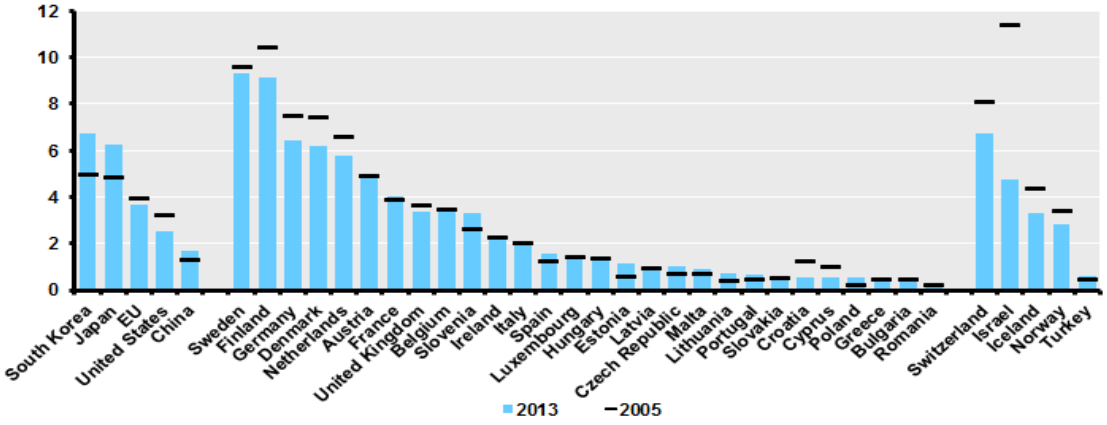
Source: EU Industrial Scoreboard, 2016

Box: Key data on the role of European industry in Europe

Industry accounts for the largest contributions to the economy's R&D intensity and trade balance (64%[46] of manufacturing on private R&D investments and over 80% of all exported goods). The strongest sectors also being technology and knowledge intensive are machinery and vehicles which represent 42% of exported goods, while other manufactured goods and chemical products represent 23% and 16% respectively.[47] More than 19% of the production volume of the EU-28 is highly dependent on key enabling technologies.[48] [49] The ICT sector also plays a key role for Europe's global competitiveness and growth. In 2014 (latest available data), the sector generated a value added of EUR 593 billion (4.2 % of EU GDP), employed 6.3 million people (2.8 % of EU total employment) and generated 16% of total business expenditure in R&D; ICT contributed 19-28% to the EU Innovation output indicator, highlighting the key trends in the digitalisation of industry.

As regards patenting activities, the EU performs on a similar level in international patent applications as the USA, but is outperformed by Japan and South Korea.[50] In many European countries, **the number of international and national patent applications has declined in the recent past**, while patenting is expanding quickly in East Asian countries. As a result, Asian countries, especially China, are catching up in world patent shares, while EU's share is declining and that of the USA, long in decline, has stabilised.

Figure 16 Patent applications (WIPO-PCT) per billion GDP (PPS€), 2005 and 2013



Source: European Commission, Data source: Eurostat, OECD

[46] Latest Eurostat data, October 2016
[47] EU Industrial Structure Report 2013
[48] Eurostat based figures from 2015.
[49] KETs Observatory, European Commission, December 2015.
[50] European Commission, Science Research and Innovation performance of the EU, 2016

Against this overall background, the second priority of Horizon 2020 is to foster Industrial Leadership with the aims to speed up the development of the technologies and innovations that will underpin tomorrow's new technology, keep leading industries at the forefront of global competition and help innovative European SMEs to grow into world-leading companies. **The technology-driven approach adopted under the Leadership in Enabling and Industrial Technologies (LEIT) programme, the provision of risk finance and the support of innovation in SMEs based on a demand-driven, bottom-up logic are all assessed as still relevant** given current challenges.[51]

The added value of Horizon 2020 programme is the focus on business-oriented research & innovation and exploitation opportunities. In effect, the current programme allows industries, and especially SMEs, to develop first concepts, then prototypes and patents for new products and services which can actually arrive to the market.

D'Appolonia SpA, Italy

Horizon 2020 allocates € 17.0 billion ((21.6 % of Horizon 2020 budget) for actions to directly support Europe's industrial base and to make Europe a more attractive place to invest in R&D. These are all actions which aim at leveraging significant private sector investment, including through a larger use of financial instruments (equity and debt) and through funding specifically for SMEs, so in effect the total funding invested in R&I through this priority is expected to be a multiple of what Horizon 2020 invests.

The need for R&I to contribute to tackling societal challenges

The third pillar of Horizon 2020 "Societal Challenges" responds to the policy priorities and societal challenges that were identified in the Europe 2020 strategy. Since the adoption of Horizon 2020, **the role of R&I to contribute to tackling societal challenges has further increased with the adoption of the UN's Sustainable Development Goals[52] and the Paris Climate Change Agreement (COP21)**[53] in 2015, providing a global framework to European action. The post 2015 Sustainable Development Agenda calls on all countries to enhance research, upgrade technological capabilities, encourage innovation, increase the number of R&D workers per 1 million people and increase public and private R&D investment in line with the universal 17 SDGs[54]. In 2016, the Commission published its Communication on the Sustainable Development Goals ("Next Steps for a Sustainable European Future[55]") which ensures that all EU policy measures take on board SDGs at the outset. Research and innovation are mentioned as crucial means to implement certain SDG targets, with a particular reference to FOOD 2030.[56]

The thematic assessments suggest that **the challenges remain valid for R&I investment and are even reinforced by the SDGs framework and the socio-economic context**. However, Horizon 2020's objectives in the societal challenges pillar as currently articulated in the legal basis are in several cases regarded as very broad and "all inclusive" - not providing an optimal basis for programme priority setting, monitoring progress or evaluating programme performance. Based on results from the thematic assessment **the Science with and for Society programme is also regarded as highly relevant to the overarching challenges facing Europe in transversal areas of Horizon 2020 in particular the need for greater support for citi-**

[51] See Annexes Part 2 for in-depth assessments of Horizon 2020 specific objective including each Societal Challenge.
[52] Available at: http://www.un.org/sustainabledevelopment/sustainable-development-goals/
[53] Available at: http://unfccc.int/paris_agreement/items/9485.php
[54] As highlighted in the report of the High Level Expert Group on the "Role of science, technology and innovation policies to foster the implementation of the SDGs", European Commission, 2015
[55] Available at: http://europa.eu/rapid/press-release_MEMO-16-3886_en.htm
[56] European Commission, Staff Working Document (2016)319, European Research and Innovation for Food and Nutrition Security, 2016.

zen science and user-led innovation. The European Economic and Social Committee (EESC), however, questioned whether the programme sufficiently involved real "societal" stakeholders and requested clarification about whether all societal groups can and should participate in SWAFS[57].

Horizon 2020 allocates the highest share of its budget for tackling societal challenges (€ 29.7 billion, i.e. 37.8% of Horizon 2020 budget). These correspond to the key policy objectives of Europe 2020 and to concerns shared by all Europe's citizens. A stronger focus is put on close to the market activities and radical technological breakthroughs. The underlying rationale is that big opportunities exist to turn the challenges of today into the business opportunities of tomorrow and investing public money on research and innovation can make the EU exit the crisis successfully while addressing citizens' concerns. These amounts are complemented by those dedicated to support the EIT (€ 2.7 billion), which gets an important budget increase compared to FP7, and the JRC, which continues its role in contributing scientific expertise to the Union's policy making process. Additional funding for nuclear energy research activities is also available through the Euratom programme.

6.1.2. The relevance of Horizon 2020 to address European objectives

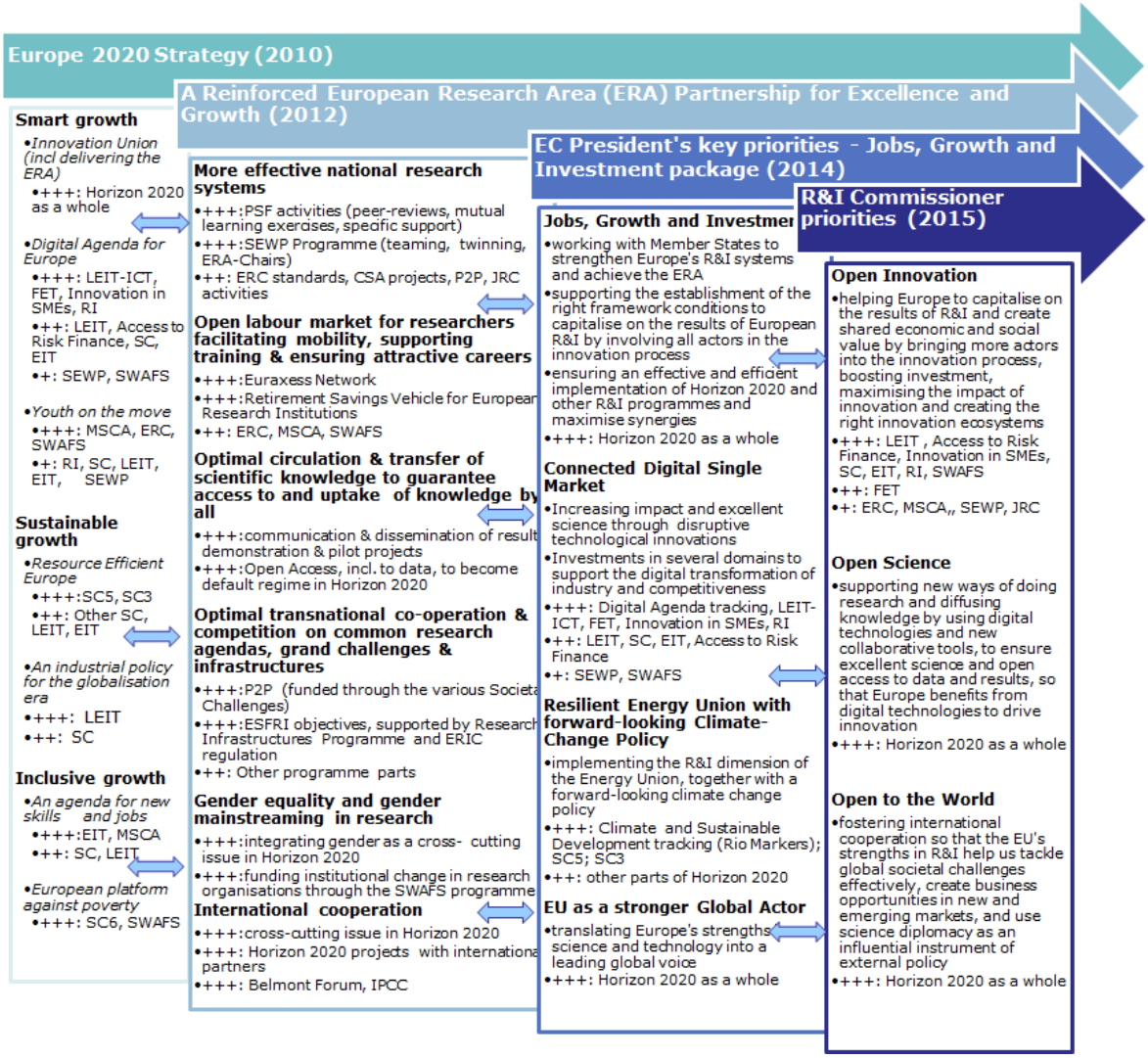
Strengthening the Union's scientific and technological bases, notably in support of its industrial competitiveness, is enshrined as an objective in the EU Treaty[58]. While Horizon 2020 was adopted in late 2013, before the 2014 new European Commission came into office, it is the EU's main funding programme for R&I until 2020 and thus is an important mechanism for supporting and delivering on the current (and future) set of EU policy objectives. Horizon 2020 was adopted in the context of the Europe 2020 Strategy[59]. This strategy seeks to achieve smart, sustainable and inclusive growth in Europe, including by devoting 3% of EU's GDP to R&D by 2020. The Juncker Commission 10 priorities[60] provided an update and focus to these goals whereas the "3 Os", put forward by the R&I Commissioner, which call for open science, open innovation and openness to the world[61] complement the research-policy objectives since 2015.

Evidence collected within the thematic assessments as well as the work of an Expert Group[62] shows that **Horizon 2020 remains an important mechanism for supporting and delivering on the current set of EU policy objectives as well as international priorities**[63]**.** Horizon 2020 directly addresses the long-term objectives of Europe 2020 and, in particular, many of the commitments of the 'Innovation Union'. Even if not initially developed according to these priorities, Horizon 2020 in its current setting is also assessed by European Commission services as relevant to contribute delivering on the current priorities, in particular to Jobs, Growth and Investment, the Digital Single Market, a Resilient Energy Union, and the EU as a

[57] European Economic and Social Committee, Information report on Interim evaluation of Horizon 2020, 2016.
[58] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:12012M/TXT&from=en
[59] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF
[60] https://ec.europa.eu/priorities/publications/president-junckers-political-guidelines_en
[61] More information on the Open Innovation, Open Science and Open to the World (3 O's) approach available at: http://ec.europa.eu/research/openvision/index.cfm
[62] European Commission Expert group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020, Applying relevance-assessement methodologies to Horizon 2020 (forthcoming report). A text mining approach was developed to investigate whether keywords from key EU and international documents are present in Horizon 2020 Regulation and the first Work Programmes. This approach was not applicable in the case of the Excellent Science pillar because of its bottom-up nature.
[63] Investment in R&I is also recognised as an important aspect of EU's comprehensive response to harnessing globalisation, COM(2017) 240.

Stronger Global Actor (see Figure 17 for a detailed overview of how Horizon 2020 aligns to each of the key EU priorities).

Figure 17 Relevance of Horizon 2020 in the framework of evolving EU priorities 2010-2015



Note : +++ : very relevant to address these priorities, ++ : partially relevant, + : slightly relevant
Source: European Commission, DG RTD A5, based on thematic assessments

Stakeholder position papers: Horizon 2020 is addressing policy priorities of Europe.

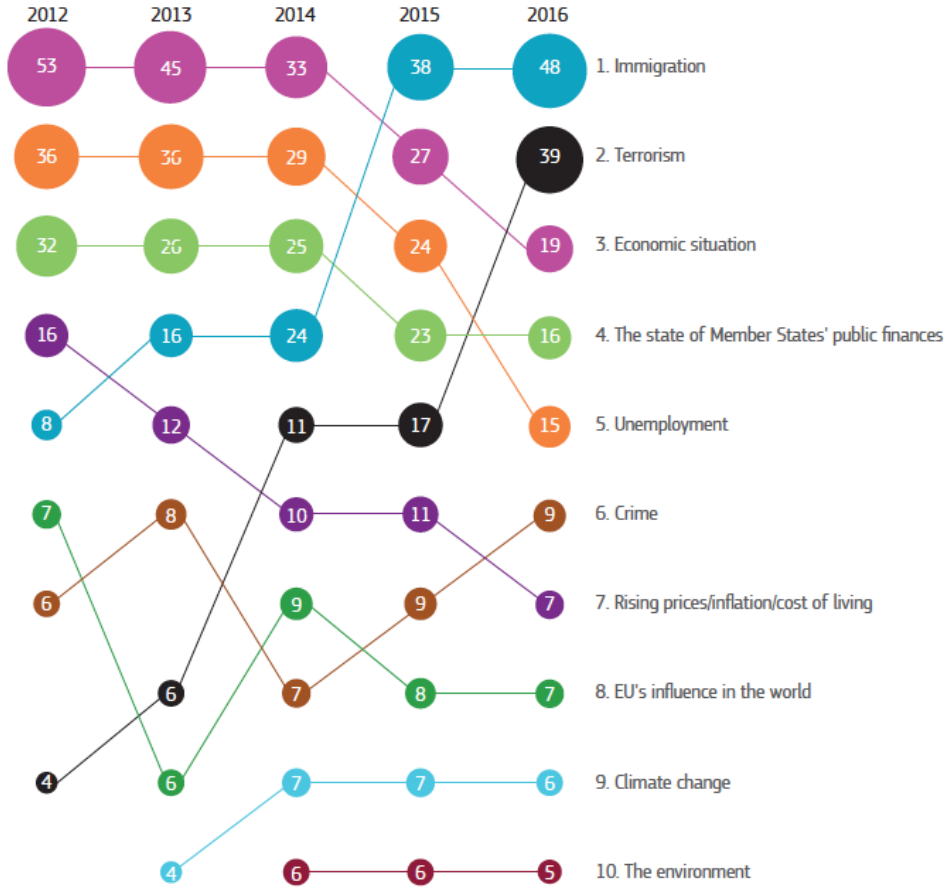
The majority of position papers from stakeholders representing different stakeholder groups commented on the role of Horizon 2020 in policy priorities. More than half of those who commented depict a positive view of the contribution of Horizon 2020 to current policy priorities.

For instance, in their position papers stakeholders note that: Horizon 2020 is tackling current challenges of Europe by contributing directly to Europe's competitiveness which leads to jobs and growth; a few position papers highlighted contribution of Horizon 2020 to the realisation of the European Research Area (ERA) by funding collaborative research, trans-national infrastructure and mobility; position papers from businesses that addressed this point specifically noted that the (societal) "challenge driven" research and innovation approach of Horizon 2020 and the fact that the programme covers the whole innovation chain is crucial for a competitive European industry; position papers received from international stakeholders that addressed this point also mention that Horizon 2020 plays a role in addressing challenges that are of global nature.

6.2. Does Horizon 2020 allow adapting to new scientific and socio-economic developments?

Whereas high (youth) unemployment remains the biggest socio-economic concern and challenge in many Member States in 2016 associated to slow economic growth, **the EU has to respond to new emerging challenges, such as armed conflicts, rising migration flows or global health emergencies and terrorism** (see Figure 18).[64] More specifically, the increase in the threat of terrorism, with major incidents occurring in several Member States, the increase of the sharing economy and bottom up citizen centred innovative solutions, and huge step-change progress in some areas of technological developments (examples include 3D printing, smart phone applications, 5G) are some of the developments impacting the context of the programme.

Figure 18 What issues are Europeans most concerned about?



Note: Data are in percentage of EU-total respondents. Respondents were asked to select two issues within a pre-defined list.
Source: Eurobarometer.

Source: Eurobarometer data, cited in European Policy Strategy Centre (2016), EU2016: From trends to policies- Key trends

Horizon 2020 has built-in flexibility[65] to tackle new and unexpected challenges and thus allows for a more flexible approach to respond to the new emerging challenges compared to

[64] This shift is observed across the Union with the exception of Portugal, where fears around public finances and unemployment rank second and third after immigration, and Romania, where crime comes third.
[65] See Article 12 and 15 of Horizon 2020 Regulation.

FP7.[66] The strategic programming approach (see previous section) involving advice, evidence and foresight aims to support flexibility in its implementation[67].

So far, **the Horizon 2020 Work Programmes have responded to some pressing new challenges.** The possibility afforded by the financial regulation to award grants without a call for proposals in exceptional and duly substantiated emergencies, is indeed an option that can increase the flexibility of the 'Societal Challenges' pillar, as demonstrated by the swift research response to the recent Ebola outbreak (see box below). Also the SC6 Work Programme 2016-2017 reflects the increasing awareness of the topic of migration. Thematic assessments under Societal Challenges however point out that **two-year programming is at times too rigid to integrate swiftly new and "urgent" topics dictated by external events or disruptive and counter-intuitive technologies and business models**. The FET assessment confirms that in its current design FET has the potential to keep closing the gap between research and innovation, but also highlights the **scope for better coordinating the various stakeholders so as to ensure a stronger alignment of basic/fundamental research with future needs**. In the SC6 assessment, it appears that there are also emerging needs that the SC6 programme does not fully cover yet such as the Refugee crisis and the future of the EU after the "Brexit".

Box: Horizon 2020 reacting to the outbreaks of Ebola and Zika

The outbreak of Ebola in West Africa was the major international public health emergency of the past few years. SC1 promptly supported urgent research on Ebola by launching – for the first time – two fast-track procedures completed in a very short timeframe.[68] EUR 24.4 million from Horizon 2020 were mobilised despite not being foreseen in the Work Programme. In parallel, the IMI-Ebola+ call (a PPP between EU and EFPIA) was launched in record time taking into consideration the dual nature of IMI. This Horizon 2020 SC1 research response, very significant in scale, with a total of EUR 140 million, in turn, leveraged a further EUR 101 million from the European pharmaceutical industry.

Horizon 2020-funded Ebola actions have already delivered significant results: supported the R&D of all 3 leading Ebola vaccine candidates, provided evidence that the initially proposed treatments of antiviral favipiravir and plasma from survivors are not effective, developed diagnostic tests and produced critical new knowledge about the virus itself. Most significantly, in spite of the enormous challenges, the research was done timely and with due respect to all H2020 and international ethical standards[69]. These actions have placed the Commission second only to the US Government in terms of commitments made[70]. The Commission has also strived to coordinate other Ebola research funders by establishing frameworks for cooperation to enable a swift and effective global research response in future outbreaks.

SC1 has taken the lead in establishing the Global Research Collaboration for Infectious Disease Preparedness (GloPID-R) that links together research funders, the scientific community, industry, patient groups and public health actors. Its goal is build up the research capacity so that an effective research response can be launched within 48 hours of an outbreak. It was tested with the **Zika outbreak** in Latin America in 2015, when the Work Programme was updated to include in emergency a call on Zika research, in coordination with other funders of preparedness research. Through this call, EUR 30 million were allocated to address the urgent Zika research gaps. Additionally, from other Work Programme 2016 calls, EUR 15 million were allocated for research on Zika vaccines and for infrastructures for mosquito research.

[66] The FP7 ex-post evaluation concluded that even though FP7 responded to the economic crisis it was not flexible enough to respond to new emerging challenges.
[67] As an illustration the European Commission 2015 paper on 'Strategic Foresight: Towards the 3rd Strategic Programme of Horizon 2020' identifies potentially important emerging issues and disruptions for Horizon 2020 to feed into the discussion for the upcoming Work Programmes.
[68] While following all Horizon 2020 rules as the Financial Regulation foresees the possibility to award grants without a call for proposals in exceptional and duly substantiated emergencies. This procedure was planned during September 2014, with results announced and projects launched in October. The IMI-Ebola+ call was launched on 6 November, with results announced mid-January 2015.
[69] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5240928/
[70] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5112007/

The bottom-up, open and non-prescriptive nature of most of the actions supported under the Excellent Science pillar[71] **allowed adapting flexibly as needs arose, channelling funds to new and promising research areas, including on multidisciplinary research** and integrating effectively the European Open Science Cloud into the forward vision for e-infrastructures. For example, MSCA have demonstrated a certain level of flexibility by responding to the emerging challenge of migration flows through initiatives aimed at welcoming researchers to Europe. This is also the case beyond the Excellence pillar: funding for 'Science4Refugees' projects has been introduced into the Science with and for Society programme. Similarly, FET-funded interdisciplinary research has responded quickly to evolving economic and societal needs, such as those arising from privacy and security concerns, complexity of socio-economic (e.g. financial) and socio-technological systems, or in extremely competitive emerging industry areas such as graphene, quantum technologies and biotechnology. FET-Open is explicitly non-topical and non-prescriptive in order to allow for new ideas, within the broadest spectrum of themes and disciplines.

As highlighted in the thematic assessments, **new socio-technological developments call for a constant review of Horizon 2020 priorities and scouting of developments**. Evolutions since the adoption of Horizon 2020 of the socio-technological framework include an increased importance and visibility of **digitisation and the new role of consumers**. For example, technological developments are dramatically increasing the capacity of research infrastructures to collect and produce data and the developments in distributed computing, overall computer power and high-volume data transmission have combined to produce an **explosion of data-driven science**, giving scientists in many disciplines inter-operable access to research data of a hitherto-unimagined scale and diversity.[72] [73] The 2016/2017 work plan for European research infrastructures included the European Open Science Cloud pilot, which has delivered a further leg to the European structure to deliver the open data and research agenda and underpin the digital single market.

The manufacturing industry has become more service focused, by the **increasingly blurring product-service boundaries**. Firms previously focussed on straight manufacturing are positioning themselves as "solution providers", often based on using advanced technologies in their products and digital and data based services. Customisation or after-sales services are examples. While this approach has been taken up in the LEIT-NMBP Work Programme, selected projects do not reflect yet the importance of these developments in terms of their planned activities.

Based mostly on a keyword text mining approach (also containing phrases and topics), which compares the degree of matching between keywords extracted from the Horizon 2020 establishing act (Council Decision 2013/743/EU) and Work Programmes (2014-15 and 2016-17) against keywords extracted from international and EU policy documents, social media, and patents and publications, an expert group concluded that Horizon 2020 takes into account subsequent technological and scientific advances to a high degree.[74] Moreover, an external study looking at the keywords of the FET projects abstracts, highlight the high number of **FET projects that focus on technologies that are expected to have significant potential to drive economic im-**

[71] Under this pillar, research proposals tend to be less constrained by policy objectives set out in a Work Programme established years earlier, and as such can target topical issues using the latest scientific and technological approaches.
[72] See thematic assessment of Research Infrastructures
[73] Riding the wave. How Europe can gain from the rising tide of scientific data. 2010
[74] European Commission Expert group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020, Applying relevance-assessement methodologies to Horizon 2020 (forthcoming report)

pact and disruption by 2025[75]. Also **the ERC is reinforcing 25 of 28 key fronts of research** (Figure 19).

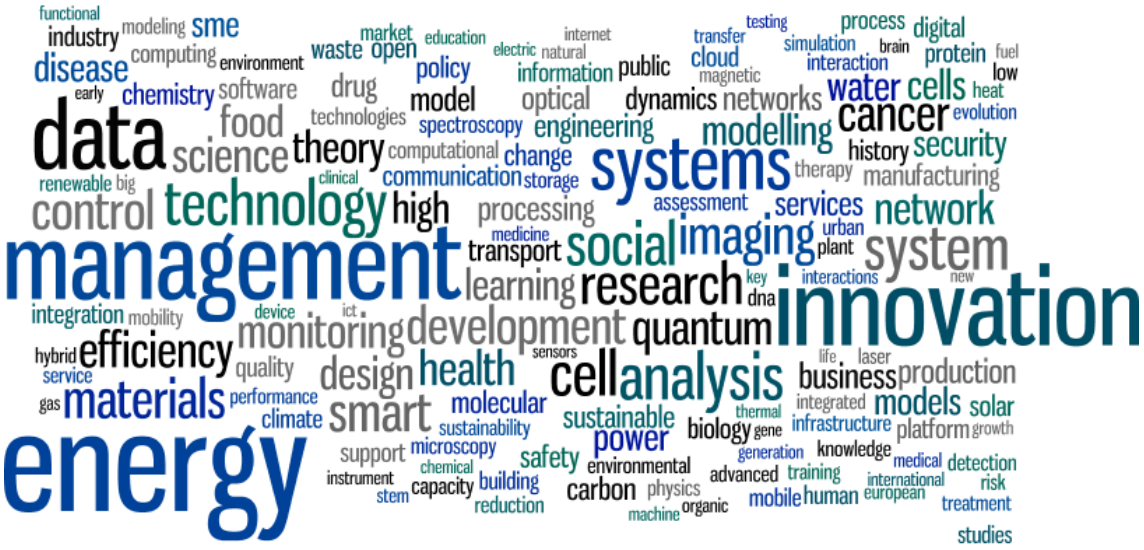
Figure 19 Key hot and emerging research fronts where ERC grantees are working

Hot research fronts where ERC grantees are working	
1. Outbreak, prevention and control of microbial contamination of fresh produce; 2. Mechanism of plant innate immunity; 3. Microplastic pollution in the marine environment; 4. Biodiversity loss and its impact on ecosystem functions and ecosystem services; 5. Global warming hiatus; 6. Carbon cycle of inland waters and the ocean; 7. Clinical trials of direct-acting antivirals (DAAs) for hepatitis C infections; 8. Immune checkpoint inhibitors anti-PD-1 antibodies in melanoma immunotherapy; 9. The molecular mechanism for origin, development and differentiation of macrophage; 10. Differentiation, function, and metabolism of T cells;	11. Phosphors for white LEDs; 12. Sodium-ion batteries; 13. Galactic center gamma-ray excess; 14. Property and application of monolayer/few-layer black phosphorus; 15. Observations of the cosmic microwave background (CMB) by Planck; 16. Baryon acoustic oscillation (BAO) related research based on sky survey missions like SDSS; 17. The internet of things, cloud manufacturing and related information technology services; 18. Research on measurement-device-independent quantum key distribution; 19. DEA (Data Envelopment Analysis) based assessment of environmental and energy efficiency.
Emerging research fronts where ERC grantees are working	
1. Effects of systemic insecticides (neonicotinoids and fipronil) on non- target organisms and environment; 2. Elemental composition of the North Atlantic Ocean and Southern Ocean; 3. Principles of chromatin looping and evolution of chromosomal domain architecture;	4. Research fronts on perovskite 5. Experimental realization of fractional Chern insulators; 6. Studies of Comet 67P/Churyumov-Gerasimenko by Rosetta.

Source: ERCEA, Thematic assessment of the European Research Council (see Annex 2), 2017

Figure 20 provides an indication of the current thematic coverage of projects based on the frequency of keywords used in all Horizon 2020 selected projects. This shows the current strong focus of the more than 11,000 selected projects on 'energy', 'data' and 'systems'.

Figure 20 Wordcloud of frequency of keywords from Horizon 2020 projects



Source: Horizon 2020 CORDA, date: 01/01/2017. The size of the word depends of its frequency in projects' keywords

[75]McKinsey (2013). Disruptive technologies: Advances that will transform life, business, and the global economy.

The flexibility of Horizon 2020 to adapt to new scientific and socio-economic developments is nuanced by the results of the stakeholder consultation. 36% of respondents agreed fully or to a large extent that Horizon 2020 thematic coverage is flexible enough to cope with changing circumstances, 41% agree only to some extent, and 12.4% fully disagree. NGOs tend to disagree more than the other categories of respondents (16% full disagreement rate). Also a high percentage of respondents agree, at least to some extent, that Horizon 2020 supports the latest developments in R&I at the national/ European and international level (93% of agreement rate). The most positive respondents are businesses and public authorities and the most negative are NGOs. When asked about whether Horizon 2020 priorities address the current challenges confronted by the European Union (e.g. migration, terrorism, ageing population), only 35% of the consultation respondents think the programme does fully or to a large extent, 42% to some extent and 8% judge that it is not the case at all. Academia and research organisations tend to be more positive (86-83% think it does at least to some extent) than business (71%).

Stakeholder position papers: Improvements are needed regarding Horizon 2020 flexibility to changing priorities

In their position papers a few stakeholders also commented on the programme flexibility and stated that improvements are needed mainly regarding Horizon 2020 flexibility to changing priorities but concrete examples substantiating such statements are not evident. However, one research organisation noted the rapid response to emerging areas such as migration, Ebola and Zika is a good practice example of flexibility of the programme that could be applied to other parts of the programme.

6.3. Is Horizon 2020 responding to stakeholder needs?

6.3.1. Involvement of stakeholders in programme design

Compared to FP7, stakeholders are much more closely involved in the programme design through the 19 Horizon 2020 Expert Advisory Groups[76] which have been set up as consultative bodies for the individual programme elements of Horizon 2020[77], targeted and open public consultations on future research themes,[78] European Technology Platforms (ETPs), which develop R&I roadmaps for action at EU and national level in some sectors, Programme Committees composed of representatives from Member-States and European Innovation Partnerships (EIP). The priorities and activities under Contractual Public-Private Partnerships build on an agreed relationship between the European Commission and the private sector in defined areas, and on specific roadmaps with Key Performance Indicators and a commitment to additional investments on the private side. In addition, the Citizen and Multi-Actor Consultation on Horizon 2020 ('CIMULACT') project[79] started in 2015 to improve the engagement of citizens and provide concrete input to the European R&I agenda.

"There has been significant improvement in Horizon 2020 in comparison to FP7. However, there is still some issue on transparency on how the work programmes and calls are set. There seems to be a lack of long term impact as call topics often lack continuity and are funded from different angles for the same topic, which fails to connect in a holistic, long term solution. The participant portal although highly simplified and unified, still pose a challenge for newcomers to navigate through."

Italy, European Academy of Bozen/ Bolzano

[76] The Expert Advisory Groups produce reports and recommendations that contribute towards defining the Work Programme. Full list and open call for expression of interest: http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=h2020-experts. The mandate of the selected experts is for a period of 2 years with the possibility of renewal for a further maximum 2 years.

[77] http://europa.eu/rapid/press-release_IP-13-1026_en.htm When launched in 2013, nearly 40% of their members (20-30 per group) had not advised on previous EU research programmes, ensuring a 'fresh approach' in the new programme

[78] e.g Call for Ideas launched for Societal Challenge 5. This includes open public consultations as well as dedicated written consultations and events targeted at respective stakeholder groups.

From the thematic assessments, it appears that **the introduction of the strategic programming process has improved the intelligence base underpinning programming choices and has helped better define the focus of the programme in line with stakeholder needs.** The translation of high level challenges and objectives into specific call topics is however not always clear to external stakeholders. Moreover, it was found difficult to establish clear links between high-level policy objectives and the related quantitative targets and the specific contribution expected from some topics.[80] Room for improvement is also identified in reconciling the perspectives of short to mid-term legislative and specific policy making tasks of policy DGs with a long term and systemic view on R&I**.** The thematic assessment on SEWP also highlights that supporting world-class excellence requires long-term commitment, and continuity also on the public and policy side, e.g. through structural reforms.

More than 80% of the stakeholder consultation respondents agreed that the frequency of the calls of the Horizon 2020 Work Programmes and their clarity are either "good" or "very good". The majority of respondents have a positive opinion on the transparency in the process of formulating the Work programme (67%) and the ease of finding the right call for their proposal. There are however also high levels of dissatisfaction with 26% that found that these are "poor" or "very poor".

Stakeholder position papers: Stakeholders have different opinions on the degree and appropriateness of their involvement in Horizon 2020 design.

In their position papers, some stakeholders commented on the degree of their involvement in the design of Horizon 2020 and its activities, but their opinions differ. Of those commenting some have a positive view on the current level of involvement and see the agenda setting process contributing to a comprehensive and widely supported programme. Several others however noted the current design of the Work Programmes is not transparent. In general, organisations found lacking involvement of stakeholders from their particular field. For instance, among others, the following issues were highlighted: inadequate coordination with the Members States specifically mentioned by Germany and France but also by stakeholders in academia; Estonia as well as one SME noted that larger players seem to have more influence on the research programme and the call topics; and a few stakeholders that commented on this issue from the industry and the business community noted they are not well represented in the Horizon 2020 projects, working groups, advisory groups and committees (their representation is reportedly below 20%).

6.3.2. Programme attractiveness and take-up

The **high demand for programming funds** is an indication of the value stakeholders attach to the programme. Compared to FP7, the number of proposals submitted to Horizon 2020 has increased significantly. Whereas FP7 generated around 135,000 proposals in the 7 years of its existence (around 20,000 per year), as of 1 January 2017 – after three years - more than 100,000 proposals had been submitted under Horizon 2020, which is an average of more than 33,000 per year. **The most attractive programme part in terms of proposals submitted is the SME instrument, followed by the ERC, MSCA, LEIT-ICT[81] and the Health Societal Challenge.[82] In FP7, the private sector submitted 25.4% of the applications; this share has increased to 37.4% in Horizon 2020.** Each higher or secondary education institution (HES) on average applies more often to Horizon 2020 compared to private companies. In the

[79] http://www.cimulact.eu/

[80] For instance, what will be the contribution to "an 80-95% decrease in greenhouse gas emissions by 2050" that will be provided by a certain project concentrating of improving powertrain efficiency in Societal Challenge 4.

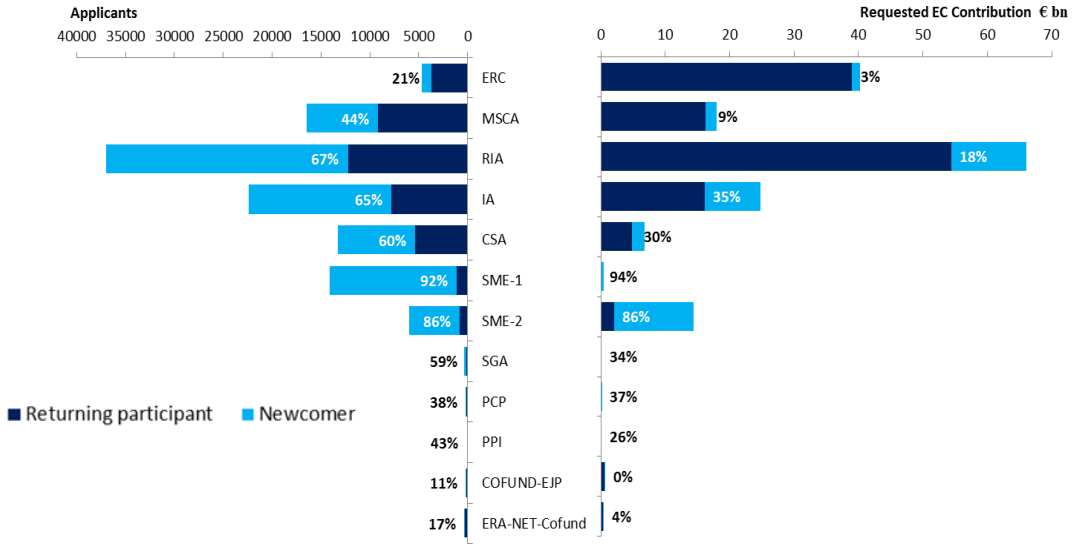
[81] This includes Open Disruptive Innovation projects implemented through the SME instrument.

[82] An in-depth discussion on oversubscription is presented in Section 7 "Efficiency".

first three years of Horizon 2020 implementation, each HES applied 28 times on average compared to 2.6 times for private companies (1.2 times on average for SMEs).

The increased interest is prominent thorough Horizon 2020, but especially for the SME Instrument, which has generated more than 30,000 proposals compared to around 5,000 in FP7 (under Research for the benefit of SMEs). Overall, in Horizon 2020, SMEs submitted 99,434 applications in eligible proposals, which is around 26.2% of the total for Horizon 2020 (against 23.7% in FP7).

Figure 21 Proposals submitted and funding requested per programme part



Source: Corda, cut-off date by 1/1/2017

Noticeably, **78% of all organisations that applied to Horizon 2020 funding in the first three years of programme implementation were newcomers** (i.e. have not received funding under FP7), the majority of them was from the private sector. More specifically, the programme generated interest of 35,288 new SMEs, representing more than half of the new applicants from the private sector (55,296) as well as 5,022 new higher or secondary education institutions, 5,150 new research organisations and 3,925 new public bodies, and 5,376 'Other' organisations (which include most of the civil society organisations) indicating the continued relevance of the programme for new players, including for organisations representing citizen's interests. In particular, the large majority of applicants (91.3%) to the SME Instrument are new to the Framework Programmes.

Figure 22 Number of distinct applicants and applications per type of organisation

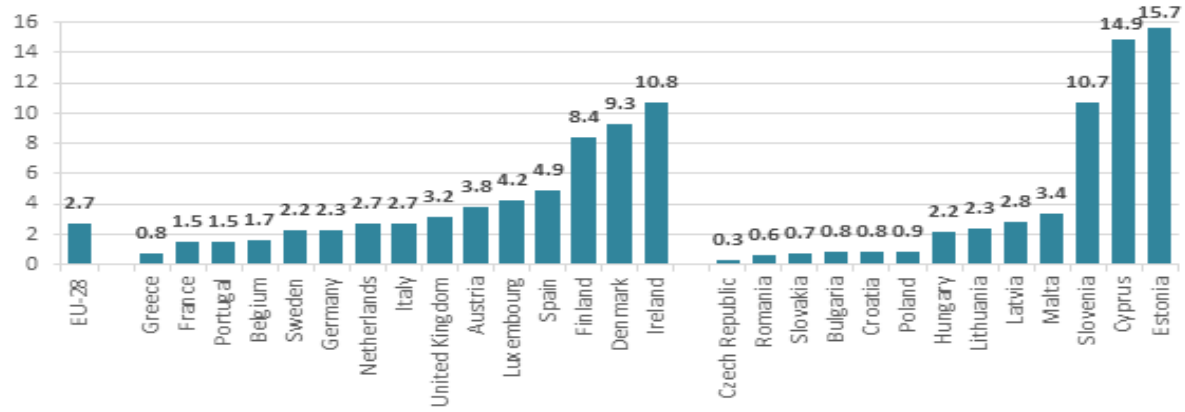
	Number of distinct applicants		**Number of applications**	
	Total	*Out of which from new players*	Total	*Out of which from new players*
Private Sector	55,296	*46,034*	141,880	*84,462*
out of which SMEs	*35,288*	*28,551*	*99,434*	*58,646*
Higher or secondary education institutions	5,022[83]	*3,024*	140,900	*7,973*
Research Organisations	5,150	*2,464*	68,346	*5,341*
Public Bodies	3,925	*2,815*	13,551	*5,480*
Other	5,376	*4,309*	14,492	*8,460*
Total	**74,769**	***58,646***	**379,169**	***111,716***

Source: Corda, cut-off date 1/1/2017 (success rate is calculated excluding grants to named beneficiaries)

[83] This covers e.g. universities, academies, colleges, technical schools and high schools.

The SME Instrument assessment looked at the number of excellent proposals as a percentage of the target group of innovative, growth ambitious SMEs per country. The reach-out to the target groups differs from country to country. **In some small and mid-sized Member States, such as Estonia, Cyprus, Slovenia, and Ireland, the SME Instrument persuades over 1% of the target group to submit competitive proposals.** The EU28 average is 0.27%[84].

Figure 23 Penetration rates of the SME Instrument per Member State (SMEs reached per 1,000 of the target population)



Source: Interim evaluation of 'Innovation in SMEs', Technopolis, based on CORDA data (July 2016).

6.3.3. Stakeholder views on the support offered

6.3.3.1.Reasons for participation and types of support

According to the stakeholder consultation, **the main reasons for participating in Horizon 2020 are financial support, access to new knowledge and know-how, and unique collaboration opportunities with existing or new European or international partners**. Interdisciplinary work and the opportunity to work with other types of actors also stand out[85]. Reasons for participation are also illustrated by the word cloud in Figure 24.

It follows from the stakeholder consultation that **grants are regarded as the most relevant forms of funding provided through Horizon 2020, followed by co-fund, prizes, financial instruments and public procurement.** [86] Collaborative grants and ERC stand out as being particularly relevant to respondents. Almost 7.5% of the respondents who did not participate in Horizon 2020 underline lacking adequate type of financial support for their work and 14.6% mentioned that the programme lacked a relevant area/ topic for their needs.

A dedicated survey asked SMEs and intermediaries organisations about their views on the design of the SME instrument. The most attractive features include the fact that this support is available to a single company, the size of the grant, the rate of funding and the openness of

[84] Calculated as the ratio between the total number of quality applications made to the SME instrument and the target number of SMEs (in thousands). It is understood as the number of SMEs reached per 1,000 of the target population.
[85] Respondents also refer to products, solutions development and commercialisation (mainly quoted by businesses); internationalisation, visibility and enhancement of the participants' research profile (mainly quoted by academia); the ability to advance global knowledge and solve societal challenges such as climate change and health; and the ability to perform or have access to high-profile research. Some business respondents also mention growth opportunities through activity development and a better or secured position on markets, as well as the ability to develop innovation faster.
[86] Very few beneficiaries of the Access to Risk Finance programme part replied to the stakeholder consultation on the interim evaluation (0.8% of respondents). Detailed consultation results per organisation type are provided in Annex Part 2.

topics. Especially SMEs are very positive about the possibility to resubmit proposals, as well as about the time period from application to grant.

Figure 24 Please share with us a short, telegraphic testimonial. What does Horizon 2020 mean to you? What is its main feature?

Wordle®, Source: Replies to stakeholder consultation questionnaire launched in the framework of the Interim Evaluation of Horizon 2020, October 2016-January 2017, N=1704

Stakeholder position papers: The transnational and multi-sectorial approach for excellent research and innovation is working well.

Some stakeholder position papers including academia, research organisations, public authorities and NGOs commented on the transnational and multi-sector collaborative approach for excellent research and innovation and perceive it as an "*attractive*" and "*successful*" method and "*the backbone*" of Horizon 2020. However, one SME was particularly critical noting there is already enough interdisciplinary and that insisting on it makes research lose its focus.

As regards the openness of the calls, the right balance has to be found between being too prescriptive and not sufficiently. Whereas the FET assessment points out that the open and non-prescriptive nature of the calls leads to a dispersal of approaches and solutions that may result in imbalances in the number of proposals across topics impeding the cross-fertilisation of experience, under the Industrial Leadership Pillar the LEIT-ICT assessment highlights that there is not enough room for openness in the calls for topics and ideas of the research community, creating the risk that quality research is not funded because it does not fit the calls or their timelines. For LEIT-Space a risk is identified of a focus in the programme design towards the specific needs of each segment, thus lacking the integrated approach needed for the longer-term creation of competitiveness by fostering the inclusion and strengthened position of European SMEs in the global supply chains. A number of respondents to the call for ideas for a European Innovation Council argued that call themes should not be pre-defined but rather be more open and bottom-up. In order to fill the gaps in EU support, many stakeholders called for dedicated calls for disruptive technologies and improved access to risk financing[87].

In general, **Horizon 2020 covers topics responding to the needs of stakeholders;** stakeholder only mentioned a few examples of topics not covered in Horizon 2020. However, a

[87] Available at: https://ec.europa.eu/research/eic/pdf//eic_call_for_ideas-overview.pdf#view=fit&pagemode=none

majority of stakeholders responding to the stakeholder consultation pointed out that Social sciences and Humanities are not sufficiently included in the calls.

Stakeholder position papers: Social sciences and humanities need to be better integrated in the programme design.

Some stakeholder position papers from different types of organisations mentioned that social sciences and humanities (SSH) are currently not adequately integrated in Horizon 2020 specifically in Pillar 2 and 3. Stakeholders stressed SSH have an equal capacity to solve the challenges of society today than natural sciences. In their opinion SSH needs to be better integrated from the design of work programmes, description of calls to project evaluation (i.e. ensure at least one evaluator has SSH expertise).

6.3.3.2. Addressing the needs of citizens

From the thematic assessments, it appears that **the innovations arising from Horizon 2020 are likely to benefit all types of stakeholders -including citizen-**, through an enhanced capacity to address several of Europe's most pressing societal challenges, from living with climate change to improved civil security. Moreover, these new applications and service areas are perceived as promising economic growth and employment opportunities. At different Technology Readiness Levels (TRLs), and depending on the specific challenges addressed, the projects are involving different types of partners from the 'triple helix', that is industry, academia and governments, and in less frequent cases society (e.g citizens, civil society organisations - CSO). Based mostly on a keyword text mining approach (also containing phrases and topics), which compares the degree of matching between keywords extracted from the Horizon 2020 establishing act (Council Decision 2013/743/EU) and Work Programmes (2014-15 and 2016-17) against keywords identified by the experts as pertaining to EU citizen needs, an expert group concluded that EU citizen needs are broadly covered in all pillars - revealing a 50 to 75% correspondence between keywords in both Work Programmes and the Horizon 2020 establishment act and keywords identified by the experts as pertaining to EU citizen needs.[88]

The area of citizen science often falls between the categories: It is science, but it is also education, culture and a science and society activity. It happens often that citizen science (especially citizen science initiated by the public) does not get funding because funders do not feel responsible for that subject area.

European Citizen Science Association, Switzerland

As part of MSCA, the European Researchers' Night attracts up to one million citizens every year, and has brought researchers closer to the general public, increased awareness of R&I activities and encouraged young people across the EU to embark on research careers. The thematic assessments however highlight the **gap in society in understanding of the benefits of publicly-funded research and overall room for improvement in bringing research closer to the general public and encourage young people to embark on research careers**. **The involvement of representatives of civil society still appears to be low (even in the Societal Challenge 6 dedicated to inclusive society) compared to the traditional R&I actors, like academia and industry.**[89] This is happening despite the efforts to open the programme to new players and to empower citizens, in particular through citizen science/citizens observatories (Societal Challenge 5).

[88] European Commission Expert group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020, Applying relevance-assessment methodologies to Horizon 2020 (forthcoming report)

[89] As an illustration, in the transport thematic assessment, the limited involvement of representatives from the softer transport modes is considered an issue. This may partially be due to the fact that stakeholders such as civil society organisations representing citizens at large, pedestrians, passengers of all transport modes and unions are not constituted in well-defined groups, as the majority of other more traditional transport modes are.

The Science with and for Society programme part is one key way Horizon 2020 responds to citizen needs[90]. Although there is strong support for the involvement of civil society in Horizon 2020 the vast majority of representatives of Civil Society Organisations (CSO) surveyed by the European Economic and Social Committee (EESC) (83%) agree or strongly agree that there is a **lack of knowledge exchange between the scientific community and civil society**. Responsible Research and Innovation (RRI)[91] is a cross-cutting issue in Horizon 2020, which aims to encourage societal actors to work together during the whole R&I process to better align R&I with the values, needs and expectations of society. However, an external study[92] found that **CSO participation in FP6, FP7 and Horizon 2020 was/is however marginal**. The share in funding of CSOs is even lower than the share in institution numbers and in project participations, even if - as of April 2015-, Horizon 2020 exhibited an increase on a low level (2.3% compared to 1.4% in FP7). This contrasts with the monitoring data suggesting that 11% of Horizon 2020 projects are RRI relevant. As such, it is currently not clear whether or how these RRI-relevant projects really are "*instances where citizens, CSOs and other societal actors contribute to the co-creation of scientific agendas and scientific contents*". Also the network analysis performed in this study points out that **CSOs that do participate generally take on non-core roles in project consortia**.

49% (1706) of the stakeholder consultation respondents agreed fully or to a large extent that Horizon 2020 priorities address the main citizens' needs, whereas 37% (1302) agree to some extent and 5% judge that it is not the case at all. The most negative respondents are NGOs. 48.5% (1698) of respondents agree that an increased involvement of citizen in priority setting is needed to further maximize the socio-economic impact of the EU framework programme for research and innovation whereas 37.9% (1320) disagree (13.6% (473) do not know). The most positive are NGO. Whereas business umbrella organisations are more negative, a slight majority of individual SME respondents agree together with individual research organisations, academia and public authorities.

Box: Examples of promotion of Responsible Research and Innovation across Horizon 2020

Under **SWAFS** the VOICES and CIMULACT projects have recently invited citizens to interact directly with EC services. These projects will harness the knowledge and views of citizens to help shape future Work Programmes. In 2016 two topics under SWAFS also invited stakeholders to reflect on the main science and society issues that should be tackled through Horizon 2020.

In 17.4% of **Societal Challenge 1**'s projects, citizens, CSOs and other societal actors contribute to the co-creation of scientific agendas and contents[93]. They are representatives of patients or users who provide useful, sometimes crucial, information on the needs and expectations of important stakeholders, thereby influencing the project's design. Such organisations are highly involved in the European Innovation Partnership for Active and Healthy Ageing initiative. They also play an active role in the definition of personalised medicine.

Under **Societal Challenge 2** a large number of projects implement the multi-actor approach. The multi-actor approach aims at more demand-driven innovation through the involvement of various actors all along the project. It includes existing knowledge into scientific work: end-users and practitioners are involved, not as a study-object, but in view of using their entrepreneurial skills and practical knowledge for developing innovative solutions. The multi-actor approach ensures the link between Research and Rural Development policies through the approach which implies the involvement of all concerned actors in all phases of project activities. The multiactor

[90] It has three specific objectives: the co-operation between science and society, the recruitment of new talent for science, and the pairing of scientific excellence with social awareness & responsibility

[91] Responsible research and innovation is promoted via: public engagement, open access, gender, ethics, science education, and integrated actions that for example promote institutional change.

[92] WU Vienna in collaboration with FAS Research and De Montfort University (forthcoming), data of April 2015

[93] Data on this cross-cutting issue is provided by EC Project Officers during grant agreement preparation.

approach is implemented as part of the European Innovation Partnership "Agricultural productivity and Sustainability"[94]

Under **Societal Challenge 3** a number of projects (e.g. Nobel Grid, Empower, Flexiciency, Flex4Grid) enable the active participation of citizens in the energy system, e.g. through the development and deployment of advanced ICT tools and services and promoting the role of prosumers (e.g. in smart grids). Under the 2014 and 2015 calls 16 projects are supported[95] targeting explicitly citizens, consumers and/or local stakeholders with the aim of raising awareness, building capacities and increasing their involvement for facilitating the uptake of innovative energy solutions.

A chapter dedicated to the societal dimension is included in the Work Programmes for **Societal Challenge 4** Smart, green and integrated transport since the start of Horizon 2020. Amongst the activities, the project MOBILITY4EU[96] brings together the civil society and the transport stakeholders to co-design transport solutions embedding societal needs.

Societal Challenge 5 continues to support citizens' science actions, capitalising on the results of FP7 projects (i.e. MyGeoss, Citizens Observatories). The goal is to empower citizens, providing them tools to measure and share, through apps, environmental parameters like air quality, noise, alien invasive species, etc. momentum, with a very active European Citizen Science Association (ECSA)[97].

Societal Challenge 6 projects make efforts to reach the specific stakeholders and the general audience with web-based platforms, social media and communication resources. For example the project DANDELION (Promoting EU funded projects of inclusive, innovative and reflective societies) aims to support the uptake and valorisation of Inclusive, Innovative and Reflective Societies research and improve its dissemination towards citizens, policy makers, academia and media. This will be achieved through a series of innovative and creative communication activities targeted at a range of audiences.

Under **Societal Challenge 7** a number of projects (CITYCoP, ICT4COP, INSPEC2T, TRILLION, Unity) share a common aim of engaging citizens in Community Policing and strengthening citizens-law enforcement relations. Overall, this enhanced collaboration between community and law enforcement agencies aims to maximise the safety and security of all citizens.

6.4. Key conclusions on the relevance of Horizon 2020

Horizon 2020's original **rationale for intervention** and objectives remain valid and the challenges identified at programme launch still exist. The level of R&D expenditure in the EU-28 lies at 2.03% in 2015, which is still below the 3% target of the Europe 2020 Strategy. In spite of some improvements, the 'innovation gap' identified at programme launch still exists. The EU-28 continues to be less innovative than key competitors, but performance differences have become smaller. In particular Europe still displays a structural gap in R&D investments (public and private) and in the uptake of innovation, together with lower productivity growth. It also lags far behind key competitors in high tech sectors. In addition, patent applications are declining in many EU countries and Europe displays a relative lack of young companies that have grown into world-leading innovators, in new innovation-based growth sectors and is home to fewer young companies that have grown into world-leading innovators. It is now more clearly recognised that such companies play a key role in bringing about the necessary breakthrough, market-creating innovation. The Societal challenges identified at programme launch remain valid and are even reinforced by the SDGs/COP 21 framework and the evolution of the socio-economic context. Strengthening Europe's science base, boosting industrial leadership, addressing societal challenges and cooperating internationally remain instrumental for achieving many of the key EU policy objectives. However, the translation of high-level objectives into work programmes, calls, and projects is not straightforward (lack of clear pre-

[94] http://ec.europa.eu/eip/agriculture/
[95] such as: FosterREG, TOPTEN ACT, SMART-UP, STEP_BY_STEP, DOMINO, Digi-Label, RESCOOP Plus
[96] Available at: http://www.mobility4eu.eu/
[97] Available at: http://ecsa.citizen-science.net/

defined intervention logic). The programme objectives as currently articulated in the legal basis are in several cases regarded as very broad and "all inclusive" - providing no indication of what success would look like on programme completion. As such, the current definition of objectives is assessed as not providing an optimal basis for programme priority setting, monitoring progress or evaluating programme performance.

Horizon 2020 has been **flexible** enough to adapt to new emerging needs (e.g. Ebola and Zika outbreaks, migration) and is in line with subsequent technological and scientific advances. The bottom-up, open and non-prescriptive nature of most of the actions supported under the Excellent Science pillar allowed adapting flexibly as needs arose, channelling funds to new and promising research and training areas, including on multidisciplinary research. The two-year work programming may however at times be too rigid to adapt to new and "urgent" topics dictated by disruptive and counter-intuitive technologies and business models. Evolutions of the socio-technological framework (incl. digitisation, servitisation, data revolution, social conflict, violence and security concerns, SDGs) are expected to profoundly impact the Horizon 2020 context in the coming years, calling for a constant review of priorities and scouting of developments. A right balance is also to be found between being too prescriptive or not enough, depending on the pillars and areas. There is also scope for ensuring a stronger strategic alignment of basic/fundamental research with future needs.

The programme is broadly **in line with stakeholders needs** and is attractive for newcomers, generating a high demand given funding available. Financial support, access to knowledge and expertise, and collaboration with European or international partners are the main reasons for participating. Grants for collaborative projects are perceived by stakeholders as the most relevant form of funding for their needs. Compared to FP7, the strategic programming process has improved the intelligence base underpinning programming choices and has helped better define the focus of the programme in line with stakeholder needs. However, the transparency in the Work Programme formulation process, the participation of stakeholders/citizens in the agenda-setting and the ease of finding the right call are areas for improvement. Horizon 2020 innovations are likely to benefit all types of stakeholders, including citizens- and have the capacity to address several of Europe's most pressing societal challenges, from climate change to improved civil security. There is however, a gap in society in understanding the benefits of publicly-funded research and overall room for improvement in bringing research closer to the general public.

7. HOW EFFICIENT HAS HORIZON 2020 BEEN SO FAR?

This question aims to consider the relation between the inputs of the programme (i.e. resources, budget, selection processes) and the outputs and impacts achieved by the programme. Since this is a mid-term review of the programme, the assessment mainly refers to the efficiency of the programme management (e.g. grant management, proposal evaluation) and implementation processes (e.g. selection and participation patterns). This makes it possible to shed light on whether the way in which the programme is managed is likely to influence positively or negatively the outputs that will be generated.

Expectations from Horizon 2020 in terms of efficiency

Compared to FP7 Horizon 2020 is expected to make EU research and innovation funding simpler to access, not only for established players, but also for newcomers. Administrative costs for applicants and participants are expected to reduce drastically, which is expected to significantly improve accessibility, in particular for SMEs, and increase levels of support

from all types of stakeholders. Per euro disbursed, implementation costs are expected to be lower under Horizon 2020 than under FP7 because of far-reaching integration, simplification and harmonisation (common rules benefitting stakeholders but also lowering the Commission implementation cost), and externalisation. Combined with the increased benefits expected from Horizon 2020 compared to FP7 this is expected to result in an increased efficiency.

The analysis looks closely into the administrative cost as well as aspects of the simplification of the programme for the programme beneficiaries (i.e. cost of writing proposals) as well as the Commission services (i.e. cost of administrating and running the programme). In addition, it assesses the use of new management processes by looking at the efficiency of the externalisation to the Executive agencies, one of the key management decisions taken to decrease the administrative cost of the programme. To understand to which extent programme management processes might influence the types of projects selected and the motivations for applying, the assessment also looks into the efficiency of the current application as well as the proposal evaluation processes. Finally an analysis of the funding distribution is performed in order to identify possible deviations from expectations based on the objectives set.

Summary box: Key findings on the efficiency of Horizon 2020

- ✓ Based on macro-economic projections, Horizon 2020 is as cost-effective as FP7 and comparable to the expected cost-effectiveness of public spending in research.
- ✓ Compared to FP7, Horizon 2020's efficiency is positively influenced by the extensive externalisation of programme implementation to new management modes including Executive Agencies.
- ✓ Simplification reduced administrative burden for participants and led to large decreases in the time to grant.
- ✓ Current administrative expenditure is below the target and is particularly low for the executive agencies.
- ✓ The new funding model is attractive for stakeholders and did not led to a significant change in funding rates compared to FP7.
- ✓ Horizon 2020 suffers from underfunding resulting in large-scale oversubscription, much larger than under FP7, which constitutes a waste of resources for applicants and a loss of high quality research for Europe.
- ✓ The proposal evaluation process is generally highly regarded but some aspects such as the feedback to applicants could be improved.
- ✓ Despite the low success rates, and cost of proposal writing, the costs on stakeholders seem to be proportionate given the (expected) benefits of participation, which go beyond the financial contribution received.
- ✓ The balance in project size did not change significantly compared to FP7 and does not have a negative impact on newcomers in the programme.
- ✓ Horizon 2020 funding reaches a wide range of stakeholders, including SMEs and a high number of newcomers. However, a large share of funding is still concentrated to a few players.
- ✓ Horizon 2020 is open to world and has a broad international outreach but funding of participants from third countries has decreased compared to FP7.
- ✓ Horizon 2020 promotes intensive collaboration between different types of organisations, scientific disciplines and sectors.

7.1. Overview of budgetary allocations

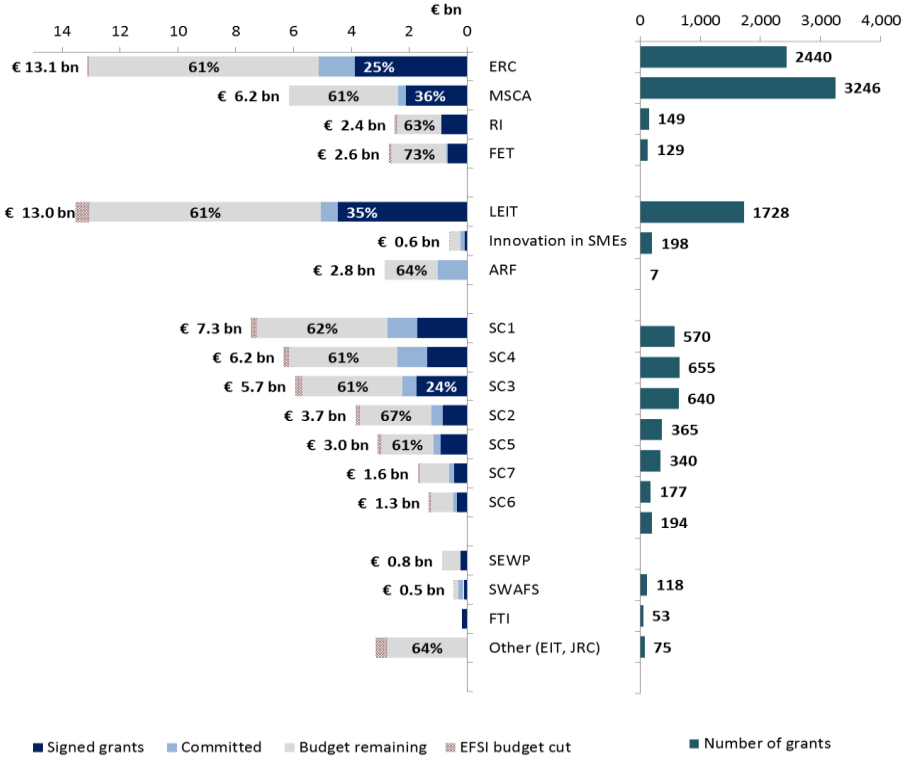
During the first three years of the programme 38% (EUR 29.0 billion) of the total Horizon 2020 budget was committed to all activities including the administrative expenditure, calls and other activities (e.g. PPPs, events, studies). **Grants remain the most prominent type of**

support from the programme: 69% of the programme commitments (EUR 19.9 billion) were allocated to grants[98]. EUR 7.5 billion (36.8%) was allocated in Pillar 1: Excellent Science, EUR 4.5 billion (22.3%) to Pillar 2: Industrial Leadership, EUR 7.4 billion (36.0%) to Pillar 3: Societal Challenges and EUR 944.1 million (4.9%) to additional priorities[99].

Horizon 2020 grants are implemented through 12 different types of actions[100]. Four types of actions received 86% of the overall funding and 72% of the total number of grants: Research and innovation actions (RIA, 39.3% of the funding, 15.1% of allocated grants); ERC actions (19.0% of the funding, 21.9% of the allocated grants); Innovation actions (17.2% of the funding, 6.2% of the allocated grants); and the MSCA grants (10.3% of the funding and 28.4% of the allocated grants) (see Figure 5 in Section 5.1).

In the second year of the programme implementation, the overall Horizon 2020 budget was cut by 2.9% (EUR 2.2. billion) to contribute to the creation of the European Fund for Strategic Investments (EFSI) and provide support via financial instruments. Financial instruments such as loans and guarantees are currently provided, among others, within the Access to Risk Finance (ARF) and Societal Challenge 1-Health and Societal Challenge 3-Energy part of the programme. These activities are being implemented by the European Investment Bank (EIB) and the European Investment Fund (EIF).

Figure 25 Horizon 2020 budget, mid-term rate of commitments (all) and implementation of grants (left) and the number of grants signed per programme's part (right)



Source: EC DG RTD analysis based on CORDA, cut-off date by 1/1/2017, Regulation (EU) No 1291/2013, Regulation (EU) 2015/1017 and budget data. Note: Total budget figures relate to revised Horizon 2020 budget after the ESFI cut. Committed budget to all activities (grants as well as other activities such as conferences, events, studies, PPPs, Art.185, prizes).

[98] Based on CORDA data excluding grants under Euratom, cut-off date by 1/1/2017 and Regulation (EU) No 1017/2015
[99] For further information regarding the budget allocation see Section 5- Implementation State of Play.
[100] Implementation data for other non-grant based instruments is currently not tracked in a comparable way.

7.2. How efficient are the programme management structures?

7.2.1. New Management Modes

New Management Modes (NMMs) are a new way to manage Horizon 2020 implementation activities with the use of external bodies (e.g. Executive Agencies, Joint Undertakings) with the aim to increase the efficiency and effectiveness of the programme.[101] The Commission services are expected to focus on core institutional tasks, such as policy-making, implementation and monitoring of the application of EU law, and strategic management, whereas the NMMs aim to deliver effective and efficient implementation of the programme.

Horizon 2020 grant management has been delegated to four Executive Agencies[102]. Already in FP7 two Executive Agencies (REA and ERCEA) implemented almost 30% of budget. However, in the first three years of Horizon 2020 almost 60% of the budget is implemented by the four executive Agencies (REA, EASME, ERCEA and INEA).

The governance structures of the Executive Agencies are designed to ensure proper supervision by the Commission and transparency. Special attention is paid to ensuring the effectiveness and efficiency of the feedback loop feeding project results from the Executive Agencies back to the Commission for policy purposes. Also, single set of rules for participation and dissemination in Horizon 2020 across all actors implementing the programme were established under Horizon 2020.

Based on the Cost Benefit Analysis[103] the "Communication to the Commission on the delegation of the management of the 2014-2020 programmes to Executive Agencies"[104] prior to the launch of Horizon 2020 noted, that delegation of programme management tasks to External Agencies is a fully relevant solution to improve cost-effectiveness due to:

- **Higher specialisation**: As a result of their experience and specialisation in specifically defined tasks, the agencies guarantee a high quality of programme management and better service delivery in terms of faster contracting, faster approval procedures for technical and financial reports and quicker payments.

- **Creation of synergies between closely related portfolios:** Giving the agencies coherent programme portfolios was expected to create synergies between closely related policy domains and foster knowledge spill-over.

- **Existing communication and outreach channels of the agencies**, which overtime developed to keep them close to beneficiaries were expected to provide increased level of direct exchanges with beneficiaries through "info days", kick-off meetings for larger and multi-annual projects, and monitoring visits.

- **Continuous simplification of processes and procedures** (e.g. simplified forms of grants, proportionate controls and electronic application forms) were expected to result in higher productivity.

[101] European Commission
[102] The division of labour between the Commission and the Executive Agencies is defined and documented in Delegation Acts.
[103] DG GROW 2013 Cost Benefit Analysis (CBA). The report is referred extensively in SEC(2013) 493 final Accessed at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52013SC0493(01)
[104] Ibid.

- **Lower cost:** A lower number of full-time equivalents (FTEs) required to manage the programmes due to specialisation and recruitment of a larger share of contract agents compared to Commission officials.

The analysis estimated the administrative savings compared to the "in-house" scenario to EUR 43.1 million and EUR 44.6 million in case of REA and ERCEA respectively. In the case of Horizon 2020 a key assumption allowing for such savings in addition to the factors outline above, was a larger size of Horizon 2020 grants in comparison to FP7[105].

Recent external evaluations of REA and ERCEA[106] demonstrated that Executive Agencies improve cost-effectiveness of the grant management and that both agencies exceed even the positive estimates made in the Cost-Benefit Analysis. In the 3 years covered by the evaluation report REA and ERCEA managed to save EUR 53.4 million (REA) and EUR 46.5 million (ERCEA) compared to the fully "in-house" implementation mode. The additional savings achieved in both agencies are due to lower than estimated staff costs and lower cost of overheads[107]. At the same time the evaluation concluded that ERCEA and REA reached very high levels of satisfaction with their performance among their beneficiaries and independent experts: 82% in case of REA and 93% in case of ERCEA.

To help coordinate and deliver the programme, a Common Support Centre (CSC) has also been set up in the Commission. The CSC centralises services, which were previously decentralised. It provides services in legal support, ex-post audit, IT systems and operations, business processes, programme information and data to all research DGs, Executive Agencies and Joint Undertakings implementing Horizon 2020. This has brought considerable simplifications to Horizon 2020, both externally for the stakeholders and internally for the Commission services involved in Horizon 2020. A separate more detailed mid-term review of the CSC is underway and will be finalised by the end of 2017.

It seems that the most resource intensive parts of the programme (i.e. actions with a high number of grants) are externalised: the Commission implements larger but fewer collaborative grants (EUR 7.6 billion allocated to 1,550 grants)[108]; the Executive Agencies implement smaller and more numerous grants a large part of which are single-beneficiary[109] (EUR 11.7 billion allocated to 9,207 grants).[110] Based on the existing evidence, smaller and more numerous grants are more resource intensive, and agencies manage almost six times as many projects as the Commission[111]. The overall budget of Horizon 2020 is managed by nine different Directorates-General (DGs)[112] of the Commission and implemented by 23 different bodies.[113]

[105] REA http://intranet-rea.rea.cec.eu.int/sites/rea/about/governance/Documents/Establishment%20Act.pdf and http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0779&from=EN

[106] Public Policy and Management Institute, Evaluation of the operation of REA (2012-2015), 2016 and Evaluation of the operation of ERCEA, 2016

[107] Costs related to the work environment include: Rental of buildings and associated costs; Information and communication technology; Movable property and associated costs; Current administrative expenditure; Postage and telecommunications.

[108] Such as and the LEIT-NMBP, Research Infrastructures and SC1 programme parts are fully managed by the Commission

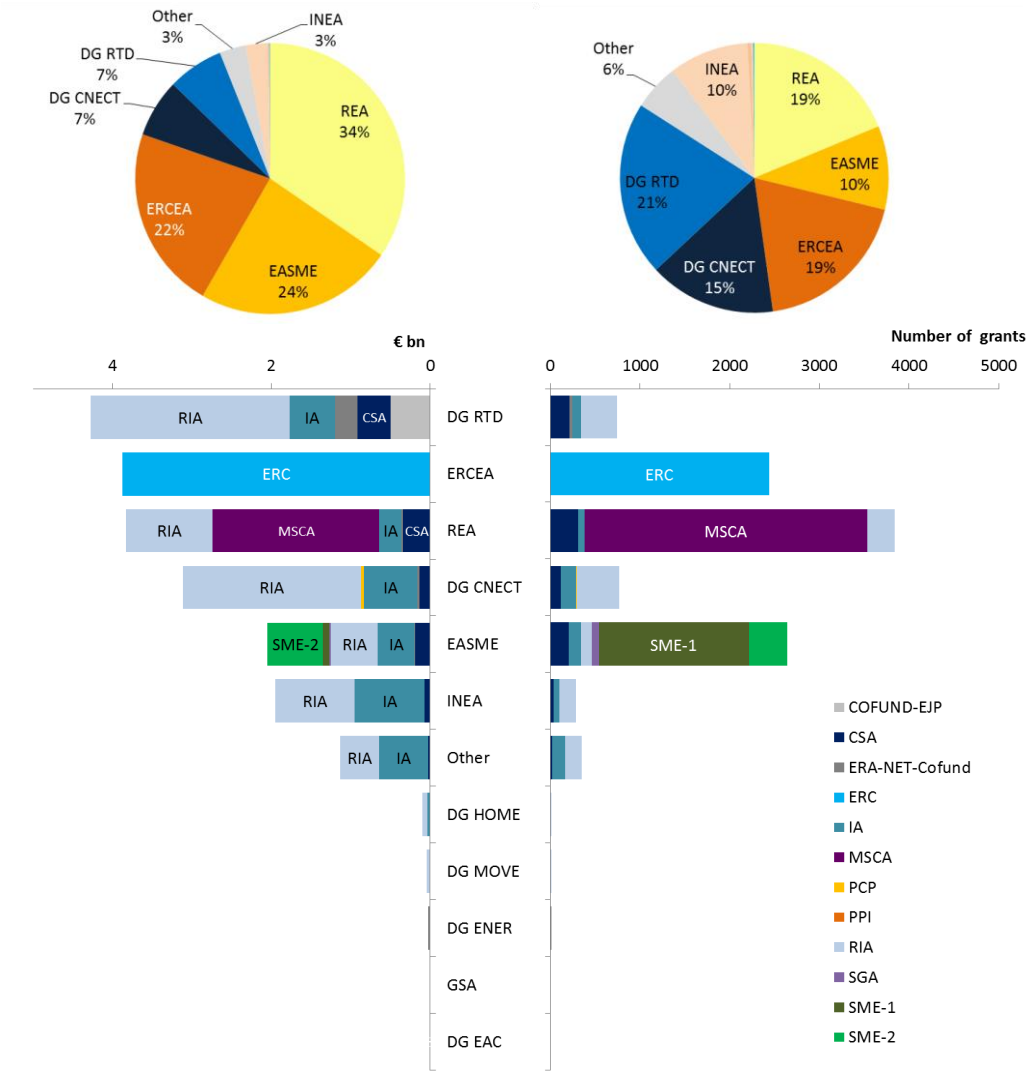
[109] Such as the SME instrument, ERC and MSCA actions

[110] The remaining 351 grants (EUR 1.1 billion) are managed by other bodies.

[111] The CBA study on the Executive Agencies (2013) assumes more resources are need to manage smaller and numerous grants compared to larger and few grants: the FTE days per 100,000 EUR are higher for smaller projects 7 to 10 FTE man days per 100,000 EUR (projects size from 50k to 1 million such as SME Instruments, MSCA-ITN, MSCA-Cofund) when compared to 4 FTE man days per 100,000 EUR for larger projects (project size from 5 – 6.8 million security, ICT, H2020 – food agriculture).

[112] DG Research and Innovation (DG RTD), DG Communication Network, Content and Technology (DG CNECT), DG Education, Youth, Sport and Culture (DG EAC), DG Energy (DG ENER), DG Internal Markets, Industry, Entrepreneurship and

Figure 26 Horizon 2020 mid-term implementation by implementing body: budget allocation (right) and number of grants (left)



Source: EC DG RTD analysis based on CORDA, cut-off date by 1/1/2017

Figure 27 below briefly summarises further centralisation measures put in place to increase efficiency of Horizon 2020.

SMEs (DG GROWTH), DG Mobility and Transport (DG MOVE), DG Migration and Home Affairs (DG HOME), DG Agriculture and Rural Development (DG AGRI) and the Joint Research Centre (JRC).

[113] Six Commission DGs, four executive agencies, four public-public partnerships (P2Ps), seven public-private partnerships (PPPs), the European Institute of Innovation and Technology (EIT) and the European Investment Bank (EIB).

Figure 27 Centralisation measures under Horizon 2020

Centralisation measure	Description
Centralisation of the proposal evaluation process	REA takes care of the logistics of the evaluation and the management of the evaluation experts (except for ERCEA and EASME) as well as the validation of legal entities for the whole of Horizon 2020;
Common Support Centre	DG RTD hosts the Common Support Centre (CSC) which provides support with legal matters, IT, external ex-post audits and dissemination activities to all entities involved in the management of Horizon 2020;
Centralisation of policy and budgetary related issues	Policy and budgetary issues are also centralised in various departments of DG RTD outside the CSC (coordination of overall policy activities, evaluation of the programme, financial programming, international cooperation, management of the guarantee fund, coordination with executive agencies).

Source: European Commission

Horizon 2020 is more efficient in terms of administrative expenditure when compared to FP7. The administrative expenditure is particularly low for the Executive agencies. Currently the administrative expenditure of Horizon 2020 is below the allowed 5%[114] in the legal base and estimated below EUR 1131 million (excluding EIT, JRC and Euratom) in the first three years of the programme implementation. This includes the administrative costs of all DGs including the Common Support Centre and Executive Agencies.[115] The administrative expenditure of Executive agencies is particularly low: 2.75 % for ERCEA, 2.6% for REA, 0.77% for INEA and 2.7 % for EASME. As noted, based on the existing evidence from external evaluations[116] and Cost-Benefit Analysis[117], this is mainly a result of lower staffing costs (agencies are mostly staffed by Contractual Agents) and lower overhead costs thanks to a high degree of specialisation in each agency and lower overall number of employees. To compare, FP7 had a level of administrative expenditure of 5% for the FP7 Ideas specific programme and 6% for FP7 Cooperation, Capacities and People specific programmes[118].

The oversubscription to Horizon 2020 during the first three years (see Section 7.4.1) increased the cost of the evaluation process. Based on the cross-analysis of these different administrative sources containing the number of evaluators, associated costs and number of proposals evaluated in FP7 and Horizon 2020 [119], it is estimated that on average, 76% more proposals are evaluated per year under Horizon 2020 when compared to FP7 (19,340 proposals under FP7 compared to 34,025 under Horizon 2020)[120]. Proposals under Horizon 2020 are on average evaluated by more evaluators compared to FP7[121]: the average number of evaluators per proposal was between 3 and 4 for most programme parts in FP7, while it ranged mainly between 4 and 5 in Horizon 2020. However, each evaluator spends less time per proposal if compared to FP7: on average 0.7 days under Horizon 2020 compared to 0.8 days under FP7. The average cost per evaluation per day has also decreased (from EUR 606

[114] 4.6% for the year 2020 only
[115] European Commission. The adopted legal base for the specific programme Horizon 2020 allows administrative expenditure of 5% of the overall Horizon 2020 budget for the period 2014-2020 (4.6% for the year 2020 only).
[116] Public Policy and Management Institute, Evaluation of the operation of REA (2012-2015), 2016 and Evaluation of the operation of ERCEA, 2016
[117] DG GROW 2013 Cost Benefit Analysis (CBA).
[118] Annual Activity Reports 2016, calculation by the Commission.
[119] CORDA, EMM2, FP7 Universe and Horizon 2020 Universe.
[120] CORDA, cut-off date by 1/1/2017
[121] CORDA and FP7 and Horizon 2020 Universe, cut-off date 1/1/2017. The difference remains high also if accounting for two stage proposals: 6 evaluators per proposal under Horizon 2020 against 4 evaluators under FP7.

under FP7 to EUR 568 under Horizon 2020). The observed decrease in costs comes from lower travel costs since most of the evaluations in Horizon 2020 are done remotely. It is estimated that the cost of proposal evaluation increased on average from some EUR 35 million per year under FP7 to some EUR 65 million under Horizon 2020. The increase in total costs is mainly due to the higher number of submitted eligible proposals to the programme.

In general, consulted stakeholders are content with the current support provided by the Commission services (including agencies). 73% (1,927) of consultation respondents state that the support provided by the Commission services during grant preparation and implementation is either "very good" or "good". The analysis of open responses to the stakeholder consultation also evidenced a few testimonials of good working relationships with the project officers. However, a majority of respondents who wrote something about this relationship underlined the delays they experienced in receiving answers to their request from the project officers and some ask for more personalised support from the Executive Agencies.

7.2.2. The impact of simplification and the new funding model

Simplification is a central aim of Horizon 2020, which should be fully reflected in its design, rules, financial management and implementation.[122]

Compared to FP7, Horizon 2020 was constructed from the outset around a simplification[123] **of its architecture, rules, procedures and control strategy including a simplified funding model.** A single set of rules applies to the whole R&I support provided, ranging from frontier research over technological development to close to market activities. In order to ensure coherence of this legal frame with all other EU funding programmes the rules have been aligned to the Financial Regulation applicable to all EU funding programmes.

Figure 28 Horizon 2020 simplification measures and comparison with FP7

Simplification measure	Horizon 2020	FP7
Single reimbursement rate	A single reimbursement rate in a given project, without differentiation between organisation categories or types of activities. The reimbursement rate is up to 100% of the eligible costs for Research and Innovation Actions and up to 70% for Innovation Actions (with one exception: non-profit organisations are reimbursed 100% also in Innovation Actions).	Reimbursement is determined by a matrix of organisation categories and activity types.
Single flat rate	A single flat rate for contributing to the indirect costs. This flat rate of 25% is applied to the direct costs[124]	Indirect costs (overheads) are calculated by four different methods (two flat rate models, depending on the organisation categories; real indirect costs and a simplified method of determining real indirect costs. The real indirect cost options were a considerable source of financial errors.

Source: European Commission

[122] See Recital 20 of the Horizon 2020 Regulation. The assessment of the new funding model introduced in Horizon 2020 is also required by its Rules for Participation (regulation (EU) No 1290/2013 of the European Parliament and of the Council)

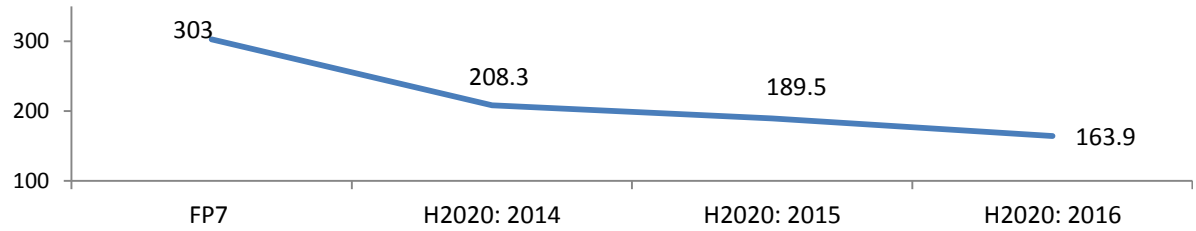
[123] The use of simplified forms of grants under the MSCA (unit costs), streamlined ex-ante checks, reduced requirements for work time recording, reduced audit burden, an acceleration of the granting processes and fully paperless proposal and grant management. For further details, please see Horizon 2020 Monitoring Report 2015.

[124] Except costs for subcontracting, costs of financial support to third parties and in-kind contributions not used on the beneficiary's premises

In parallel, the Commission streamlined, harmonised and accelerated procedures and processes linked to programme and project implementation. **The harmonisation of all processes and guidance documents across all implementing bodies provides for a uniform application and interpretation of the rules, improving quality and stringency of procedures.** For example, the electronic-only grant management system has embedded many automatic checks: it provides for enhanced transparency and systematic automatic document management and archiving – allowing for IT supported detection of risks and irregularities. Horizon 2020 also makes **further use of the 2-stage approach** in parts of the programme, with the aim of reducing the burden of proposal writing and evaluation for unsuccessful applicants. In the first stage, the applicants submit a short project description that is evaluated. Successful applicants are invited to submit a full proposal in the second stage.

The first three years of Horizon 2020 have shown a significant reduction of the time elapsing between the closure of a call and the signature of the Grant Agreement (i.e. Time to Grant), from an average of 303 days in FP7 to an average of 192.2 days, which is a decrease of 36.6% (more than 110 days). The average number of days is continuing to decline. A 21.3% reduction in time to grant (TTG, 44.4 days) is observed from 2014 to 2016. The total number of projects signed within the TTG limit is 91.6%. For the SME instrument, which benefits from a particular reduced TTG (6 months for Phase 2 and 3 months for Phase 1), the current TTG is slightly higher than expected, i.e. about 106 days for Phase 1, and 185 days for Phase 2. Improvements are still expected, and already noticeable - in particular for Phase 2 TTG coming down from 252 days. More than 80% of the stakeholder consultation respondents agreed that the time taken to evaluate the proposal and to sign a grant agreement are either "good" or "very good".

Figure 29 Time-to-grant in days



Source: CORDA, Signed Grants cut-off date by 1/1/2017 (excluding grants to named beneficiaries & ERC)

As regards the new funding model it is based on two main features: a single reimbursement rate and a single flat rate, which is represents a major simplification compared to FP7 (Figure 28). This new funding model puts the focus on the costs that are directly related to the project. It was expected to simplify the financial management of projects, by a reduced complexity of the financial rules; reduce the financial error rate detected in ex-post audits; increase legal certainty for beneficiaries; increase the attractiveness and ease of access to the programme, in particular for newcomers, smaller actors, SMEs and industry; and contribute to the acceleration of the granting processes. **The thematic assessments confirm that the expected benefits have largely materialised.**[125]

[125] See in particular the thematic assessments for MSCA, FET, ICT, LEIT-NMBP, LEIT-SPACE, SC1, SC2 and SC4.

Box: The impact of the funding model of Horizon 2020 against specific criteria

As noted in the legal base[126], the interim evaluation should assess the funding model of Horizon 2020 against specific criteria. The following provides a summary[127] of this assessment:

The participation of participants that have at their disposal high-end research infrastructures or have a history of using full-costing in the Seventh Framework Programme: Participation of research organisation and higher or secondary education institutions in Horizon 2020 is similar to FP7 and was not influenced by the funding model (22% versus 24% rate of participation for research organisations and 34% versus 37% for higher or secondary education institutions)[128].

The simplification for participants that have at their disposal high-end research infrastructures or have a history of using full-costing in the Seventh Framework Programme: The impact of simplification for those participants was assessed by the level of use of the "Large Research Infrastructure" (LRI) scheme. This scheme was designed to respond to the concerns of some large research organisations on the single flat rate for indirect costs. Until January 2017, 13 entities[129] lodged a request for an ex-ante assessment of the methodology for LRI[130] This confirms that the number of applicants for the LRI scheme remains modest.

The acceptance of the usual accounting practices of beneficiaries: Based on the qualitative analysis of the open questions received through stakeholder consultations as well as the position papers, stakeholders note more should be done to match the organisations' accounting practices.

Extent of use of the additional remuneration to personnel as referred to in Article 27 of Regulation (EU) No 1290/2013: The feedback received from Member States' representatives and stakeholders indicates that the implementation of the additional remuneration scheme is complex. Furthermore, they noted the scheme has a negative financial effect on those beneficiaries whose usual remuneration practices are based on very variable levels of remuneration. In some Member States the salaries of researchers in the public sector are strongly dependent on availability of external funding. Under those remuneration schemes, project-triggered remuneration may count, for example, for as much as two third thirds of the total salary of the employee. That leads to situations where the cap of EUR 8,000 results in the ineligibility of a substantial part of the personnel costs. For certain groups of beneficiaries, the provisions on additional remuneration imply that the eligible personnel costs for the same person for the same work are lower in a Horizon 2020 action than in a FP7 project.

The **new funding model** has mobilised and largely satisfied stakeholders. It can also be assumed to have contributed to the attractiveness of Horizon 2020 as reflected in application statistics. For around 90% of universities and more than half of research organisations which have used in FP7 the 60% flat rate method for indirect costs, the Horizon 2020 funding model has brought little change compared to FP7 in terms of funding rate[131] and has therefore not had any major impact on the participation pattern of research organisations and universities. Responding to the concerns of some large research organisations about the single flat rate for indirect costs, the Horizon 2020 Rules for Participation have provided for a specific "Large Research Infrastructure" scheme that, as intended, is now being used for a selected number of large research organisations with expensive research infrastructure doing research as their core business. For industry and other organisations using in FP7 the real indirect cost option, the Horizon 2020 funding model represents a major change. An estimation of the effective funding rates was made, based on the known real indirect costs of the most frequent FP7 industry participants (non-SMEs) using the real indirect cost option. This analysis results in an

[126] See Article 32 of the Horizon 2020 Regulation.
[127] A more detailed assessment is included in Annex 1.
[128] Based on CORDA, cut-off date by 1/1/2017
[129] Nine research organisations, three higher education establishments, and one enterprise
[130] Four entities (research organisations) have received a positive ex-ante assessment while two (research organisation) have been found not compliant. For five entities the work is ongoing.; two entities have voluntarily withdrawn their application.
[131] The funding rate is expressed as a percentage of the Commission's contribution to the total project costs.

estimated average real funding rate for (non-SME) industry in Horizon 2020 in the area of 58%, i.e. an increase of 4 percentage points compared to FP7 for this type of beneficiaries.

At programme level, the indirect costs in Horizon 2020 were estimated for all beneficiaries of RIA and IA projects on the basis of the ratio between real indirect and direct costs for participants in FP7 collaborative projects[132]. As a result, **the overall funding rate between FP7 and Horizon 2020 has not changed and remains 70% of total costs[133].**

Another feature of the Horizon 2020 funding model, the additional remuneration scheme has been perceived by Member State representatives and stakeholders as being difficult to implement and having a negative financial effect on those beneficiaries whose usual remuneration practices are based on very variable levels of remuneration. The above shows that the new funding model has overall had positive effects on stakeholder appreciation, time-to-grant and attractiveness. The effects on the simplification of financial management in the projects and on the error rate cannot yet be assessed, as very few financial reports were yet submitted and no ex-post audits were yet finished.

One area for improvement is the broader acceptance of beneficiaries' usual accounting practice. Stakeholders indicate that there are still too many instances where they have to collect data and information specifically for obligations in their Horizon 2020 grants, in parallel to their usual accounting system. This concerns in particular the obligations on staff time recording, the accounting for depreciation of equipment and for internally provided consumables and services, the handling of personnel costs outside closed financial years and some accounting detail for beneficiaries outside the Euro zone. The Commission has already reacted to these concerns and adapted the Horizon 2020 model grant agreements accordingly. Another area for improvement concerns the unintended effects of the additional remuneration scheme with the EUR 8000 capping. Opportunities for further simplification will also open with the revision of the EU Financial Regulation and the Commission initiative on Budget Focused on Results. The Commission proposal for the revision of the Financial Regulation provides for better conditions for the use of simplified forms of funding (unit costs, flat rates, lump sums).

Still, stakeholders find that the costs of participating in Horizon 2020 have decreased but insufficiently. Further simplification and more flexibility are regarded as needed. In the Simplification survey[134] 77.5% of responding project's participants noted that the single reimbursement rate in a project is 'very beneficial' or 'fairly beneficial' and 74.3% that the single flat rate for indirect costs is 'very beneficial' or ' fairly beneficial'. In the interim evaluation stakeholder consultation slightly more respondents think that the cost of participating in Horizon 2020 compared to FP7 has decreased with the simplification measures.[135] Still, out of the

[132] The methodology identifies a coefficient (funding intensity) for each type of organisations (distinguishing SMEs and large entities) calculated as the real indirect cost/direct cost (IC/DC) ratio for FP7 collaborative projects. The coefficient is then applied to the equivalent types of organisations in Horizon 2020 RIA and IA projects and multiplied to their direct cost.

[133] The new funding model simplified the funding rate for beneficiaries, but made the monitoring of the funding rates for the programme as a whole more complex. Differences in reimbursement of indirect costs under Horizon 2020 imply, that beneficiaries no longer report the real indirect project costs (i.e. under Horizon 2020 indirect costs are calculated automatically as a share of direct costs). As a result, the reported total project cost under Horizon 2020 programme is lower than the actual total project cost. To overcome the shortcomings of the collected project data, the Commission estimated actual indirect project cost under Horizon 2020 based on real indirect project costs reported in FP7.

[134] In 2015 the Commission launched an online survey on the perception of the simplification measures by stakeholders, addressed to all contacts in ongoing Horizon 2020 grants. The results cover the first 20 months of Horizon 2020 implementation and was published on 30 May 2016. In total 4185 responded.

[135] 20% (521) of the consultation respondents shared the view that the costs of participating in Horizon 2020 are lower than in the previous FP7, 14% (364) felt they are higher and 36% (950) felt they are similar. However a high percentage of respondents (30.7%) declared they could not respond to this question due to lack of knowledge of FP7.

835 respondents who did not participate in Horizon 2020 (31% of the total number of respondents), 106 explained that the main reason was that the Horizon 2020 project implementation rules were cumbersome. Furthermore, based on the analysis of responses to open questions, stakeholders acknowledge that progress has been made but many mention that further simplification is needed. The analysis shows that more could be done in terms of cost reimbursement and to match the organisations' accounting practices (65.4% (1,732) of the survey respondents felt that the acceptance of organisations' accounting practices in the programme was "good" or "very good" and 17.9% (475) viewed it as "poor" or "very poor").

Stakeholder position papers: Simplification is welcomed but further steps are needed.

In their position papers, some stakeholders representing different types of stakeholder groups commented on the simplification measures under Horizon 2020 and have a positive view. In particular, they see the participant portal and shorter time to grant as important improvements. However, they also noted that further simplification efforts are needed for instance related to preparation and submission of proposals, reimbursement rules, cost declarations and recognition of nationally accepted and audited accounting practices.

7.2.3. Financial instruments

The efficiency of the Financial instruments (FIs) can be assessed at an overall governance level involving DG RTD, the European Investment Fund (EIF) and the European Investment Bank (EIB); at a more operational level using financial intermediaries (in case of intermediated instruments) to implement the FIs; and at the level of the final beneficiaries.

The costs for DG RTD in using the EIB and EIF to manage the instruments includes setting up the contract ('Delegation Agreement') with these two entrusted entities; the allocation of funds, monitoring and reporting, and overall supervision. The costs of managing the financial instruments lies in the overheads, namely the costs of the personnel needed to process applications, monitor loans and investments, reporting to DG RTD/EIF and/or EIB and to manage the FI entities themselves (where new entities are created to specifically operate an FI, e.g. a new venture capital fund). The cost for the final beneficiaries relates to the price for the financing, typically in the form of interest and/or equity, and administration.

Overall, the assessment of the efficiency of managing the instruments is fairly positive.[136] Even if it might be difficult for financial intermediaries and other stakeholders to distinguish between the different financial instruments under the EIB Group, the fact that they are under the same organisation helps EIF guide financial intermediaries to identify and apply for the most appropriate instrument.

Results of a survey of intermediaries performed in the framework of the interim evaluation indicate that the costs of managing the instruments are generally in line with the expectations of the financial intermediaries and in line with other financial schemes they manage. The most positive assessment in terms of expectations versus actual costs relates to the level of human resources needed to implement the instrument concerned. However, there is some concern in relation to monitoring and reporting requirements. While there is an understanding among financial intermediaries that reporting is necessary, there is also a wish to simplify requirements and shift away from requirements that must be fulfilled manually. Some intermediaries also highlight that reporting and monitoring costs seem to be growing.

[136] Interim evaluation of financial instruments under Horizon 2020 (2017), see Annex 2

7.3. How efficient are the communication and application processes?

7.3.1. Communication and information activities

Horizon 2020 funded activities to attract programme participants. These were organised mainly by the executive agencies: EASME in 2015 had three 'infodays' attended by close to 2,000 participants, the agency is also using social media and participate in major events[137]. ERCEA is also active on social media, its website attracts more than half a million visitors yearly, and the Agency organises stands in 3 to 5 selected scientific conferences every year. REA oversaw the evaluation activities; in 2015 alone had more than 8,800 experts on site in Brussels, and handled 10,700 requests for information from the Horizon 2020 helpdesk. In the stakeholder consultation, 69.9% of the respondents rate the communication activities on Horizon 2020 to attract applicants as either 'very good' or 'good', whereas 22% find them 'poor' or 'very poor'.

Horizon 2020 encourages dissemination and exploitation of research results. Beneficiaries have an obligation to promote funded projects and their results, and communication forms part of the activities expected to generate project impact. To guide communication efforts, Horizon 2020 requires projects to develop and implement a communication plan, which goes beyond the project's own community to include "the media and the public".[138] Within the projects, a large number of communication activities are also undertaken to disseminate and communicate the projects' results of the knowledge generated. Validated periodic reports from the first 726 projects show that these have spent EUR 57.6 million on communication and dissemination covering many different types of activities including 308 brokerage events, 3,451 communication campaigns, 270 conferences, 1,626 workshops 2,385 press releases and 8,938 popularised publications.

Citizens are not an important target group of these activities, but rather a secondary or tertiary audience. Projects stating that they intend to target citizens typically mention websites, newsletters, publications, social media channels as means to reach the general public. However, it is only in cases where consumer engagement is a key for project success that proposals contain elements of a dedicated communication strategy for the public.

7.3.2. Application and evaluation process

In the first three years of Horizon 2020, 74,769 distinct higher or secondary education institutions, private companies, research organisations, public entities and others applied for Horizon 2020 funding. The expenses related to processes on writing, coordinating consortia and administrative questions vary greatly on the types of proposal, single beneficiary vs. collaborative projects, salary level of participants involved, administrative support needed etc. Studies have shown that depending on their age and position, researchers spend between 5 – 10% of their time applying for research funding.[139]

> *From FP7 to Horizon 2020, the bureaucracy has been much reduced and overall process has been positively streamlined. However, the effort of writing winning proposals has almost doubled since FP7 calls, creating and overall higher costs of participation to Horizon 2020.*
> Italy, Satner Reply SpA

[137] For example, the EU Sustainable Energy week, Green Week, SME – instrument Innovation Summit

[138]) As an illustration, the mapping of SC2 funded projects show that they target a broad range of stakeholders as potential users of their outputs but dissemination and communication efforts are largely targeting stakeholders which are expected to be "immediate users" of project results.

[139] E.g. see http://www.eui.eu/Documents/MWP/Publications/20111012MWP-ACOSurveyResearchFunding-Full.pdf

Three quarters (75%) of the respondents to the simplification survey with experience in FP7 and Horizon 2020, confirmed that, overall, the processes in Horizon 2020 are much simpler than in FP7. The survey results on the time spent on preparing proposals is presented in the box below.

The European University Association (EUA) states that these numbers are in line with costs reported by their members. EUA estimates the cost per proposal to range from EUR 10,000 to EUR 100,000 and applies these numbers to the overall numbers of proposals and retained proposals in the first year of Horizon 2020 to calculate the cost of unfunded projects, which is estimated between EUR 268 million and EUR 2.68 billion.[140]

Box: Time spent on proposal preparation

- 52.3% of coordinators in a multi-partner project say that they spent more than 30 days, 32% stated that they spent between 15-30 days preparing a proposal.
- 14.3% of partners in multi-partner projects declare spending more than 30 days, 52.6% that they spend between 15 and 30 days.
- 19.3% of participants to single beneficiary projects (non-SMEs) state they spend more than 30 days, and 60.4% between 15 and 30 days.
- 59.8% of SMEs in mono-partnered projects state that they spent more than 16 days and 27.7% say that they spend less than 15 person days.

Source: European Commission Simplification Survey[141]

Based on the approach from the EUA **it is estimated that it costs Horizon 2020 applicants EUR 1908.9 million or EUR 636 million annually to write proposals**[142]**. Out of these costs it is estimated that EUR 1.7 billion would be spent on writing proposals that do not get funded including EUR 643.0 million for non-funded high quality proposals alone**.

Figure 30 Estimation of cost of proposal writing

	Eligible proposals (excluding resubmission)	Cost of writing proposals (EUR million)
High expense level: EUR 50 000[143]	22267	1113.4
Medium expense level: EUR 20 000[144]	24572	491.4
Low expense level: EUR 10 000[145]	18774	187.7
Very low expense level: EUR 5000[146]	23292	118.9
Total	**88905**[147]	**1908.9**

Source: CORDA per 1/1/2017, excluding resubmissions, estimation by Commission Services.

[140] EUA Member consultation - A contribution to the Horizon 2020 mid-term review, http://www.eua.be/Libraries/publications-homepage-list/eua-membership-consultation-2016-a-contribution-to-the-horizon-2020-mid-term-review.pdf?sfvrsn=4 The EUA states that "the real costs for the development of proposals cannot be easily calculated and may also vary from one system to another". Among the factors that come into play: the seniority of the researchers involved, salary levels in the country, the extent to which proposal drafting requires the drafting of original text, the information required by the proposal template.

[141] Available at: http://ec.europa.eu/research/participants/data/ref/h2020/other/events/survey/h2020_simplification-survey_final-report_en.pdf

[142] See detailed methodology in Annex 1.

[143] Instruments included: RIA and IA, COFUND-EJP/PCP/PPI/ERA-NET

[144] Instruments included: CSA, ERC ADG/COG/LVG/ POC/STG, MSCA Cofund/ITN/RISE

[145] Instruments included: MSCA-IF and SME-2

[146] Instruments included : SME-1 and Stage 1 applications in two stage applications

[147] Including Stage 1 proposals

There is room for improvement in the current evaluation process. The thematic assessments of FET, LEIT-ICT, the SME Instrument and SC4 highlight **dissatisfaction with application procedures, proposal evaluation and selection and reporting procedures**. In addition they note that **the quality of feedback provided to applicants is an area for improvement.** This is also reflected in the stakeholder consultation results, where 62,2% (1647 of 2648) respondents that had participated in Horizon 2020 of the respondents assess the quality of the feedback from the evaluations as "good" or "very good", while 34% (905) judged it as "poor" or "very poor" (which was the highest score reached by the "poor" and "very poor" categories compared to the other items related to the implementation aspects of Horizon 2020 which were submitted to the opinion of respondents). The numbers show that NGO's are least positive (55.6% very good or good), followed by Academia (59.2% good or very good).

In the open questions of the stakeholder consultation, some respondents ask for more transparency and an improved quality of the evaluation feedback they receive. Respondents complain that not enough details are provided, that the quality of the feedback varies greatly from one evaluation panel to the other, and that discordant views can be provided to the participant. The selection of experts for proposal reviews is also questioned - respondents stress that expertise in the field is not always available. Some mention evaluations should not only be done remotely. Reviewed position papers also echoed such concerns (see box below).

Stakeholder position papers: some aspects of the current evaluation process of Horizon 2020 proposals should improve.

In their position papers some stakeholders from academia, research organisations as well as public authorities and business commented on the evaluation process and noted that the quality of the current process should improve. A variety of issues was highlighted, in particular: the Evaluation Summary Reports are reportedly too short and provide generic and not tailored feedback. A few stakeholders noted the reports were not accurate; evaluation committees should have a balanced representation of stakeholders including industry, business participants and SHH experts. Few business representatives further noted the selection rules of expert panels, especially around conflicts of interest seem to put off industry experts as evaluators; evaluators should have the necessary expertise and training and consensus meetings should be reintroduced.

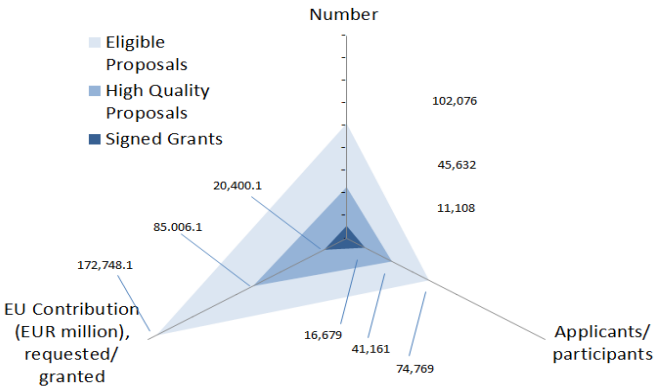
7.4. How efficient is the distribution of funding?

7.4.1. Success rates and oversubscription

The strong increase in interest in Horizon 2020 means that demand vastly outstrips supply, leading to oversubscription. An additional EUR 62.4 billion would have been needed to fund all the proposals evaluated as high quality. The average success rate of Horizon 2020 dropped to 11.6 % compared to FP7, which had an overall success rate of proposals of 18.4%. While the popularity and high demand for parts of the programme show that they are offering support in the right areas, and that only the very best proposals offering scientific excellence are indeed being selected, too much oversubscription could cause disillusionment and dissatisfaction and leave good proposals unfunded and to be resubmitted. As of January 2017 Horizon 2020 attracted 102,076 eligible proposals (requesting funding of EUR 172.8 billion), 45,632 of these were assessed of high quality (44.7% of total eligible proposals); 11,108 grants were signed.[148] [149]

[148] Success rate measured in terms of EU financial contribution was 12.7% and in terms of applications 14.1%.
[149] Detailed implementation data covering the first three years of Horizon 2020 can be found in Annex – Part 2.

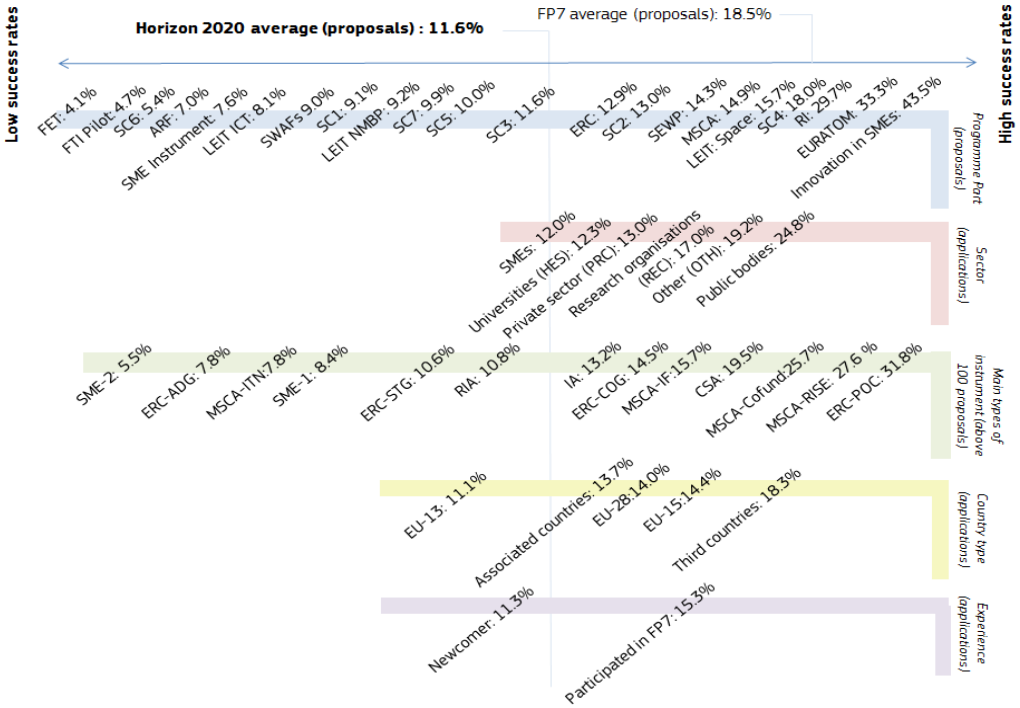
Figure 31 Overall proposal and grant data



Source: CORDA, cut-off date by 1/1/2017

However, **oversubscription is unequally distributed throughout the programme parts in Horizon 2020 and varies across countries, sectors, instruments and levels of experience**. The success rates per programme part, types of instrument, country type and level of experience (newcomer to Horizon 2020 compared to FP7) are presented in the Figure below. Applicants with previous FP7 experience, from third countries, public bodies, applicants to the ERC Proof of Concept and MSCA-RISE have the highest success rates. The lowest rates are found in FET, the SME-Instrument and SC6, whereas the highest are found in Research Infrastructures, Innovation in SMEs and SC4[150].

Figure 32 Success rates (programme part, sector, type of instrument, country type and level of experience)

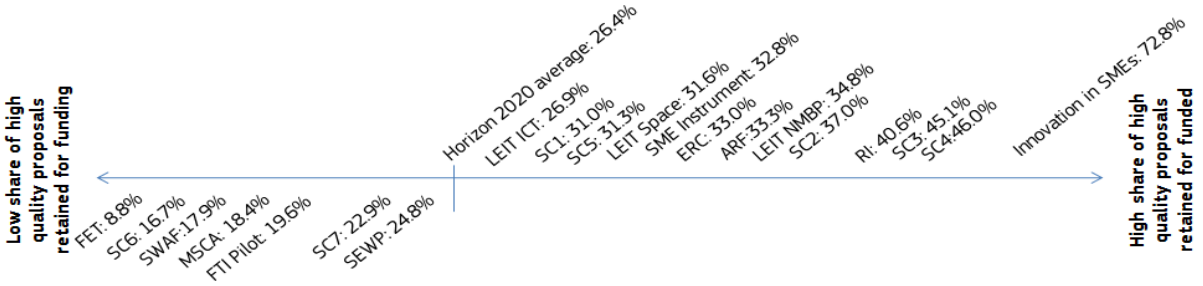


Source: CORDA, Signed Grants cut-off date by 1/1/2017 (excluding grants to named beneficiaries)

[150] The calculation of success rates is based on full proposals, i.e one proposal is counted only as second stage of a 2-stage proposals, not including the proposals which are excluded in stage 1. This means that some parts of Horizon 2020 success rate actually report higher success rates, than would have been the case including stage 1. An example of this is SC4, which has a comparably high success rate, due to the exclusion of proposals in stage 1, as reported in Figure 34.

Figure 33 shows that the share of high quality proposals receiving funding represents up to 72.8% in Innovation in SMEs and less than 20% under SC6, SWAFS, MSCA and FTI Pilot. **This indicates an underfunding of substantial parts of the programme where the current budget supports less than 1 out of 5 high quality proposals.** FET has the lowest rate of high quality proposals funded, where less than 1 out of 10 is retained for funding. According to the FET assessment, whereas stakeholders have repeatedly called for the budget to be increased to match the clear demand and address this issue, the "backloaded" FET budget profile in the last years will also help to alleviate this.

Figure 33 Share of high quality proposals funded



Source: CORDA, Signed Grants cut-off date by 1/1/2017 (excluding grants to named beneficiaries)

In some of parts of Horizon 2020 2-stage calls were used to cope with oversubscription. In the first stage the applicants submit a short project description that is evaluated. Successful applicants are then invited to submit a full proposal in stage 2[151]. In total in Horizon 2020 by 1 January 2017, 10,001 proposals were submitted in this staged approach, which equals a share of 9.8% of the total number of full proposals submitted. Of these 3,144 were invited to submit a full proposal.[152] Of the submitted full proposals 19.6% were main listed for funding, which is 8 percentage points higher than the average proposal success rate in Horizon 2020.

New rules were introduced in the 2016-2017 Work Programme for 2-stage proposals that regulated the number of proposals that passed to the second stage as a function of available budget: according to this rule, stage 2 proposals accounted for three times the available budget, or as close as possible. The share of proposals being invited to submit full proposals therefore depends on the number of proposal submitted at first stage, their quality, and the budget they request. For 2-stage calls closed in 2016, as effect of the new rule , out of 1,112 proposals submitted in the first stage, 416 submitted a full proposal in the second stage and 162 were finally retained: the success rate of second stage is 38.9%, almost doubling the success rate of all 2-stage calls (19.6%). The introduction of this new rule has so far proved to be effective.

Following a pilot in FP7 (XTrack), FET-Open (which previously used a 2-stage call) now applies a single-stage call with very short proposals (up to 7 pages). A survey among applicants and evaluators shows general satisfaction with this approach.

Oversubscription and the low success rate are among the most commonly quoted issues of the programme raised during the stakeholder consultation, leading to calls for the budget for those

[151] Unlike other parts of the Framework Programme the ERC has a single-submission, two-step evaluation process. Also since the 2015 calls (based on the results of the 2014 calls) applicants can be restricted from submitting proposals to future ERC calls for up to two years based on the score given to their proposals. These restrictions are designed to allow unsuccessful PIs the time necessary to develop a stronger proposal.

[152] Including 166 proposals that were invited, but for different reasons decided not to submit.

areas to be increased: a majority of respondents (89% or 3,099) "strongly agreed" or "agreed" that an increased budget is needed for financing R&I at EU level.

Stakeholder position papers: Oversubscription is one of the most commonly quoted issues of Horizon 2020.

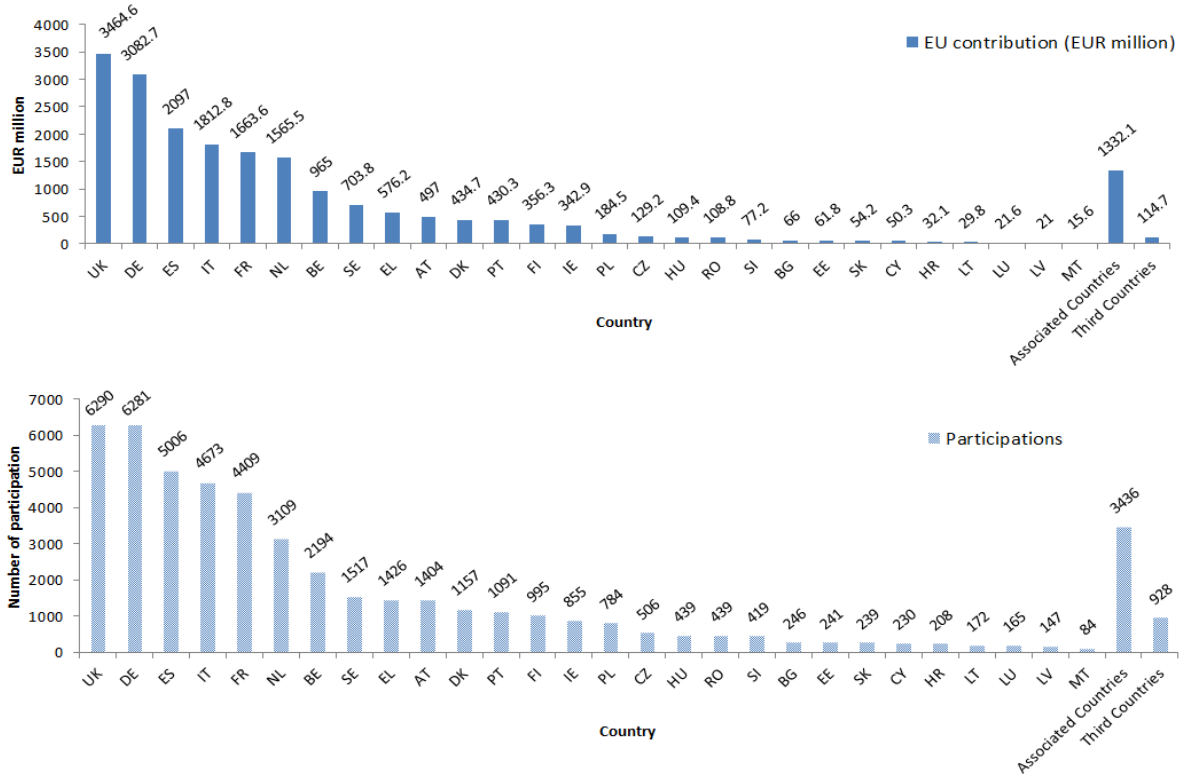
In their position papers, the majority of stakeholders touch upon the issue of oversubscription in Horizon 2020. In general they elaborate that oversubscription discourages participation, reduces the quality of evaluations, '*wastes*' too many resources and leaves a number of high quality proposals unfunded.

Stakeholders also proposed a variety of solutions on how to reduce oversubscription rate: increase budget especially for the bottom-up calls to better meet the demand; reduce scope of the narrower calls and improve and expand the 2-stage proposal procedure with the success rates at the second stage reaching 30% to 50%. Increase the time between the first and the second step so that proposers receive negative feedback before preparing their submission to the second step. Make step one lighter. A few noted that the current introduction of 2-stage proposal procedure to manage oversubscription in certain calls is welcomed, but the process is not selective enough in the first stage.

7.4.2. Distribution of funding per type of organisation and country

Participants from 131 different countries benefited from Horizon 2020 in the first three years. EU-28 countries receive 92.9% of the funding (91.1% of participations). Associated countries account for 6.5% (7.0% of participations), with Israel and Norway being the most active, whereas third countries had 0.6% of the funding (1.9% of participations). In total, 87 third countries participate in Horizon 2020, with USA and South Africa being the most active. The share of funding allocated to the EU-13 is 4.4% and 88.5% to EU-15 countries. Germany and the UK receive the largest shares of funding and participations. Participants from the UK coordinate almost 1 out of 5 projects.

Figure 34 Summary graphs (EU contribution and participation per country)



Source: Corda, cut-off date by 1/1/2017

The funding disbursed under Horizon 2020 is so far concentrated. **Participants from five countries received 59.4% of the overall funding**, with participants from Germany receiving 17% of the overall funding, whereas participants from Bulgaria, Latvia, Lithuania and Malta receive 0.1% each. The five countries with the highest share of participants also represent 64.5% of the investment in R&I (GERD) in Europe. **There are big differences** (18.4 percentage points) **between the countries in terms of shares of SME participation -** with Hungary, Estonia and Cyprus having the largest share of around 30% of SME participation and Sweden, Romania and Croatia all below 20%. In total EU-13 have a lower success rate of 11.1% compared to EU-15, which register 14.4%. Third countries have in total the highest success rate of 18.3%. In total 133 countries participated in Horizon 2020. Detailed performance of countries is provided in Annex 1.

We observe strong "old boys clubs" cooperation patterns, poorer visibility of EU-13 excellence but also week involvement of EU-13 in testing new technologies resulted from Horizon 2020 projects. Therefore efforts to support wider participation need to be significantly strengthened in all parts of Horizon 2020 and the next FP. Such approach would not only support less participating regions, but also clearly demonstrate European added value.

Poland, National Contact Point

Participants from EU-13 Member States represent 8.5% of the participations in Horizon 2020 and receive 4.4% of the overall funding, which is slightly more than under FP7 (respectively 7.9% and 4.2%). Overall the EC contribution to participants from EU-13 countries increased from approximately EUR 270 million per year in FP7 to EUR 300 million per year under Horizon 2020. Some EU-13 countries are in spite of overall lower Horizon 2020 contribution outperforming the EU-15 average. E.g. Slovenia, Cyprus and Estonia outperform the EU-15 averages, taking into account the size of the population, the number of researchers and national investments in R&D. Furthermore taking national investments in R&D into account, EU-13 Member States on average outperform EU-15 Member States by 6.7%. The variations in Horizon 2020 funding to a large extent can thus be explained by differences in national investments in R&I. Overall applications from EU-15 Member States (14.4%) have a higher success rate than applications from EU-13 (11.6%).

Figure 35 Key data on participation per country group

		Horizon 2020			
	FP7, EU-13	EU-13	EU-15	EU28	Overall
Share of EC contribution	4.2%	4.4%	88.5%	92.9%	100%
Average EC Contribution per year (EUR million)	272	302	6,015	6,318	6,800
Annual EC contribution per inhabitant (in EUR)	*3*	3	15	12	n.a
Annual EC Contribution per researcher FTE (in EUR)	*1,321*	1,271	3,808	3,475	n.a
EC Contribution per EUR million spent on R&D (public and private, GERD)	N/A	67,524	63,277	63,429	n.a
Share of participations	7.9%	8.5%	82.6%	91.1%	100%
Share of SME participation	9.3%	21.8%	21.2%	21.3%	20.7%
Share of newcomers participations	N/A	31.2%	19.7%	20.8%	21.1%
Share of private sector participation	28.7%	31.1%	34.2%	33.9%	33.2%
Share of unique participants	10.9%	11.7%	76.9%	88.6%	100%
Success rate of applications	18.0%	11.1%	14.4%	14.0%	14.1%
Share of Projects Coordinator s in Signed Grants	9.7%	5.1%	87.6%	92.7%	100%

Source: European Commission, cut-off data 1 January 2017, and HLEG report on FP7 ex-post evaluation

Noticeably, EU-13 countries record a higher share of SME participation that under FP7 (from 18.2% to 21.8%) which is above the performance of EU-15 countries. The private sector participation also increased compared to FP7 (from 28.7% to 31.1%). **There are however big**

differences between countries as regards the shares of SME participation - with Hungary, Estonia and Cyprus having the largest share of around 30% of SME participation and Sweden, Romania and Croatia all below 20%.

As the size of these Member States vary greatly comparing on absolute numbers can be misleading. Normalising per inhabitant, per researcher and per million invested in R&D nationally nuances the picture:

- **Per inhabitant EU-15 receive EUR 44 compared to EUR 9 for the EU-13**. This however does not take into account the differences in the size of the R&I sector in the relevant Member States.
- Including the number of researcher FTE **EU-15 receives EUR 11,423 and EU-13 receives EUR 3,812.** Differences in salaries and reimbursement rates can partly explain this difference.
- Per EUR million invested from the private and public sector in R&I, the EU-13 receives **EUR 67,524 from Horizon 2020 compared to EU-15, which receives EUR 63,277. This is 6.7% higher for EU-13.**

Some of the main causes of low participation by certain Member States in past EU Framework Programmes were: insufficient R&D investments in those countries; lack of synergies between certain Member States' national research systems and EU research; lagging system learning effects and access to existing networks; differential wage levels between countries; insufficient and ineffective information, communication advice and training.[153]

Figure 36 Horizon 2020 contribution normalised by inhabitant, researcher and R&I investment nationally

Country	H2020 contribution (EUR million)	Horizon 2020 contribution: Per inhabitant	Per researcher FTE	Per EUR million spend on R&D
Austria	576	66	13,609	55,170
Belgium	965	85	17,518	95,806
Bulgaria	30	4	2,095	68,791
Croatia	32	8	5,042	85,644
Cyprus	62	73	71,860	768,657
Czech Republic	129	12	3,393	39,751
Denmark	497	87	11,887	61,706
Estonia	66	50	15,767	217,990
Finland	430	78	11,470	70,879
France	2,097	31	7,812	43,110
Germany	3,464	42	9,690	39,735
Greece	435	40	12,396	258,158
Hungary	109	11	4,298	72,008
Ireland	356	75	16,610	121,962
Italy	1,664	27	13,786	75,991
Latvia	22	11	5,978	141,825
Lithuania	21	7	2,585	54,264
Luxembourg	54	94	18,892	80,767
Malta	16	36	19,094	230,759
Netherlands	1,566	92	20,337	114,857
Poland	185	5	1,908	42,743
Portugal	343	33	8,663	149,794
Romania	77	4	4,422	98,703
Slovakia	50	9	3,492	54,245
Slovenia	109	53	13,848	128,243
Spain	1,813	39	14,806	137,627
Sweden	704	71	10,249	48,267
United Kingdom	3,083	47	10,654	70,251
EU-28	**18,953**	**37**	**10,426**	**63,429**
EU-13	**907**	**9**	**3,812**	**67,524**
EU-15	**18,046**	**44**	**11,423**	**63,277**

Source : European Commission

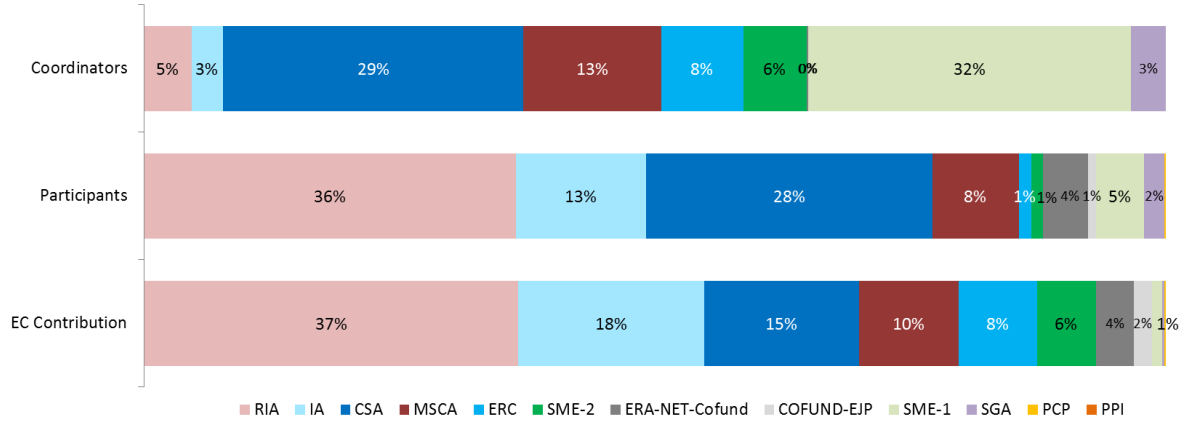
Widening participation is recognised and addressed as a cross-cutting issue in Horizon 2020. The different actions undertaken to widen participation across Horizon 2020 have successfully managed to raise awareness and bring EU-13 stakeholders closer to Horizon 2020, through networking, information sharing and exchange of best practices. **Some programme parts**

[153] Commission analysis of September 2011, at the request of the Polish Presidency, see http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2014728%202011%20INIT This has been confirmed by other studies, analysis and public discussions, for instance the FP7 MIRRIS project.

register however a better EU-13 participation than others, and better than in FP7, but still quite low. The picture is therefore diversified and a causality link between measures in place and participation/success rates cannot be defined. **Participants from EU-13 Member States represent 8.5% of the participations in Horizon 2020 and receive 4.4% of the overall funding, which is slightly more than under FP7 (4.2%).** Some EU-13 countries are in spite of overall lower Horizon 2020 contribution outperforming the EU-15 average. E.g. Slovenia, Cyprus and Estonia outperform the EU-15 averages, taking into account the size of the population, the number of researchers and national investments in R&D. Furthermore taking national investments in R&D into account, EU-13 Member States on average outperform EU-15 Member States with 6.7%. This implies that the variations in Horizon 2020 funding to a large extent can be explained by differences in national investments in R&I.

Most of the EC contribution received by participants from EU-13 countries come under Innovation Actions (37%) and Research and Innovation Actions (18%), followed by Coordination and Support Actions (15%), Marie-Sklowdowska Curie Actions (10%) and ERC (8%).

Figure 37 Distribution of EU-13 coordinators, participants and EC contribution per type of action



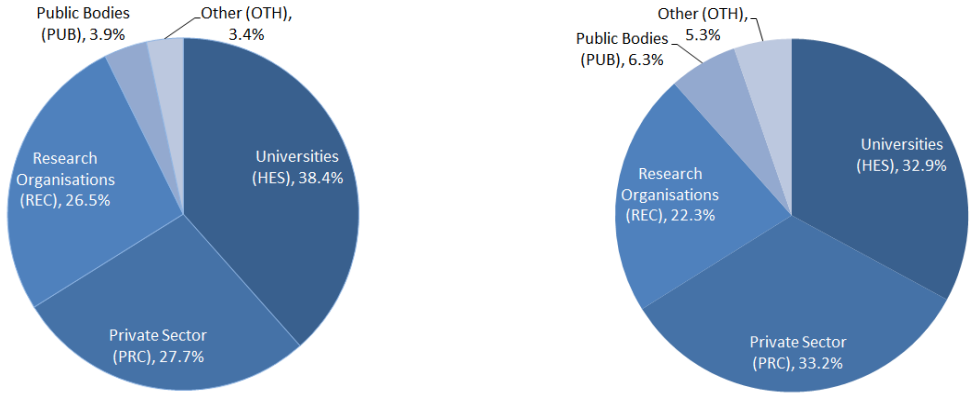
Source: EC DG RTD analysis based on CORDA, cut-off date 1/1/2017

By 1 January 2017, higher or secondary education institutions (HES) and research organisations combined attract 64.9% of the funding, private sector 27.7%, and public authorities and others 7.3%. Each HES participates on average 11.4 times and receive EUR 5.5 million, each company participates 1.6 times on average and receive EUR 0.5 million.

SMEs attract 16% of Horizon 2020 funding and represent 20.7% of the participations. **Under the LEIT and Societal Challenges pillars, the SMEs receive 23.9% of the funding and had 26.9% of the participation – exceeding by far the 20% target of funding in LEIT and Societal Challenges allocated to SMEs.**[154] The share of EC funding allocated through the SME instrument between 2014 and 2016 is 5.6 % of the total budgets of the specific objectives LEIT and the priority Societal Challenges and it represents EUR 881.7 million.[155] This share is increasing from 5% in 2014 and 5.1% in 2015 to 5.6% in 2016: the favourable trend is in line with the minimum target of 7%.[156]

[154] More information available at: https://ec.europa.eu/programmes/horizon2020/en/area/smes
[155] For the calculation of the share of EC funding allocated through the SME instrument, data are not based on Corda but on the budget earmarked to the SME instrument in the Work Programmes.
[156] Regulation (EU) No 1291/2013 establishing Horizon 2020, Annex II.

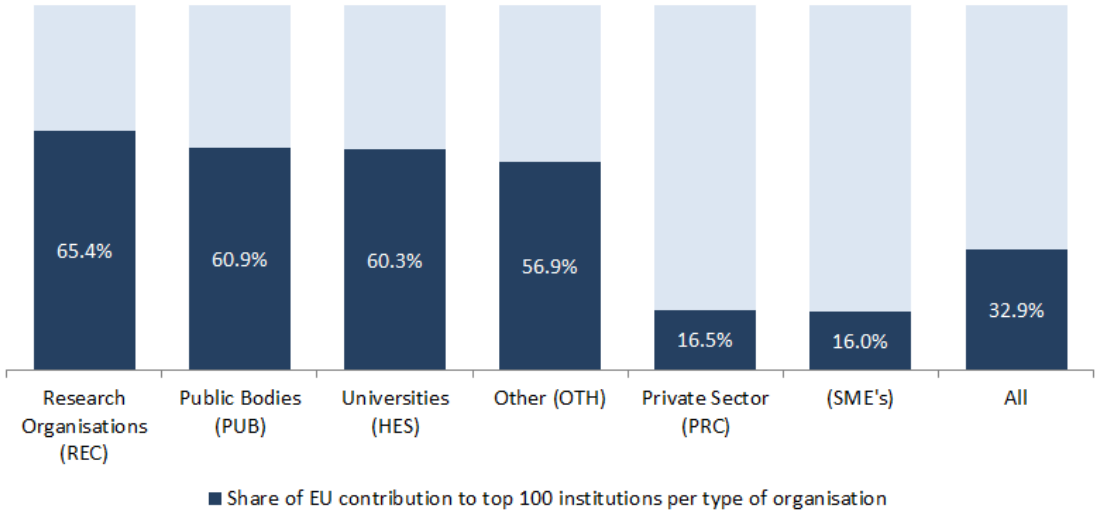
Figure 38 Share of participations and EU contribution per type of organisation (EU contribution left, participation right)



Source: Corda, calls until end 2016, Signed Grants cut-off date by 1/1/2017

Overall, in Horizon 2020, the 100 institutions receiving most funding received 32.9% of the total budget. Amongst research organisations and higher or secondary education institutions, this concentration of funding is particularly strong. The 100 research organisations receiving the most funding, got two-thirds (66.2%) of the funding, while higher or secondary education institutions in the top 100 received 60.5%. The centralisation is less pronounced for the 10367 private companies that participated in Horizon 2020, where the top 100 received 17.7% of the funding. This share was even lower for SMEs, where 16.2% was allocated to the top 100. **In FP7 the 100 organisations receiving the most funding, received 34.6% of the funding, which is 1.7 percentage points higher than in Horizon 2020**. The top 100 private sector companies received 16.5% in Horizon 2020, compared to 18.9% in FP7.

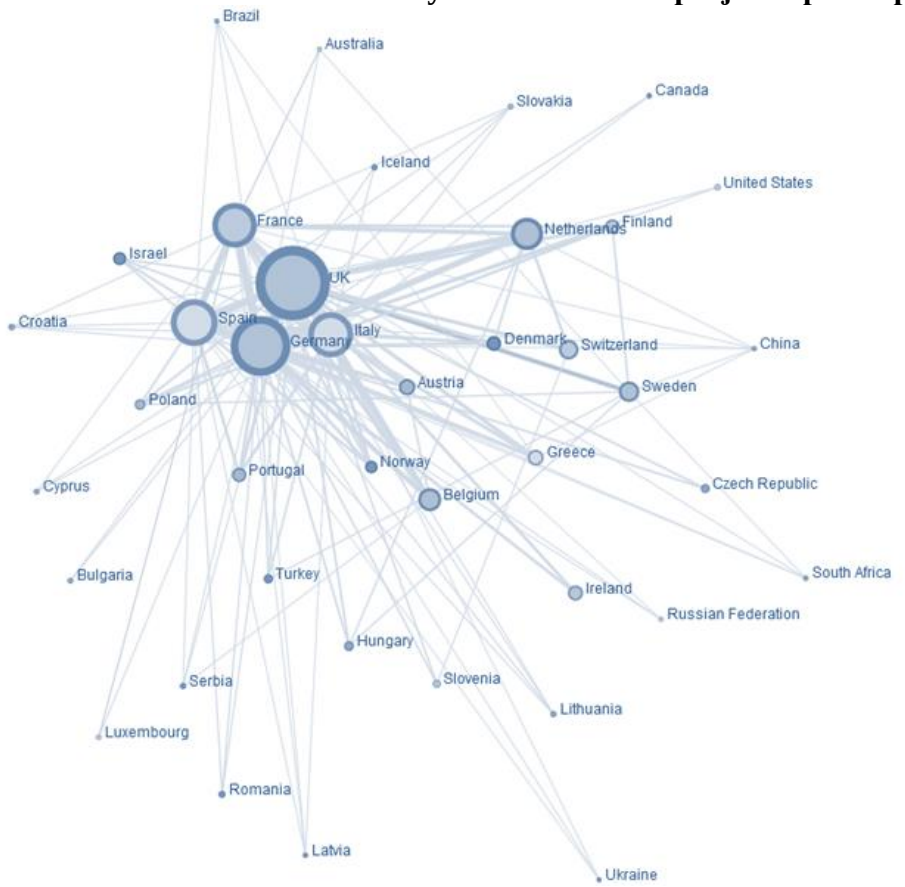
Figure 39 Share of funding going to the top 100 most receiving organisations, per type of organisation



Source: Corda, Signed Grants cut-off date by 1/1/2017

Figure 40 provides an overview of Horizon 2020 cooperation networks between countries based on the number of collaborative projects they participate in. The picture shows a concentration around larger and older Member States such as the UK, Germany, Spain, Italy and France, with Third Countries and newer Member States in the periphery of the network. The figure includes countries with over 20 projects and over 20 collaborations.

Figure 40 Horizon 2020 network at country level – based on projects' participations



Source: European Commission, based on JRC Technology & Innovation Monitoring (Cut-off date: 01/01/2017)

7.4.3. Distribution of funds per project size

Horizon 2020 is expected to provide an appropriate balance between small and large projects.[157] The RIA and IA actions involve on average 11.6 partners which is only a 3% decrease if compared to FP7 collaborative projects (12.0).

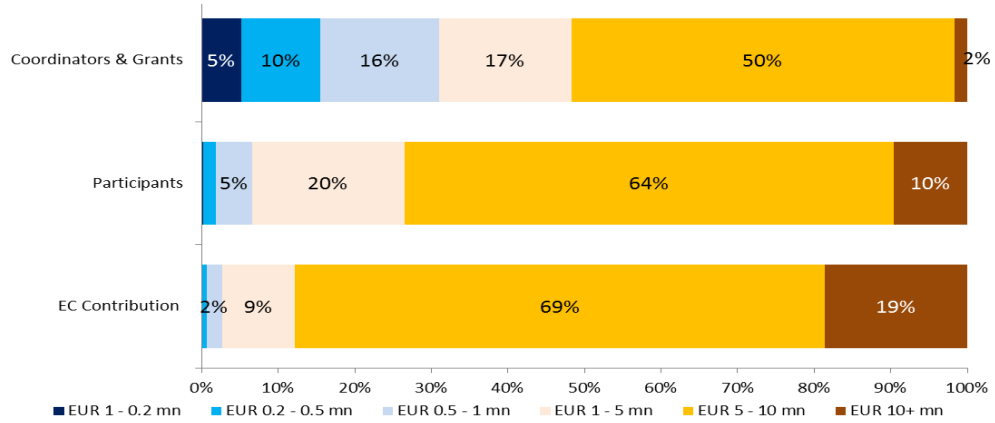
Based on a methodology developed by the Commission services combining budget and participation data[158], **the overall balance between large and small projects under Horizon 2020 remains similar to FP7.** Under FP7, 36.7% of collaborative projects were regarded as large and 63.3% as small, with 23.8% of the funding going to large projects and 76.2% to small projects. This ratio has been maintained in Horizon 2020, when looking at Innovation Actions and Research and Innovation Actions only (IA and RIA): 36.4% of the Horizon 2020 projects are regarded as large by having more than 3 participants per EUR million and 63.6% are small. In terms of funding and based on this approach 24.8% of the Horizon 2020 funding (IA and RIA) goes to large projects and 75.2% to small projects.

In terms of participation, large projects seem to attract a higher share of newcomers and EU-13 participants into the programme if compared to smaller projects.

[157] See Recital 23 of Horizon 2020 Regulation and Recital 13 of Council conclusions of May 2016. It should be noted that the notion of "large" and "small" project and the "appropriate balance" has not been defined in the Regulation.
[158] See Analysis 2, Annexes Part 2/3 Section 7 for more information.

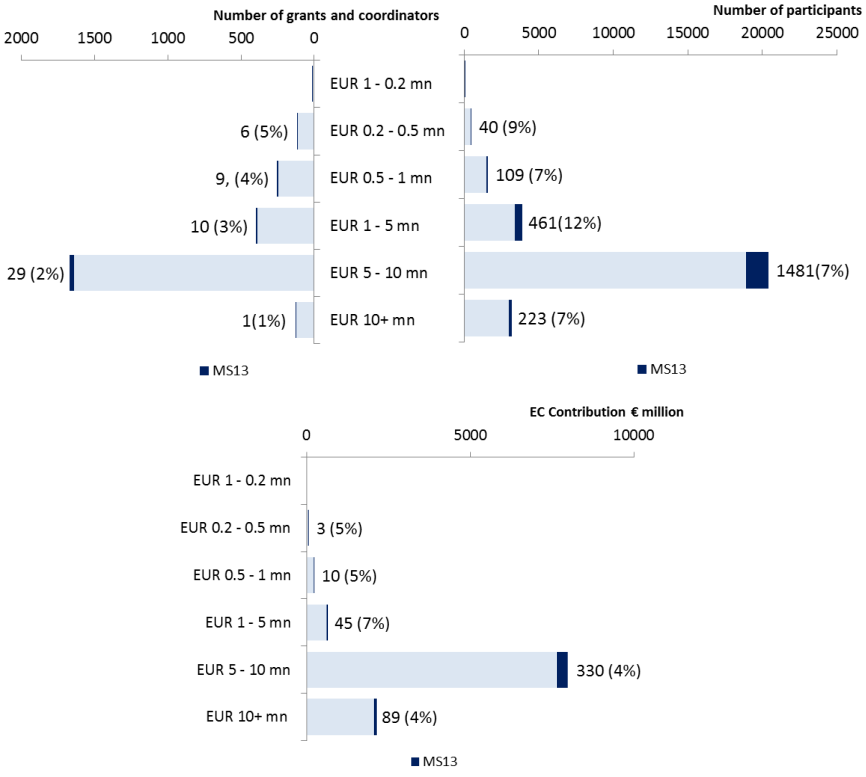
A majority of the EC contribution is currently allocated to projects above EUR 5 million (92%). A closer look at EU-13 participation patterns by budget categories shows that most EU-13 participants are within projects with budgets higher than EUR 5 million and 88% of the EC contribution by EU-13 received is currently from such large projects (Figure 41).EU-13 seem to coordinate and lead more if projects are smaller (but the current sample size is too low to draw conclusions). At the same time, EU-13 seem to participate best in the EUR 1 – 5 million bracket[159]. A full discussion on project size is available in Annex 1.

Figure 41 Share of total EU-13 coordinators, grants, participants and EC Contribution by project size



Source: EC DG RTD analysis based on CORDA, cut-off date 1/1/2017

Figure 42 Project size (budget) and participation of EU-13 (%)



Source: European Commission, DG RTD analysis based on CORDA, cut-off date 1/1/2017

[159] The share of EU-13 participants is significantly higher than in other brackets. There is no statistically significant differences between the share of participations in small projects under EUR 1 million or big projects above EUR 5 million.

In their open comments to the stakeholder consultation respondents asked for more opportunities for small projects (although some respondents are in favour of more support for large-scale demonstrators), more prescriptive calls (in order to avoid the current high number of applicants); and more funding opportunities for SMEs.

Stakeholder position papers: There needs to be a balance between small, medium and large projects.

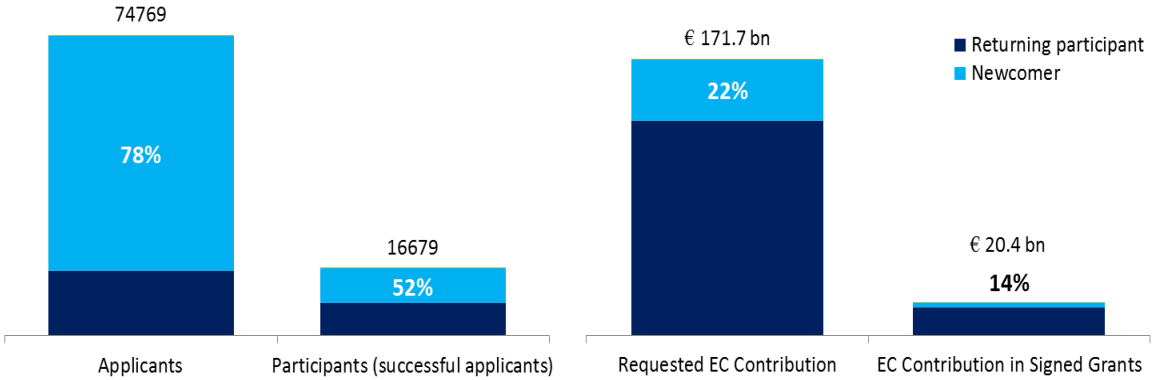
In their position papers, some stakeholders commented on the project size in Horizon 2020. The majority of those commenting noted a better balance between small, medium and large projects should be achieved within the programme. However, stakeholders do not seem to agree on how such balance should look like. For instance, it was noted that the effectiveness of very large consortia in some projects should be reviewed. At the same time few stakeholders noted larger projects are more efficient. Few others stated smaller projects allow for higher participation of SMEs and newcomers into the programme and can be as effective as large projects.

7.4.4. Participation of newcomers

The ability to attract newcomers (not participating to FP7) is essential to the openness of Horizon 2020. 78% of all organisations that applied to Horizon 2020 funding in the first three years of programme implementation where newcomers. But their success rate is considerably lower when compared to returning participants (9.2% compared to 13.95%). In addition, on average each returning participant applied for the funding 17 times which increased their probability of success (newcomers on average applied only twice).

As a result, newcomers represent 52% of all organisations participating in Horizon 2020 (and almost half of them are SMEs), but they received only 14% of the total budget implemented in the first three years of the programme. The majority of newcomers participate in the IA and RIA actions (54%) followed by the SME Instrument (33%). The main underlying reason is that these instruments account for a large part of the total funding. A more in-depth analysis of newcomers (including gateways used for joining the Programme) is available in Annex 1. In FP7 70% of all organizations participating were newcomers at the programme end[160]. Horizon 2020 needs to continue attracting newcomers to reach a comparative share of newcomers at the programme end.

Figure 43 The number of (newcomers) applicants and participants (left) and the total requested and obtained EC contribution in signed grants (right)

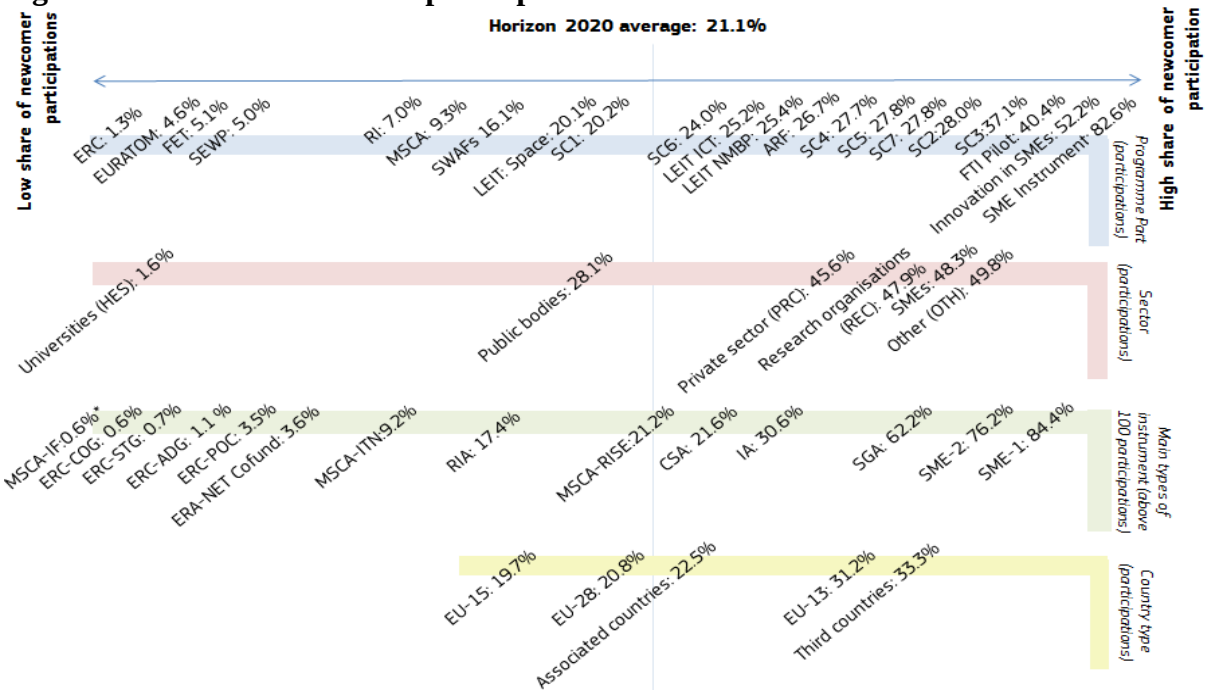


Note: The percentages refer to newcomers. The figures above the bar refer to total numbers for the programme as a whole. Source: CORDA cut-off date 1.1.2017

[160] Several studies (incl the ex-post evaluation of FP7) have shown the share of newcomers to be above 70%, however this information was not obtained in a structured way during the FP7 programme.

There are vast differences between programme parts, country groups, sectors and types of instrument in attracting and selecting newcomers. **In spite of the bulk of the newcomers having origin in EU-15, newcomers represent a larger share of EU-13 participations compared to EU-15 (31.2% against 19.7%), and the share of EU-13 countries in participations from newcomers is larger than in participations from returning participants (11% against 3%), suggesting that the Framework Programme is opening up the "clubs".** Regarding the instruments, the SME Instrument and Innovation Actions have above average shares of participations from newcomers compared to other funding instruments.

Figure 44 Share of newcomers participations

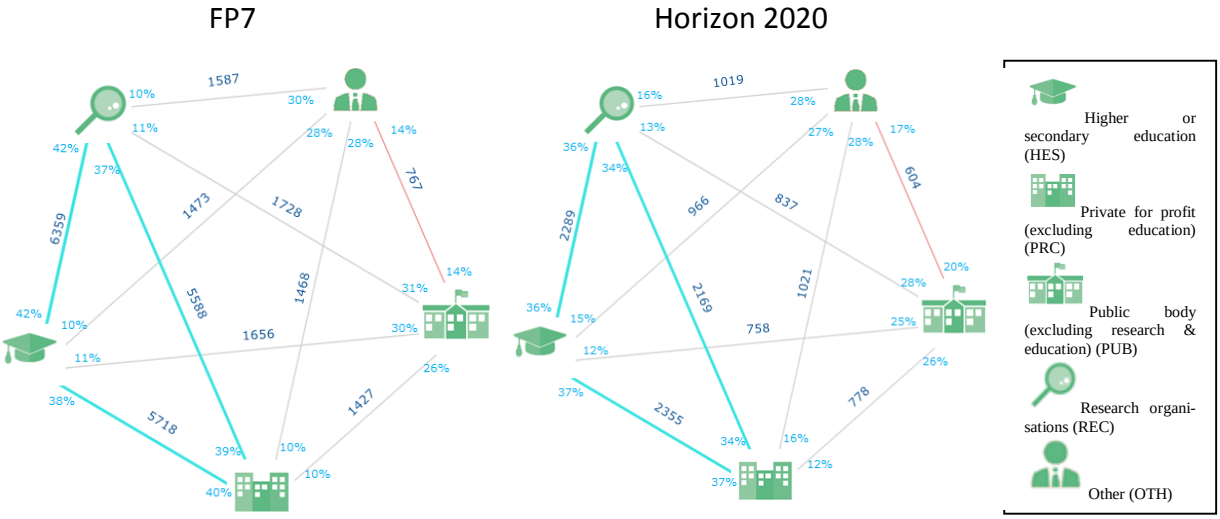


*Source: CORDA, Signed Grants cut-off date by 1/1/2017. *MSCA-IF list the host institution as a participant. The majority are European universities which explains the low share of newcomers.*

7.4.5. Intersectorality and profile of participating companies

Based on a review of the participations to collaborative projects, the main collaborations so far occur between the higher education sector and private firms (2,355 collaborative projects), the higher education sector and research organisations (2,289 collaborative projects) and between the private-for-profit sector and research organisations (2,169 collaborative projects). Private companies have become the main partner of the academic sector under Horizon 2020 projects, as opposed to research organisations in FP7.

Figure 45 Number of collaborative projects between types of institutions, FP7 and Horizon 2020



Source: JRC Technology and Innovation Monitoring tool data. Cut-off date: 01/01/2017; Graphics and computation: European Commission services

Looking at the main domains of academic publications of participants to Horizon 2020 projects (independently of their Horizon 2020 project) it appears that **Horizon 2020 projects are supporting interdisciplinary networks** (see Figure below)[161]. However, only a few unusual interdisciplinary collaborations are observed such as the collaboration between the energy field and computer sciences. Four main clusters of cooperation seem to be emerging based on the first three years of programme implementation, namely:

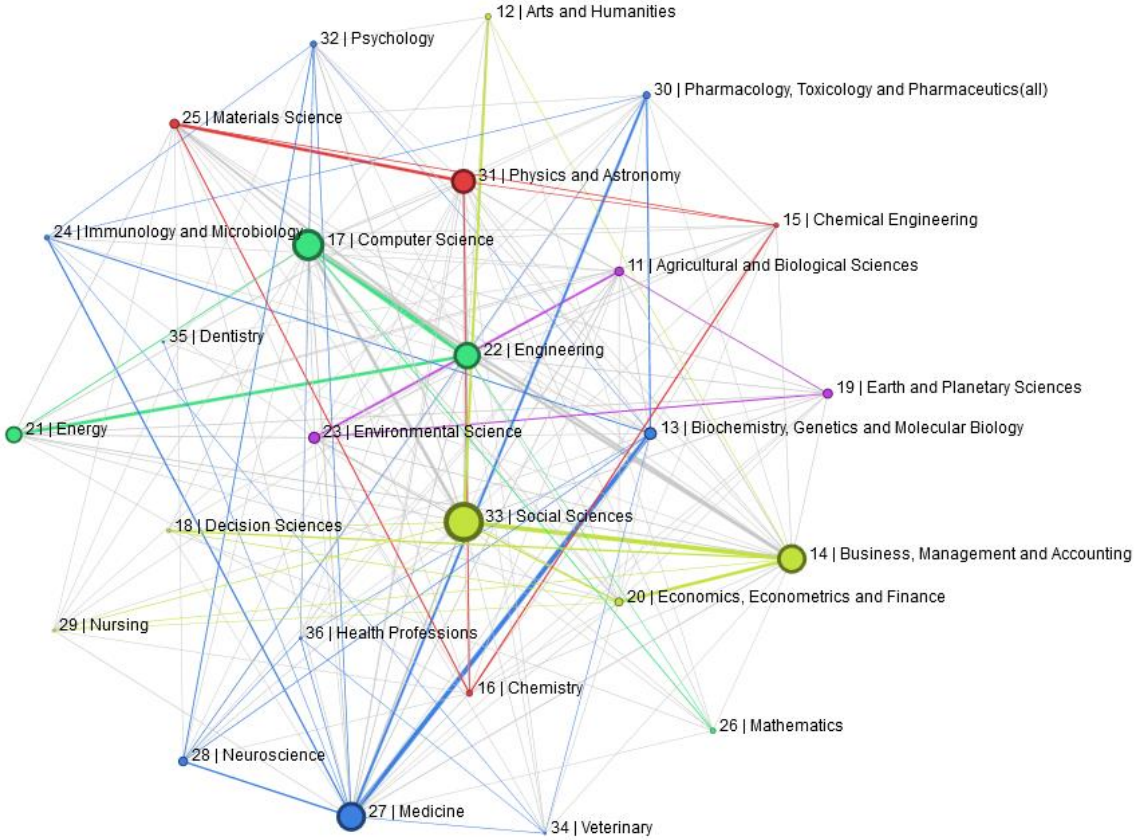
- Physics and astronomy, material sciences, chemical engineering and chemistry;
- Medicine neurosciences, immunology and microbiology, psychology, pharmacology, toxicology and pharmaceutics, biochemistry, genetics and molecular biology and veterinary fields;
- Social sciences business, management, decisions sciences, economics, econometrics, finance and nursing; and
- Computer science, engineering and energy fields.

Box: The value of intersectorality for breakthrough innovation – Example from SPIRE

Among the contractual Public-Private Partnerships (cPPPs) SPIRE is on track towards achieving a reduction of fossil energy intensity of up to 30% by 2030, a 20% reduction in non-renewable primary raw material intensity and a 40% reduction of greenhouse gas emissions by 2030, enabled by a systemic cross-sectorial integration of innovative processes and systems. Factories of the Future is another cPPP working on breakthroughs in industrial manufacturing, reducing the use of materials and waste generation by 20% compared to the situation today across the manufacturing sector.

[161] Horizon 2020 projects were classified according the Scopus bibliographic database which includes scientific, technical, medical, and social sciences (including arts and humanities). The classification was done based on text mining and machine learning performed by the Joint Research Centre of the European Commission.

Figure 46 Collaboration networks in Horizon 2020 projects between different academic fields



Source: JRC Technology Innovation Monitoring. Based on CORDA data cut-off date: 01/01/2017

Looking closer at industry participation, Figure 47 shows companies participating in Horizon 2020 by number of employees and EC contribution received (grants only). Companies involved in Horizon 2020 have a number of characteristics:[162]

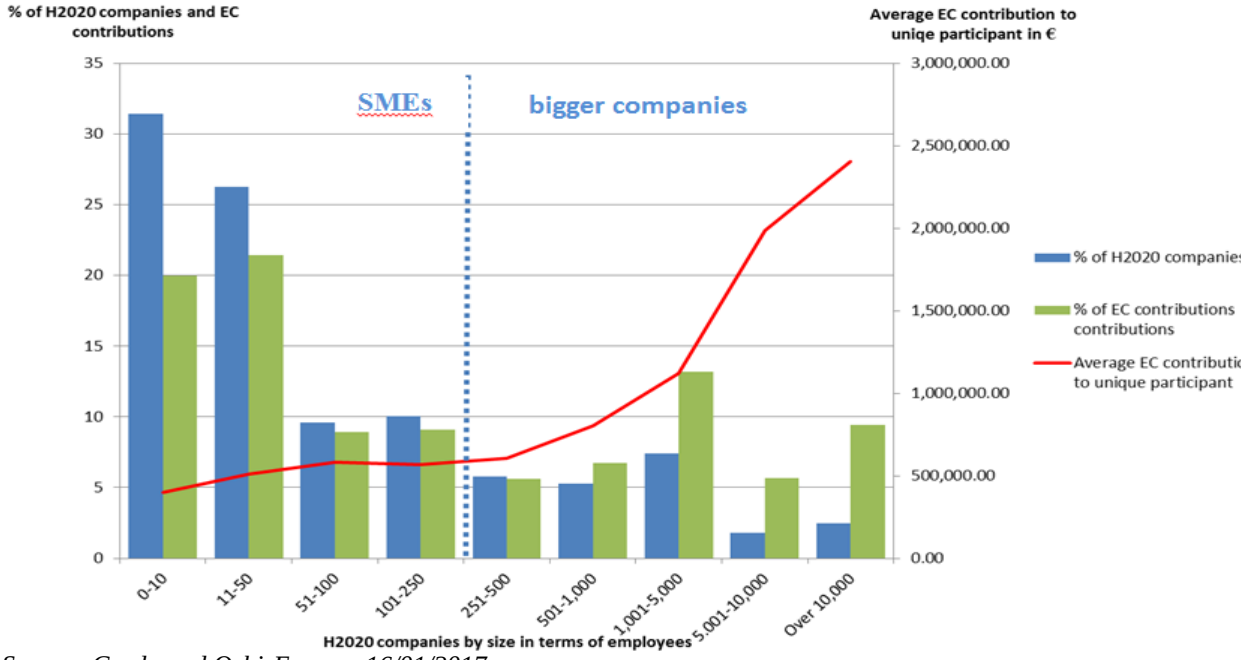
- **In terms of employees SMEs represent more than 75% of all Horizon 2020 companies and receive almost 60% of EC contribution**. More than half of Horizon 2020 companies have 50 or less employees.
- 73% of Horizon 2020 companies have revenues lower than EUR 50 million.
- 60% of Horizon 2020 companies were created after 2000 and 27% after 2010.
- The oldest and most established companies get the highest grants.[163]

Looking at sectoral patterns, 80 % of total grants to Horizon 2020 companies go to the three biggest sectors: 35% to Manufacturing, 30% to Professional, Scientific and Technical Activities, and 16% to the Information and communication sector. The amount of grants awarded to each sector roughly is proportionate to the number of companies in that sector: **the Horizon 2020 allocation seems to be not sector-specific** (chart below). The only slight exceptions are Manufacturing (relatively more grants) and Professional, scientific and technical activities (relatively less grants). This may be because of equipment costs in manufacturing and rela-

[162] For full analysis, see Annex 2.
[163] The scope included in this analysis varies from the scope in CORDA. E.g. for SMEs in CORDA, these are mainly (except for the SME instrument) based on self-declaration, where as in this analysis of companies, the data in ORBIS were filtered on two SME criteria (less than 250 employees and less than 50 million in turnover) to identify SMEs..

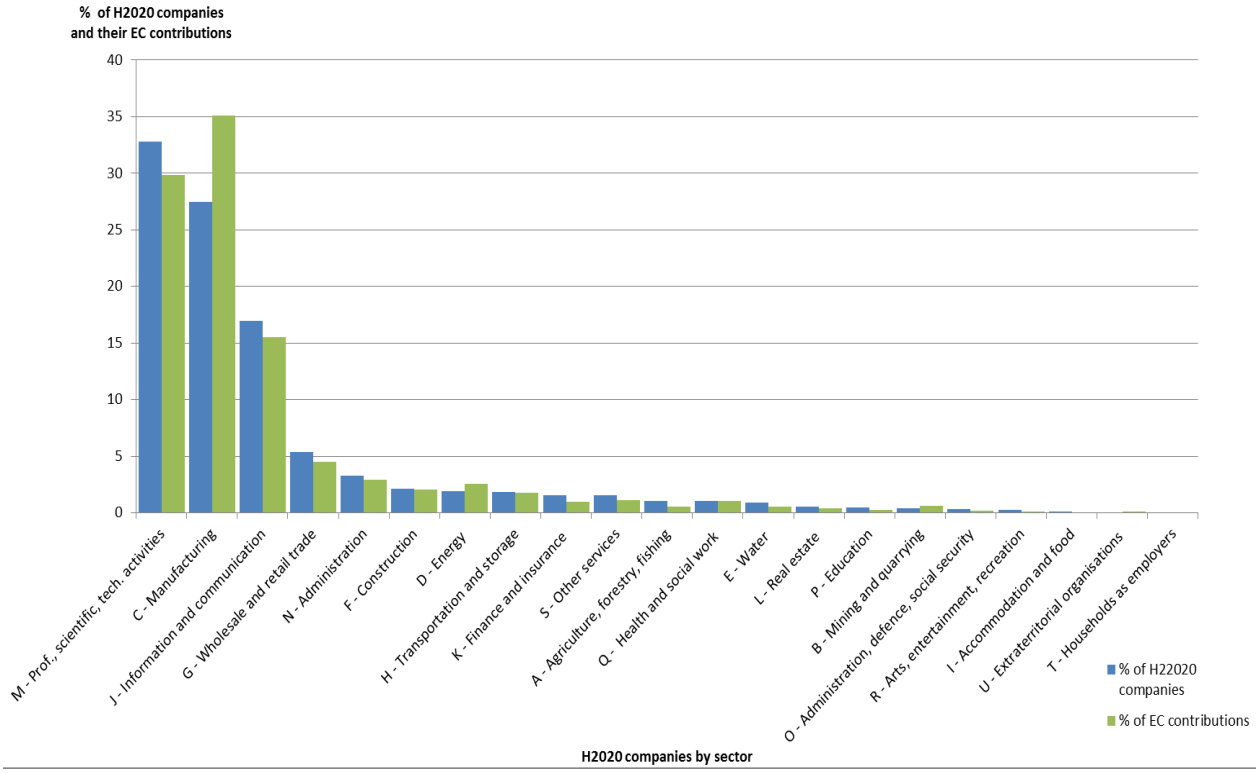
tively smaller grants to consultancy companies. In terms of intersectoral collaborations of companies, the wholesale trade sector and the digital sector tend to collaborate more with other sectors.

Figure 47 Horizon 2020 companies by number of employees and EC contribution received (grants only)



Source: Corda and OrbisEurope, 16/01/2017

Figure 48 Horizon 2020 grants to businesses by sector (N = 9,748 companies)



Source: OrbisEurope, Corda, 16/01/2017.

7.4.6. International cooperation

International cooperation activities should be maintained at least at the level of FP7.[164]

Horizon 2020 has a broad international outreach, in total applicants from 188 countries have applied and participants from 131 countries have been funded (including EU, associated and non-associated third countries). Yet the mainstreaming of international cooperation across Horizon 2020 did not lead to a transversal increase of international participation across the programme. **The share of third-country participations and funding going to third-country beneficiaries has decreased when compared to FP7**, mainly due to the discontinuation of the dedicated schemes in FP7 and the change in the eligibility conditions for funding participants from Brazil, Russia, India, China and Mexico.[165] **Third countries represent 2.5% of the participations and 0.8% of the funding in internationally open collaborative projects** (compared to 4.3% and 1.8% respectively in FP7); and 1.9% of beneficiary participations (compared to 3.6% in FP7)[166] and 0.6% of the funding in all Horizon 2020 projects (compared to 1.3% in FP7). So far 87 third countries have participated in Horizon 2020 (compared to 131 third countries in FP7). Amongst countries that are not automatically eligible for funding from Horizon 2020, the most active in terms of participations are the USA, China, Canada, Australia and Brazil as compared to USA, Russia, China, Brazil and Australia under FP7. Nine of these countries have established co-funding mechanisms to provide funding to their participants in Horizon 2020 projects.

> *[The discontinuation of Horizon 2020 would be] an absolute catastrophy. Our research has become highly international and our main partner is located in Germany. It is very difficult to find adequate local funding to enable co-operation into the EU and as such H2020 funding is invaluable. If this funding should fall away, our research effort would contract by about 70%.*
>
> S. van der Spuy, Stellenbosch University, South Africa

So far, projects resulting from joint/coordinated calls in Horizon 2020 have similar participations and EU contribution as in the corresponding period of FP7. Projects under public-private partnerships have either no or very few international participants (except for the Innovative Medicines Initiative) whereas public-public partnerships show a stronger international participation, with third-country participation share in ERA-NETs at around 5% and the European and Developing Countries Clinical Trials Partnership featuring the participation of 14 African countries. Participations in MSCA account for more than half of all participations of third countries in Horizon 2020. **There is also a greater level of investment in multilateral initiatives compared to FP7.** In health-related initiatives, during 2014-2015 around EUR 114 million were invested, leveraging around EUR 532 million from third countries. In activities related to climate action and the environment such as the 'Belmont Forum', the Group on Earth Observation (GEO) and the Intergovernmental Panel on Climate Change (IPCC), the total Horizon 2020 budget for these topics is close to EUR 200 million, while the total investment by all partners is estimated to be around three to four times this amount. Another example relevant in this context is the developing international maritime research component, notably across the Atlantic (Galway Declaration).

[164] See Recital 41 of the Horizon 2020 Regulation.
[165] See Performance Analysis of International Participation in Horizon 2020, European Commission, 2016.
[166] Taking the considerable share of international partner-organisations in MSCA into account, the participations of third countries are "3.9% of the participations (compared to 5.3% in FP7).

In terms of associations to Horizon 2020, there are now 16 countries that have signed an association agreement[167] Some countries (Switzerland, Norway, Iceland, Israel and the Faroe Islands) have long-standing participation in the EU Framework Programmes and a very strong performance. For the others (e.g. countries from the European Neighbourhood like Armenia, Georgia, Moldova, Tunisia and Ukraine) the association has contributed to the integration of their research and innovation systems in the European Research Area even though several still lack the national capacity needed to fully benefit from their association.

The scientific cooperation between the EU, US and Canada is proceeding with mutual satisfaction in the Arctic in particular under the **Transatlantic Ocean (and Arctic) Research Alliance** launched by the **Galway declaration** in May 2013. Two Arctic Working Groups have been established in 2014 with the US and Canada. The activity of these Working Groups has triggered an improved cooperation and the decision to invest in a consistent package of Arctic research activities in the Work Programme 2016-17 focused on climate change issues, which has attracted further US and Canadian investments.

Stakeholder position papers: A sharp decline in the participation of international partner countries is worrying.

In their position papers, a few stakeholders from different stakeholder groups are worried about the observed drop in global cooperation in Horizon 2020 and noted the issue should be addressed strategically. Some advised rules for participation and regulatory framework should be simplified for instance through a standard contract with global acceptance and guarantee of IP rights. Other noted the programme should introduce topics which explicitly flag international collaboration, have a ring-fenced budget or a separate pillar for international collaboration.

7.5. To what extent is Horizon 2020 cost-effective?

It is early to compare the cost and the benefits of Horizon 2020. Specifically, as the benefits are still emerging: **The benefits of the R&I investments are an outcome of a complex set of interactions and investments made today are expected to bring return on a much longer timeframe.** As a reminder projects completed at the time of this evaluation represent only 0.6% of the funding allocated for the three first years of the programme.

The costs of Horizon 2020 relate to the amount of resources needed to have the programme up and running. This includes, for instance, the administrative costs of the Commission and the various implementing bodies, the cost of application (i.e. cost of writing proposals), the cost of proposal evaluation and the cost of managing the projects by the project coordinators. The efficiency section provides some estimates of such costs, however costs incurred by participants are difficult to estimate based on existing data.

As elaborated in the effectiveness section, the benefits of Horizon 2020 are numerous and hard to monetise. Compared to a reference scenario in which Horizon 2020 would have not been implemented, the results of macro-econometric modelling analysis are that every EUR 1 spent under Horizon 2020 brings an estimated benefit in terms of GDP increase between EUR 6 to 8.5 by 2030.[168] Applying this formula to the total Horizon 2020 direct budget of EUR

[167] Of these, 12 since the start of the programme and 4 in 2015 and 2016, including Switzerland, which was partially associated until the end of 2016 and is now associated to all parts of Horizon 2020.
[168] This is based on projections up to 2030 of the NEMESIS macro-econometric model. It should be noted that the same model projected the economic performance of FP7 somewhat higher per EUR invested compared to Horizon 2020. According to the study, the lower performance of Horizon 2020 seems to be linked to the decreased co-funding rate.

69.3 billion between 2014 and 2020[169], the expected benefit is in the range of EUR 400 to EUR 600 billion over the period from 2014 to 2030. **The macro-economic model further estimates that the annual internal rate of return of the Horizon 2020 is 30% by 2030**. This is in line with the expected return of public spending in research; based on economic literature it is estimated between three and eight times higher than the initial investment[170]. If these projections materialise, Horizon 2020 can be assessed as cost-effective.

7.6. Key conclusions on the efficiency of Horizon 2020

The actual cost-effectiveness of the programme is difficult to assess as the programme first at a very early stage of implementation and only partial effects can be measured so far (see Effectiveness assessment). However, based on the macro-economic modelling exercise, using projections up to 2030, the estimated rate of return of Horizon 2020 is 30% and its expected benefit is in the range of EUR 400 and EUR 600 billion over the period from 2014 to 2030[171]. If such projections materialise, the programme can be assessed as cost-effective.

In terms of programme management, the efficiency of Horizon 2020 is positively influenced by the **externalisation and simplification**. Compared to FP7, the externalisation increased efficiency since almost 60% of the budget is outsourced to the New Management Modes such as Executive Agencies which are more efficient in grant management compared to in-house commission services. There is evidence this resulted in increased administrative efficiency. Current administrative expenditure remains below the 5% mentioned in the legal base. The administrative expenditure is particularly low for the executive agencies mainly due to higher specialisation and lower staff costs. Simplification of participation rules has decreased costs for the participating stakeholders. The simplification efforts have had other positive effects, in particular on the Time-to-Grant (on average 192 days, 100 days faster than in FP7).

The new **funding model** has overall had positive effects on stakeholder appreciation, time-to-grant and attractiveness. While a direct comparison of funding levels is not possible, estimations show that the average real funding level in Horizon 2020 remains at the 70%, the same as in FP7. Another feature of the Horizon 2020 funding model, the additional remuneration scheme has been perceived by Member State representatives and stakeholders as being difficult to implement and having a negative financial effect on those beneficiaries whose usual remuneration practices are based on very variable levels of remuneration. One area for improvement is the broader acceptance of beneficiaries' usual accounting practice. The Commission has already reacted to these concerns and adapted the Horizon 2020 model grant agreements accordingly. Another area for improvement concerns the unintended effects of the additional remuneration scheme with the EUR 8000 capping.

In terms of the efficiency of the funding distribution higher interest from stakeholders resulted in lower **success rates** than in FP7. Many high quality proposals were not funded. At the

[169] These figures include only first, second and third pillars of Horizon 2020 - hence excluding the specific objectives Spreading Excellence and Widening Participation (SEWP) and Science with and for Society (SWAFS), as well as Euratom, EIT and non-nuclear direct actions of JRC.

[170] The internal rate of return was calculated as the actualisation rate that equalizes the actualized sum of GDP gains to the actualized sum of the Horizon 2020 contribution. It increases slightly in time as annual GDP gains stay positive in most countries up to 2050 while EC contribution stops after 2022. This 30% rate of return is in line with the econometric literature results (cf. Hall, Mairesse and Mohnen, 2011). According to most studies, the overall value generated by public research is between three and eight times the initial investment, which in rates of return represents a median value between 20% and 50% (cf. Georghiu, 2015).

[171] NEMESIS econometric model.

same time, higher number of proposals resulted in increased cost of proposal evaluation and might have an impact on the quality of the feedback provided to applicants, which is an area of concern. There is scope for further reduction of administrative burden in both project administration and proposal writing. Despite the low success rate and costs borne by stakeholders for proposal submission, early evidence indicates costs on stakeholders are proportionate given the expected benefits from participation, which are expected to materialise in the future and go beyond the financial contribution received. The effects on the simplification of financial management in the projects and on the error rate cannot yet be assessed, as very few financial reports were yet submitted and no ex-post audits were yet finished.

In terms of **participation**, 52% of all organisations participating in Horizon 2020 are newcomers (and almost half of them are SMEs), but they received only 14% of the total budget. The majority of newcomers participate in the IA and RIA actions followed by the SME Instrument. Even if participants come from 131 countries, the funding is concentrated in terms of participants and countries, but to a lower degree than in FP7. The participation of low R&I performing countries remains low with noticeable performance differences and heterogeneity among the EU-13 countries and across Horizon 2020 programme parts. In general widening participation is limited by the excellence-based focus of Horizon 2020. There is also a greater level of investment in multilateral initiatives compared to FP7 but the decrease in participation of international partners in Horizon 2020 is a cause for concern. The decreased was mainly caused by the discontinuation of the dedicated schemes in FP7, the change in the eligibility conditions for funding participants from certain third countries and recent conflicts and socio-political developments in neighbourhood countries affecting their ability to participate.

8. HOW EFFECTIVE HAS HORIZON 2020 BEEN SO FAR?

This question aims to provide an insight into whether Horizon 2020 is on track to meet its objectives. Whereas detailed assessments of progress for each specific objective are provided in Annex 2, this assessment aims at providing a synthetic overview of the overall progress being made according to key expected impacts, which are not mutually exclusive and cover in each case the whole programme**: scientific impact, innovation/economic impact and societal impact**. The following analysis is structured according to these key strands of impacts, results and early outputs and identifies factors that might affect progress positively or negatively.

Overall it should be kept in mind that R&I are long term and risky endeavours creating knowledge, spill-overs and ground-breaking results that can only very partially be captured after such a short programme implementation.[172] The figures presented in the subsequent analysis are therefore a very small fraction of the output to be expected (projects completed at time of this evaluation represent 0.6% of funding allocated so far). In the following analysis quantitative data from monitoring systems and external studies is thus combined with qualitative data stemming from interviews, surveys of beneficiaries (and non-participants for the counterfactual analysis), project's reviews, expert groups as collected for the 18 in-depth the-

[172] *"Basic research is particularly important, as it gives rise to significantly larger knowledge spillovers than applied research while making applied research much more productive (Akcigit, Hanley and Serrano-Velarde, 2014). The history of science shows that many of the great breakthroughs resulting from scientific research were regarded as significant only in hindsight (Kirshner, 2013). They were not the result of a focused effort to achieve a specific impact, but instead reflected serendipity. Ensuring a balance between basic research, driven by excellence, and more focused, mission-oriented research is therefore an important challenge for public funding."* Chapter 5, The OECD Innovation Strategy - 2015 revision, http://www.oecd.org/sti/innovation-imperative.htm

matic assessments performed for each programme part (see Annex 2) to provide a picture of the progress so far. Results from the stakeholder consultation contextualise the findings.

8.1. What is the progress made towards achieving scientific impact?

The objective of Horizon 2020 is to reinforce and extend the excellence of the Union's science base and to consolidate the European Research Area (ERA) in order to make the Union's research and innovation system more competitive on a global scale.

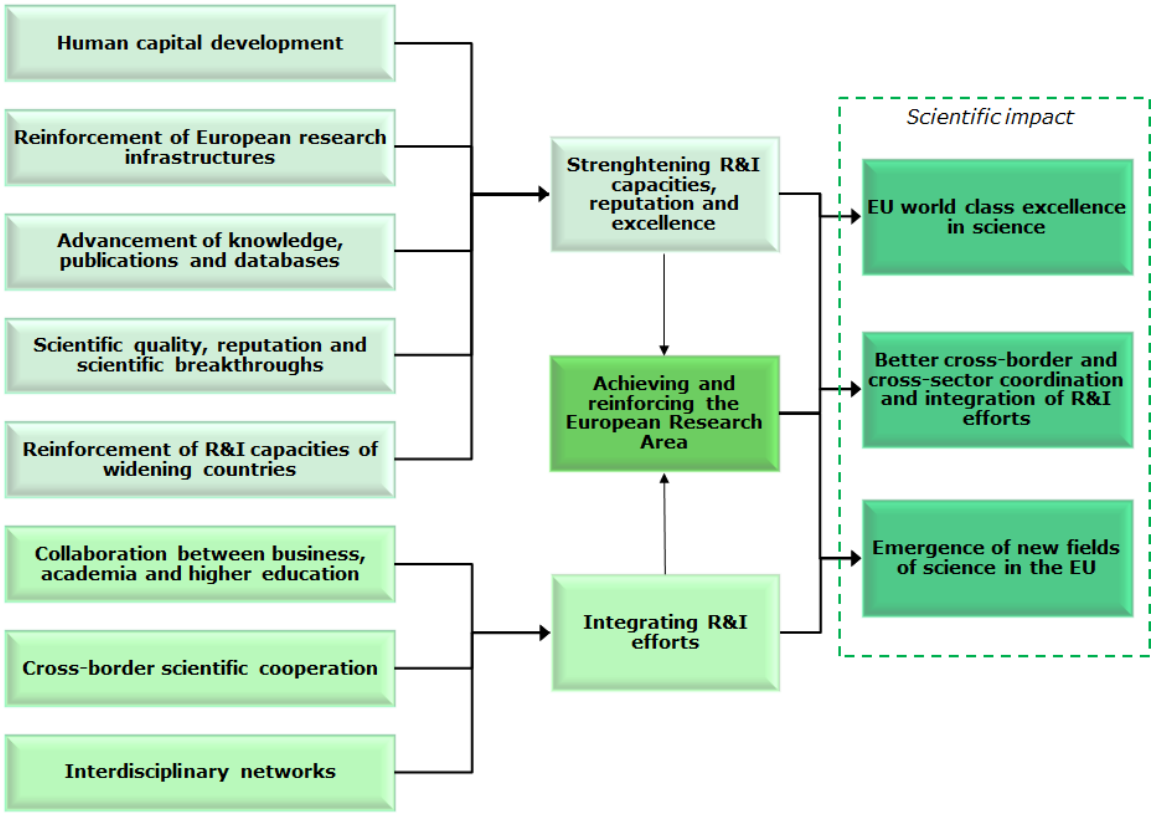
Expectations from Horizon 2020 for achieving scientific impact

Based on the Horizon 2020 impact assessment, **excellence remains the main guiding principle in Horizon 2020 as in FP7.** Scientific excellence remains promoted through the pan-European competition for funding, as well as the screening for excellence in all project's proposals. Therefore all actions across all Horizon 2020 pillars are expected to contribute towards achieving scientific impact.

As regards the **continuous effort to spread excellence and build up R&I capacities across the EU-28**, the FP7 Capacities programme aimed specifically at developing the potential of EU-13 countries to participate to a larger extent in the programme. Horizon 2020 includes a specific programme part dedicated to 'Spreading Excellence and Widening Participation', in addition to making it a cross-cutting issue in the whole programme. The objective is to ensure that participants from all EU countries are able to take part in the programme through a reinforcement of the excellence base and more R&I-conducive policy frameworks.

Figure 49 provides an overview of the approach used for analysing progress towards the achievement of scientific impact. Overall - from the review of the programming documentation - it is expected that Horizon 2020 will contribute to reinforcing Europe's scientific excellence; to improving trans-national and cross-sector coordination and integrating R&I efforts; and to enabling the emergence of new technologies or fields of science in the EU. Progress on these fronts is analysed according to early outputs and results on the strengthening of R&I capabilities, reputation and scientific excellence (human capital development, reinforcement of EU research infrastructures, advancement of knowledge, publications and databases, scientific quality, reputation and scientific breakthroughs and the reinforcement of R&I capabilities of widening countries) and on the integration of R&I efforts (cross-sectoral, trans-national and interdisciplinary collaboration). Progress on these strands is expected to support the consolidation of the European Research Area.

Figure 49 Approach towards analysing progress towards scientific impact



Source: European Commission

Summary box: Key findings on the progress towards achieving scientific impact

- ✓ Horizon 2020 is making progress towards delivering scientific impacts through the reinforcement of R&I capabilities, scientific excellence and reputation and through the integration of R&I efforts.
- ✓ Horizon 2020 succeeds in attracting and involving the EU's and world's best research institutions and researchers.
- ✓ In particular ERC and MSCA, but also other Horizon 2020 parts, train large numbers of researchers and contribute to Europe's human capital development, which in turns makes EU an attractive destination for excellent researchers worldwide.
- ✓ Pan-European research infrastructures supported by Horizon 2020 already contribute to Europe's excellent science with tools, materials and data accessible from across the EU and by supporting the mobility and training of researchers.
- ✓ Horizon 2020 has already succeeded in generating, and can legitimately be expected to continue to generate, a very large number of scientific publications and data. These are already to a large extent, but not yet fully, openly accessible to the wider scientific community and public.
- ✓ The first scientific publications resulting from Horizon 2020 are world class.
- ✓ Horizon 2020 has the potential to generate a large number of scientific breakthroughs.
- ✓ Horizon 2020 builds cross-sectoral, inter-disciplinary, intra- and extra-European research and innovation networks.
- ✓ Horizon 2020 is also making progress, albeit slowly, on spreading excellence in Europe.
- ✓ The Horizon 2020 funding measures are crucial to accompany the realisation of the European Research Area, notably through their effect on coordination, common agenda setting and pooling of resources, and to continue shaping the landscape of European research institutions.

8.1.1. Progress on strengthening R&I capacities, reputation and scientific excellence

One key objective of Horizon 2020 is to support the strengthening of R&I capacities, reputation and scientific excellence by supporting human capital development, European research infrastructures, the advancement and sharing of knowledge and scientific quality and breakthroughs. Early evidence indicates that the programme is making progress on these fronts.

8.1.1.1.Human capital development

Figure 50 Horizon 2020 Key Performance Indicators related to human capital development

Key Performance Indicators (KPIs)	Progress so far / Target
Human capital development	
MSCA-Number of researchers undertaking international mobility under the Marie Skłodowska-Curie actions.	27 000 (9000 per year) [173] Target: 65,000 researchers (incl. 25,000 PhD candidates)
MSCA- Number of researchers undertaking mobility between academic and non-academic sectors	4 000 Target: 65,000 researchers (incl. 25,000 PhD candidates)
Annual number of research positions advertised on EURAXESS Jobs	The number of research positions advertised on EURAXESS Jobs between 1 January and 31 December 2015 comprised 286,525 job vacancies and 62,088 fellowships.

Source: Corda, Signed Grants cut-off date by 1/1/2017

Horizon 2020 is already supporting human capital reinforcement throughout its activities, the most direct way being through the direct support to individual researchers in MSCA, ERC and FET. However, through the **development of partnerships, knowledge creation and circulation, the impacts of the programme on human capital are much wider**, as detailed in the thematic assessments. A study on the effects of participating in an FP project from a human resource perspective showed that researchers that participate in FPs strengthen almost all skills and capacities.[174] The Research Infrastructure programme also plays a major role in promoting research mobility, within the EU and more globally not only due to the movement of scientists to work at different sites but also due to the synergistic development of common standards, research protocols, tools and platforms, which are engendering a greater portability of skills, data and knowledge across the European scientific community.

As regards the share of researchers in the active population (indicator monitored under the Europe 2020 Strategy), the indicator is progressing well given that **the number of Full-Time Equivalent (FTE) researchers increased each year since 2010 and reached the value of 1.87 million FTE researchers in the EU-28 in 2015 (1.73 in 2013).** An external study[175] identifies a number of **300,000-340,000 researchers in the EU Framework Programmes teams which are fully or at least partly involved in EU-funded research activities**. These data imply that **EU research funding contributed to the activities of around 1 in 5 researchers in Europe**. Going further, the study indicates that the FP7 research teams had, on average, 24.4% more researchers in 2015 than compared to the year when the application for

[173] To be funded under the budget of the MSCA Calls for the years 2014-16.
[174] 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
[175] PPMI study, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming.

EU funding was made. The corresponding growth rate was estimated at 12.6% for the non-FP teams, resulting in 11.8 percentage points faster overall growth of the teams which participated in the EU FPs. This difference translates into some 45,000-50,000 additional research jobs created in FP7 when extrapolated and aggregated for the whole programme.

A more in-depth assessment of the effects of Horizon 2020 on the career, reputation or profile of researchers involved would require information on the individual researchers involved in the collaborative projects (e.g. through their DOI[176]), which is not available.

Box: Examples of reinforcement of human capital in Horizon 2020

Marie Skłodowska-Curie Actions (MSCA) have funded the training, mobility and career development of around 27 000 researchers during the first three years of Horizon 2020. All fellows will experience mobility be-tween countries and an estimated 12 000 will benefit from some form of cross-sectoral mobility out of or into an academic setting. Furthermore, MSCA are attracting and retaining excellent researchers in Europe, with around one in four fellows coming from countries outside the EU Member States or Associated Countries.

ERC: An analysis in 2014 of over 7,000 leading researchers in Europe found that 30% had applied to the ERC's calls and around one in six were ERC grant holders. According to the ERC thematic assessment, there is also already evidence of the longer term impacts of ERC grants on careers, on training highly skilled postdocs and PhDs, on raising the global visibility and prestige of European research and on national research systems through its strong benchmarking effect. A recent ERCEA analysis showed that 71% of the Starting Grant 2009 grantees, outstanding researchers on the verge of establishing an independent research career, made progress on their career path or improved their academic status as a result of the ERC project, most of them reaching a top academic position. Over the course of the 6,500 currently running ERC projects around 28,000 PhDs and postdocs will be part of the teams. According to the ERC thematic assessment, the prestige of hosting ERC grant-holders and the accompanying 'stamp of excellence' are also intensifying competition between Europe's universities and other research organisations to offer the most attractive conditions for top researchers and to increase investment in research capacity and excellence.

A relatively high proportion of **ICT projects** participants perceive a fair or high impact of their projects on their ability to access new knowledge and increase staff skills. Another example is the **FET Flagships** that help recruit, educate and develop research talents in Europe. Building up new interdisciplinary science-and-technology communities is also a hallmark of **FET-Proactive**.

8.1.1.2.Reinforcement of European research infrastructures

Figure 51 Horizon 2020 key performance indicators related to the reinforcement of European research infrastructures

Key Performance Indicators (KPIs)	Progress so far / Target
Reinforcement of European research infrastructures	
Number of national research infrastructures networked (in the sense of being made accessible to all researchers in Europe and beyond through Union support)	National research infrastructures networked thanks to Horizon 2020 support by the end of 2015 were 363. The target by the end of Horizon 2020 is 900.
Number of researchers who have access to research infrastructures through support from Horizon 2020	33 741[177] Target: 20,000 additional researchers during Horizon 2020

Source: Corda, Signed Grants cut-off date by 1/1/2017

[176] DOI stands for Digital Object Identifier. It is a serial code used to uniquely identify electronic documents, such as scientific publications. For Horizon 2020 project reporting, publications resulting from funded projects are reported by providing their DOI. All related information on the publication is then automatically transferred into the project reporting system. This information is not available so far for individual researchers in Horizon 2020.

[177] This amount is calculated on FP7 grants as data from H2020 grants is not yet available

Thanks to Horizon 2020 support, a total of 363 national research infrastructures have been made accessible to all researchers in Europe and beyond, out of a target of 900 by the end of Horizon 2020[178]. According to the thematic assessment of Research Infrastructures, the development of EU research infrastructures has raised awareness of the burgeoning potential and stimulated scientific communities across the EU. In close conjunction with ESFRI[179], it has enabled the EU to be effective in conceiving and delivering large research infrastructure projects at the European and global scale. These would not otherwise have been realised because of their large size, cost and complexity, which has required an EU-wide common vision and the combined efforts of several Member States to initiate them. The *ESFRI Strategy Report on Research Infrastructures/Roadmap 2016* lists 29 such infrastructures that have reached the landmark (implementation) phase, and another 21 in development. These include world-leading infrastructures across all the disciplines of science. All are potentially open to all EU Member States, and many are attracting participative interest more globally. Thirteen new Pan-European research facilities are based on the new legal framework for the European Research Infrastructure Consortium, ERIC, which entered into force in 2009 and at least four more ERICs are expected to be launched in 2017.

Joining forces to boost the ERA (best brains, the best solutions, the best research infrastructures); Horizon 2020 focus on areas where regional/national programmes are not sufficient and the EU level is vital; Excellent research infrastructures must be strongly supported because they are often the main reason why top scientists decide to come to Europe; know-how spreading in the EU; bringing disciplines together; international visibility of EU participants

Germany, Helmholtz Association

The pan-European e-infrastructures support the networked provision of computing infrastructure and the development of major data-driven research infrastructures. A single and open European space for online research where researchers enjoy leading-edge, ubiquitous and reliable services and open access to e-Science environments is being created through the federation of e-Infrastructure resources at regional, national, institutional and European level realising the European Open Science Cloud (EOSC) vision put forward in the European Cloud Initiative[180]. 35 e-Infrastructure grants have integrated, federated and/or consolidated e-infrastructure services into strong pan-European e-Infrastructures that will form the nucleus of the EOSC and enable the creation of new forms of science.

Example box: ELIXIR-EXCELERATE[181], a Horizon 2020 infrastructure project

Project Type: INFRADEV; Budget: € 19 million; September 2015 - August 2019

The project is aiming at accelerating the implementation and early operation of ELIXIR, the European life science Infrastructure for Biological Information, identified by ESFRI and the European Council as one of the three Europe's priority research infrastructures. With 41 partners in 17 countries this grant coordinates and enhances existing resources into a world-leading data service for academia and industry, grow bioinformatics capacity and competence across Europe, and complete the management processes needed for a large distributed infrastructure. Four use cases: rare diseases, human data, plant genotype-phenotype and marine metagenomics, will help best tuning the services.

The development of distributed European infrastructures and networked infrastructures based around the shared distribution and access to data, materials and tools has been transformative and stimulated scientific communities across Europe into cooperation - creating a solid basis for EU-level research. As none of the Horizon 2020 projects on

[178] A detailed assessment of progress made under the Research Infrastructure programme is provided in Annex 2.
[179] European Strategy Forum on Research Infrastructures: http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri
[180] European Cloud Initiative - Building a competitive data and knowledge economy in Europe, COM(2016) 178 final
[181] https://www.elixir-europe.org/news/elixir-accelerates-major-horizon-2020-funding

Research Infrastructures has been concluded to date, it is not yet possible to provide information on the users supported. The number of researchers who had access to research infrastructures through FP7 support until 2015 is 33,741[182].

8.1.1.3.Advancement of knowledge, publications and databases

Figure 52 Horizon 2020 key performance indicators related to the advancement of knowledge, publications and databases

Key Performance Indicators (KPIs)	Progress so far / Target
Advancement of knowledge, publications and databases	
Number of peer-reviewed publications	4043 Target: FET: 25 publications/EUR 10 million ; Societal Challenges: 20 publications/EUR 10 million
Chapters in books	373
Number of Publications in conference proceedings/ workshops	3,138
Number of Books/Monographs	49
Number of Thesis/Dissertations	78
Other publications	548
Total number of Publications ➔ Peer-reviewed in Open Access	8,246 60.8% to 68.7%[183]
Number of projects that make scientific data accessible and re-usable and number of scientific datasets made accessible and re-usable.	65% of the projects covered by the scope of the pilot (2014-2015 figures) participate in the pilot and 34.6% opt-out. Outside the areas covered by the pilot, a further 11.9% of projects participate on a voluntary (opt-in) basis.

Source: Corda, Signed Grants cut-off date by 1/1/2017

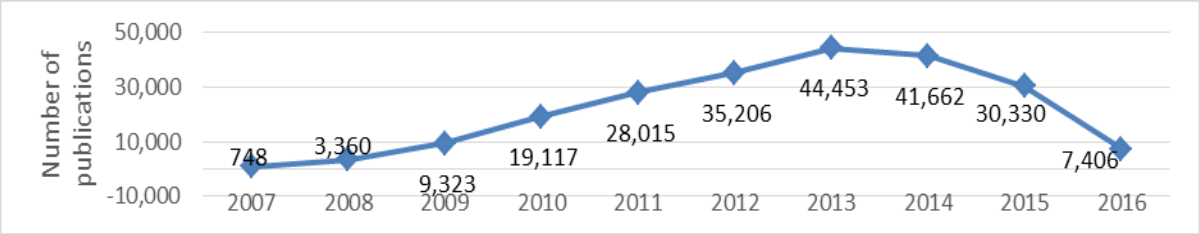
Even if not translated fully into measurable items, **the advancement of knowledge is one of the major effects of Horizon 2020**. Looking at the typical outputs measured under an R&I programme, **Horizon 2020 projects have already generated 8,246 publications[184]. About half of them (4,043) are peer-reviewed and include articles, reviews and conference proceedings.** While the publication output in the first three years of Horizon 2020 seems lower than the corresponding amount in the first three years of FP7 (13,431 - see Figure below), the apparent decline in number of peer-reviewed publications is an artefact of the lengthy peer-review system and the journal indexing process impacting all bibliometric databases. Also, based on the experience of FP7, the number of publications per year tends to increase significantly after the first three years of the programme and reaches its peak at its end. The current figures are, therefore, a small fraction of the total output to be expected. The remaining publications are mainly publications related to workshops, books or chapters in books, thesis or dissertations or other publications.

[182] This amount is calculated on FP7 grants as data from Horizon 2020 grants is not yet available

[183] The lower bound is based on OpenAire (22/02/17), while the upper bound is based on Corda.

[184] Data related to indicators on publications are self-reported by beneficiaries during and at the end of the projects, usually between 12 and 18 months from the projects'start date. There is a time-lag between the start of the project and the delivery of first scientific results. Based on the experience of FP7, the number of publications per year tends to increase significantly after the first three years of the programme and reaches its peak at its end. It is therefore expected that Horizon 2020 publication output will significantly increase in the next years, when a critical mass of projects will have achieved a higher level of maturity. Performing a comparison with FP7 at this stage would thus be premature.

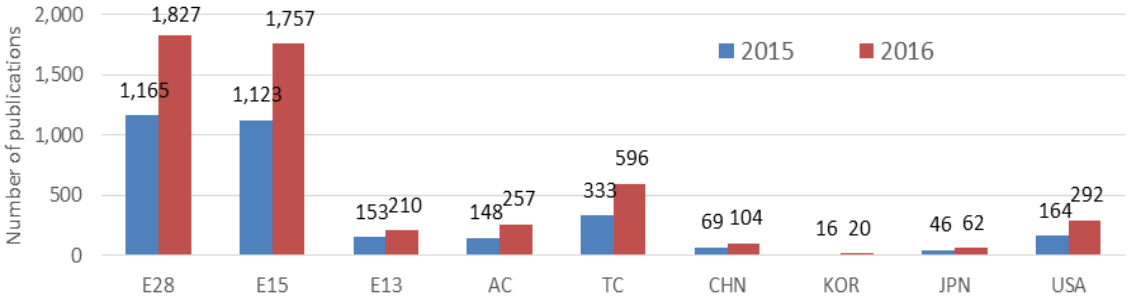
Figure 53 FP7 yearly peer-reviewed publications – all total output 2007-2016



Source: Scopus [study by Elsevier]

An analysis of the number of Horizon 2020 peer-reviewed publications based on Scopus data (2015 and 2016 only) shows an overall increase between 2015 and 2016. Whereas most publications come from the EU-15 geographical group participants from the USA record the highest number of Horizon 2020 publications for the non-EU countries, as also seen in FP7.

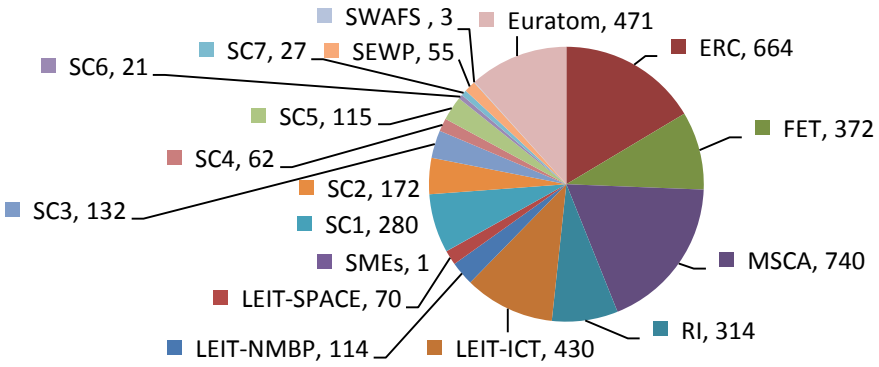
Figure 54 Total publication output of Horizon 2020-funded research per geographical group, per year 2015-2016



Source: Scopus [study by Elsevier]

Not surprisingly a slight majority (52%) of the peer-reviewed publications come from the Excellent Science pillar (mostly MSCA followed by ERC and FET)[185]. Also 15% of the peer-reviewed publications in Horizon 2020 derive from more industry-focussed LEIT projects, of which 70% from LEIT-ICT projects. In addition, 20% derive from projects in Societal Challenges, mainly from the Health Societal Challenge (SC1).

Figure 55 Number of peer-reviewed publications from Horizon 2020 projects per programme part



Source: Corda (cut-off date 1 January 2017)

[185] The figure for FET is incomplete as for instance the two FET Flagships Horizon 2020 projects only started in April 2016 and have not reported publications yet; publications relating to the 2.5 year ramp-up phase funding in FP7 are 782 peer-reviewed scientific publications for Graphene and 272 for the Human Brain Project respectively.

Horizon 2020 aims at opening as much of the data from EC-funded research to the wider scientific community to maximize access and usage and reduce unnecessary replication. While open access to research data is applicable by default in Horizon 2020, the Commission also recognises that there are good reasons to keep some or even all research data generated in a project closed. However the OpenAire database and Corda data indicate that a **significant proportion between 61% and 69% of Horizon 2020 peer-reviewed publications are published in open access**.[186] This figure is confirmed by data collected by the Commission: 65.4% of the projects covered by the Open Data pilot (2014-2015 figures) make scientific data accessible and re-usable. Furthermore, outside the areas covered by the pilot, a further 11.9% of projects participate on a voluntary (opt-in) basis.

Stakeholder position papers: Views on the Open Data initiative diverge.

In their position papers, quite a few stakeholders representing different stakeholder groups commented on the Open Data initiative but their views diverge. Some stakeholders in particular NGOs, research organisations and academia welcome the Open Data initiative and call for greater transparency and open access. Yet others including representatives of businesses and industry but also academia pinpoint that an Open Access to data requires strict conditions to be met such as the waterproof Intellectual Property protection system needs to be put in place, the Open Access should be voluntary and evaluated by the beneficiary on the case-by-case basis - opting out should stay a possibility, a sustainable model should be ensured, involving all relevant stakeholders in the transition and governments should fund the extra costs that comes with keeping data open (for example for the ICT tools).

8.1.1.4.Scientific quality, reputation and scientific breakthroughs

Figure 56 Horizon 2020 key performance indicators related to the progress towards scientific impact

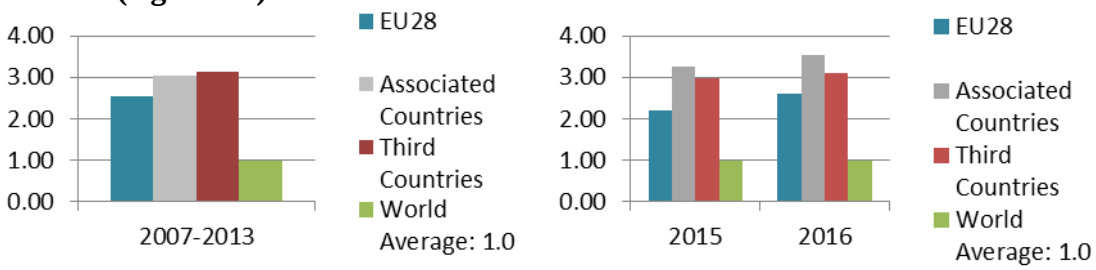
Key Performance Indicators (KPIs)	Progress so far / Target
Scientific quality, reputation and scientific breakthroughs	
ERC – Percentage of publications from ERC funded projects which are among the top 1 % highly cited	7.0%[187] Target: 1.8

Source: Corda, Signed Grants cut-off date by 1/1/2017

Looking at the quality and influence of the outputs produced so far, there are already indications of the high quality and reputation of the activities performed. Looking at a proxy indicator on the quality of the publications produced, the preliminary assessment of the the Field-Weighted Citation Impact (FWCI)[188] of the 4,043 Horizon 2020 peer-reviewed publications confirms the trends observed in the period 2007-2013 for FP7: **publications from FP7 and Horizon 2020 projects are cited more than twice the world average (FWCI of 2.46).** For 2015 and 2016, the EU-28 group Horizon 2020-funded output was 3.74 times more represented in the world's top 1% of cited research than the EU-28's overall publication output. **For EU-15 and EU-13, Horizon 2020-funded output was proportionally higher in the top 1% category by factors of 3.65 and 5.57 respectively. The EU-13 group enjoyed the highest relative increase, between 2015 and 2016, over their own overall FWCI, with 1.84 and 2.29 ratio increases, respectively**.

[186] As calculated using OpenAire, 22/02/17.
[187] Preliminary estimate based on ERC publications from FP7 projects.
[188] Field-weighted Citation Impact normalises citation differences between research fields, with a world average set to 1.0

Figure 57 Field Weighted Citation Impact for FP7 publications (left side) and for Horizon 2020 (right side)



Source: Scopus (Elsevier study, forthcoming)

While 664 peer-reviewed publications can be attributed to ERC under Horizon 2020 projects, 7% of ERC 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 compared with 1.7% of publications with an EU author. In 2014, 20% of the Nature and Science papers that have authors based in the EU and the Associated Countries were ERC funded publications. ERC funding has gone from contributing less than 0.1% of EU top 1% publications in 2007 (2) to nearly 7% in 2014.

Whereas it is too early to identify major scientific breakthroughs for most of the Horizon 2020 projects, there is already early indication of potential breakthroughs. Qualitative analysis of ERC funded work since its creation in 2007 confirms the breakthrough nature of the work performed[189]. **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 four ERC grantees have been awarded the Fields Medal after being funded by the ERC.** As an illustration, the 2016 Nobel Prize in Chemistry - Prof. Ben Feringa – was awarded support from FP7 (ERC Advanced Grant, Marie-Curie Action, Mobility programme and NMP programme) and Horizon 2020 (ERC advanced Grant) prior to the award of his Nobel Prize in Chemistry in 2016 (see Figure 58). As of December 2016, based on an ERC review, ERC grantees had been the recipients of 526 major prizes, awards and other forms of recognition.

The ERC is the single most successful European research funding instrument ever, raising our reputation and attracting talent to us due its strong recognition of bottom-up excellent science!
CESAER, Belgium

Horizon 2020 beneficiaries have also contributed to major scientific discoveries including the Higgs Boson at CERN[190], the detection of gravitational waves[191] and the discovery of a planetary system composed of seven Earth-like worlds (exo-planets) located relatively close to Earth in 2017[192]. FET-funded projects can also be expected to play a significant role in creating new knowledge and helping to develop high-risk innovative projects that can give the EU a competitive edge and to generate major breakthroughs in ICT.

[189] Based on a qualitative evaluation of 199 completed ERC-funded projects from the first two calls 71% of projects were considered to have made a scientific breakthrough or major scientific advance. A different peer review evaluation of a sample of top 1% most highly cited ERC-funded papers considered 21% of the 56 papers reviewed to have made a landmark contribution to their field, including the identification of new entities or phenomena, methodological advances in the study of a topic and the elaboration of theoretical principles.

[190] See https://ec.europa.eu/research/mariecurieactions/news/eu-marie-curie-actions-fellowships-news-18-07-2012-higgs-boson_ga

[191] See https://ec.europa.eu/research/mariecurieactions/news/20160615-eu-research-gravitational-waves_en

[192] See https://erc.europa.eu/sites/default/files/press_release/files/SPECULOOS_Highlight.pdf

Figure 58 Major recognition prizes (Nobel Prizes, Fields Medals, Wolf Prizes, Lasker Award, Millennium Technology Prize, Crafoord Prize, Abel Prize) received by beneficiaries of past EU Research Framework Programmes and Horizon 2020

Name of awardee	Award, year of award	Support granted before Horizon 2020	Support under Horizon 2020
Leif Andersson	Wolf Prize in Agriculture, 2014	FP7 (ERC AdG2011)	
Alain Aspect	Wolf Prize in Physics, 2010	FP7 (ERC AdG2010)	
Artur Avila	Fields Medal, 2010	FP7 (ERC StG2010)	
David C. Baulcombe	Lasker Award for Basic Medical Research, 2008,Wolf Prize in Agriculture, 2010	FP7 (ERC AdG2008)	
Thomas Ebbesen	Kavli Prize (Nanoscience), 2014	FP7 (ERC AdG2008)	
François Englert & Peter W. Higgs	Nobel Prize (Physics), 2012	FP7 (Marie-Curie Actions)	
Bernard L. Feringa	Nobel Prize (Chemistry), 2016	FP6 (Mobility); FP7 (Marie-Curie Actions, ERC AdG2008, NMP)	ERC AdG2015
Albert Fert & Peter Grünberg	Nobel Prize (Physics), 2007	FP3	FET
Andre Geim & Konstantin Novoselov	Nobel Prize (Physics), 2010	FP7 (ERC StG2007 for K. Novoselov)	FET
Michael Grätzel	Millennium Technology Prize, 2010	FP7 (ERC AdG2009)	
Martin Hairer	Fields Medal, 2014	FP7 (ERC CoG2013)	
Theodor Hänsch	Nobel Prize (Physics), 2005	FP5	FET
Ilkka Hanski	Crafoord Prize in Biosciences, 2011	FP7 (ERC AdG2008)	
Serge Haroche	Nobel Prize (Physics), 2012	FP6 ; FP7 (ERC AdG2009)	FET
Stefan Hell	Nobel Prize (Chemistry), 2014	FP4 (Marie-Curie Actions) ; FP7 (Health)	
Lars Klareskog	Crafoord Prize in Polyartheritis, 2013	FP7 (ERC AdG2009, ERC PoC2011)	
Elon Lindenstrauss	Fields Medal, 2010	FP7 (ERC AdG2010)	
Harmut Michel	Nobel Prize (Chemistry), 1988	FP7 (Health)	
Edvard I. Moser & May-Britt Moser	Nobel Prize (Physiology or Medicine), 2014	Edvard I. Moser: FP5 (NMP) ; FP7 (ERC AdG 2008 & 2013, Marie-Curie Actions, Health) May-Britt Moser: FP5 (NMP) ; FP7 (Marie-Curie Actions, ERC AdG2010, Health)	FET
Christiane Nusslein-Volhard	Nobel Prize (Physiology or Medicine), 1995	FP7 (Health)	
Stuart Parkin	Millennium Technology Prize, 2014		ERC AdG2014
James E. Rothman	Nobel Prize (Physiology), 2013	FP7 (Marie-Curie Actions)	
Jean-Pierre Sauvage	Nobel Prize (Chemistry), 2016	FP6 (Marie-Curie Actions, IST, Mobility, NMP)	MSCA, FET
Stanislav Smirnov	Fields Medal, 2010	FP7 (ERC AdG2008)	
J. Fraser Stoddart	Nobel Prize (Chemistry), 2016	FP4 (TMR) ; FP7 (NMP)	NMBP, MSCA
Endre Szemeredi	Abel Prize, 2012	FP7 (ERC AdG2012)	
Kajita Takaaki	Nobel Prize (Physics), 2015	FP7 (Marie-Curie Actions)	MSCA RISE
Jean Tirole	Nobel Prize (Economic Sciences), 2014	FP7 (ERC AdG2009, MSCA)	
John E. Walker	Nobel Prize (Chemistry), 1997	FP7 (Health)	
Torsten N. Wiesel	Nobel Prize (Medicine), 1981		FET
Anton Zeilinger	Wolf Prize in Physics, 2010	FP7 (ERC AdG2008)	
Peter Zoller	Wolf Prize in Physics, 2013	FP7 (ERC SyG2012)	

Source: European Commission

Example box: Result of ERC project amongst top ten physics discoveries of the last decade

ERC grantee Leo Kouwenhoven recently proved the existence of the "Majorana fermion", a particle theorised in the 1930s. Detecting Majorana's particles is not only exciting for particle physicists; thanks to their properties they could prove useful as stable "quantum bits" of information that could make quantum computers a reality. In October 2015, the result of Prof. Kouwenhoven's team was listed among the top 10 physics discoveries of the last 10 years by *Nature Physics*. The properties of the Majorana fermions could bring us one step closer to the much-talked-about high-speed quantum computers. In theory, the nature of the particles that can simultaneously be their own opposite could become a building block for quantum information processing and transmission.

Leo Kouwenhoven received an ERC Synergy Grant in 2012 together with Lieven Vandersypen and Carlo Beenakker to further work on bridging the gap between science and engineering in the field of quantum computing[193].

Microsoft has recently hired four leaders in the field of quantum computing, including Leo Kouwenhoven, who will now build a Microsoft lab on the Delft campus[194].

Example box: Results of the Graphene FET Flagship

The Graphene Flagship, which was launched in 2013 and will span over 10 years, is one of Europe's biggest ever funded research initiatives. It consists of an academic-industrial consortium of more than 150 partners in over 20 European countries. It covers the entire value chain, from materials production to components and system integration, and aims at developing applications in areas such as flexible electronics, printed electronics, 5G mobile technologies, batteries, aerospace, medical applications, filtration and automotive.

A recent remarkable breakthrough of the Flagship is the first fully functional microprocessor made from graphene-like materials that is a first step toward ultra-thin, flexible devices and holds promise for integrating computational power into everyday objects and surfaces. Another breakthrough is the development of graphene-based neural probes to examine brain activity in high resolution, which can help to better understand diseases such as epilepsy and disorders that affect brain function and motor control, as well as to improve neuroprosthetics by enabling control of artificial limbs. Additional promising results include highly efficient solar cells and ultrahigh sensitivity graphene infrared detectors (key for security screening).

In line with the progress registered to date on this front, **75% of the stakeholder consultation respondents think that Horizon 2020 is fully or to a large extent helping to foster excellent science,** whereas 2.9% think this is not the case at all. Looking at the breakdown by categories of respondent, research organisations and academia are above the average in favour of the statement, while even business recognises "to a large extent" that Horizon 2020 is helping to foster excellent science. The least positive are NGOs.

Stakeholder position papers: Excellence should remain the main driver of Horizon 2020 and subsequent programmes.

In their position papers, some stakeholders representing different stakeholder groups underlined that excellence should remain the highest priority and the driving principle of the Horizon 2020.

8.1.1.5.Reinforcement of R&I capacities of widening countries

Horizon 2020 aims to fully exploit the potential of Europe's talent pool and to ensure that the benefits of an innovation-led economy are both maximised and widely distributed across the Union in accordance with the principle of excellence.

[193] http://www.tnw.tudelft.nl/fileadmin/Faculteit/TNW/Actueel/Nieuws/Archief_2013/07_juli_2013/Mourik_Zuo_copy_ENG.pdf

[194] http://www.nature.com/news/quantum-computers-ready-to-leap-out-of-the-lab-in-2017-1.21239

The EU funding from Horizon 2020 to EU-13 countries remains at a low level even if slowly increasing (4.2% in FP7, 4.4% in Horizon 2020). All programme parts have to contribute to spreading excellence and widening participation as a cross-cutting issue. In addition Teaming, Twinning and ERA Chairs are the key measures falling under the dedicated programme part on Spreading excellence and widening participation (SEWP). Based on the information collected, by extrapolation, **it is expected that the SEWP projects will achieve their targets and contribute to the SEWP objectives**[195]. The main expected outputs from these projects are related to the **strengthened institutional, scientific and networking capacities of centres of excellence and knowledge and research institutions located in low performing regions and Member States** - on the basis of partnerships with internationally leading institutions and researchers -, **improved R&I policy frameworks and support provided to strategic planning and implementation**.

Box: SUPREME, a twinning project for Polish energy infrastructure[196]

EU Contribution: EUR 1 million ; Start date: 01/11/2015

The transition from fossil fuels to renewable and sustainable energy sources has become the EU's top developmental priority, with low-performing countries in Central Europe facing the most urgent need. Poland's continuing economic progress has not come without significant costs; due to its history in electricity production, in 2009 it had the highest rate of production by coal of any EU Member State. This made Poland Europe's third largest polluter in terms of damage to society, home to six of Europe's 30 most damaging power-plants, and among Europe's worst for public exposure to harmful pollution. At the same time it was experiencing rises in domestic electricity demand twice the EU average. While Polish research now has expertise in many of the technologies needed for energy transition, it lacked critical knowledge in modelling, planning, integrating, and managing large scale renewable energy systems in a flexible and effective manner. The project twins one of Poland's best energy research centres, the Instytut Maszyn Przeplywowych Im Roberta Szewalskiego PAN with expertise in Denmark, the Netherlands, and Austria. Focusing on needed knowledge transfer in integrating energy technologies, the project's mix of extended staff exchanges, joint work, Summer Schools, and other events is expected to create a long-lasting and effective partnership with a strong impact on Poland's energy systems infrastructure.

With regards to Teaming phase 1, Twinning and ERA Chairs, 112 projects contribute to the SEWP's objectives in the 19 Widening countries. Out of a total of EUR 254 million allocated, 73% went so far to partners from low R&I performing countries. The number of projects currently under implementation varies among countries with Portugal, Estonia, Poland and Cyprus being most successful in terms of participation. **The Teaming action has attracted a lot of attention at political level, with submitted proposals either coordinated or supported financially by national or regional authorities**.[197] Equally, countries took the initiative to link the actions with their Operational Programmes in the European Structural and Investment Funds (ESIF) (e.g. Poland, Czech Republic). **The objective of strengthening framework conditions for R&I is pursued primarily by the Policy Support Facility**[198] **providing on-demand advice to policy makers on national R&I systems**.[199] Bulgaria, Czech Republic,

[195] The current ongoing projects (Teaming phase 1, Twinning and ERA Chairs) represent only 14% of the total available budget for the SEWP. The Teaming phase 2 projects, which have been approved but do not appear yet in the financial reporting because the grant agreements have not been signed yet, will allocate additional 17% of the SEWP budget (10 phase 2 projects of maximum EUR 15 million each) which is a significant investment for the selected institutions and countries.
[196] http://cordis.europa.eu/project/rcn/200260_en.html
[197] In several countries (e.g. Poland), national competitions were held by relevant Ministries in order to identify the best proposals for facing the competition at the European level – a first in the history of Framework Programmes.
[198] Available at: https://rio.jrc.ec.europa.eu/en
[199] It has so far provided/is providing support to eleven countries. Bulgaria, Czech Republic, Hungary, Latvia, Slovakia and Slovenia belong to the group of countries which currently combine the Widening actions with PSF and will also benefit of significant investments for Teaming 2.

Hungary, Latvia, Slovakia and Slovenia are currently combining widening actions with the PSF and will also benefit from investments for Teaming 2.

Together with Teaming, Twinning and ERA Chairs, COST[200] (promoting networking and connecting pockets of excellence) also plays a role in improving the international positioning of the R&I stakeholders in each country: there are currently 3234 ongoing participations in projects in Widening countries within the COST programme.

Box: Spreading excellence in Europe - Examples across Horizon 2020

In **Research Infrastructures**, a Memorandum of Understanding was signed in October 2016 between the CERIC-ERIC and SHARE-ERIC networks of research infrastructures to boost regional cooperation and collaboration in different fields (active ageing, transport and connectivity, education, research and innovation) and support scientists from low R&I performing countries to access research infrastructures.

The **European Institute of Innovation and Technology (EIT)** widened the geographical coverage of its Knowledge and Innovation Communities (KICs) by mainstreaming the EIT Regional Innovation Scheme (RIS) actions into KICs activities and earmarking a dedicated budget for 2016 activities. The RIS initiative is targeted at countries which have no participating organisations into the existing KICs and belong to the 'moderate and modest innovators' groups identified in the 2015 Innovation Union Scoreboard.

In the **Bioeconomy/biotechnology** field a Letter of Intent was signed[201] in 2016 between the Bio-based Industries Joint Undertaking (BBI JU), its private member, Bio-based Industries Consortium (BIC), and 8 Polish regions for cooperation and awareness raising in the regions. The Lodz Bioregions Declaration[202] aims to establish a Central and Eastern European Bioregions Forum for the development of bioeconomy at local and regional levels, and to help establish synergies in the implementation of ESIF, including research, education and training, transfer of knowledge and other activities.

The **European Research Council (ERC)** also takes measures to enhance the awareness of the ERC grants schemes in countries which have been relatively unsuccessful in hosting ERC Principal Investigators, following a Working Group on Widening European Participation set up in 2013. The ERC also published guidelines for public authorities and other organisations that wish to set up fellowship programmes to fund short-term visits of potential ERC applicants to current ERC grantees' teams. Five countries - Czech Republic, Estonia, Hungary, Poland and Slovenia - as well as the Belgian region of Flanders, have set up such fellowship programmes so far.

64.7% of the stakeholder consultation respondents agreed fully or to a large extent that Horizon 2020 helps spread excellence and widen participation. The share is similar for EU-15 and EU-13 respondents, but respondents from third countries (72.3%) and associated countries (67%) are more positive. The most positive types of stakeholders are SMEs and individuals whereas the least positive are NGO.

Stakeholder position papers: Widening participation is crucial, but should not come at expense of excellence.

In their position papers, some stakeholders representing different stakeholder groups commented on a need for a more balanced participation of different stakeholders within the Horizon 2020 programme and in general welcomed the "Spreading excellence and widening participation" activities of the programme. Most commonly, stakeholders mentioned low participation rates of EU-13 due to their lower research and innovation capacities. However, there seems to be an agreement that this issue should not be addresses by changing the nature of the current research funding which is based on excellence. Some other solutions were proposed such as: greater use of the European Structural and Investment Funds (ESIF) for capacity building in research and innovation or for financial incentives to catch up with research systems, follow-up and opening of the twining and teaming mechanisms, introduction of a milestone prize mechanisms, extension of the ERA Chairs to early stage researchers; and introduction of bottom-up networking instrument for experienced researchers across Europe.

[200] Available at: http://www.cost.eu/
[201] European Bioeconomy conference, Lodz/Poland, 6-7/10/2016
[202] Available at: http://bioeconomy.lodzkie.pl/wp-content/uploads/dekl_en.pdf

8.1.2. Progress on improving R&I integration

One key objective of Horizon 2020 is to support the integration of R&I efforts across Europe by building trans-national and cross-sectoral bridges. Early evidence indicates that the programme is making progress on these fronts.

8.1.2.1. Collaboration between businesses and academia

The intersectoral collaboration patterns within projects is analysed under Efficiency (7.4.5). Looking at the types of outputs generated so far, **across the whole programme more than one publication out of 5 (21.5%) is so far based on the cooperation between academic and private organisations**. Going beyond traditional research and innovation projects, MSCA feature non-academic sector partners playing a strong role in joint researcher training projects and 25% of its publications are public-private co-publications. Also based on their thematic assessment FET projects – involving also high tech research intensive SMEs - have the potential to improve R&I integration and help achieve the EU's goal of becoming the world's leading research area and market for digital technologies by spreading new ideas, methods, approaches or technologies into the industrial R&D community. Thanks to their long duration, FET Flagships specifically enable the participating research groups to build up expertise and create durable links between academia and industry[203]. Also, while the involvement of industry (including SMEs) in the Research Infrastructures activities and projects is still limited, a number of targeted measures were launched to increase their interaction with industry in particular as regard the supply of high tech components.

8.1.2.2. Integrating the knowledge triangle of higher education, science, and innovation through the European Institute of Innovation and Technology

As part of Horizon 2020, the European Institute of Innovation and Technology (EIT)'s specific objective is to integrate the knowledge triangle of higher education, research and innovation and thus to reinforce the Union's innovation capacity and address societal challenges. The EIT is designed to achieve its goals primarily through the Knowledge and Innovation Communities (KICs) [204], which bring together higher education institutions, research organisations, industry and other stakeholders to create critical mass needed to stimulate innovation and operate in specific societal challenges. In the period covered by the Horizon 2020 interim evaluation, KICs operated in the fields of climate change, health, energy, raw materials and the digital economy and society.

The independent external evaluation of the EIT[205] has found that, even though the EIT has contributed to progress in addressing specific structural weaknesses in the EU's in-

[203] For example, in the GRAPHENE Flagship, this is key for advancing technology through different Technology Readiness Levels and for completing value chains needed to achieving tangible societal and industrial impact.

[204] The KICs are independent legal entities, structured around a partnership of core partners representing all sides of the "knowledge triangle". Each KIC has to develop and deliver a portfolio of activities in three areas: (i) Research/ Innovation projects: the KICs link universities, research institutes and business through their innovation project portfolios. Innovation projects comprise demonstrators, pilots, proofs of concept etc. All innovation projects are required to develop clearly identified products that address a specific business opportunity that is supported by a market study; (ii) education: a set of post-graduate (MSc/ PhD) programmes and executive/ professional development courses characterised by a multidisciplinary approach, significant business involvement in the development of learning outcomes and often, cross-border mobility; (iii) business creation and support activities: a range of business support services, often badged as a start-up accelerator scheme, to help entrepreneurs translate their ideas into successful businesses. These services focus on areas such as support for technology, market assessment, access to human resources and seed and venture capital through specific KIC innovation funds

[205] The independent external evaluation of the EIT is a mandatory requirement from the Regulation (EC) No 294/2008 as amended by the Regulation (EU) No 1292/2013 establishing the EIT (EIT Regulation).

novation capacity, there is a strong need to pursue the EIT's mission to integrate the knowledge triangle of higher education, research and innovation including industry.

The performance audit issued in April 2016 by the European Court of Auditors[206] contained a set of recommendations which are in an advanced stage of implementation. Further recommendations have been given through the report of the High-Level Group appointed by Commissioner Navracsics.[207] In particular, an amended EIT legal basis, revising the EIT's funding model, is expected to be tabled to the European Parliament and Council at the beginning of the second quarter 2018.

Most of the objectives/actions defined in the 2013-2015 EIT business plans have been accomplished, which is demonstrated by fact that **the EIT has achieved most its targets set for the KPIs and other indicators**, as shown by the figures below.

Figure 59 Key Performance indicators for the EIT

Indicator 1: Organisations from universities, business and research integrated in the Knowledge and Innovation Communities (KICs)		**2014**	**2015**	**2016**
	Target	240	450	500
	Actual results	550	800	1052*
Indicator 2: Collaboration inside the knowledge triangle leading to the development of innovative products, services and processes		**2014**	**2015**	**2016**
# Start-ups and spin-offs set-up	Target	30	280	400
	Actual results	181	250	381*
# Innovations	Target	300	800	1500
	Actual results	1184	2145	3565*

***** *Expected results, based on the indications in the KICs´ business plans. Source: EIT*

Figure 60 Innovation KPI performance of the KICs (2013-2015) [208]

Indicators	**2013-2015 Actual**	**2013-2015 Target**
Number of eligible applicants for EIT labelled PhD and Master programmes	12,783	11,577
Number of available seats for EIT labelled PhD and Master programmes	3,168	1,864
Number of new graduates	776	842
Number of business ideas incubated	1,249	1,076
Number of start-ups/spin-offs created	216	310
Number of knowledge adoptions (by KIC partners) that are direct output of a KIC Activity	429	326
Number of knowledge transfers (from one KIC partner to another KIC partner or to third parties) that are direct output of a KIC Activity	308	260
New or improved products/services/processes launched	212	290

Source: EIT

[206] European Court of Auditors, Special Report 04/2016, http://www.eca.europa.eu/Lists/ECADocuments/SR16_04/SR_EIT_EN.pdf

[207] European Commission, The Future of the European Institute of Innovation and Technology (EIT) – Strategic issues and perspectives, https://ec.europa.eu/education/sites/education/files/eit-hlg-final-report_en.pdf

[208] The figures concern the outputs and results of the three first wave KICs (which comprises EIT Digital, EIT Climate and KIC InnoEnergy), over the period 2013-2015. Note that the each KIC has also a set of KIC-specific KPIs that – as the core KPIs – are annually tracked, reported and audited.

The number of start-ups and spin-offs set-up by the KICs is slightly below the target, even though KICs keep on generating new ventures at a faster pace. Business ideas are screened by the KICs, only the most promising ones are then passed to the following support stages (and encouraged to be transformed into new ventures); this aspect might partially explain the gap between target and actual results. Furthermore, some ideas might need a longer incubation period before being translated into a marketable proposal. Figures related to support to innovation show that those activities are producing outcomes beyond the initial expectations, as evidenced by the adoption and the transfer of knowledge within the KICs and towards external partners. The only indicator that falls behind is the one related to new products/services/processes launched; 73% of the target has been achieved. According to the survey of KIC partners, 70% of KICs´ partners believe that the KICs have been 'effective' or 'very effective' in supporting knowledge transfer between businesses and universities/ research organisations.

In the EIT stakeholder consultation, almost **90% of respondents said that Europe's innovation capacity depended on bringing together education, research, business and other innovation actors (knowledge triangle integration).** Furthermore, over 80% of stakeholders think that EIT's focus on specific societal challenges in the Horizon 2020 context is important. Overall, stakeholders have recognised the EIT's progress in bringing together education, research and business organisations to create pan-European networks in specific fields.[209]

8.1.2.3.Trans-national cooperation

Most of the EU-funded projects are collaborative projects with at least three organisations from different EU Member States or Associated countries, which is reflected in the trans-national co-publication patterns. Based on an analysis of co-publications **whereas scientific networks are widening within the EU-28 to include more smaller countries compared to FP7 the breath of the networks at international level is decreasing, which is a cause for concern given the higher impact of internationally co-authored publications.**

At the EU-28 level, based on an analysis of publications, the most frequent co-publications occur between the larger and more R&D intensive countries. The smaller research nations do collaborate often with each other and with at least one of the R&D intensive nations. The most represented countries in Horizon 2020 publications are Germany, the Netherlands, the UK, France, Italy and Spain. Whereas Germany, the Netherlands and the UK continue to co-publish largely between themselves as observed in FP7, Belgium and France also joined this trend under Horizon 2020. Spain and Italy remain part of their own group but are now co-publishing more with smaller Member States, including Cyprus, Romania, Croatia and Greece. While the Nordics and Ireland formed their own group under FP7, they now collaborate more with the eastern European countries. Further analysis of cooperation networks is provided under Section 10 on the EU added value of Horizon 2020.

Supporting the 'Open' character of the programme, **Horizon 2020 publications including authors from associated and third countries score up to more than three times as much as much as the world average**[210]. The most frequent co-publications occur between the EU28 group, the USA, Japan, Canada, China, Russia and Switzerland, just as in FP7. In addi-

[209]http://ec.europa.eu/dgs/education_culture/more_info/consultations/european-institute-innovation-technology_en.htm
[210] Study on overall output of select geographical group comparators and related FP7- and Horizon 2020-funded publication output, Elsevier, 2017.

tion, in FP7 many countries collaborated in publications with only one other EU28 Member State, and this has so far also been the case for Horizon 2020. However, under FP7 many non-EU countries also had extensive links with other non-EU countries, whereas under Horizon 2020 this link is currently only observed with the USA[211].

Box: Trans-national circulation of knowledge – Example from ERC and FET

ERC: The share of ERC publications with international co-authorship is 56% and 34% of all ERC reported publications have at least one author affiliated to an institution based in a non-ERA country. For the ERC top 1% highly-cited publications this rate is 46%. The collaboration with third countries is most intense with US-based authors: 22% of all ERC reported publications have at least one US-based author or 64% of ERC reported publications written in a non-ERA collaboration (75% if only top 1% papers are considered). Another indication that ERC is viewed positively on the global stage is that since 2012 a series of "Implementing Arrangements" have been negotiated with peer funding organisations around the world providing opportunities for early-career scientists supported by non-European funding agencies to temporarily join a research team run by an ERC grantee in Europe. Also, the proportion of ERC grantees with non-ERA nationality in Horizon 2020 is about 9.1% (compared to 7.1% in FP7). However many of these were already based in Europe at the time of application. On the other hand, around 23% of the PhDs and post-docs in ERC teams were from outside Europe, the largest number being from China, the USA and India. This shows the potential of ERC PIs to attract talented early-stage researchers to Europe from around the world.

FET: The GRAPHENE Flagship has already held several international collaboration workshops with the USA, Japan and Korea, and has now put in place mobility funding grants for young researchers, in close collaboration with the US-National Science Foundation.

8.1.2.4.Interdisciplinarity

Interdisciplinarity is promoted throughout Horizon 2020 in order to develop solutions going beyond the scope of a single discipline or area of research practice. According to a study run by Elsevier[212], **the share of Horizon 2020 publications which are inter-disciplinary is relatively high and slightly increasing as compared to FP7.** For the EU-28, out of their total number of Horizon 2020 publications, 7.55% is inter-disciplinary (compared to 7.45% in the first three years of FP7). For EU-15, their share is 7.29% (compared to 7.53% in the first 3 years of FP7). For EU-13, their share is 10.19% (compared to 5.87% in the first 3 years of FP7). This means that **the EU-13 produces more inter-disciplinary publications when compared to the EU-15** and that the share of inter-disciplinary publications of the EU-13 countries in Horizon 2020 has doubled compared to their inter-disciplinary publications in FP7.

The Future and Emerging Technologies programme has so far 1,278 participations of researchers in world-class research teams pursuing grand interdisciplinary scientific and technological challenges. The range of topics addressed is very broad, e.g. Artificial Intelligence for creativity, robots inspired by living creatures; artificial limbs that can feel as well as move; understanding financial crises and global epidemics; unbreakable cryptography, artificial photosynthesis, quantum technologies, the human brain, new materials like graphene, nanotechnologies, and next-generation computing.

[211] For more information see section on EU Added Value
[212] Elsevier, Study on overall output of select geographical group comparators and related FP7- and Horizon 2020-funded publication output, forthcoming

Box: Interdisciplinarity in Future and Emerging Technologies (FET)

Interdisciplinarity is the hallmark of FET, with projects involving fields as diverse as ICT, engineering, biology, medicine, mathematics, material science, neuroscience, energy, music, economics, finance, climate science and many more. FET calls for genuine exchanges and mutual learning among distant disciplines, sometimes even creating new fields of enquiry at their intersection (e.g., neuro-IT). As an illustration, to achieve their objectives and technology development targets, each of the two FET Flagships seeks to foster synergies and establish collaboration across 100+ partnering organisations. The Flagships Panel recognises that, by bringing together researchers from different scientific disciplines and technology fields, the Flagships started creating an unprecedented level of collaboration and community building in Europe. For example, in 2016, HBP released its six ICT Platforms, which are the core of the emerging HBP research infrastructure for brain research. This was the result of an extensive multidisciplinary effort involving more than 750 scientific collaborators and engineers from 114 institutions in 24 European countries.

When looking only at the interdisciplinary Horizon 2020-funded research, the Field Weighted Citation Index (FWCI) for the period so far indicates that these **Horizon 2020 interdisciplinary publications are cited 78% more than the world average in this field** (FWCI of 1.78) and this is rising on a per year basis. As already highlighted in section 8.1.1.4, the FWCI of all Horizon 2020 publications so far, compared to the world average, is 2.46, which indicates that Horizon 2020 interdisciplinary publications have so far a relatively lower scientific impact than Horizon 2020 field-specific publications.

8.1.3. Contribution of Horizon 2020 to the achievement and functioning of the European Research Area

Horizon 2020 shall support the achievement and functioning of the European Research Area (ERA).[213]

According to the Treaty, it is the European Union's objective to strengthen its scientific and technological bases by achieving a European Research Area ('ERA') in which researchers, scientific knowledge and technology circulate freely, and by encouraging the Union to advance towards a knowledge society and to become a more competitive and sustainable economy in respect of its industry. **The Horizon 2020 funding measures are crucial to accompany the realisation of ERA, notably through their effect on coordination, common agenda setting and pooling of resources, and to continue shaping the landscape of European research institutions.** But, on its own, Horizon 2020 cannot change the structure of national research policies and systems nor remove the legal and practical obstacles for achieving the ERA.

As discussed earlier and summarised in the Table below Horizon 2020 supports the ERA policy priorities (e.g. researcher mobility and careers, research infrastructures, knowledge transfer, etc.), the monitoring of progress and foster stronger partnerships with Member States and the private sector to invest more efficiently. It leads by example in gender, ethical issues and Open Access to research results and encourages the development of framework conditions to help European searchers to remain in or to return to Eu-

"Horizon 2020 contributes considerably to establishing the European Research Area based on excellence. Mobility and bottom-up grants are vital instruments in this regard. Expected impact in SC6 often calls for unified solutions (one best practice to be implemented in all European nations). If H2020 made more room for diversified approaches, considering different geographical levels, instead of looking for only one possible European approach, the total European added value might increase further."

Denmark. Copenhagen Business School

[213] Article 5 of the Horizon 2020 Regulation.

rope, and make Europe a more attractive destination for the best researchers. A number of related actions that started with FP7, like ERAnets and the pilot ERA Chairs initiative are pursued in Horizon 2020. New initiatives, like the "Teaming Competition for Excellence" and a more focused strategy of international cooperation are introduced in Horizon 2020 to better serve the objectives of ERA to promote scientific and technological excellence of the EU. **Horizon 2020 provides support to Member States and the main stakeholders in implementing the ERA reform agenda** across six key priorities, progress of which is summarised in the Table below.

75% of the stakeholder consultation respondents think that Horizon 2020 is fully or to a large extent 'helping to support the development of the ERA, a unified area open to the world, in which scientific knowledge, technology and researchers circulate freely'. Only 2.2% do not share this view at all. The least positive are umbrella organisations representing businesses and NGOs.

Figure 61 State of play on ERA priorities

ERA priority	Horizon 2020 support	State of play[214]
More effective national research systems	New 'Policy Support Facility' tool[215]	Most countries have made progress in the field of research excellence (average increase 6.4% over the period 2010-2013 and almost all of them have adopted national strategies for research and innovation). Several Member States are redefining their National R&I strategies further based on a broad concept of innovation, encompassing education, research and innovation to achieve greater efficiencies
Optimal transnational co-operation and competition on common research agendas, grand challenges and infrastructures	Public-Public Partnerships, European Strategy Forum for Research Infrastructures	The Framework Programmes since FP6 provide support to P2Ps, rising from EUR 380 million in FP6 (2.1% of the budget) and mobilising around EUR 1.25 million national funding to about EUR 2.5 million in Horizon 2020, representing 3.1% of its budget and expected to mobilise EUR 6 to 8 million national funding for transnational R&I projects. Participating countries consider the P2Ps as a cornerstone of the programme and key to the achieving of the ERA: ten Joint Programming Initiatives have been launched to date and all have adopted Multiannual Implementation Plans. In addition, in 2014-2016, some 48 ERA-NET Cofund actions were selected for funding. The European Commission has been working with the European Strategy Forum on Research Infrastructures (ESFRI) and the major result of this work is the ESFRI Roadmap. First published in 2006 and after its updates in 2008, 2010 and 2016, the ESFRI Roadmap identifies vital needs for new European Research Infrastructures for the next ten to twenty years. It is doing so in various scientific macro-domains, ranging from health and environment to social and cultural domains. The ESFRI Roadmap consists currently of 21 ESFRI Projects that are well advanced from a maturity point of view and 29 projects that have reached already their implementation phase, so-called ESFRI Landmarks. 13 pan-

[214] European Commission, 3rd ERA Progress Report: The European Research Area: time for implementation and monitoring Progress, 2016

[215] The Policy Support Facility provides topic-specific (mutual learning exercises) or country-specific (peer reviews of national R&I systems, or specific support to a policy reform) support at the request of Member States. Two Member States and one associated country have already been reviewed, while many other requests are arising. Recurrent feedback received on the PSF work has shown that the operational recommendations formulated by leading experts and policy practitioners prove valuable as catalysers and to support countries in implementing national R&I reforms. For example, the renewed Science Agenda of Bulgaria pays particular attention to the recommendations formulated by the dedicated PSF Peer Review.

ERA priority	Horizon 2020 support	State of play[214]
		European facilities are based already on the new EU Regulation - the European Research Infrastructure Consortium, ERIC - which entered into force in 2009 and at least four more ERICs are expected to be launched in 2017. Horizon 2020 funding aims at supporting the different phases of the research infrastructure life cycle from the preparation, implementation and long-term sustainability to the efficient operation and transnational access and use of research infrastructures. Preliminary results indicate that the number of national research infrastructures (networked thanks to Horizon 2020 support) was 363 by the end of 2015. The target by the end of Horizon 2020 is 900.
An open labour market for researchers facilitating mobility, supporting training and ensuring attractive careers	Euraxess, Marie Skłodowska-Curie actions and Resaver pan-European pension scheme	The number of research positions advertised on EURAXESS Jobs (as at November 2016) comprised 278,518 job vacancies and 64,777 fellowships .The number of Euraxess posts has increased by 7.8% a year on the period 2012-2014.
Gender equality and mainstreaming in research Encouraging gender diversity to foster science excellence and relevance	Gender integration across Horizon 2020, Science with and for Society funding scheme	Horizon 2020 integrates gender as a cross-cutting issue and funds institutional change in research organisations through the 'Science with and for society' funding scheme under Horizon 2020. The number of women grade A professors has increased on average by 3.4% over the period 2007-2014.
Optimal circulation and transfer of scientific knowledge for access and uptake of knowledge by all	Communication and dissemination of programme results, demonstration and pilot projects	Open access to peer-reviewed scientific publications resulting from Horizon 2020 is mandatory since 2017. The use of a Data Management Plan is required for projects participating in the Open Research Data Pilot. Based on 2014-2015 figures 65.4% of the projects covered by the scope of the pilot on Open Access participate in the pilot and 34.6% opted out for IPR reasons, personal data protection concerns, national security or other reasons. Furthermore, outside the areas covered by the pilot, a further 11.9% of projects participate on a voluntary (opt-in) basis. In order to comply with the open access publications requirement, beneficiaries must, at the very least, ensure that their publications can be read online, downloaded and printed. In 2014, approximately 52% of EU-28 publications were available in Open Access.
International cooperation	General openness to participation in programmes by any researcher in the world	The number of scientific co-publications with non EU countries increased on average by 4.1% over the period 2005-2014.

Source: ERA progress report 2016

8.2. What is the progress made towards achieving innovation and economic impact?

The objective of Horizon 2020 is to speed up development of the technologies and innovations that will underpin tomorrow's businesses and help innovative European SMEs to grow into world-leading companies.

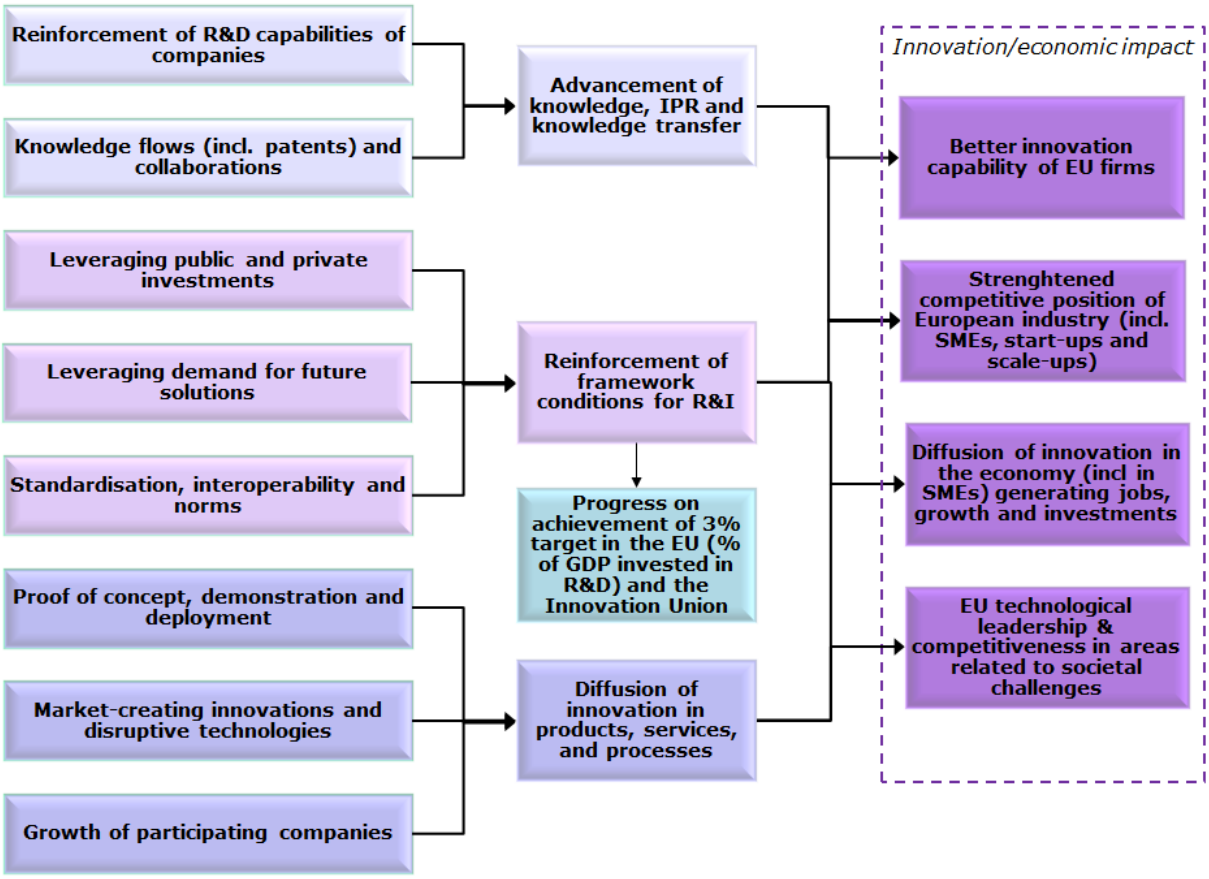
Expectations from Horizon 2020 for achieving innovation and economic impact

Compared to FP7 Horizon 2020 is providing a **stronger emphasis on supporting closer to market applications and innovation**. Based on the Horizon 2020 impact assessment, it is expected that the 'seamless support form research to innovation, from idea to market' will al-

low for supporting all stages in the innovation chain through in particular more support for closer to market activities and an improved framework of public-private partnerships.

Figure 62 provides an overview of the approach used for analysing progress towards the achievement of innovation and economic impact. Overall - from the review of the programming documentation - it is expected that this will lead to a better innovation capability of EU firms; a strengthened competitive position of European industry; a European technological leadership and competitiveness in areas related to societal challenges; and the generation of jobs, growth and investments through the diffusion of innovation in the economy. These changes are expected to depend on the advancement of knowledge and technologies, IPR and knowledge transfer (reinforcement of R&I capabilities of companies, knowledge flows and collaborations), on the reinforcement of framework conditions for R&I (leveraged demand for future solutions, leveraged investments and standardisation and interoperability) and the delivery of close to market outputs and diffusion of innovation in products, services and processes (proof-of-concept, demonstration activities, innovations on the market, growth of participating companies).

Figure 62 Approach towards analysing progress towards innovation & economic impact



Source: European Commission

Summary box: Key findings on the progress towards achieving innovation & economic impact

- ✓ Horizon 2020 is creating networks between businesses, and between the business sector, universities and research institutions, which is key for bringing knowledge quickly to market and gaining industrial leadership.
- ✓ Horizon 2020 provides companies, and in particular SMEs, with access to risk finance to carry out their innovation projects, thereby addressing an important market failure.
- ✓ Horizon 2020 invests in demand-driven innovation through innovative instruments including procurement and prizes but with low levels of take-up so far.
- ✓ Horizon 2020 already generates large numbers of high quality, commercially valuable patents and other intellectual property rights.
- ✓ Horizon 2020 already generates proofs of concept and demonstrators and supports the deployment of innovative solutions supporting the commercialisation and diffusion of innovation.
- ✓ Horizon 2020 projects already produce new knowledge, strengthen capabilities, and generate a wide range of innovation outputs including new technologies, products and services.
- ✓ Horizon 2020 has potential in terms of generating breakthrough, market-creating innovation but such support can be strengthened substantially.
- ✓ Technological, regulatory, standards, technical and access to finance, as well as lack of customer acceptance of new solutions may impede Horizon 2020's full effectiveness in terms of market uptake.

8.2.1. Progress on advancing knowledge, IPR and knowledge transfer

One key objective of Horizon 2020 is to support the advancement of knowledge, IPR and knowledge transfer through the reinforcement of the R&D capabilities of companies, the creation of collaboration networks and public-private partnerships. Early evidence indicates that the programme is making progress on these fronts.

8.2.1.1.Reinforcement of R&D capabilities of companies

Under all programme parts **the development of new knowledge and related learning effects are amongst the most frequent outputs expected** from the projects. For private partners, acquiring new knowledge and building R&I capacity are decisive economic factors and even more for SMEs. As an illustration 49% of ICT project participants surveyed expect a high project impact on their ability to innovate, which is a prerequisite for the activities to achieve an impact in research, development and demonstration.

> *Horizon 2020 is the opportunity to establish R&D Know-How and expand your network of partners.*
> Austria, Fronius International GmbH

8.2.1.2.Knowledge flows and collaborations

Figure 63 Horizon 2020 Key Performance Indicators related to knowledge flows and collaborations

Key Performance Indicators (KPIs)	Progress so far / Target
Knowledge flows and collaborations	
Patent[216] applications	153 Target: 3 patent applications per €10 million funding
Patents awarded	39

Source: Corda, Signed Grants cut-off date by 1/1/2017

[216] Based on beneficiary reporting.

Across the thematic assessments, **the partnerships and networks that are created, allowing for knowledge exchange and technology transfer, are considered critical success factors for future innovations**. The flow of knowledge between the stakeholder communities, thanks to the creation of networks and partnerships, as well as the transfer of technology, data and information among the participants as well as with the broader community constitute key elements for the creation and diffusion of innovation. As an illustration, a survey of LEIT-Space industry participants indicates positive progress especially in an improved positioning in the international community and a strengthening of their international partnerships (45%) and improved links with industry (35%). One in four respondents also indicated positive effects on R&D capabilities, links with academia, and access to new markets. A relatively high proportion of ICT project participants[217] also perceive a high impact of their project in terms of access to international technological/scientific networks (over 80 % of participants perceived a high or fair impact in this area). Collaboration with both developers and end-users are important areas where the ICT projects are perceived to have an impact by over 40% of participants. Research-industry collaboration patterns (including research-industry) are discussed in the preceding section 8.1 on scientific impact.

> *It provides the opportunity to small/medium companies to enter smoothly into international projects and cooperation schemes. It is a good school to benchmark the abilities/competencies of our organisation against other SME or partners. It teaches cross cultural management and risks. It is a great opportunity to open the mind or wider the mind of our staff.*
>
> France, GNSS Technologies

Regarding the key performance indicators related to knowledge flows through Intellectual Property Rights (IPRs), **beneficiaries of Horizon 2020 projects have declared 187 IPR applications[218]so far of which 69 were awarded**. These are very early indications, and the numbers will greatly increase as projects are completed. The vast majority consists of patents (153 applications and 39 awards[219]) and trademarks (24 applications which have been all awarded). The limited amount of applications from Horizon 2020 projects so far is related to the short time span under consideration and thus cannot be compared to FP7[220]. Not surprisingly given the higher Technology Readiness Level (TRL) supported (TRL of 6, demonstration level) and the shorter duration of projects (Phase 1 runs up to half a year, Phase 2 up to 2 years), two thirds of patent applications and of trademarks applications derive directly from the SME instrument (phase 2) projects, while 34 patent applications result from projects in ERC-Proof of Concept which are also shorter term (maximum 18 months duration). Cross-checking the information on IPR applications by type of action, 112 out of 144 IPR applications in LEIT and Societal Challenges stem from SME-instrument Phase 2 projects (93 patents, 15 trademarks and 4 others). On the other hand, a limited number of IPRs are so far attributable to Innovation Actions and to Research and Innovation Actions, despite the fact that these actions absorb more than half of the Horizon 2020 funding.

Considering that in FP7 18% of projects in the Cooperation theme have reported at least one IPR protection[221], these elements would suggest that, while single-beneficiary projects (SME instrument Phase 2 and ERC Proof-of-Concept) have been so far more successful than collab-

[217] Survey performed within the thematic assessment of ICT projects under Horizon 2020 (CARSA, forthcoming).
[218] Beyond patents and trademarks, this category includes also Utility models, Registered designs and other.
[219] The bulk of patents are expected to come in from 2018 onwards, as the usual project lasts four years. It is difficult to compare this with the number of the first years of FP7. For FP7, patent applications are registered cumulatively in the Commission's Respir system (which does not cover all parts of FP7, e.g. no ERC and JTIs). Up till February 2017, FP7 projects register 2,380 patent applications.
[220] The European patent grant procedure may take three to five years from the application date. European Patent Office, https://www.epo.org/service-support/faq/own-file.html#faq-274.
[221] RESPIR-SESAM Research Performance and Impact Reports (FP7). Report generated on: 2017/02/03.

orative projects in applying for IPR, it is likely that IPR applications deriving from projects in Innovation Actions and Research and Innovation Actions will take a more significant share in the near future. According to an external study based on counterfactual analysis[222], **EU-funded research teams are around 40% more likely to be granted patents or produce patent applications (25% of respondents produced at least one IPR output in 2015) than non-funded units** (18%). The data also show that the **patents produced in the FPs are of higher quality and likely commercial value than similar patents produced elsewhere**.

Example box: Nanopilot, a Horizon 2020 LEIT-NMBP project on nanopharmaceuticals

Nanotechnology applied to medicine (nanomedicine) promises more effective and better targeted drugs, with reduced side effects for patients, but these nanopharmaceuticals are still at a very early stage of development. The aim of NanoPilot (RIA; 6.3 million EUR; January 2015 – December 2018). is to establish a flexible and adaptable pilot plant for nanopharmaceuticals. It will provide specific tools and services to SMEs and researchers to validate their technologies and to be able to produce nanopharmaceuticals of sufficient quantity and quality to enter clinical testing. Not only does this help to overcome R&D challenges, but it also offers a solution to the high cost of manufacturing (e.g. clean rooms and special equipment), as well as compliance with regulatory requirements. Three different applications show the flexibility of the planned facility: the treatment of dry eye syndrome, a HIV nanovaccine and a drug for the treatment of painful bladder syndrome. The pilot line will be validated in the project and will continue its certified services after the project, for further drugs and diseases. The consortium includes the operator of the pilot line, an SME, two university institutes which develop the nanopharmaceuticals, and a specialist institute on nanosafety.

8.2.1.3. Specific focus on Public-Private Partnerships (PPPs), including Joint Technology Initiatives and Contractual PPPs (cPPPs)

Two different types of Public-Private Partnerships (PPPs) are implemented within Horizon 2020.

The Joint Undertakings (JUs)[223] are PPP[224] in industrial research at European level. Currently seven JUs organise their own research and innovation agendas[225] and award Horizon 2020 funding for projects on the basis of competitive calls: Clean Sky 2 (CS2), Fuel Cells and Hydrogen 2 (FCH2), Innovative Medicines Initiative 2 (IMI2), Electronic Components and Systems for European Leadership (ECSEL replacing ARTEMIS and ENIAC), Bio-based Industries (BBI), Single European Sky Air Traffic Management Research (SESAR) and Shift2Rail.

The contractual public-private partnerships (cPPPs) involve dedicated arrangements between the Commission and private associations representing industrial technologies interests. On the basis of mutually prepared roadmaps, cPPPs provide direct input into the preparation of priorities for Horizon 2020 Work Programmes in pre-defined areas of significant industrial relevance[226]. Currently there are, ten contractual public-private partnerships[227] set up directly un-

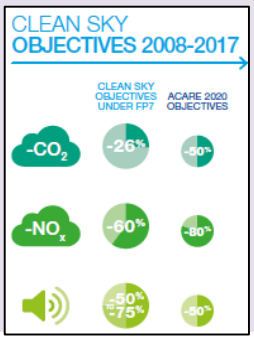
[222] PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming.
[223] Article 187 of the Treaty on the Functioning of the EU (TFEU) states that 'the Union may set up Joint Undertakings or any other structure necessary for the efficient execution of Union research, technological development and demonstration programmes'.
[224] In addition to the institutionalised PPPs, also the contractual Public-Private Partnerships (cPPPs) have a legal basis in Article 25 of the regulation establishing Horizon 2020. Please note that the assessment of cPPPs is not included in this document but will be part of the overall SWD, planned for 2017.
[225] An exception is the SESAR JU agenda which is set by the Member States and various Air Traffic Management. (ATM) stakeholders and the members of the PPP in the framework of the European ATM Master Plan.
[226] Moreover, depending on the cPPP, they can:

der Horizon 2020: Factories of the Future (FoF); Energy-efficient Buildings (EeB); European Green Vehicles Initiative (EGVI); 5G Infrastructure; Sustainable Process Industry (SPIRE); Robotics; Photonics; High Performance Computing; Big Data Value and - more recently – Cybersecurity. They are implemented through calls under Horizon 2020 with a total Union contribution of EUR 6.6 billion[228].

Example box: Public-private collaboration for greening European aeronautics – The Clean Sky Joint Undertaking

Launched in 2008 Clean Sky is the largest European research programme developing innovative, cutting-edge technology aimed at reducing CO2, gas emissions and noise levels produced by aircraft. Equally funded by the EU R&I framework programmes (FP7 and then Horizon 2020) and the industry, Clean Sky contributes to strengthening European aero-industry collaboration, global leadership and competitiveness. Through its six Integrated Technology Demonstrators, it aims to bring technologies to maturity that could, as a set of solutions, deliver a substantial majority of the environmental goals set under the Strategic Research and Innovation Agenda of the Advisory Council for Aviation Research and Innovation in Europe.

In 2017 the first Clean Sky programme is being finalised: some 20 large Demonstrators have been completed by 600 participants in 24 EU countries, bringing together thousands of experts from leading companies, universities, SMEs and research centres and thousands of components used in current aircraft and helicopters have been reviewed to identify the areas that can be significantly improved in order to reduce CO2 emissions and noise by 2020.



Clean Sky 2 is larger in scope than the initial Clean Sky Programme with a total budget of nearly €4 billion. Building on its predecessor's success, it aims to achieve a higher level of technology integration at aircraft level and to raise the maturity level of systems incorporating these new technologies. A regular schedule of two Calls for Proposals/Partners per year is foreseen through to 2020, with roughly €90 million available in indicative call value per year.

Example box: Public-private collaboration for keeping Europe at the forefront of technology development in Electronic Components and Systems – The ECSEL Joint Undertaking

ECSEL implements pilot lines which are large projects (IA) at high Technology Readiness Levels. These are providing a means for producing realistic research demonstrators in industrial environment, thus bridging the gap between research and innovation in the area of electronic components. This is a game changer for the increase of economic and innovation impact of EU funding to the strategic electronic components field. A similar type of actions is now implemented in the Photonic contractual Public Private Partnership with similar results and impact on the research and innovation ecosystems.

This section assesses the different types of PPPs on their openness, transparency and effectiveness based on an internal Commission assessment. More details are in the Annexes.

- help structure the research domain in the field including at Member State level, and contribute to the emergence of a real EU industrial policy in the field;
- support innovation take up;
- contribute to framing related policy issues, e.g. standard developments;
- help structure international cooperation issues in the field;
- provides a platform to link towards other sectors, especially in the context of identification of use cases.

[227] The first four take forward public-private partnerships established under FP7.

[228] Excluding budget for the Cybersecurity cPPP.

Box: Joint Undertakings monitoring data (February 2017)

- 35 JU calls launched and concluded.
- 1677 eligible proposals, involving 11.719 applications.
- 473 proposals (28%) retained for funding with a total EU financial contribution amounting EUR 2162.1 million.
- 351 signed grants totalling EUR 1.384,8 million of EU funding.
- Among the participants: 15.4% HES, 59.8% PRC and 18.7% REC. SME participation equals 19.5 %.

Contractual Public-Private Partnerships monitoring data

FoF, EeB, EGVI and SPIRE	5G, HPC, Photonics, Robotics, Big Data
➢ 27 calls launched and concluded ➢ 1,704 eligible proposals, involving 19,466 applicants. ➢ 231 signed grants totalling EUR 1.217,5 million of EU funding. ➢ Among the participants: 15.8% HES, 58.8% PRC and 20.3% REC. ➢ The number of SME participations is at least 29.9 % of the total.	➢ 6 calls (16 topics) launched and concluded ➢ 1,030 eligible proposals, involving 8,986 applicants ➢ 154 signed grants totalling EUR 713.3 million of EU funding ➢ Among the participants (in terms of funding): 33% HES, 40% PRC, 23% REC, OTH 2% and PUB 1%. In terms of participations: 30% HES, 45% PRC, 19% REC, 3% OTH and 2% PUB. ➢ The number of SME participations is at least 21% of the total.

More in-depth evaluations of Joints Undertakings and the Contractual Public-Private Partnerships will be available in Autumn 2017.

(a) Openness

Overall, the JUs and cPPPs demonstrate openness. All JUs have an open access policy towards membership. However, despite the straightforward and open criteria for membership, the size of the financial "entry ticket" or (annual) membership fees, influences substantially the type, size and/or composition of the entities that can become members and, hence, have access to the full package of JU benefits. Due to the substantial financial commitments that members have to make, SMEs, small universities and research organisations may face financial barriers in becoming a JU member. The openness to membership may also impact the participation in the Programme and the respective EU budget. The assessment shows that JUs apply an open participation policy in their programmes through the launch of "open calls". However, for several JUs, certain activities or topics and/or a predefined percentage of the budget is reserved for members only.

To demonstrate openness towards newcomers and players such as SMEs, small universities and research organisations, the JUs are applying a number of targeted measures ranging from applying variable levels of membership (e.g. full members vs. associated partners) with varying levels of (financial) commitments up to the launching of calls for proposals dedicated to non-members. Despite these efforts, many small stakeholders decide to abstain from membership due to the costly and long-term commitment expected from them. Instead, they prefer to participate in the open calls as "beneficiaries" rather than "members". With regard to SMEs, in addition to financial considerations that themselves constitute a barrier to membership, they sometimes face difficulties in participating in open calls. Poor networking capacities that deprive them from participating in strong and competitive consortia are a frequently cited reason. Conscious of these difficulties, the JUs take specific measures to stimulate and increase the presence of SMEs in their activities by, among others, providing for SME representation in the governing boards, simplifying the rules for participation, launching special calls for SMEs and defining call topics that are particularly appealing to SMEs. **Overall, considering**

the membership composition of the JUs and the top ranking beneficiaries in open calls, one can conclude that all JUs are attracting prominent players in their respective fields of activity not only in terms of size and position in the market but also in terms of R&D intensity and innovation potential.

The contents of roadmaps agreed in the context of cPPPs also feed into calls in the Horizon 2020 Work Programme and participants are subject to the same rules of participation as in other parts of the programme. For all the cPPPs agreed with the Commission, the percentage of EU funding allocated to non-members ranges from 47% to 77% depending on the partnership, and non-member participants make up from 54% to 77% in the 2014 calls. In addition, the associations constituting the private side are open to new members. In many industrial sectors and cPPPs, the associations work closely with related European Technology Platforms to develop their strategies and roadmaps. These platforms are also open to new members and do not require a financial commitment, thus opening up participation in particular to SMEs. SME participation varies across cPPPs and ranges from 11% to 35%.[229].**The strong participation of non-members, as well as highly innovative and research-intensive industrial players, shows that the priorities of the cPPPs are highly attractive to a vast range of stakeholders**.

Box: Joint Undertakings' openness in figures

- Overall for all JUs, 27% of the beneficiaries are newcomers.
- Overall 23,3% of JUs applicants are SMEs.
- SME Success rate for all JUs:
  - In terms of applications: 34,6%
  - In terms of requested EU contribution: 29,6%
- SME participation rate in JUs:
  - In terms of participations: 19,5% (slightly below Horizon 2020 overall : 19,9%)
  - In terms of EU contribution: 18,3% (significantly higher than Horizon 2020 overall: 15,9%)
- The JUs meet the Horizon 2020 objective of 20% participation rate for SMEs.

So far, JUs almost meet the overall Horizon 2020 objective of a 20% participation rate for SMEs. JU specific SME participation figures can be found in Annex 1.

Box: Participation in calls of Contractual Public Private Partnerships

cPPPs[230]	**FoF**	**EeB**	**EGVI**	**SPIRE**	**5G**	**HPC[231]**	**Photo-to-nics[232]**	**Robo bo-tics[233]**	**Big data[234]**
% of Non-members in the participations	77	75	67	73	71	62	80	58	78
% of Non-members in the EC funding	77	70	53	71	60	60	71	46	71
% of Industry in the participations	61	57	60	59	64	22	51	37	55
% of SMEs in participations	>35	>33	>15	>27	>17	>11	>28	18	>25

Source: European Commission

[229] cPPPs are not comparable with each other since not all of them have been active for the same time.
[230] Data referring to the 2014 calls (unless otherwise stated). Big Data cPPP entered into force on 1 January 2015, Cybersecurity cPPP on 5 July 2016.
[231] Approximate figures coming from 29 projects that started in 2015.
[232] Calculated for all funded projects in 2014-2016. The non-membership participation and funding is based on the 100 members of the board of stakeholders of the PPP.
[233] Relating to 2014-2016 calls.
[234] Calculated over all projects selected in the Big Data call of 2016. Both 'full members' and "associate members' of the Big Data Value Association (BDVA) are counted as 'members', the rest as "non-members".

The cPPPs are included in the Horizon 2020 Work Programme and applicants are then subject to the same rules of participation as in other parts of the programme. In particular, the percentage of participations from non-members is above 50% for all cPPPs, and in cases such as FoF, Photonics and Big Data a participation of above 75% is observed. The level of funding is also demonstrating this high participation from outside the cPPP association. **The average success rate in the cPPPs[235] is well above the overall average in Horizon 2020 at 11.6%.** In some cPPPs, the success rate demonstrated in terms of the ratio of successful proposals is far beyond this average, e.g. EGVI at 19.9% and SPIRE at 14.4%.

There is a major variation in EU-13 participation between the different cPPPs. At the same time, consortia that involve participants from the EU-13 are considerably more likely to be selected than quality projects that do not have members from the EU-13. By way of example, in the case of cPPPs under LEIT-NMBP, 41% of all selected proposals have at least one participant from the EU-13. Only 27% of the corresponding unfunded proposals in the same calls had at least one EU-13 participant. The highest participation of EU-13 partenrs (67%) is in the cPPP Energy-efficient Buildings projects. A significant finding is that both projects and quality proposals are very rarely coordinated by an organisation from the EU-13. As regards to newcomers to Horizon 2020, the overall average is 52.1%, as reported above. In the cPPPs under the NMBP programme, 33,0% had not participated in the previous Framework Programme. In addition, 54,6% had not participated in the NMP part previously, showing a large increase in interest for the programming under LEIT-NMBP.

(b) Transparency

The approach of the JUs towards their respective stakeholders is open and inclusive as they consider them as partners rather than competitors. The transparency of the cPPPs arises at two levels, at programming level, and at project level.

All JUs have put in place a wide range of mechanisms in order to ensure an open and non-discriminatory attitude towards their wider stakeholder community, including the general public. These mechanisms include various communication tools like an up to date, informative and interactive website, the use of social media, organisation of and/or participation in events, seminars and conferences and publications in written press. The JUs are employing the more "classic" range of communication tools but also other mechanisms that aim at enhancing inclusiveness and transparency, such as close cooperation and coordination with other JUs, including stakeholders' advisory bodies in their organisation and setting up separate Memoranda of Understanding with European regions seeking synergies with other (national and regional) programmes.

To disseminate project results as widely as possible, the JUs use a variety of tools. Most of them reserve a dedicated space on their website for the dissemination of project results and publishable project summaries; some also provide online a fully searchable project database. Project results are also widely communicated through publications and articles, social media and the organisation of, or participation in, dedicated events.

In general, JUs try to inform and raise the awareness of their beneficiaries on the existing common support services and existing IT tools provided to facilitate access to both project results and access to research data sets. However, only few beneficiaries so far seem to be

[235] 13,6% in the case of the calls for FoF, EeB, SPIRE, and EGVI for three call years, 2014-2016.

convinced and willing to take this extra step. A lack of resources to sustain and maintain data generated by the project beyond its lifespan is one of the cited reasons.

At the level of programming, the process involving industrial stakeholders includes publicly available strategic research agendas and roadmaps. There are also Partnership Boards between Commission services (DG RTD/DG CNECT) and the industrial association to ensure relevant needs and innovation trends are reflected in the programme. In addition, the Programme Committee configurations with Member State representatives for the various parts of Horizon 2020 give direct technical input on work programmes and are formally invited to support the work programme on the basis of a vote. Thus, national administrations have a major say on the contents of the work programme.

At the individual project level, all cPPPs are fully integrated in the Horizon 2020 dissemination platforms. Moreover, the associations organise public events, forums, publications and announcements to further the added value and impact of individual projects. Open access to data has been introduced in the cPPPs: all new projects are by default in the programme, unless they opt-out with a justification. A step beyond the Open Access to project results is the Open Access to Data.

(c) Effectiveness and European added value

The progress towards achieving the common Horizon 2020 and JU-specific objectives is measured by a set of Key Performance Indicators (KPIs) common to all JUs[236] and a set of JU-specific KPIs[237]. The contractual arrangements with the cPPPs build on industrial roadmaps with ambitious goals and KPIs related to technological achievements as well as market needs. For the JUs, the KPIs are regularly monitored and reported on in the Annual Activity Reports of the JUs. Overall on the basis of early and partial data available on the KPIs and on the basis of expected results of the already funded projects (no project reports are yet available), **the JUs seem to be on track in terms of carrying out their planned activities, achieving their specific objectives and ultimately contributing to the overall Horizon 2020 objectives**. A detailed overview of the JU specific KPIs and their first measurement or estimates can be found in Annex 1.

Under the cPPPs, projects typically address industrially relevant demonstrators and pilots to validate technology developments and integration at higher technology readiness levels. Among the industrial commitments established for the cPPPs, they have to report on the development of new types of high-skilled jobs and of new curricula. **The projects within the NMBP cPPPs have reported a wide range of results regarding new types of new high-skilled jobs, the highest average being in FoF (Factories of the Future), with 3.5 new jobs profiles per project. EeB (Energy-efficient Buildings) projects currently report 0.8 jobs per project, with 1.6 in FP7. EGVI also contributed to save time in performing research activities while structuring the whole value chain and avoiding duplication of efforts. Several similar initiatives have been implemented at national level, testifying to the benefit of this specific funding scheme**.

[236] Based on Annex II (PERFORMANCE INDICATORS) to Council Decision 2013/743/EU).
[237] With the exception of SESAR JU that is not subjected to a predefined set of KPIs.

First estimates (see Annex 1) demonstrate that the **JUs are well on track in achieving and, in some cases, exceeding their legally minimum foreseen leverage effect**[238]. In the case of the cPPPs under the NMBP thematic area, the current leverage factors range between 1.5 and 3.5.[239]

In EGVI projects, on the basis of 2014 estimates, the additional private investments are expected to lead to a leverage factor of 3. In the Photonics PPP, the industrial investment has been estimated as being 4.3. This is based on confidential information received from 80 companies for their investment in 2014-2015. As with the JUs, the overall leverage effect of each cPPP can only be assessed beyond the end of the programme.

Figure 64 Contractual Public Private Partnerships today

	First call year	Maximum EU Funding (million €)
Factories of the Future (FoF)	2009	1150
Energy-efficient Buildings (EeB)	2009	600
Green Vehicles (EGVI)	2009	750
Future internet (5G)	2014	700
Sustainable Process Industry (SPIRE) **Robotics**	2014 2014	900 700
Photonics	2014	700
High Performance Computing	2014	700
Big Data	2015/2016	534
Cybersecurity	2017	450

Source: European Commission

8.2.2. Progress on reinforcing framework conditions for R&I

One objective of Horizon 2020 is to help reinforce the framework conditions to perform R&I in Europe through standardisation and interoperability efforts, the leveraging of demand for future solutions as well as of public and private investments for R&I. Early evidence indicates that the programme is making only slight progress on these fronts.

8.2.2.1.Standardisation, interoperability and norms

In the context of the global market, the development and/or compliance with international standards is a critical factor in competitiveness. The progressive evolution of the focus of the programme towards higher TRL makes increased attention to the development of standards and/or stronger requirements for compliance with existing standards even more important for commercialisation success. **To support the commercialisation or diffusion of innovation in the economy, some projects aim at the development of standards and norms in particular under the LEIT programme but progress seem to be limited so far.** Under LEIT-NMBP, projects deal with standardisation mainly by referencing standardisation bodies and specific standards relevant to their field of endeavour. Regulation activities, standardisation and norms account for about 14% of the expected outputs from the LEIT-NMBP projects. LEIT-Space interviewees criticise the **limited attention to the issue of standardisation of products and services**, despite the fact that interoperability is considered overall as the key to success. In LEIT-ICT, where the contribution to standards is part of the expected impacts of a

[238] Leverage effect defined as total amount of funds leveraged through a JU divided by the respective EU contribution to this initiative. As the number of signed grant agreements increases, a more detailed reporting on the leverage effect will be possible. However, the overall leverage effect can only be assessed at the end of the programme

[239] On the basis of a methodology accounting only for current investments and discounting future investments.

number of topics, a specific action was introduced in the WP 2016-17 to reinforce the EU presence in the international ICT standardisation scene.

8.2.2.2.Leveraging demand for future solutions

The use of new instruments such as the pre-commercial public procurement (PCP), public procurement for innovation (PPI) and inducement prizes clearly aim at leveraging demand for future solutions. **Evidence of outputs so far is however still lacking on the effects of the PCP and PPI** since the first projects were signed only in 2015[240].

Given the current lack of information and the small scale of the PCP and PPI so far, the main type of action supporting more user-driven innovation and leveraging demand for future solutions in Horizon 2020 comes from the inducement prizes, which provide alternative opportunities to develop innovative solutions by offering a reward for completing a specific technological challenge[241]. The first ones were launched in 2015: five inducement prizes with a budget of EUR 6 million[242] together with three recognition prizes with an overall budget of EUR 1.33 million[243] were selected. Up to the end of 2016, 12 Horizon inducement prizes have been launched and six more will follow in 2017. They target challenges such as Sharing of Spectrum, Breaking the Optical Barrier, Aging population, Mother and child health, CO2 reuse, Clean car engines, Cyber security, Materials for Clean Air, etc. For example, EUR 1 million under SC1 *Horizon Prize for Better Use of Antibiotics* was awarded to Minicare HNL for developing a rapid test to allow healthcare providers to decide which patients with upper airway infections can be spared from antibiotics[244]. However, **overall more could be done to support demand for innovative solutions and user-driven innovation.**

8.2.2.3.Leveraging public and private investments

Figure 65 Horizon 2020 KPI related to leveraging public and private investments

Key Performance Indicators (KPIs)	Progress so far / Target
Leveraging public and private investments	
Total investments mobilised via debt financing	EUR 29 600 million (2014 to 2016) Target: €25 billion
Total investments mobilised Venture Capital investments	No data available yet[245]. Target: €25 billion
Number of organisations funded and amount of private funds leveraged	5 700 organisations funded & EUR 13 235 million of private funds leveraged. (2014 to 2016) Target: 5,000 organisations funded & €35 billion of private funds leveraged

Source: Data from European Investment Bank,

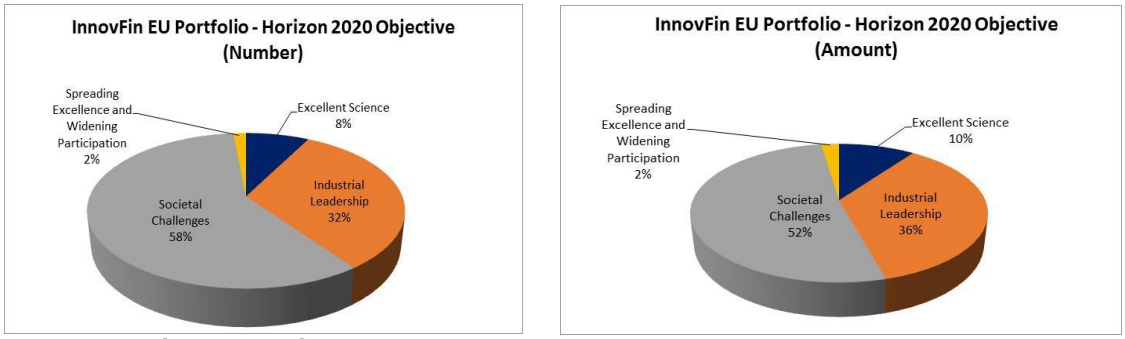
[240] In 2015, six projects were signed that are implemented through PCP or PPI (total EC contribution of EUR 18.5 million). Three PCPs of those are procuring early 2017, two other PCPs have finished the open market consultation and will start procuring soon. The PPI has not started procuring yet as certification of solutions is still ongoing. Three additional projects submitted under a deadline in 2015 were signed in 2016 (EC contribution of EUR 7.9 million). One PCP is already procuring, the other two PCPs of this batch are preparing the procurement. In the second semester of 2016 another 5 PCPs and 1 PPI projects from 2016 call deadlines were signed (EC contribution of EUR 25.2 million).
[241] They are only awarded based upon the achievement of the target set, solving the challenge defined
[242] There has been no budget executed yet.
[243] EUR 0.15 million of the budget has been executed so far.
[244] Available at: http://ec.europa.eu/research/horizonprize/index.cfm?lg=en&pg=prizes
[245] The instrument has been implemented as from 2015 after amendment to the Delegation Agreement between the Commission, the EIB and the EIF.

One key element for reinforcing the framework conditions for performing R&I in Europe is to ensure public and private funding are available beyond Horizon 2020 support from e.g. own funds of beneficiaries, risk capital, regional/national funds. While there is no official definition of leverage, it is assumed that it represents the additional investment mobilised by the project beyond the initial project total cost. This includes, for instance, venture capital investment or additional private/public investment in project results such as innovations. **Most projects are in their early stages and hence did not secure additional funding yet.** However, early evidence shows that **out of the 10,000 companies taking part in Horizon 2020, in the first three years 255 benefitted from the financial instruments in the Access to Risk Finance programme (InnovFin) for investments in scaling up**[246]. Under this programme, a total of 5,700 organisations have been funded – which is above the target set of 5,000 - and EUR 13,235 million of private funds leveraged (2014-2016) (target: EUR 35 billion). The total investments mobilised via debt financing in 2014/2015 is EUR 29 600 million, which is above the target of EUR 25 billion).

Stakeholders interviewed for the InnovFin interim assessment see the **effectiveness of InnovFin as particularly strong with regard to the objective of increasing private investment in R&I as well as increased risk financing (number of entities and volume of funds). They are more cautious about InnovFin's contribution to strengthening EU venture capital in terms of attracting institutional investments.**

The two pie charts below show the shares of the InnovFin EU portfolio going to different parts of Horizon 2020 in terms of amount and numbers of projects. In terms of both amounts and number of projects, most is going to Societal Challenges, followed by Industrial Leadership and Excellent Science.

Figure 66 InnovFin portfolio spread within Horizon 2020



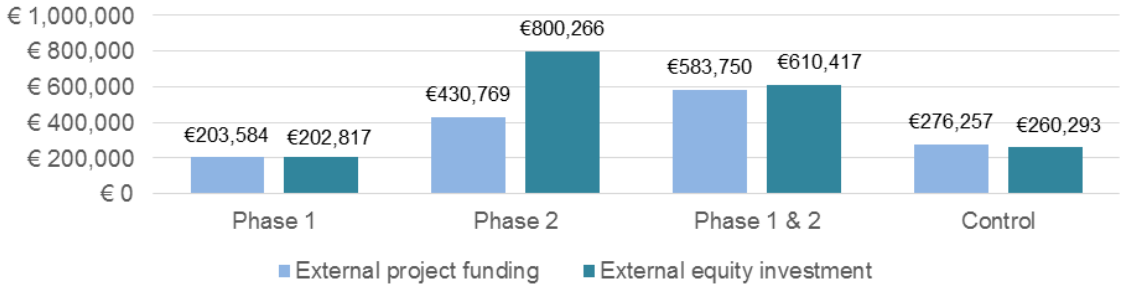
Source: Annual Operational Report, 2017

Also out of the 2,236 SMEs taking part in the SME Instrument by end-2016, 88 companies secured a total of EUR 481 million venture capital during or after the project.[247] These numbers are expected to increase in the years to come when more projects start delivering results. Based on the thematic assessment, SME Instrument funding indeed creates a leverage effect in the form of private co-funding of the innovation project. More private than public investors commit to co-financing SMEs that participated in Phase 2 projects, but the volume of public funding is increasing. The survey shows there is a **leverage effect of approximately EUR 800,000 per SME in Phase 2.** However the relatively small number of Horizon 2020 grant beneficiary firms accessing the Access to Risk Finance offer in their growth phase points to a

[246] Source : European Investment Bank, data per January 2017
[247] EASME, Accelerating Innovation in Europe, HORIZON 2020 SME Instrument Impact Report 2017 Edition

potential lack of integration/interconnection between the grant and non-grant based instruments available to firms at different stages of the innovation cycle.

Figure 67 How much funding have you attracted since you first applied or were first awarded an SME Instrument grant (excl. SME Instrument funding)?



Source: Technopolis, based on SME survey data, Sample size: 284 – 293 (Phase 1) 91 – 94 (Phase 2) 20 – 24 (Phase 1&2) 1,229 – 1,293 (control)

Box: The InnovFin Infectious Diseases (InnovFin ID) loan facility

The InnovFin Infectious Diseases (InnovFin ID) loan facility, launched in 2015, operated with the EIB aims to facilitate the development of innovative vaccines, drugs, medical and diagnostic devices or novel research infrastructures in the field of infectious diseases. By 1 October 2016, three deals have been concluded, with a total loan volume of EUR 45 million. The first loan went to the Swedish SME for the further development of a diagnostic device for HIV viral load testing[248]. The second loan was secured with the French biopharmaceutical company Transgene SA to develop new treatments for hepatitis, HPV-induced cancer and tuberculosis[249]. The third loan will help a Finnish IVD SME to finalise and scale up their manufacturing, validation and commercialisation of a diagnostic tool for Infectious Diseases[250].

The specific LEIT-NMBP survey of project's coordinators shows also positive signals with regard to additional investments in particular in the exploitation of results. 26% of LEIT-NMBP projects indicated that they have already invested additional funds – not initially budgeted – to pursue their exploitation objectives - mainly from private sources, but also public funds in a minority of projects. 91% of NMBP projects plan to mobilise additional funds to invest in exploitation. 29% of projects plan to rely exclusively on private funds for further commercialisation activities, while 62% plan to add public funds to the mix (private and public investment). In another field of intervention of Horizon 2020, the Teaming phase 2 projects under SEWP are expected to leverage more than EUR 100 million from public funding (ESIF and national) which are to be invested in complementary infrastructures and equipment.

Turning to the Public Private Partnerships (PPPs) and the contractual PPPs they aim to leverage private investment in key industrial sectors - with however different methodologies leading to differences in data interpretation. In both cases, the overall leverage effect of each PPP/cPPP can only be assessed beyond the end of the programme[251].

The results of a representative survey of Horizon 2020 project coordinators' point to a substantial self-declared leverage effect expected from their projects. 70% of the beneficiaries expect to secure additional R&D funding from private/industrial sources, and particularly in SC2, SC5, LEIT ICT, LEIT-Space and Fast Track to Innovation Pilot. Although this

[248] Available at: http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2015&na=na-130715
[249] Available at: http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2016&na=na-280116-2
[250] Available at: http://www.eib.org/infocentre/press/releases/all/2016/2016-175-finland-innovfin-european-support-for-innovation-in-finland.htm
[251] See dedicated section 8.2.1.3 on Public-Private Partnerships

result may be explained by the fact that beneficiaries of ongoing projects tend to overestimate their expected project outcomes, this is still a very high number and the success of the related activities should be further monitored in the future. In addition to private/industrial sources, a large majority of the beneficiaries expect to attract additional funding from other EU programmes (83%), public national/regional schemes (78%) and own sources (77%). Project coordinators based in the EU-13 expected to secure additional own and public national/regional funds less frequently than the EU-15 beneficiaries.

Figure 68 Do you expect that your consortium partners' involvement in the project will help them secure additional R&D funding in the future from the following sources? Horizon 2020 project coordinators (by funding source)

Horizon 2020 programme part	Own funding of project partners	Public national/regional schemes	Other EU programmes	Private/ industrial sources
Excellent Science				
FET (n = 15)	80 %	78.9 %	83.3 %	68.4 %
Research Infrastructures (n = 26)	76.2 %	95.5 %	100 %	77.3 %
Industrial leadership				
LEIT-NMPB (n = 95)	75,9%	71,7%	71,5%	72,4%
Subtotal within LEIT-NMPB: PPP projects (n=32)	63,8%	79,7%	75,9%	70,3%
LEIT-ICT (n = 182)	82,4%	81,5%	84,7%	82,5%
LEIT-Space (n = 36)	85,0%	92,1%	91,7%	81,5%
Innovation in SMEs (n = 32)	56,7%	58,3%	71,0%	32,6%
Societal Challenges				
SC1 (n = 100)	70,3%	74,7%	80,1%	68,0%
SC2 (n = 43)	83,9%	78,5%	88,1%	77,5%
SC3 (n = 131)	77,4%	75,3%	84,0%	66,9%
SC4 (n = 96)	74,2%	74,5%	77,2%	72,4%
SC5 (n = 71)	85,8%	85,7%	82,5%	76,4%
SC6 (n = 32)	80,8%	86,1%	88,5%	60,1%
SC7 (n = 31)	72,1%	76,8%	76,8%	71,3%
Spreading Excellence and Widening participation + Science with and for Society + other programmes				
SEWP (n = 24)	59.3 %	78.6 %	92.9 %	82.1 %
SWAFS (n = 9)	87.5 %	100 %	100 %	75 %
FTI Pilot (n = 10)	83.3 %	83.3 %	83.3 %	83.3 %
Euratom (n = 3)	100 %	50 %	66.7 %	33.3 %
Total	77.1 %	78.1 %	82.5 %	72.4 %
Total number of valid responses	**932**	**928**	**926**	**923**

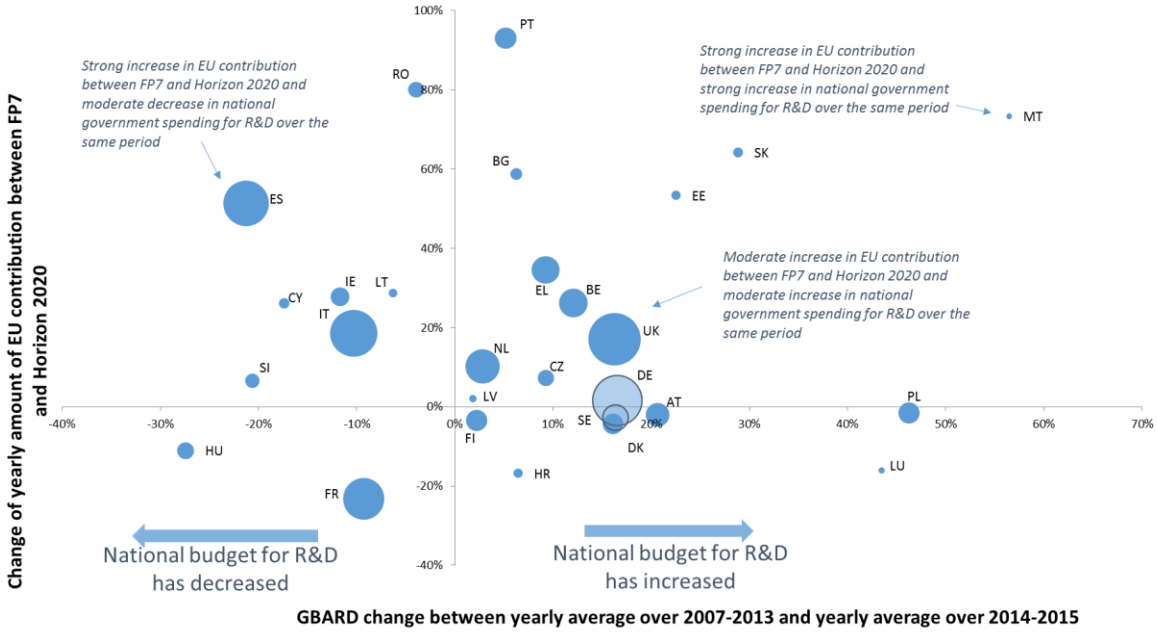
Note: This table shows the percentage of respondents who chose the "yes" option. N shows the maximum number of valid responses received to these questions in each Horizon 2020 programme part.Source: Survey of representative set of Horizon 2020 project coordinators, PPMI, 2016

Looking closer at the relationships between the different levels of R&I support, little statistical evidence is found about a complementarity or substitutability between funding received in the context of the Framework Programmes and the level of public funding for research at national and regional level. However comparing data on participation to the Framework Programmes at country level with national budgets for R&D over the same period still provides insights on the extent to which their evolution correlates or not.

All EU Member States are positioned in Figure 69 in terms of change in total government budget allocations for research and development (GBARD) and change in EU contribution received by participants in each Member State between the Framework Programmes[252]. 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 increased their national R&D budget. Participants from countries in the upper part of the graph receive in total more funding from the EU under Horizon 2020 than under FP7, while countries in the lower part receive less.

While some countries present simultaneously a decrease in their national budget for R&D and an increase in the EU contribution their participants receive from the Framework Programmes, this result is not systematic for all countries. Figure 69 shows a cluster of several countries that have experienced a moderate increase in both indicators, and even countries that have seen both funding measures increase strongly over the period.

Figure 69 Change in GBARD and change in EU contribution between FP7 and Horizon 2020 per Member State (size of circles: number of applications per Member State in Horizon 2020)

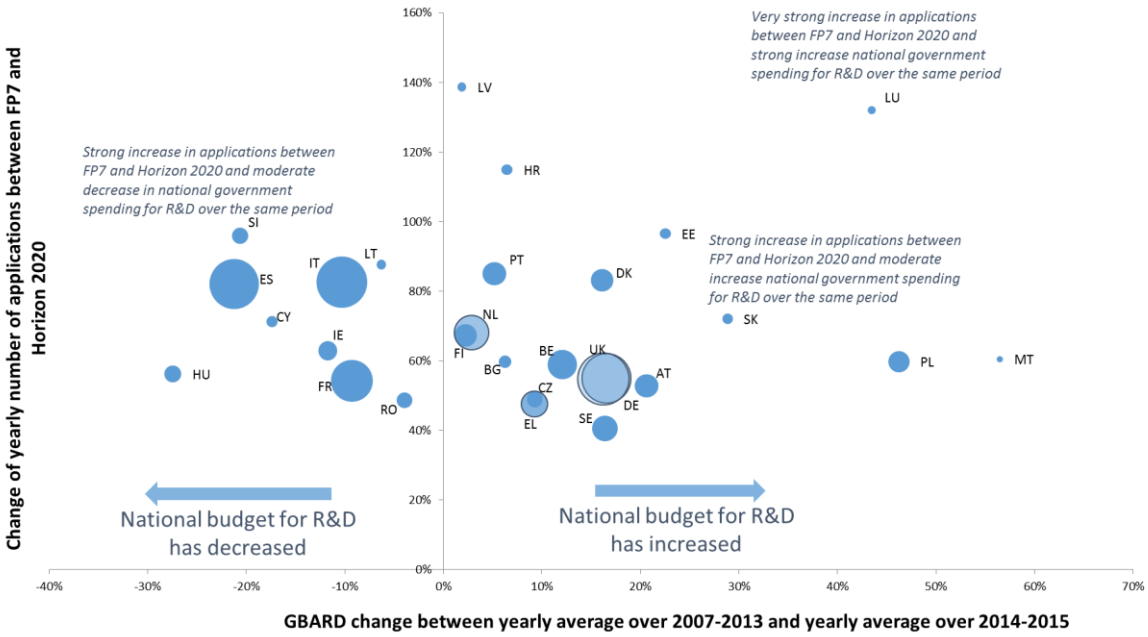


Source: Eurostat (GBARD) and Corda (EU contribution), analysis by European Commission, DG RTD.

Figure 70 illustrates an increase in the number of applications to the Framework Programmes for all EU Member States between FP7 and Horizon 2020. While a couple of large countries (Spain and Italy) present a strong increase in the number of applications combined with a reduction of national budgets for R&D, this situation does not apply to a majority of Member States. Hence, increases in applications to the Framework Programme do not seem to correlate with budget cuts of national governments. Overall - from this analysis - there is no direct evidence of a pattern in the way countries have mobilised together national and EU funding for their R&I activities over the recent years.

[252] 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 per Member State is the growth rate between the yearly average EU contribution going to participants from each Member State under FP7 and the yearly average under Horizon 2020.

Figure 70 Change in GBARD and change in number of overall applications between FP7 and Horizon 2020 per Member State (size of circles: number of applications in Horizon 2020)



Source: Eurostat (GBARD) and Corda (applications), analysis by European Commission DG RTD.

8.2.2.1. Progress on the 3% target of the Europe 2020 Strategy and the Innovation Union

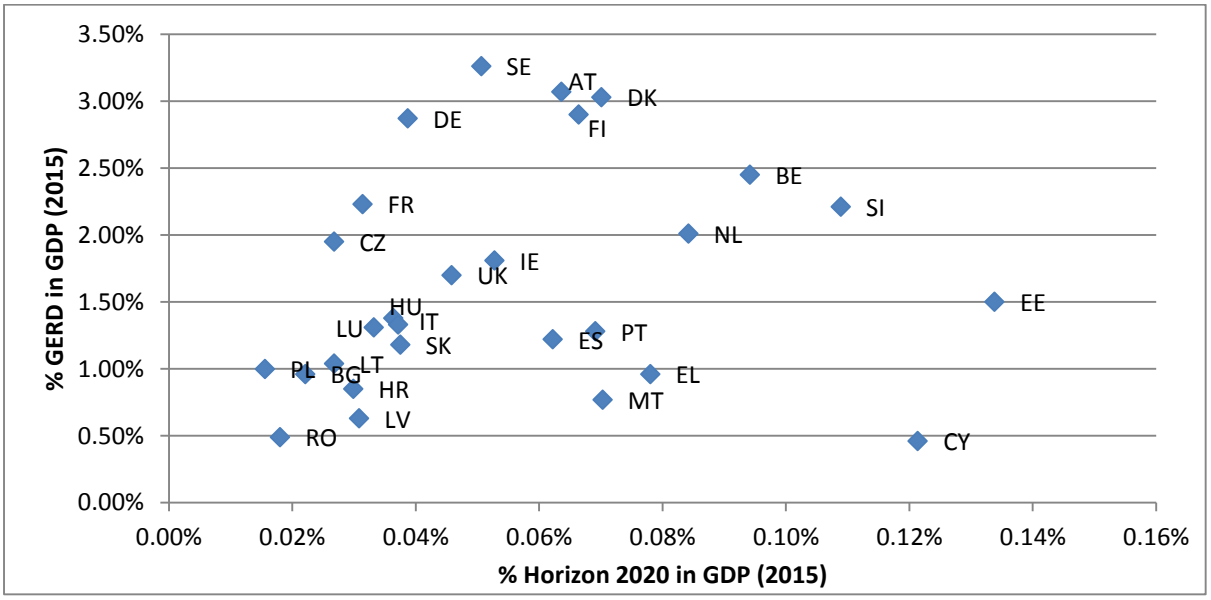
The Europe 2020 strategy for smart, sustainable and inclusive growth established in 2010 defined a headline target according to which 3% of the EU's GDP should be invested in R&D. **The R&D intensity (R&D expenditure as a % of GDP) in the EU increased from 1.93% in 2010 to 2.03% in 2013, but has stagnated since then**.

However, the contribution of Horizon 2020 to this target can only be limited, given that based on Eurostat statistics for 2015 and the average allocations of Horizon 2020 per year, the Horizon 2020 investment in 2015 represented less than 3% of the overall R&D spending[253] in the EU and approximately 10% of its public R&D allocations[254]. Considering that the overall EU R&D investment (both public and private) amounted to about EUR 300 billion in 2015, in order to meet the 3% target the EU should increase by an additional EUR 150 billion per year its public and private investment in R&D. In addition, quantifying the contribution of Horizon 2020 to this indicator would require a further breakdown of Horizon 2020 spending between R&D and innovation, which is not available.

The figure below puts in perspective the direct Horizon 2020 contribution (excluding in-kind contribution and indirect leverage effect) as share of GDP in 2015 (horizontal axis) and the R&D intensity in the same year (vertical axis) for each Member State. It is not possible to conclude that higher shares of Horizon 2020 contribution per country are directly correlated to higher R&D intensity in Member States.

[253] Gross Expenditures on Research and Development (GERD)
[254] Government Budget Appropriations and Outlays on R&D (GBARD)

Figure 71 Overview of Horizon 2020 contribution per country and research intensity of countries (as % of GDP)



Source: European Commission, DG RTD, unit A5, based on CORDA (Annual Monitoring Report 2015) and Eurostat data (2015).

The Europe 2020 strategy also put forward seven flagship initiatives. One of these is the 'Innovation Union'. Horizon 2020 implements the Innovation Union by bringing together all existing EU research and innovation funding, providing support in a seamless way from idea to market, through streamlined funding instruments and simpler programme architecture and rules for participation. Horizon 2020 implements a number of the specific commitments made in the Innovation Union, notably in: focusing on societal challenges, simplifying access, involving SMEs, strengthening the ERC, strengthening financial instruments, supporting public procurement of innovation, facilitating collaboration, and supporting research on public and social innovation.

In the context of the Innovation Union, the 2016 edition of the **Innovation Output Indicator**[255] **shows progress compared to the start year 2011 and the year before. On average, the indicator has progressed by about one percentage point per year in the reference period.** National performance varies significantly compared to the respective baselines. For this indicator as well, it is not possible to establish a clear correlation between the performance of Member States in terms of the Innovation Output Indicator and the share of Horizon 2020 funding in their GDP.

[255] The Innovation Output Indicator has 2014 as the latest reference year for the underlying data and is based on five output indicators (PCT patents, employment in knowledge-intensive activities, knowledge intensive exports and services, innovativeness of fast-growing enterprises)

Having marked a definite shift towards innovation, Horizon 2020 has contributed significantly to this flagship. The Innovation Union was evaluated in 2015[256] to take stock of the progress and set out next steps. The overall conclusion was: *'Six years after the Innovation Union was launched as one of the pillars of the Europe 2020 growth strategy, the evaluation shows that impressive progress has been made in numerous fields. Great progress has been achieved in making Europe a more innovative continent since the launch of the Innovation Union in 2010. Nevertheless, the world has evolved since then and new elements need to be taken into account to better tackle the challenge of innovation in Europe*'. There is still uncertainty about some of the legislative actions mentioned in the Innovation Union, regarding the Unitary Patent. The commitments that require greater involvement of Member States appear to have progressed to a lesser extent, either because of the long legislative processes (e.g. directives ratification), or because they are less binding in nature.

Figure 72 Innovation Output Indicator per EU Member State and share of Horizon 2020 contribution in GDP

Indicator	IOI (EUR)		% Horizon 2020 in GDP
Year nominal	2011	2014	2014
EU28	100,0	103,6	0,06%
Austria	95,3	104,0	0,07%
Belgium	100,5	99,8	0,09%
Bulgaria	61,6	68,3	0,03%
Cyprus	92,7	105,5	0,16%
Czech Republic	84,6	90,4	0,03%
Germany	118,9	120,8	0,06%
Denmark	116,7	114,9	0,08%
Estonia	78,5	78,1	0,15%
Greece	74,5	73,5	0,10%
Spain	84,2	83,7	0,07%
Finland	112,4	112,2	0,09%
France	105,7	110,8	0,04%
Croatia	62,9	59,8	0,03%
Hungary	92,4	92,7	0,05%
Ireland	119,3	122,3	0,08%
Italy	90,6	89,9	0,04%
Lithuania	61,5	58,5	0,02%
Luxembourg	133,8	117,5	0,05%
Latvia	72,3	70,6	0,05%
Malta	75,0	87,3	0,04%
Netherlands	103,5	106,5	0,10%
Poland	79,1	81,2	0,02%
Portugal	70,7	73,0	0,08%
Romania	71,3	75,0	0,02%
Sweden	127,2	124,5	0,07%
Slovenia	85,5	87,2	0,11%
Slovakia	87,5	91,6	0,01%
United Kingdom	105,6	110,5	0,06%

Source: European Commission, DG RTD, based on Corda and Eurostat data

The Digital Agenda for Europe aspires to make every European digital. The contribution of Horizon 2020 to the Digital Agenda is analysed in the box below.

Box: Contribution of Horizon 2020 to the Digital Agenda for Europe

The Digital Agenda for Europe – a Europe 2020 Flagship aspires to make every European digital. The EU's Digital Single Market Strategy[257], launched in May 2015, builds on these foundations, aiming to remove regulatory barriers and move from 28 national markets to a single one, to unlock online opportunities and make the EU's single market fit for the digital age. This was followed by a communication package outlining plans for Digitising the European Industry (DEI) in 2016. The forward looking strategy aims at bringing the technologies which are driving the new industrial revolution to European industry and society. Horizon 2020 is a key instrument to support the DEI objectives. The Digital Agenda indicator allows tracking spending related to digital R&I throughout Horizon 2020. Preliminary data - based on an indicator[258] aimed at estimating the ICT component of

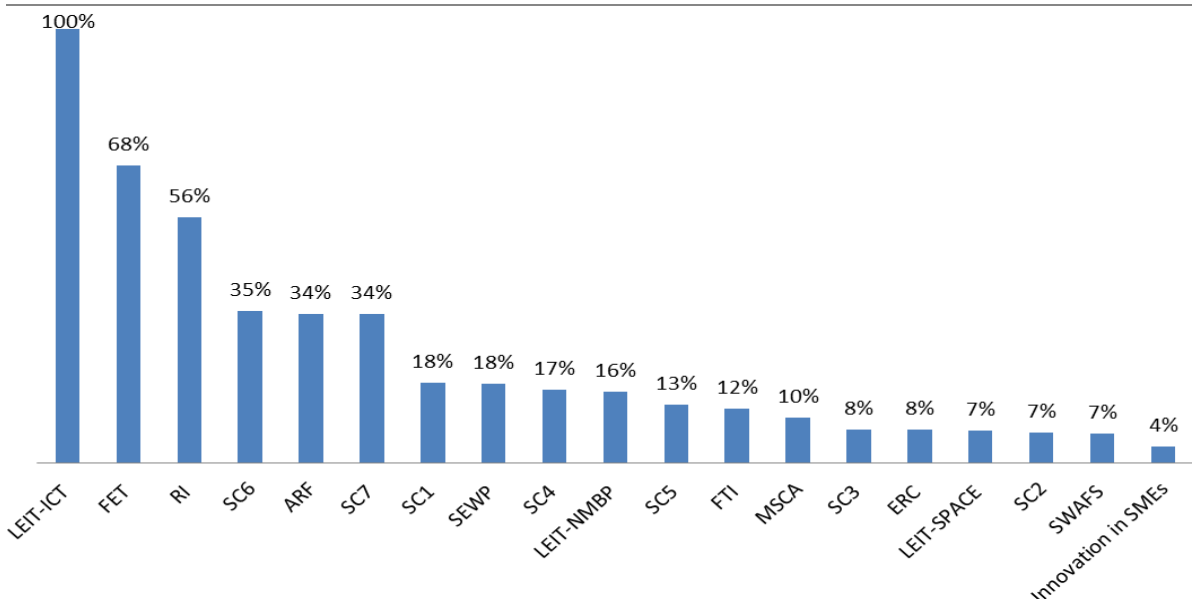
[256] Available at http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2015/state_of_the_innovation_union_report_2015.pdf

[257] Available at: http://europa.eu/rapid/press-release_IP-16-1407_en.htm

[258] "Digital Agenda" tracker, based on the RIO-marker methodology: Projects for which ICT R&I is the principal (primary) objective are marked with 100%, indicating that 100% of the project budget contributes to ICT R&I. Projects for which ICT R&I is a significant, but not predominant objective are marked with 40%, indicating that 40% of the project budget contributes to ICT R&I. This indicator has been recently introduced and may be subject to furhter refinement.

projects - for the calls up to January 2017 show that about EUR 5.3 billion (or 30% of overall EC funding in Horizon 2020) are contributing to ICT R&I, thus providing an important input to the progress towards the Digital Single Market objectives. This budget goes beyond what is allocated through dedicated topics to ICT and signals the cross-cutting nature of digital technologies and their societal relevance.

Figure 73 EC Contribution to the Digital Agenda, Share of EC contribution (%), by programme part



Source: CORDA data, extraction 1 January 2017

8.2.3. Progress on delivering close to market outputs and diffusing innovation in products, services and processes

One key objective of Horizon 2020 is to deliver close-to market outputs and diffuse innovation in products, services and processes (proof-of-concept, demonstration activities, innovations on the market, growth of participating companies). There are already signs of progress on this front, mostly from the few SME Instrument and ERC Proof of concept completed projects, and the review of a set of ongoing projects. However there are also already indications that more could be done to support service innovation and user-driven innovation and to alleviate barriers to reach the market and ensure innovation take up.

8.2.3.1.Proof of concept, demonstration and deployment

Figure 74 Horizon 2020 Key Performance Indicators related to proof of concept, demonstration and deployment

Key Performance Indicators (KPIs)	Progress so far / Target
Proof of concept, demonstration and deployment[259]	
Within the innovation actions, share of EU financial contribution focussed on demonstration and first-of-a-kind activities	86.5% was focussed on demonstration and 7.7% of first of a kind activity
Number of prototypes	229
Number of testing activities	801
Nr. of clinical trials	81
Nr. of projects with innovative products	160
Nr. of projects with innovative processes	73
Nr. of project with innovative methods	76

[259] Based on beneficiary reporting.

Key Performance Indicators (KPIs)	Progress so far / Target
Number of participating firms introducing innovations new to the market ..(of these SMEs)	538 (299) Target: 50% of participating SMEs introducing innovations new to the company or the market (period of the project plus 3 years)[260]
Number of participating firms introducing innovations new to the company ..(of these SMEs)	471 (251)

Source: Corda, Signed Grants cut-off date by 1/1/2017

Even if this is still early in terms of implementation, **Horizon 2020 is already making progress in supporting proof-of-concept, demonstration and deployment of innovative solutions but this could be further reinforced.** Currently, 87% of the funding within innovation actions is allocated to demonstration actions and 8% to first-of-a-kind activities[261]. Results from the Fast Track to Innovation (FTI) pilot are presented in a dedicated section (8.2.3.5). Internet of Things (IoT) large scale pilots launched in 2016 will notably make use of the portfolio of technologies and tools so far developed and demonstrated in reduced and controlled environments and extend them to real-life use case scenarios with the goal of validating advanced IoT solutions across complete value chains with actual users and proving its enormous socio-economic potential.

Not surprisingly given their shorter term nature and their higher TRL, **projects within the SME instrument (Phase 2) are producing so far more closer to market outputs per EUR 100 million compared to other types of action**, followed by innovation actions. So far, **3.6% of participating SMEs introduced innovations new to the market and 3.0 % innovations new to the company.** According to the thematic assessment of the SME Instrument, Phase 1 of the SME Instrument is effective in fostering a better understanding of the feasibility of an innovative idea and its development among the beneficiaries. Positive effects were created also on the SMEs' strategic intelligence and their capacity to manage innovation processes. The integral coaching system set up for both Phase 1 and Phase 2 projects has been an important enabling factor for these positive developments among the beneficiaries. Clear benefits include e.g. fine-tuning the business plan, and better networking. **Phase 1 SME Instrument beneficiaries show a steeper growth path than unsuccessful applicants, as well as in their capacity to take a strategic approach to risk identification and management.** Other areas of major improvement were 'innovation project formulation', 'idea management and involvement of staff, clients, and suppliers in innovation' and the 'overall innovation strategy' (30% of respondents).

The LEIT projects are also on track to deliver innovations (output involves demonstrators, pilots, and increase in the TRLs visible) and bring clear market orientation. Nevertheless, related to the emphasis to higher TRLs **some concerns were raised by the experts on an apparent trend of diminishing funds in Horizon 2020 for lower TRLs (2-4).** In particular, in the field components and systems (LEIT ICT) while the investment in ECSEL to address industrial challenges is well justified, the diminishing funds in Horizon 2020 for lower TRLs raise concerns. Notwithstanding the impact orientation, for NMBP, there are concerns regarding the limitations to cover for the lower TRLs (between blue sky research and TRL 3-4 e.g. FETs).

[260] Based on survey of beneficiaries.
[261] The remaining 5% of the projects are not classified.

Box: Illustrations of how proof of concept, demonstration and diffusion of innovation are supported under Horizon 2020

The **ERC Proof of Concept Grant** (PoC) aims to explore the commercial and social potential of ideas arising from ERC grants. Since 2011 there have been around 540 Proof-of concept projects supported and 180 concluded. Of the first 140 projects around 20% of them spun-out a new venture. In November 2015 the European Business Angels Network (EBAN) awarded its first-ever prize for "Innovation in Science Venture Finance" to the ERC as recognition of its efforts to bring frontier research closer to the market[262].

LEIT ICT projects aim at translating R&I into commercially viable undertakings, thus helping bridge the gap between research and the market. Ongoing projects include Demonstrating/Piloting Activities primarily relating to areas such as Content Technologies and Information Management, Robotics and Future Internet, Micro-and Nanoelectronics and Photonics and the ECSEL JU. First of a kind market replications are expected in a number of projects. The **Innovation Radar** identified 274 innovations in Horizon 2020 ICT projects[263], the majority of which are significantly improved products or new products which are going to be exploited either commercially (170 innovations) or internally by the organisations (61). For some of them (53) there are no plans for exploitation yet.

According to the **LEIT-NMBP** assessment, 75% of the projects aim at developing a new product; 60% a new process; 24% a new service[264], and 4% an organisational or business model innovation. Particularly relevant are demonstrators on technology integration in an industrial environment, for example those from the dedicated Pilot Lines call, which include also open access pilot lines for SMEs. A total of 77 pilot lines have been developed so far. The NMBP work programme has set out specific requirements with regard to an initial description of the business plan already at proposal stage. This requirement stems from evidence that dealing with business plans at the end of the projects would be too late to be effective.

The FET Innovation Launchpad is modelled after the ERC Proof-of-Concept scheme and seeks to give innovators and entrepreneurs freedom and flexibility to innovate from results of previous or ongoing FET-funded projects. In order to create a wider and more diverse support base from which to take these innovations forward, the participation of new actors and of young and high-potential researchers and high-tech innovators is further encouraged in FET WP2016-17 (already with success in WP2014-15).

Under **Societal Challenge 2** flagship projects are expected to create direct and indirect employment in some of the lagging regions of Europe. For example, the FIRST2RUN project is a flagship demonstration of an integrated biorefinery which is expected to revitalise local economies across Europe by reconverting old industrial sites and creating skilled jobs: an estimated 60 new skilled jobs will be created for every kiloton of bioplastics produced, taking into account the whole value chain, from agriculture to the end life of the final products.

Under **Societal Challenge 7** the C-Bord project intends to develop and test a comprehensive and cost-effective solution for the inspection of containers, and large-volume freight, in order to protect EU borders. In doing so, it proves its capability through live field trials under real conditions at different border control points

8.2.3.2.Market-creating innovations and disruptive technologies

Looking at the disruptive character of the innovations supported by Horizon 2020 which could have the potential to generate growth and jobs, **there are already expectations of innovation breakthroughs but the early stage of programme implementation does not allow seizing the potentially ground-breaking impact of longer term projects**.

Innovation actions belong to the key new actions introduced in Horizon 2020 to help bringing discoveries to the market. Most of them demonstrate the application of new knowledge in real-life conditions. The very first projects started in 2014 and it still is too early for them to produce final results (expected only in 2018-2019). Looking into the projects based on proposal texts of 227 innovation actions a study[265] identified three categories of projects:

[262] http://www.eban.org/eban-winter-university-2015-in-copenhagen-highlights
[263] Data up to July 2016.
[264] indicating that these will play a role in the current tendency in European industry to introduce services.
[265] Grimpe, C. et al., Study on innovation in Horizon 2020 Innovation Actions - A content analysis of 233 innovation project proposals awarded in 2015, Final report to the European Commission, 2017. For this study, 227 Innovation Actions were

- 'Pioneering' projects: scoring high on technological novelty, market scope and innovation readiness, but low on ecosystem embeddedness (64 projects out of the 227 projects). They seem to focus on breakthrough technological results that may create markets. Pioneering projects involve relatively more private companies, esp. SMEs, and research institutions.
- 'Diffusing' projects: emphasising ecosystem embeddedness and scoring lower on the other three aspects (58 projects). They aim at the diffusion and exploitation of the innovative solution in the ecosystem. The diffusing projects involve less companies and more public bodies.
- 'Sustaining' projects: the remaining 105 projects pay only modest attention to each of the four aspects. They are dominated by higher education institutions.

Whereas it is still too early to characterise these innovation actions and their impacts, these initial findings indicate that **a quarter of innovation actions have a disruptive, market-creating potential, and that companies and research institutions play a leading role in these initiatives**.

As another new instrument to directly support innovation, the assessment of **the SME Instrument** shows that it **caters for different types of innovation strategies, including both incremental and disruptive innovation strategies and the relatively short innovation cycles of SMEs**. A large majority of SME Instrument surveyed applicants state that their project has the potential to shape/ create new markets (74% think so to a large extent), to change value chains (67%), and is technologically new (56%). Moreover, a majority of respondents finds their innovation project radical (60%). However the SME Instrument focusses especially on product innovations,[266] product performance innovations, business model innovation. **Service innovations, network innovations, and customer engagement innovations are less supported**. Interviewees, agencies and SMEs surveyed all concur in their assessment that **the SME Instrument is an effective tool to speed up the introduction of innovations on the market**. **More than half (53%) of Phase 2 beneficiaries have already reached the market, or expect to do so in less than one year.** A relatively high proportion of multi-beneficiaries from both Phase 1 and Phase 2 together reported that their innovation was already on the market (24%).

Box: The Open Disruptive Innovation scheme under the SME instrument[267]

The Open Disruptive Innovation (ODI) scheme is the most popular topic within the SME instrument (one-third of proposals submitted). According to project participants, it contributes to the growth of highly innovative SMEs including start-ups. The most popular innovation fields of applicants include health, photonics and cloud computing. The case study interviews and desk research indicated that projects which implemented at least one Phase of the ODI scheme gradually increased their turnover and number of employees. Phase I supported in developing business market strategy which helped to expand their innovative product further. The turnover already increased slightly and the participants are expecting a gradual increase in the following years.

Many disruptive innovation products and services implemented under the ODI scheme have been commercialised and put to widespread use. For instance, after Phase I Global PERES, which offers an innovative device and mobile application designed to detect freshness of product and a risk of food poisoning, became popular in Europe and in the US.

selected that started in 2015. The texts of the granted projects were analysed using content analysis methodology, based on keywords that indicate four innovation aspects: technological novelty, market scope, ecosystem embeddedness and innovation readiness.

[266] Not normalised for a potential overrepresentation of successful applicants, which causes relatively high percentages.

[267] Source : CARSA study

Project participants indicated that the ODI scheme supported their disruptive innovation to be further developed and expanded. Particularly Phase I was pointed out as essential. It supported SMEs to gain more knowledge and experience of entering to new markets and further helped to build a contact network for new potential clients. Project participants indicated that throughout the Phase I they all have established good networks in Europe. Overall, the scheme is highly selective with a funding rate of 5,3% of the total ICT submissions. According to desk research unsuccessful proposals often fail due to the lack of a) market analysis to assess the competition and b) a robust and realistic emphasis on the commercialisation at the end of the project. There is only a small amount of projects which received grants for Phase II after the implementation of Phase I.

Beyond the Innovation Actions in the cPPPs, the LEIT-NMBP portfolio has also a fair share of projects that are new to the world or at least the EU (41%), according to the coordinators. The remainder (59%) is somewhat less novel, mostly a combination of existing technologies and their adaptation to another application area or sector, or to the specific production processes of a company (new to the company). The degree of 'radical' innovation seems to be a matter of individual project ambition, can be related to the expected impacts in topics, or is inherent in the technology (e.g. nano-medicine, biotechnology). **The ambition in terms of innovation is higher in RIA projects and projects with lower TRLs. Interestingly, projects coordinated by a private company are also associated with a higher level of ambition in terms of innovation than the ones led by a higher education institution or a research institute.**

A Commission consultation (Call for Ideas[268]) conducted in 2016 revealed that **a large number of stakeholders consider that important gaps still exist in EU support for disruptive, market-creating innovation and other forms of support for young innovative companies, such as effective mentoring and coaching schemes**; that a genuinely bottom-up approach should be introduced to allow projects from any sector(s) to apply for funding; and that the funding instrument landscape remains too complex and difficult for innovators to access.

As presented in the Box below, while supporting established innovators and technological novelty, the programme has not been able yet to fully capture the potential of young, fast-growing companies.

Box: The involvement of leading companies in Horizon 2020

Comparing various lists of innovative companies with the Horizon 2020 participants, many of the top 'established' innovative companies take part, but – despite many positive examples, e.g. in the health sector[269] – **almost none of the young and quickly growing innovative companies take part to Horizon 2020**. Bigger companies and established innovators included in the European Patent Organisation top 50 European Patents Applicants, the R&D Scoreboards, and Thomson Reuters top global innovators rankings are greater beneficiaries of Horizon 2020 funds than younger innovators from the Wired Europe's hottest start-ups, Deloitte's fastest growing European tech companies, Forbes' most innovative companies, and CB Insights' Unicorns list. Out of the first ranking only two benefited from Horizon 2020 funding thus far. Additionally, CB Insight's list of unicorns or young fast growing companies reaching a capitalisation of $1 billion indicates that 18 out of the 176 are EU-based. Yet, no company in this list is currently benefiting from Horizon 2020. In similar lines, only 12% of the companies from the MIT smartest companies and 3% from the Forbes most innovative companies rankings participate in Horizon 2020.

8.2.3.3.Growth of participating companies

Across the thematic assessments, **Horizon 2020 is seen as generating a potential to improve the competitive advance of participants. The expected improvement mainly re-**

[268] https://ec.europa.eu/research/eic/pdf//eic_call_for_ideas-overview.pdf#view=fit&pagemode=none
[269] In Societal Challenge 1 (SC1 - health), Horizon 2020 has funded 2 of the 11 top spin-off European healthcare companies which later became unicorns: Galapagos and Immunovia.

lates to access to new markets and the competitive position of partners internationally. While it is too early to have information on the growth of participating companies, early evidence collected in the thematic assessment suggests that **the SME Instrument has a good potential to reach its intended effects on the profitability and growth of the beneficiary innovative SMEs**. **There are clear indications that SME Instrument beneficiaries realise faster growth paths than control groups and the scale-up of their activities is more likely and/or more significant**. Phase 2 beneficiaries that went through Phase 1 report higher profitability, while Phase 2 beneficiaries report stronger market presence, even at the implementing stage of their project. The SME Instrument is intensively used by start-ups, especially the Phase 1 strand. The characteristics of Phase 2, in terms of e.g. time-to-grant and cash flow constitute a hindering factor for a more intensive participation of start-ups in that component of the instrument.

Based on a review performed under SC2, **expected direct impacts on growth and jobs of 55 SME Phase 1 and 26 Phase 2 projects under SC2 include EUR 1.5 billion / EUR 1 billion of additional turnover for the next five years, and the creation of 1500 / 1000 jobs over the next three years respectively.** These impacts do not include indirect impacts generated through supply chain and multiplier effects.

Providing an indication of potential growth paths, an external study[270] found evidence of the improved research capabilities and excellence of the FP7 research teams. According to the counterfactual analysis of FP7 survey data, the beneficiary teams grew indeed at 24.4% versus 12.6% in the control group. **The estimated impact of the EU FPs on the growth of the research teams is thus positive and amounts to 11.8%.** Based on the counterfactual analysis of R&D budget data, it was further estimated that the beneficiary teams increased their R&D budgets by 22.4% since their application for EU funding. The corresponding value for the non-FP teams was -2.2%, leading to a **24.6% difference in the budget leverage created due to participation in the EU FPs.**

Barriers to innovation

From the thematic assessments **the factors that have been identified as potentially impeding full effectiveness in terms of fostering innovation with respect to market uptake and commercialisation are mainly technological, but relate also to the capacity of innovation systems to address a range of issues, from regulation and standards to technicalities and access to finance, to customer acceptance of new solutions and a lack of access to a sufficient pool of end-users.** There is also no evidence available so far on approaches allowing for the identification of the dual-use potential of project results with a view to diversify their market potential.

A study by the European Investment Bank on Access to Finance for KETs companies[271] shows that many KETs companies, especially small and middle-sized ones, struggle or fail to obtain adequate debt financing, hampering their uptake of new technologies. Despite the favourable conditions of the market, the banking sector does not meet the specific needs of many KETs companies, because of a general aversion to risk, but also because of a lack of knowledge of the KETs sectors.

[270] PPMI study, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming.
[271] Available at: http://www.eib.org/attachments/documents/innovfin_access_to_finance_conditions_kets_en.pdf

53% of the public consultation respondents think that Horizon 2020 is fully or to a large extent helping to foster European industrial leadership. Only 3.6% think this is not the case at all. The most positive respondents are businesses. If the contribution of the programme to this objective is assessed positively by a large majority of respondents, a comparatively low number of respondents (17%) agreed fully with this statement, which is far less than the number of respondents who did so for the contribution of the programme to fostering excellence in science.

8.2.3.4. Specific focus on the Fast Track to Innovation pilot

The Fast Track to Innovation (FTI) has been implemented in the form of a full-scale pilot in 2015 and 2016. It addresses industry-driven consortia seeking quick market uptake of new solutions. It offers substantial funding to test, demonstrate and validate innovations that can be co-developed by all sorts of actors with complementary backgrounds, knowledge and skills, with the aim to (re)shape value chains. **The FTI pilot evaluation concludes that the FTI is deemed a useful addition to the portfolio of Horizon 2020 instruments and needs continued support; given the levels of demand, the budget of EUR 100 million per year could be increased by at least double**[272]. Key aspects of the evaluation are summarised in the table below.

Figure 75 Key findings from the Fast Track to Innovation pilot evaluation

	Key findings of the evaluation of the Fast Track to Innovation Pilot
Contribution to innovation	The FTI is highly relevant to the broad policy goals of Horizon 2020 to promote innovation and its application. The main focus of the FTI is to take mature ideas to the market within a period of three years, by supporting a wide spectrum of activities from validation and piloting to testing and EU quality labelling. Most coordinators of funded projects made reference to overcoming barriers regarding the scale and scope of demonstration and validation activities thanks to FTI support, thereby substantially reducing risks and increasing attractiveness for future investors. 82% of the project coordinators are developing product innovations; process (29%), service (21%) and organisational (4%) innovations are also supported. 89% of project coordinators is convinced that successful completion of their projects will lead to world novelties, while an even higher percentage (96%) indicated that their innovation under development is radical – and not merely incremental – in nature. This will be re-examined in the context of the final evaluation of the FTI pilot
Industry participation	75% of all call beneficiaries in 2015 are private-for profit organisations (i.e. industry); together they will absorb over 70% of the 2015 call budget. 46.5% were registered SMEs (95 individual entities in total). This ensures market relevance and prospective tangible return on investment in the FTI, including by providing a stepping stone to scale-up of participating companies, in particular SMEs. With respect to the latter, the funding impact could be strengthened with mentoring support to participating companies. Only 16% of funding available under the call in 2015 is to go to companies counting more than 1,000 FTE – i.e. larger companies; nevertheless, as part of the stakeholder consultation feeding into the assessment, some parties called for reconsidering the intervention rate of 70% - uniform across Horizon 2020 - for this type of entities, referring to the risk for deadweight, even if FTI project coordinators and unsuccessful applicants indicated that the intervention rate and access to funding were respectively only the fifth and the seventh most important reason (out of ten) to apply. A breakdown by NACE codes helps to understand the main areas of commercial activity of

[272] 'Assessment of the 2015 Response to the Fast Track to Innovation Pilot (FTI Pilot). The assessment is mainly based on qualitative input from the side of early-stage project coordinators.

	Key findings of the evaluation of the Fast Track to Innovation Pilot
	funded firms; Architectural and Engineering Services (NACE M71) was the most prominent activity (15.1% of the firms), followed by Manufacture of machinery and equipment (NACE C28, 9.1%), Scientific Research and Development (NACEM72, 9.1%), Manufacture of computer, electronic and optical products (NACE C26, 8.6%) and Computer programming, consultancy and related activities (NACE J62, 6.6%).
Participation of newcomers	FTI emerged as the third most attractive Horizon 2020 activity, with 41.1% new industry applicants, following a comparison between FTI actions, other innovation actions and SME instrument actions across Horizon 2020 priorities in terms of new applicant participation Around 40% of FTI applicants indicated that they had previously participated to FP7; this can be explained by the fact that the FTI – unlike the SME instrument for instance – targets consortia, which by definition require connections and operational experience for their construction and administration to be successful.
Operational effectiveness and financing	Certain administrative requirements (in particular the need to comply with most of the standard features and templates for innovation actions) are deemed to have a restraining effect on the FTI's potential effectiveness. Average time-to-grant (TTG) was progressively reduced over the three cut-off dates in 2015, but with 237 days is nowhere near the six months defined in the legal base. Only 25% of project coordinators considered that they would achieve the target of reaching full commercialisation three years after project start. This raises the concern that projects are selected which have relatively mature innovation development and/or which lack adequate preparation and planning for the commercialisation process, which points to a potential lack of commercial investment expertise at the level of the evaluators. In order to ensure selection of more appropriate projects, clearer guidance on the role of Technology Readiness Level (TRL) classification is recommended, together with more emphasis on business plan and market readiness during the appraisal process, as well as a review of the competencies of experts selected for appraisal, possibly in connection with a specific call for experts with direct commercial experience to add to the existing pool.
Leverage of private investment	Project coordinators were asked whether or not since starting their projects their innovation had received further external investment. A third (32%) was either in receipt of or had plans for external investment in place. However, 29% also indicated that there had been no external investment in their innovation and did not expect any in the future. These figures may while change as projects – which were at best launched since six months at the time of the survey – progress along the innovation cycle. Follow-up interviews suggest that leveraging further investment is difficult. Most often, investors wait on the technology to be demonstrated at a large/commercial scale which points to the need for specific mentoring/coaching services

Source: FTI pilot evaluation

8.3. What is the progress made towards achieving societal impact?

Horizon 2020 responds to the policy priorities and societal challenges that are identified in the Europe 2020 strategy and aims to stimulate the critical mass of research and innovation efforts needed to achieve the Union's policy goals.

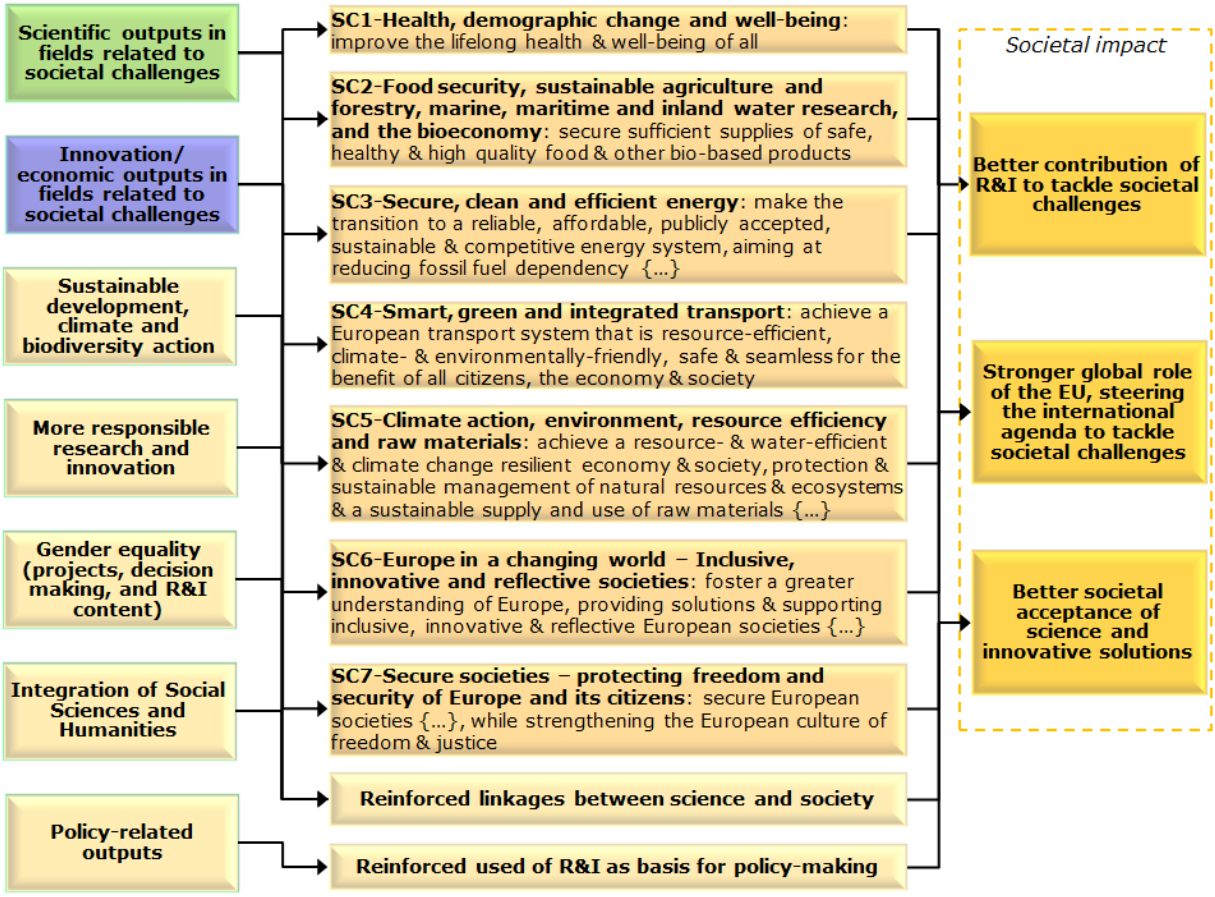
Expectations from Horizon 2020 for achieving societal impact

Whereas FP7 was focused on specific domains, Horizon 2020 puts **more emphasis on societal impact** and aims at contributing through research and innovation to tackling the major societal challenges Europe and the world are facing. This means bringing together different technologies, sectors, and scientific disciplines to find new solutions to these challenges but also taking on a stronger role at global scale for tackling these challenges. Progress is expected to depend on the typical results of R&I projects (e.g. scientific outputs, innovations) in domains of societal relevance.

As a **continuation to the Science in Society programme** in FP7, a dedicated programme part on "Science with and for society" is also included in Horizon 2020. The overall aim is to build effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility. In parallel, gender equality, responsible research and innovation, and social sciences and humanities became cross-cutting issues promoted throughout the programme.

Figure 76 provides an overview of the approach used for analysing progress towards the achievement of societal impact. Overall progress of Horizon 2020 towards societal impacts relies on one hand on the scientific and innovation/economic outputs/results/impacts (discussed in the previous sections) in fields related to societal challenges and on more horizontal progress on cross-cutting issues supported across the programme such as sustainable development, climate and biodiversity action, more responsible research and innovation, gender equality, the integration of Social Sciences and Humanities (SSH) in R&I projects and the generation of outputs for policy.

Figure 76 Approach towards analysing progress towards societal impact



Source: European Commission

Summary box: Key findings on the progress towards achieving societal impact

- ✓ Most Horizon 2020 projects, not only from the 'Societal challenges' pillar but also from the 'Excellent science' and 'Industrial leadership' pillars, are expected to generate key discoveries and technologies and cross-cutting societal impacts.
- ✓ The portfolio of Horizon 2020 projects selected under the 'Societal challenges' pillar and their progress are so far in line with the objectives set.

- ✓ Horizon 2020 projects already produce numerous results like publications, patents, prototypes, products, processes and methods in domains of societal relevance.
- ✓ Horizon 2020 has not yet met the targets for expenditure on sustainable development and climate action but it is expected that they will be achieved by the end of the Programme.
- ✓ Stakeholders are less convinced about the role of Horizon 2020 in the resolution of societal challenges than in the achievement of knowledge-related objectives, which seems to call for better involvement of end-users and communication with citizens on the contribution that R&I can make to tackling societal challenges.
- ✓ Progress is made with respect to promoting gender equality under Horizon 2020 but data quality concerns remain.
- ✓ Results are encouraging in terms of the integration of social sciences and humanities and responsible research and innovation in Horizon 2020, even if highly uneven across the programme.

8.3.1. Tackling societal challenges

Horizon 2020 is supporting seven Societal Challenges (SC) as depicted in Figure 76. The Societal Challenges pillar has so far received 36.3% of Horizon 2020 funding (EUR 7.4 billion), with the largest share going to the energy challenge (SC3 - 8.6% of Horizon 2020 funding), followed by the health challenge (SC1 - 7.6%) and the transport challenge (SC4 - 7%), with the security challenge (SC7) receiving the smallest share (2.3% of the overall funding).

The existing monitoring indicators under Horizon 2020 relate to classical outputs from R&I projects (e.g. publications, patents, prototypes) but not to their societal impact in the medium to long term on e.g. decreasing CO2 emissions, improving health of citizen or their security. On these no structured information is collected so far partly because of the difficulty to establish direct links between individual projects' outcomes and long-term impacts, notably given the time needed for the impact to be observable, and the already discussed problems of attribution. However further efforts should be made to identify whether projects under the Societal Challenges pillar are on track towards the delivery of outputs/results/impacts of benefits for society beyond more classical R&I indicators.

Figure 77 KPI for the Societal Challenges Pillar of Horizon 2020

	Publications in peer-reviewed journals	Patent applications and patents awarded	Number of prototypes and testing activities	New products, processes, and methods launched into the market
Health, demographic change and wellbeing (SC1)	280	18 patent application & 11 patents awarded	101	16
Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy (SC2)	172	5 patent application & 1 patents awarded	9	1
Secure, clean and efficient energy (SC3)	132	31 patent application & 4 patents awarded	370	41
Smart, green and integrated transport (SC4)	62	11 patent application & 4 patents awarded	30	13
Climate action, environment, resource efficiency and raw materials (SC5)	115	8 patent application & 3 patents awarded	61	24
Europe in a changing world - inclusive, innovative and reflective societies (SC6)	21	0 patent application & 0 patents awarded	1	2

	Publications in peer-reviewed journals	Patent applications and patents awarded	Number of prototypes and testing activities	New products, processes, and methods launched into the market
Secure societies - protecting freedom and security of Europe and its citizens (SC7)	27	3 patent application & 0 patents awarded	28	9
For all of Societal Challenges	**809**	**76 patent applications & 23 patents awarded**	**600**	**106**

Source: Corda, calls until end 2017, Signed Grants cut-off date by 1/1/2017

From the information available so far, as of 1 January 2017, the 2,941 projects selected under the Societal Challenges pillar already generated **809 peer-reviewed publications, mostly from the health, food / bioeconomy, energy and environment domains.** Out of the **76 patent applications and 23 patents already awarded to Horizon 2020 projects under the Societal Challenges pillar**, the majority is coming from the energy projects, followed by health and transport. Also more than half of **the 600 prototypes and testing activities already developed under Horizon 2020** are coming from the energy projects, which are also the strongest contributor to the **launch of 106 new products, processes and methods into the market**.

According to a survey of Horizon 2020 projects coordinators all projects supported under the Societal Challenges 1-7 are expected to contribute to their specific challenges in the next 10 years (see Figure below). **Projects under certain Societal Challenges (esp. SC1 'Health') are challenge-specific, whereas the projects in other Societal Challenges (e.g. SC3, SC5, SC7) and LEITs (e.g. NMPB, ICT) are expected to generate more cross-cutting impacts.** Survey data indicates particularly strong complementarity of projects between environmental objectives and bioeconomy, energy and transport (SC1 with SC2, SC3, and SC4), as well as between societal objectives and health (SC6 and SC1). The expected contribution of Excellent Science and Industrial Leadership projects to the societal challenges is rather evenly spread but some strong features emerge:

- Many projects under FET are expected to have a wider impact on Societal Challenges related to energy and the environment/climate (SC3 and SC5);
- Research Infrastructures are expected to have particularly impacts on health and food/ bioeconomy (SC1 and SC2);
- LEIT-NMPB projects are expected to have particularly impacts on health and the environment/climate (SC1 and SC5). The Public Private Partnerships under LEIT-NMPB are expected to have particularly impacts on energy and environment/climate (SC3 and SC5, related notably to the cPPP on Energy-efficient Buildings and SPIRE); The enabling nature of the NMBP programme involves support for technologies pointing to the next generation of solutions across societal challenges (addressing health, energy, climate action, the circular economy);
- LEIT-ICT projects are expected to have particularly impacts on health and societies (SC1 and SC6). The thematic assessment also shows that health, inclusion, security, energy and societal aspects play a strong role in LEIT ICT.
- LEIT-Space projects are expected to have particularly impacts on transport (SC4) and security (SC7).

Figure 78 Do you expect in the next 10 years your project to have a wider impact on any of these societal challenges? Share of project coordinators saying YES per Horizon 2020 programme part (representative sample)

Horizon 2020 programme part	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Excellent Science							
Future and Emerging Technologies (n = 16)	33.3%	40.0%	57.1%	20.0%	52.4%	30.0%	25.0%
Research Infrastructures (n = 27)	52.2%	52.4%	23.8%	18.2%	43.5%	40.9%	36.4%
Industrial leadership							
LEIT-NMPB (n = 96)	42.4%	29.0%	52.6%	23.2%	61.9%	18.0%	14.6%
Subtotal within NMPB: PPP projects (n=32)	25.9%	7.0%	69.6%	19.8%	68.3%	23.4%	9.7%
LEIT-ICT (n = 177)	52.0%	21.5%	32.2%	34.5%	30.0%	55.8%	38.5%
LEIT-Space (n = 36)	28.2%	31.4%	33.1%	52.3%	44.0%	29.0%	50.6%
Innovation in SMEs (n = 30)	24.4%	24.3%	26.8%	19.9%	19.9%	26.0%	21.5%
Societal Challenges							
SC1: Health. demographic change and well-being (n = 106)	98.1%	9.8%	1.7%	2.1%	5.3%	35.6%	9.6%
SC2: Food security. sustainable agriculture and forestry. marine. maritime and inland water research. and the Bioeconomy (n = 43)	49.2%	98.6%	21.4%	4.6%	86.4%	25.8%	14.2%
SC3: Secure. clean and efficient energy (n = 124)	21.4%	19.0%	97.5%	34.2%	86.6%	29.4%	17.7%
SC4: Smart. green and integrated transport (n = 96)	26.1%	9.3%	38.5%	96.1%	62.0%	28.9%	23.4%
SC5: Climate action. environment. resource efficiency and raw materials (n = 71)	39.2%	57.9%	57.9%	28.5%	95.7%	34.5%	26.0%
SC6: Inclusive. innovative and reflective societies (n = 32)	53.6%	16.5%	17.5%	20.7%	32.5%	90.2%	35.9%
SC7: Secure & innovative societies: protecting freedom and security of Europe and its citizens (n = 31)	38.6%	33.3%	25.7%	36.2%	30.2%	53.1%	93.3%
SWEP- SWAFS - FTI – Euratom							
Spreading Excellence and Widening Participation (n = 24)	64.0%	44.0%	52.0%	26.9%	44.0%	51.9%	35.7%
Science with and for Society (n = 10)	57.1%	50.0%	50.0%	50.0%	57.1%	87.5%	42.9%
Fast Track to Innovation Pilot (n = 10)	66.7%	33.3%	50.0%	33.3%	66.7%	33.3%	0.0%
Euratom (n = 3)	33.3%	0.0%	100.0%	0.0%	50.0%	33.3%	33.3%
Total	46.9%	29.4%	41.6%	32.8%	50.9%	38.6%	27.2%
Total number of valid responses	920	905	914	906	909	911	902

Source: Survey of representative set of Horizon 2020 project coordinators, PPMI, 2016

Figure 79 also shows more specific areas where impact is expected within the next 10 years within each specific challenge. The survey responses point to a good overall coverage and strong expected impact in many specific areas within the challenges. The relatively large number of "other" responses in SC1 'Health' indicates a broader variety of impact areas than what was outlined in the survey questionnaire.

Figure 79 Could you please indicate a more specific area within this Societal Challenge? Specific areas of expected impact, by Horizon 2020 societal challenge

Horizon 2020 societal challenge	Specific challenges within the Societal Challenges	Share of projects having impact on the specific challenges
SC1: Health, demographic change and wellbeing	Antimicrobial resistance	15.7%
	E-health & large-scale data gathering	52.7%
	Combating European/global health threats (pandemics or biological incidents, infectious diseases)	39.4%
	Other	167 responses
SC2: Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the Bioeconomy	Food waste and eating well	41.9%
	Biodiversity	43.2%
	Food security and sustainability	72.6%
	Freshwater supply	40.7%
	Productive farming	59.6%
	Improving animal health	36.5%
	Other	44 responses
SC3: Secure, clean and efficient energy	Low-energy economy	75.7%
	Increase in competitiveness in energy market	56.7%
	Secure, safe and affordable energy	69.1%
	Reduction in greenhouse gas emissions	83.2%
	Other	29 responses
SC4: Smart, green and integrated transport	Increasing the efficiency of transport	83.4%
	Seamless transport systems	48.9%
	Competitive transport industry	65.7%
	Other	41 responses
SC5: Climate action, environment, resource efficiency and raw materials	Reduction in emissions of greenhouse gasses	80.4%
	Creation and harmonisation of common European/global standards in environmental science and policymaking	44.9%
	More efficient use of raw materials/reduction of waste	67.7%
	Other	41
SC6: Inclusive, innovative and reflective societies	Reducing inequalities and social exclusion in Europe	54.4%
	Europe as a global actor	78.7%
	Transmission of European cultural heritage	37.3%
	Innovation in the public sector or ICT government	69.8%
	Other	27 responses
SC7: Secure & innovative societies: protecting freedom and security of Europe and its citizens	Resilience of society against natural and man-made disasters	55.5%
	Technologies to improve border security and fighting terrorism	46.6%
	Cyber-security technologies	36.8%
	Other	35 responses

Source: Survey of representative set of Horizon 2020 project coordinators, PPMI, 2016

Respondents to the stakeholder consultation suggest that Horizon 2020 is less helping to address major societal challenges compared to its other objectives, like delivering on growth and jobs.[273] In particular, 24% of respondents think Horizon 2020 is not helping at all to address the challenge of securing sufficient supplies of safe, healthy and high quality food and other bio-based products (SC2).

[273] A comparatively lower number of respondents agreed "fully" with the statements that were provided and more respondents expressed their disagreement. Horizon 2020 scored higher when assessed on whether it is helping to fostering a greater understanding of Europe, providing solutions and supporting inclusive, innovative and reflective European societies (SC6) (79% of agreement at least to some extent) and on its capacity to improve the lifelong health and well-being of all (SC1) (78% agree to some extent, but also 18% think the programme is not helping at all). For all the other challenges, around 30% of the respondents do not know, which is not surprising given the early stage of implementation.

Stakeholder position papers: More sophisticated measures are needed to monitor impact.

In their position papers, some stakeholders from different types of organisations commented on the monitoring system and in majority noted that it needs to improve. Most of those commenting believe the current interpretation of programme impact is narrow and too short-term focused and a more "sophisticated" approach should be adopted. Some other stakeholders call for better monitoring of downstream impacts. A few NGOs in particular stressed a need for better measurement of impact. Similarly, one public authority stressed the interpretation of impact specifically related to societal challenges should be broader in scope to account for a wide range of effects including social, economic, environmental and cultural. One business respondent stated that Horizon 2020 and the future Framework Programme should be at the forefront of practice in monitoring, evaluation and impact assessment.

Detailed assessments of progress for each Societal Challenge are provided in the thematic assessments in Annexes Part 3. A quick overview of progress is provided below.

8.3.1.1.Health, demographic change and wellbeing

While is it too early to assess its full impact, Societal Challenge 1 'Health, demographic change and wellbeing' (SC1) is on track to deliver on its objectives, leading to improved health and quality of life for citizens, more sustainable health and care systems and opening up new opportunities for jobs and growth in the sector. The only area where some implementation difficulties are met is that of clinical studies, since some projects have underestimated the undertaking required by major multi-partner international studies. However, as for FP7-Health, the main consequences are generally limited to delays in implementation that can often be solved with the extension of project' durations. SC1 has implemented calls for proposals that were directly structured along its main specific objectives. With each topic published generating high quality proposals, all objectives are being addressed. The biggest share of the funding is allocated to 'Treating and managing disease' (43%), followed by 'Active ageing and self-management of health' (13.5 %), 10.5% to 'Understanding health, wellbeing and disease' (10.5%), 'Preventing disease' (9.5%), 'Methods and data' (7%) and 'Health care provision and integrated care' (3.5%).

Based on the review of projects abstracts, ICT projects under the Excellent Science pillar relating to health issues point out their direct relevance for the development of new medication and tools for diagnosis (e.g. 3D medical imaging, development of new antibiotics, brain diseases and dementia and diagnostic tools), and several projects mention the terms health care and public health. LEIT-ICT projects are more focused on a) the provision of personalised and mobile health services and b) the provision of healthcare systems. Healthcare innovations and cost-effectiveness of health systems and the development of related services play a prominent role. Among the ICT projects placed within the priority Societal Challenges, the majority of keywords are also related to health aspects (patient and care, patient empowerment, healthcare and health monitoring), which also accounts for the highest number of projects. Under LEIT-NMBP healthcare applications have been addressed in a set calls and topics on biomaterials for health and nanomedicine. These activities have direct links to the activities in personalised medicine in the respective societal challenge. The LEIT-Space thematic assessment highlights that there may be room for improvement for supporting space research in developing applications for other sectors like health.

Example box: Immunovia AB, a Horizon 2020 health innovation project on the early diagnosis of pancreatic cancer

Project title: IMMPACT 'Clinical validation of a serum protein biomarker signature for the early diagnosis of pancreatic cancer'; SME Instrument Phase 2; May 2015-May 2017; Total cost: € 4.2 million , EU contribution: € 4.2 million.

In 2014, Immunovia AB, a Swedish health company, received an SC1 SME Instrument Phase 2 grant for a project on early diagnosis of pancreatic cancer. It has developed a method using a blood test to detect and diagnose pancreatic cancer earlier than competing methods, which increases chances to treat it. A world first in pancreatic cancer diagnostics, it could increase the overall 5-year survival rate from 3-4 % to approximately 59 %. Thanks to the EU-funding and new capital injection, the company will be able to commercialise it. In 2015, it had doubled its staff from 9 to 18 and developed enough to be accepted for trading on the Nasdaq First North in Stockholm. Before this, Immunovia carried out a promising share issue that was oversubscribed five times. It provided the company with SEK 60 million before issue costs and about 1,100 new shareholders, including many existing, new and international investors. The CEO, Mats Grahn**,** acknowledged that "*The SME instrument has been a decisive financial and confidence support to convince investors to subscribe to our share issue this year (2015) required to entry in the market in US and EU.*"

8.3.1.2. Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy

From the thematic assessment of the Societal Challenge 2 'Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy' (SC2), 75% of the 111 SC2 funded (non-SME) projects are expected to contribute to sustainable and resilient production and consumption systems and rural empowerment, 50% to food security and safety, 29% to empowering rural areas. Additionally, the majority of SME phase I project proposals and reports mention several societal benefits the innovation is expected to bring such as improved welfare for consumers or producers (which generally involve cost reductions and lower prices or higher product quality), improved food quality and food security, greater resource efficiency. The expert group also analysed the impact on society that the innovations undertaken in Phase 2 projects are expected to have if they are successfully commercialised. Most innovations are expected to improve food quality (15 out of 26 projects) and food safety (14), followed by reduction in air and soil pollution (12). Eleven projects envisage their innovations to help increase society-wide water use efficiency. Improved energy efficiency is expected from 8 innovation projects, the same number tackling food waste along the value chain, while 4 expect to reduce food waste at the source. Food security is expected to improve as a result of 7 innovations receiving Phase 2 support. Five projects stated their expected positive effect on preserving wild aquatic (4) and land (1) fauna, the same number expecting to create added value from waste and by-products, improve consumer welfare, and reduce water pollution. Animal welfare will be improved through the implementation of 4 innovation projects, while 3 expect to help improve work productivity.

The bio-economy is also addressed by the biotechnology topics in the LEIT-NMBP programme. In comparison to the Bio-Based Industries initiative (BBI), the biotechnology activities of the LEIT-NMBP programme address more upstream developments (including synergies and some demonstration). Marine-related applications ('Blue Growth') have been addressed by some of the LEIT-NMBP topics in advanced materials. The LEIT-Space thematic assessment highlights that there may be room for improvement for supporting space research in developing applications for other sectors like agriculture.

Example box: COMPARE, a Horizon 2020 food security research and innovation project on the detection of and response to disease outbreaks

Project title: COMPARE 'COllaborative Management Platform for detection and Analyses of (Re-) emerging and foodborne outbreaks in Europe'; Research and Innovation Action; December 2014 – November 2019; Total cost: € 20.85 million, EU Contribution: € 20.82 million; 29 partners.

COMPARE is a large EU project with the intention to speed up the detection of and response to disease outbreaks among humans and animals worldwide through the use of new genome technology (Next Generation Sequencing, Whole Genome Sequencing, Whole Community Sequencing). The project's partners form a multidisciplinary research network that is set up with the common vision to become: (a) the enabling analytical framework and globally linked data and information sharing platform system; (b) for the rapid identification, containment and mitigation of emerging infectious diseases and foodborne outbreaks. The system sets out to integrate state-of-the-art strategies, tools, technologies and methods for collecting, processing and analysing sequence-based pathogen data in combination with associated (clinical, epidemiological and other) data, for the generation of actionable information to relevant authorities and other users in the human health, animal health and food safety domains. Although there are rather high number of partners involved the project is well organised, and managed. This reflects in rather high number (49) of published peer review articles. In parallel to that, the project partners tends to established comprehensive database of protocols, information about reference genomes etc.

8.3.1.3.Secure, clean and efficient energy

The current project portfolio represents only 25% of the total available budget for the Societal Challenge 3 'Secure, clean and efficient energy' (SC3). The project portfolio covers a broad range of aspects within the area, is assessed as in line with the area's scope and objectives specified in the legal base and can be expected to significantly contribute to the specific objectives. The biggest share of the funding goes to 'Low-cost, low-carbon energy supply' (29%), followed by 'Reducing energy consumption and carbon footprint by smart and sustainable use' (28.8%), 'A single, smart European electricity grid' (18.9%); 'Market uptake of energy innovation' (11.8%), 'Alternative fuels and mobile energy sources' (7.7%). 'Robust decision making and public engagement' and 'New knowledge and technologies' receive respectively 2.4% and 1.3% of funding.

Energy-related keywords for ICT actions refer to the objectives of decreasing energy consumption in HPC, energy efficient computing, energy harvesting and overall increase of energy efficiency. Under LEIT-NMBP energy applications have been addressed in topics covering advanced materials and nanotechnology for energy applications. These include renewable energies, as well as storage and distribution. Energy-efficiency is addressed in the cPPPs on energy-efficient buildings (EeB), as well as some of the topics in the cPPPs on sustainable process industries (SPIRE) and Factories of the Future (FoF).

Example box: STEELANOL, a Horizon 2020 energy research and innovation project on the production of bioethanol from steelmaking process emissions

Project title: STEELANOL[274] 'Production of sustainable, advanced bio-ethANOL through an innovative gas-fermentation process using exhaust gases emitted in the STEEL industry'; Innovation Action; May 2015 - October 2018; Total cost: € 14.6 million, EU contribution: € 10.2 million.

The project demonstrates the production of bioethanol from emissions of the steelmaking process which has the potential to significantly reduce greenhouse gas emissions compared to oil-derived fuels. For this purpose, a demonstration plant of approximately 25,000 tons/ethanol per year will be built in Belgium; the first of its kind in Europe, and the largest facility built to date utilizing this technology globally. The project consortium comprises 5 partners from 4 countries. This high-risk/high-impact project is expected to contribute to achieving the targets of the Paris Agreement and advancing the circular economy.

[274] http://www.steelanol.eu/en

8.3.1.4.Smart, green and integrated transport

According to the thematic assessment of the Societal Challenge 4 'Smart, green and integrated transport' (SC4), the programme is on track towards attaining its specific objectives. The analysis of the first two SC4 Work Programmes (without SME instrument and JU), covering the period 2014-2017, shows that all main activity areas are being addressed. The analysis of the funded project portfolio shows that the funded R&I activities are progressing towards providing the required impacts. The activity area "Resource efficient transport that respects the environment" is the one that appears to have been more extensively covered so far (55.9% of funds of the first two WP) - in line with the specific objective of a sustainable transport system. Significant parts of the Specific Programme content are addressed also through other implementation instruments beyond the work programme calls, notably the Joint Undertakings (JUs). Therefore, some topics, which appear to be covered in a rather limited way in the work programmes, are addressed in a significant way through these instruments. Compared to FP7, coordinators of Horizon 2020 projects have higher expectations regarding the ability of their project to address long-term goals in transport. Over 80% of the surveyed Horizon 2020 SC4 projects' coordinators estimate that their projects' results, if implemented, will contribute to the EU transport industry competitiveness, and just below 80% expect to contribute to decarbonising and "greening" the transport system, as well as increasing its efficiency.

Applications in transport have also been addressed under LEIT-NMBP through contributions to the Electric Green Vehicles cPPP (EGVI), covering lightweight materials and next-generation batteries.

Example box: PROSPECT, a Horizon 2020 transport research and innovation project on casualty reduction

Project PROSPECT[275] 'PROactive Safety for PEdestrians and CyclisTs'; Research and Innovation Action; May 2015 – October 2018; Total Cost: € 6.9 million, EC contribution: € 6.9 million.

Even though road safety has improved in recent years, accidents remain a serious problem on European roads, where, on average, 75 people lose their lives every day and 750 are seriously injured. Vulnerable road users (VRUs) such as pedestrians, cyclists, motorbike and moped riders represent a particularly serious safety concern, since they account for a disproportionately high percentage of the total number of road fatalities and serious injuries. By seeking to reduce cyclist and pedestrian casualties, who represent the largest shares of road fatalities, PROSPECT aims at significantly improving the effectiveness of active safety systems on vehicles – and thereby contribute to the 'Better mobility, less congestion, more safety and security' area of activity in the Work Programme.

8.3.1.5.Climate action, environment, resource efficiency and raw materials

Since ongoing projects under Societal Challenge 5 'Climate action, environment, resource efficiency and raw materials' (SC5) are all in their initial phases, there are few available data on outputs. As a consequence it is still too early to assess the actual effectiveness of the SC5 WPs. It is however visible that SC5 made a difference. So far, it changed traditional R&I approaches, making more links between science and innovation through the development of new markets (e.g. climate change services, nature-based solutions) through a systemic approach implying multi-disciplinarity and a challenge-driven, solutions-oriented vision. The biggest share of the funding allocated so far went to 'Protecting the environment, sustainably managing natural resources, water, biodiversity and ecosystems' (23.6%), followed by 'Enabling the transition towards a green economy and society through eco-innovation' (21.7%), 'Ensuring

[275] http://cordis.europa.eu/project/rcn/193275_en.html

the sustainable supply of non-energy and non-agricultural raw materials' (20.9%), 'Fighting and adapting to climate change' (19.9%), 'Developing comprehensive and sustained global environmental observation and information systems' (10.9%). Cultural heritage received 2% of the funding (3 projects).

Under LEIT-NMBP climate action, resource efficiency and the circular economy is addressed in the cPPPs on energy-efficient buildings (EeB) and on sustainable process industries (SPIRE) and on factories of the future (FoF). This involves decarbonisation through energy efficiency, and in the case of SPIRE it involves also direct reductions of greenhouse gas emissions in process industries, the re-use of carbon dioxide and industrial symbiosis. Environmental protection has been fostered in the dedicated activities on nanosafety and the preservation of cultural heritage has been addressed by one topic in advanced materials. Under LEIT-Space topics focussing on EGNSS, Copernicus, earth observation are believed to address the environmental challenge.

Results of **Horizon 2020 expenditure tracking for sustainable development and climate change** show that for the first three years of activity of Horizon 2020 the amounts spent fall behind the expected expenditure for these objectives as of 1 January 2017 - reaching for climate action 27% against the target of 35% applicable to the whole period of Horizon 2020 and for sustainable development 53.3% against a target of 60 %. However, the programme represents a considerable increase in research in those areas as regards FP7. For example, the "Cooperation" part of FP7 is estimated to have contributed EUR 2.4 billion to projects related to climate action, whereas for only the first three years of Horizon 2020 the equivalent figure (i.e. LEIT and Societal challenges together) is EUR 4.2 billion. The responsible EC services identify the main difficulty to reach the expected investments emerging from the bottom-up parts of Horizon 2020, since their content is unpredictable by nature. In addition, the methodology used for this tracking is based on the "Rio Markers" concept from the OECD and its application to diverse research funding tools addressing fundamental research as well as thematic programmes still require further optimisation and fine-tuning. In particular, a better alignment of the climate action and sustainable development tracking methodology with the SDGs would facilitate implementation by clarifying the scope of climate action and sustainable development in relation to globally-recognised goals.

Example box: POWERSTEP, a Horizon 2020 resource efficiency research and innovation project on converting sewage treatment plants into power production facilities

Project title: POWERSTEP 'Full scale demonstration of energy positive sewage treatment plant concepts towards market penetration'; Innovation Action; Total cost: € 5.2 million, EC contribution: € 4 million; 12 partners.

The objective of this project is to convert sewage treatment plants (STEPs) into power production facilities (POWER). For this, the partners will design and demonstrate energy positive wastewater treatment plants with available technologies in 6 full-scale case studies located in four European countries. The estimated benefits are energy savings: 1,7 Mrd €/annum; CO2 – equivalent emission savings: 5,9 million tons; and global market value: 30 Mrd $/annum.

8.3.1.6.Inclusive, innovative and reflective societies

Projects under Societal Challenge 6 'Inclusive, innovative and reflective societies' (SC6) provide a considerable body of informed theoretical and evidence based analysis of Europe's major problems and challenges, even though results are in an early stage. A sample of 56 Horizon 2020 SC6 projects funded under the WP 2014-2015 was analysed for the SC6 thematic

assessment. They are assessed as responding to the Societal Challenge as expected and there are already first publications in high ranked scientific journals. Around 50% of the projects have already developed or expected to develop datasets/ databases. Others will produce simulation tools and other technological devices aimed to foster access to ground information and provide evidences for better policy decision making: 91.3% of the projects are aimed at making political recommendations based on scientific evidence obtained, and 65.2% work in order to have an impact on the formulation of new policies. It has fostered a culture of multidisciplinary collaboration and of societal engagement in Europe and beyond (65.2% engage with end-users during the project, including groups that traditionally have not fully participated in the co-creation of scientific knowledge and agendas, such as the youth). The rise in stakeholder diversity and cross-sectoral collaboration is expected to enable a more diversified social and economic impact, which are however difficult to measure in the lifetime of a project.

A number of ICT projects also mention terms that are related to society and inclusion especially under LEIT-ICT with major keywords mentioned being the participation of citizens and communities, usability, trust, networking, empowering and co-design. Keywords mentioned in some ICT projects under Excellent Science relate to citizen participation, citizen engagement and co-design.

Example box: QUINNE, a Horizon 2020 inclusive societies research and innovation project on the interaction between innovation and employment

Project title: QUINNE - 'Quality of jobs and Innovation generated Employment outcomes'; Research and Innovation Action; April 2015 – March 2018; Total cost: € 2.5 million, EU contribution: € 2.5 million.

QUINNE project also address the topic EURO-2-2014: The European Growth Agenda. The project investigates how job quality and innovation mutually impact each other at the organization level, and what employment outcomes result from this interaction i.e. how more and better jobs are created. The employment outcomes are then tracked in terms of their impact on social inclusion and inequality. QUINNE will produce evidence-based advice on how to boost innovation and economic and employment growth in the EU, along with an awareness of ensuing impacts on social inclusion and inequality. [276]

8.3.1.7. Secure & innovative societies: protecting freedom and security of Europe and its citizens

Based on the assessment of Societal Challenge 7 'Secure & innovative societies: protecting freedom and security of Europe and its citizens' (SC7) two thirds of project coordinators that participated in a dedicated SC7 online survey agreed that this programme part has contributed to increasing the security of Europe's citizens. The majority (75%) indicated that their project has (or will) achieve its aims in full. Only a small minority (3%) of project coordinators have indicated that their project is unlikely to achieve its aims. Most project coordinators have also indicated that end-users are very likely or somewhat likely to use the research results/outputs from their projects. End-users have been included in projects at various stages of the project cycle, including during the inception and design phase, assisting with research and development, testing project outputs (e.g. prototypes) and attending dissemination events and it would appear that some project outputs are already in use by end-users.

The biggest share of funding was allocated so far to 'Improve cyber security' (29.6%), followed by 'Strengthen security through border management' (18.1%), 'Fight crime, illegal trafficking and terrorism, including understanding and tackling terrorist ideas and beliefs' (15%), 'Increase Europe's resilience to crises and disasters' (10.2%), 'Ensure privacy and

[276] Website QUINNE: http://bryder.nu

freedom, including in the Internet, and enhance the societal legal and ethical understanding of all areas of security, risk and management' (9.9%), 'Protect and improve the resilience of critical infrastructures, supply chains and transport modes' (9.4%), 'Enhance standardisation and interoperability of systems, including for emergency purposes' and 'Support the Union's external security policies, including conflict prevention and peace-building' received respectively 4% and 3.8% of funding.

Many ICT projects are also related to security with major keywords being privacy, safety, cybersecurity, resilience and cloud security.

Example box: DARWIN, a Horizon 2020 security research and innovation project on crisis response

Project title: DARWIN[277] 'Expecting the unexpected and know how to respond'; Research and Innovation Action; 1 June 2015 - 31 May 2018; Total cost: € 5 million, EU contribution: € 5 million.

DARWIN is contributing to improve responses to expected and unexpected crises affecting critical societal structures during deliberate man-made disasters (e.g. cyber-attacks) and natural events (e.g. earthquakes). The project is developing European Resilience Management Guidelines (ERMG), which will support the ability of crisis management experts and those responsible for public safety to anticipate, monitor, respond, adapt, learn and evolve, to operate efficiently in the face of crises. After one year, DARWIN achieved promising results: i) definition of the catalogue of resilience concepts and requirements for the development of the ERMG; ii) launched the Community of Resilience and Crisis Practitioners; iii) and presented the initial evaluation plan for the pilots. The guidelines will be user-friendly and presented in formats for easy usage and maintenance. Furthermore, the project is exploring innovative tools such as serious gaming and training packages to facilitate the adoption of the ERMG. The target beneficiaries of DARWIN are infrastructure operators: service providers and related stakeholders who have responsibility for critical infrastructures that might be affected by a crisis as well as the public and media.

8.3.2. Generating science with and for society

Horizon 2020 aims to build effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility.

The dedicated programme Science with and for Society (SWAFS) implements a set of activities to build effective cooperation between science and society.[278]A review of the projects selected so far indicates that **progress is in line with expectations,** though data on the SWAFS KPI ('number of institutional changes') will only become available when projects end. [279]

The SWAFS thematic assessment highlights however several areas for improvement: **an insufficient focus on areas where the greatest impacts are expected**; the lack of clear SMART objectives defined for all topics and projects, and the under-representation of civil society and private companies in the funded actions overall and in particular in actually 'doing R&I' (for instance in citizen science activities). Also while institutional change is clearly defined for the gender equality lines (as an ERA priority) it should be further operationalised for

[277] http://www.h2020darwin.eu/

[278] The SWAFS eight line of activities are: to make scientific and technological careers attractive to young students, and foster sustainable interactions between schools, research institutions, industry and civil society organisations; promote gender equality; integrate society in science and innovation issues, policies and activities; encourage citizens to engage in science through formal and informal science education; develop the accessibility and use of the results of publicly-funded research; develop governance for the advancement of responsible research and innovation by all stakeholders and promote an ethics framework for research and innovation; take due and proportional precautions in research and innovation activities by anticipating and assessing potential environmental, health and safety impacts; and improve knowledge on science communication.

[279] The questions of public engagement in R&I activities and the coverage of Responsible Research and Innovation in Horizon 2020 are discussed in Section 6.3.3.2.

the other lines and focus should be put on sustainability of these changes. **The thematic assessment points out that SWAFS' relatively low budget means that just a handful of projects are funded per topic/line of activity; this spreads resources thinly and reinforces the need to focus on sustainable institutional changes in the programme.**

Gender equality is implemented as a cross-cutting issue in Horizon 2020. **Gender balance in decision-making is close to being achieved with 53% in advisory groups[280] and 36.7% in evaluation panels.** In addition 6022 experts, 3904 women and 2118 men, declared having a gender expertise in the EC expert database in December 2016.

Concerning the workforce, **women represent 31% of projects' coordinators**, incl. 24.5% of ERC Principal Investigators, 42.2% of MSCA Fellows and 26.9% of scientific coordinators in other Horizon 2020 activities. It represents an increase compared to FP7, where women represented overall 28.5% of projects coordinators, 20% of ERC Principal Investigators, 36.5% of MSCA Fellows and 20% of contact persons for scientific aspects in other FP7 activities.

> *The strict requirement of gender equality and the integration of the gender dimension in science and research is an important added value of H2020. It is giving a strong impetus to many supporting programmes and policies in the Member States. Unfortunately there are till now no strict consequences if these topics are not carefully attended, this means a lack of liability and a lack of sustainability. Integrating of the gender dimension in science and research means improved excellence.*
>
> Belgium, European Platform of Women Scientists

Concerning the integration of gender into R&I content, the gender-flagged topics increased from 99 among 610 topics in Work Programme 2014-2015 to 108 among 568 topics in Work Programme 2016-2017[281]. The wording of topics is often generic. At the level of projects, 32.4 % of them[282] were identified by projects officers[283] as having a gender dimension, however it appeared that **this indicator is not yet reliable as what the gender dimension consists of is not sufficiently understood.** The qualitative analysis of a subset of 111 projects from gender-flagged topics, showed the 53% included the gender dimension well or in part. The notion does not seem to be well understood yet and is often confused with gender balance in research teams, nor is it always well evaluated. Furthermore none of the 111 projects included training on gender knowledge (newly eligible cost in Horizon 2020 funding), indicating that the indications provided are not sufficient to generate take-up.

The approach of integrating the Social Sciences and Humanities (SSH) as a cross-cutting issue has meant that inter-disciplinary cooperation is dealt with in a different way as compared with FP7. A network of SSH liaison officers has been established across all Societal Challenges and LEIT parts of the programme to facilitate the integration of SSH across the programme. It also requires applicants to submit proposals and build consortia that transcend disciplinary and sectorial boundaries, bringing together scholars from SSH and from life and physical sciences, technology, engineering and mathematics (STEM) as well as researchers and practitioners across these fields. Every year a monitoring report of the SSH Integration in Horizon 2020 is carried out by DG RTD[284]. SC6 and its calls and topics attract many of the SSH disciplines. In the 2014-15 Work Programme 37% of the topics have been identified as relevant for SSH researchers, and 41 % in the Work Programme 2016-2017. **The quality of**

[280] In FP7 33% of the members of the advisory groups were women.
[281] At the level of the adoption of the work programmes – not taking into account the possible amendments
[282] The indicator does not include MSCA and ERC.
[283] Who checked at the level of the Description of Activities annexed to the grant agreement when preparing grant agreements.
[284]European Commission, SSH monitoring report 2014 and 2015

SSH integration is highly uneven across projects but almost half of the projects funded under SSH flagged topics show good or fair integration of SSH in terms of share of partners, budget allocated to them, and variety of disciplines involved. Contributions from economics, sociology, political science and public administration are well integrated while many other SSH disciplines are underrepresented, especially geography/ demography and philosophy/anthropology. The low participation of the humanities and the arts remains a challenge. Overall, EUR 433 million went to SSH partners in SSH flagged topics, representing 22% of the estimated total budget for the SSH flagged topics. In terms of countries represented, the SSH partners and coordinators in projects flagged as SSH relevant come predominantly from a group of 5-6 Member States.

70.1% of the stakeholder consultation respondents agreed fully or to a large extent that Horizon 2020 is helping to support science with and for society, 21.4% agree to some extent and 3.3% not at all. The most positive respondents are businesses and research organisations, whereas the least positive are NGO and public authorities.

8.3.3. Generating science for policy

Horizon 2020 aims to provide robust, evidence-based support for Union policies. This shall be driven by customer needs, complemented by forward-looking activities.

The objective of generating science for policy is mainly pursued through the direct research actions of the Joint Research Centre (JRC) but also through projects implemented across Horizon 2020.

The JRC direct research actions play a distinctive role in the EU policy processes by providing scientific knowledge and technological competence for EU policy making.[285] In addition to providing fit-for-purpose scientific and technical support, the JRC has to maintain an anticipatory function, a strategic dialogue with partners and a research base. It aims at fostering excellence through internal quality control and external peer review, evaluation and benchmarking, while striving for quality labels and certifications, where appropriate. It also develops new methods, tools and standards, sharing its expertise with its partners. A strong relationship between the JRC and the Member States is a high priority for the organisation. Hence to the extent possible the direct actions are implemented taking into account relevant initiatives at the level of regions, Members States or the EU, within the perspective of shaping the ERA. The JRC implements the open access policy established under Horizon 2020 and Commission policies.

From the evidence collected, the research results of the JRC have provided support to policy making under the Commission priorities; this included areas of high political activity such as the energy union, sensitive issues such as the regulatory framework for emissions from road vehicles, areas where the EU has taken a global leadership (such as the negotiations on climate change), or pressing issues such as the economic and monetary union. JRC has also started to place increasing focus on pressing issues such as security and migration, and on supporting regional economic development. DG REGIO of the European Commission established jointly with the JRC the S3 Platform[286] to support

[285] The key areas in which the JRC offers support are: energy and transport, environment and climate change, agriculture and food security, health and consumer protection, information society, innovation and growth, economic and monetary union, reference materials and standards, safety and security (including nuclear safety and security in the Euratom programme).
[286] http://s3platform.jrc.ec.europa.eu/

Member States in developing and implementing Smart Specialisation Strategies. It acts as a facilitator for regions and countries in the uptake and incorporation of the smart-specialisation concept and methodology in their R&I strategies. Over 160 regions and the majority of the Member States are registered members in this platform.

In 2013 the Board of Governors commended the JRC's internal review processes in a special report.[287] For the first years of Horizon 2020, a total number of 350 occurrences of tangible specific impacts on European policies is identified in the JRC annual activity report. The number of peer reviewed publications in high-impact journals fluctuates around 700 since JRC scientists publish between 600 and 800 scientific articles in peer-reviewed journals every year.[288] **More than 16% of JRC's peer-reviewed publications are among the world's highly cited publications,[289] confirming that scientific publications of the JRC have an impact in the international scientific community.[290]**

Science for policy is generated also through the Projects for Policy (P4P) initiative, which aims at identifying portfolios of projects linked to different thematic areas in both FP7 and Horizon 2020 in order to develop recommendations rising from the results of funded projects. For instance, a portfolio analysis of 135 projects on efficient and sustainable batteries has shown important impact on strengthening the knowledge base across the batteries supply chain in both the research sector and industry. They have furthered understanding and knowledge of materials sciences and engineering, chemistry, electrochemistry and battery cell design and performance. They have also provided industry with new knowledge and capabilities that can be used to make improvements to existing products and processes.

Similarly, a major investment, close to EUR 900 million, has been made from FP7 and Horizon 2020 to 164 collaborative projects related to rare diseases. The results of the EU-funded projects bring new knowledge on the understanding of the epidemiology, pathophysiology and natural history of rare diseases and bring forward the translation of the results into the development of new diagnostic tools and therapies for rare diseases. Concrete benefits for healthcare have been delivered in terms of clinical guidelines for the diagnosis and treatment for rare diseases. Projects also provide tools for effective and ethical sharing of research and medical data as well as insights into new methodologies for clinical trials in small populations and health technology assessment and thus strengthen the evidence base for future policy decisions regarding the regulatory pathway and access to new interventions.

87% (3018) of the public consultation respondents agreed, at least to some extent, that Horizon 2020 helps developing and implementing EU policies, yet a comparatively low number of respondents (18%) agreed "fully with this statement, which is far less than the number of respondents who did so for the contribution of the programme to support science with and for society. Also **almost all the stakeholder consultation respondents agreed (at least to some extent) that Horizon 2020 is contributing to foster the role of the European Union as a stronger global actor (92%).**

[287] Impact analysis of JRC activities - Special report for the 100th meeting of the Board of Governors, (2013)
[288] Thomson Reuters study on the research performance of the Joint Research Centre of the European Commission during the 7th Framework Programme (2007-2013) + supplement (2014-2016) in preparation.
[289] Thomson Reuters deems papers "relatively highly cited" when they are in the top 10% of the world's most frequently cited papers, taking into account year and field of publication
[290] Ex-post Evaluation of the direct actions of the Joint Research Centre under the Seventh Framework Programmes 2007-2013. The FP7 ex-post evaluation of JRC direct actions (2007-2013) highlighted that this level of scientific productivity is giving the JRC a respectable position amongst its comparators during this period.

Box: Examples of initiatives of Science for policy across Horizon 2020

The **ERC** has supported some of the world's leading economists including the Nobel Prize winners Jean Tirole, Christopher Pissarides, James Heckman as well as Thomas Piketty and Helene Rey.

The **MSCA** have launched a pilot **Society & Entreprise panel** for Individual Fellowships which is open to the participation of governmental organisations. The first call resulted in six researchers taking up their fellowships in public administrations throughout Europe.

LEIT-NMBP funds scientific and regulatory research in the area of nanosafety, contributing to EU regulations as well as to international standards in the OECD context. The NanoSafety cluster addresses policy and risk governance issues related to the use of nanotechnology. The targeted results include predictive models and harmonised standard operating procedures for nanotechnology.

SC1 launched the first European Joint Programme Cofund under Horizon 2020. The HBM4EU initiative represents a novel way of collaborating between several Commission services, EU agencies and national representatives, highlighting how research funding can build bridges between the research and policy worlds. A joint effort of 26 countries and the Commission, its aims to coordinate and advance human biomonitoring in Europe and will thereby provide better evidence of the actual exposure of citizens to chemicals and the possible health effects to support policy making.

SC3 has been supporting projects which influence policy making, notably related to energy issues, at local, national and EU level. For example, the project AURES (CSA) aims at supporting policy makers at EU and Member States level in improving the effectiveness and cost-efficiency of financial support systems for electricity from renewable energy sources, notably through improving the design of auctions. AURES will develop best practices and tailored policy recommendations for future auction designs, making it possible for policy makers and markets participant to make informed decisions when dealing with renewable support policies.

The **SC4** project LOWBRASYS[291] is tackling for the first time the issue of particles emissions from brake pads and discs, starting from the understanding of their generation and effects to methods for their measurement and reduction, thus supporting the work of the Commission DGs involved in road emissions regulation and providing input to the United Nations Particle Measurement Programme Working Group in assessing the situation and developing legislation.

Under **SC6** all the reviewed projects do consider the relevance of their outcomes to provide a basis for evidence-based policies in the diverse fields related to SC6. All projects stated that they will produce policy recommendations, and seven of the on-going projects have already Policy briefs in their webpages. Collaborations with policy makers at both national and EU level are described in most approved projects. For example the Action Plan on the integration of Third Country nationals[292] takes into account recommendations from the migration policy review of projects under FP7 and SC6.

8.4. What is the overall progress of Horizon 2020 towards its general objective?

Summary box: Key findings on the progress of Horizon 2020 towards its general objective

- ✓ Through its focus on scientific, economic and societal impact, Horizon 2020 is on track to contribute to the creation of jobs and growth and the achievement of the priorities of the Juncker Commission.
- ✓ Horizon 2020 is projected to produce large-scale economic impacts.
- ✓ Having marked a definite shift towards innovation, Horizon 2020 is contributing to the Innovation Union flagship of the Europe 2020 strategy, by improving and strengthening the framework conditions and facilitating access to risk finance for R&I.
- ✓ Horizon 2020 contributes to the achievement of a Digital Single Market.
- ✓ Horizon 2020 contributes to improved resource efficiency.
- ✓ Horizon 2020 reinforces the European Research Area.

[291] http://www.lowbrasys.eu/
[292] COM(2016) 377 final

By pursuing its general objective of building a society and an economy based on knowledge and innovation - and based on its early progress towards achieving scientific, economic and societal impact - Horizon 2020 is on track to contribute to the creation of jobs and growth and the achievement of the priorities of the Juncker Commission.

As already highlighted in the previous sections, it is difficult to assess the extent to which Horizon 2020 - which only represents a small proportion of total public R&D spending in the EU - is contributing to key performance indicators set to measure progress against the general objective (the target of 3% of GDP invested in R&D, the evolution of the innovation output indicator and the share of researchers as part of the active population).

However an external study using a macro-econometric model (NEMESIS) estimated the contribution of Horizon 2020 to growth and jobs.[293] Macro-econometric simulations were carried out using partially real data on the actual allocation of Horizon 2020 funds during the first years and partially projections on the basis of the budget available for the remaining years of its implementation. The economic impact of Horizon 2020 on EU GDP is reported in the graph below, which assesses the difference between Horizon 2020 economic performance and the reference scenario. In the context of this study, the reference scenario is based on the assumption that, at the end of FP7 in 2013, Horizon 2020 would have not been implemented. The impact follows three main phases. In the first phase (maturation) up to 2023 there are only few innovations and the increase in GDP is mainly the result of the demand induced by the investments in R&D through Horizon 2020. The recruitment of research personal increases real wages as well as final consumption. The inflationary pressures deteriorate competitiveness and the increase in demand raises imports. After 2020, the reduction of the EU contribution pushes down the GDP gains. During the second phase (innovation) up to 2030, the arrival of process and product innovations increases the internal and external demand. The external demand becomes gradually the main driver of the GDP gains. It is at the end of this second phase (around 2030) that the maximum impacts of Horizon 2020 are reached.

Compared to the reference scenario in which – after FP7 – Horizon 2020 would not have been implemented, at its peak in 2030, Horizon 2020 is estimated to bring a GDP gain of between 0.27% and 0.34% compared to the GDP of the reference scenario in 2030. During the third phase (Maturity and obsolescence), the gradual obsolescence of new knowledge progressively cancels GDP gains.

On average, the GDP gain is estimated to amount to between EUR 24 billion and EUR 35 billion per year (in 2014 prices) during 2014-2030. Over the same period of 17 years, the total GDP gain is between EUR 400 billion and EUR 600 billion: each EUR of Horizon 2020 investment brings a GDP increase of between EUR 6 and 8.5. This high economic return is justified by the assumptions that investing in R&I at EU level has a higher economic performance justified by its added values (between 15 and 21%[294]) and is better in terms of attracting additional funding (direct leverage of up to EUR 0.40 for each EUR in-

[293] The analysis has consisted in simulating different scenarios comparing the situation of the EU economy in the short (during the execution of the research programme), medium (2030) and long term (2050), to a reference scenario where, by assumption, the Framework Programme would have ceased in 2014, after the end of FP7.For all the assumptions of the model please refer to the specific study (contract n° 2012/S 144-240132): PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming. It should be bear in mind that the benefits arising from Horizon 2020 are numerous and go much beyond a strict quantification in monetary terms.

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

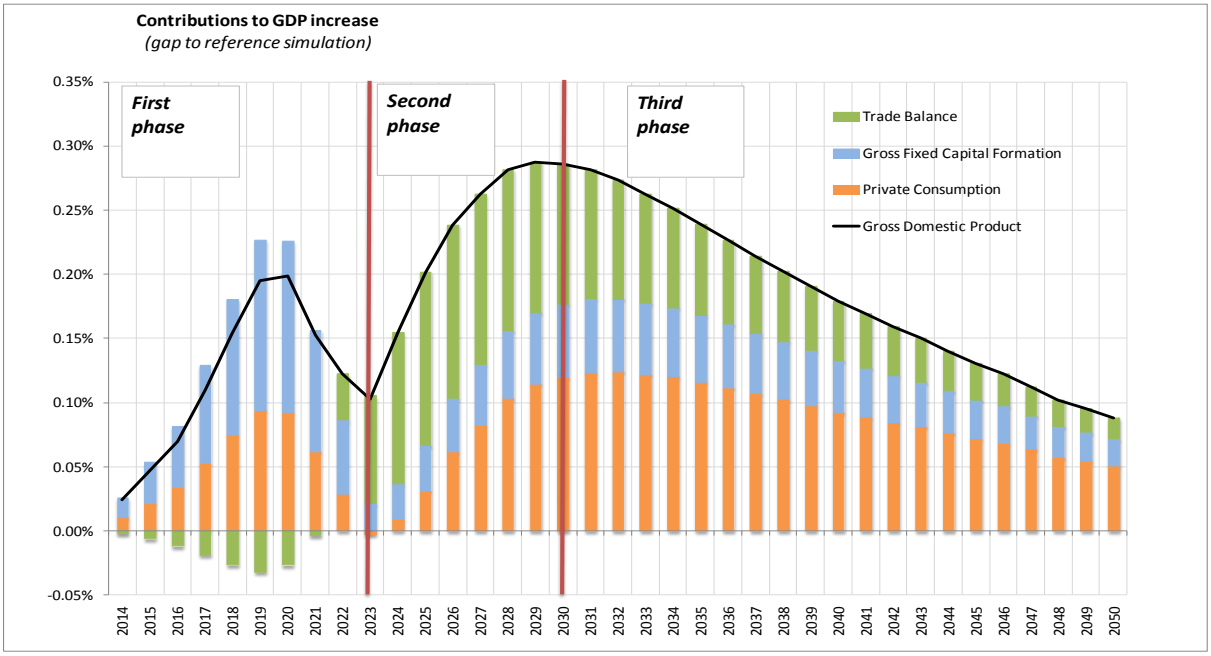
vested)[295] compared to national programmes. These ranges are, nontheless based on sensitivity analysis considering both a pessimistic and optimistic scenarios: in the pessimistic scenario, it is assumed that there is no better economic performance compared to national programmes while the direct leverage effect is the lowest (EUR 0.16 for each EUR invested); in the optimistic scenario, it is assumed that the economic performance of Horizon 2020 is 21% higher than national programmes and its direct leverage effect is EUR 0.40 for each EUR invested.

Box: Strengths and limitations of the NEMESIS model

NEMESIS is a macro-econometric model that does not rely on a general equilibrium framework. Three types of innovation activities are captured in NEMESIS: investments in R&D, investments in ICT and in other intangibles. For this reason, Di Comite and Kancs (2015)[296] consider that NEMESIS is the richest model in terms of innovation types when compared with other standard macro-economic models for R&D and innovation policies (QUEST, RHOMOLO, GEM-E3). Innovations that are generated in each sector are process and product innovations, and distinct impacts on economic growth and employment are calibrated for each type of innovation from the results of previous studies. Endogenous growth comes from the increasing returns of the accumulation of three knowledge stocks reflecting knowledge externalities that are specific to countries and sectors and to the type of investment: R&D, ICT or other intangibles. Private and public R&D is also differentiated in terms of impact. Due to its econometric nature and its departure from general equilibrium framework, the specification of NEMESIS can ensure a high level of fit with observed data.

While the strengths of NEMESIS justify its relevance for measuring the impact of R&I policies, the specificities and approach of the model also imply a number of limitations that have to be taken into account when interpreting the results of the model. First, it relies on the empirical observation of relationships and allows for flexibility in behavioural functions, which may generate inconsistencies with most recent developments in macro-economic theory. Furthermore, it does not use forward looking expectations but adaptive ones. Regarding the use of human capital in the model, NEMESIS does not link it with investments in the educational system.

Figure 80 The economic impact of the Horizon 2020 funding for research on EU28 GDP (in % deviation from reference scenario)

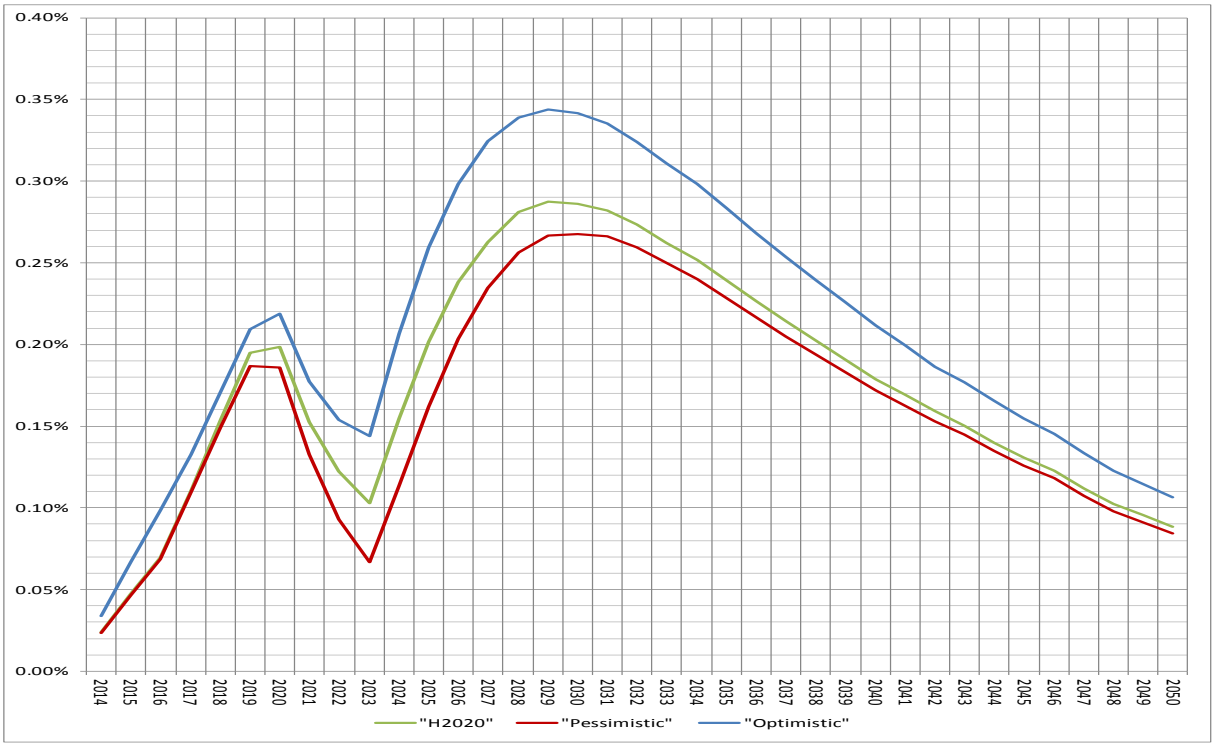


Source: PPMI based on NEMESIS model results

[295] Calculated on estimations of total costs of Horizon 2020 projects, based on real data from Corda combined with a methodology for the estimation of real indirect costs.

[296] F Di Comite and D Kancs, Macro-Economic Models for R&D and Innovation Policies (2015), IPTS Working Papers on Corporate R&D and Innovation – No 03/2015

Figure 81 Sensitivity analysis of EU GDP gains from Horizon 2020 (in % deviation from reference scenario)



Source: PPMI based on NEMESIS model results

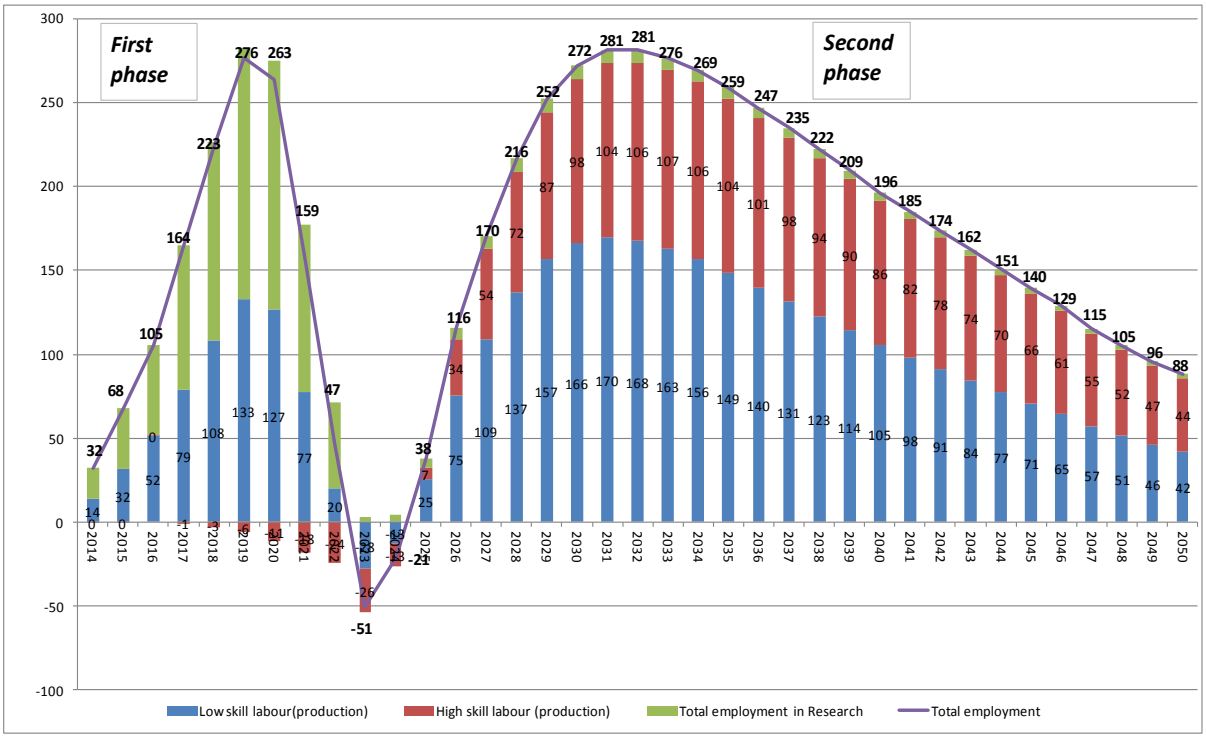
In terms of employment, two phases can be distinguished, as shown in the figure below. In the first phase, up to 2022, the EU contribution increases significantly employment in research activities, where most of the jobs are created. Job creation peaks in 2019 when the number of job is 276 000 more than in the reference scenario in the same year (150 000 of them are in research sector). Once the Horizon 2020 funding starts decreasing – i.e. beyond 2020 – employment in research comes close to zero. Innovations are not yet numerous enough to push up vigorously the demand of goods and services, while the inflationary pressures of the first period continue to lower exports: the consequence is a decrease of total employment even below the reference scenario (-51 000 in 2023). In the second phase, innovation enters into the market and pushes up the employment creation. In 2030, employment would amount to 272 000 jobs more than in the reference scenario, including 8000 jobs in research. **Taking into account the sensitivity analysis, during the period 2014-2030, the EU contribution through Horizon 2020 is forecasted to have increased the level of employment compared to the reference scenario by between 110 000 and 179 000 units, including between 29 000 and 35 000 jobs in research.**

The study brings many additional findings: **in 2030, the internal rate of return[297] of the Horizon 2020 contribution would amount to between 26% and 37%; the investments in research provoked by Horizon 2020 would increase labour productivity by between 0.16**

[297] The internal rate of return was calculated as the actualisation rate that equalizes the actualized sum of GDP gains to the actualized sum of the Horizon 2020 contribution. It increases slightly in time as annual GDP gains stay positive in most countries up to 2050 while EC contribution stops after 2022. This 30% rate of return is in line with the econometric literature results (cf. Hall, Mairesse and Mohnen, 2011). According to most studies, the overall value generated by public research is between three and eight times the initial investment, which in rates of return represents a median value between 20% and 50% (cf. Georghiu, 2015).

and 0.20%; the Horizon 2020 impact on EU external competitiveness would increment net exports by between EUR 18 and 23 billion; the final energy consumption by unit of GDP and the energy-related CO2 emissions would be reduced by 0.2%. Under similar conditions, the estimated GDP gains and the estimated job creation in 2030 are respectively 34% lower and 35% lower compared to those predicted in the ex-ante impact assessment[298]. These discrepancies seem mainly related to the size of the budget inputted in the NEMESIS model[299] and to the assumptions made for the direct crowding-in.[300]

Figure 82 Impact of Horizon 2020 on total employment in thousands (difference from reference scenario)



Source: PPMI based on NEMESIS model results

The same study included a survey of beneficiaries on this issue, and found that they expect to generate an estimated EUR 57 billion from their main innovation in the next three years. While this revenue is not factual and likely to be revised downwards in the future, it illustrates the strong confidence in the technologies developed. It is likely that very substantial revenue is yet to be accrued from the R&I activities performed.

[298] In order to make this comparison feasible, some basic assumptions were modified: notably, it was assumed that Horizon 2020 would continue beyond 2020 and its budget would increase per year by EUR 450 million after 2020.

[299] The NEMESIS calculations for the ex-ante Impact Assessment of Horizon 2020 were based on a budget of EUR 84.9 billion, while for the Interim Evaluation the budget considered was EUR 69.3 billion. Cumulating the investments beyond 2020, the total budget introduced in the model varies from 246 billion for the ex-ante Impact Assessment to 217 billion for the Interim Evaluation – a difference of 12% in the size of the budget.

[300] In the ex-ante impact assessment, the crowding-in effect was assumed to be equal on average to EUR 0.86 (each EUR of Commission contribution leading to an additional R&D expenditure of EUR 0.86 from other public and private actors), while in the interim evaluation this was estimated on conservative figures from CORDA and it was set at EUR 0.24.

Figure 83 Estimated revenue generated from the main innovations of FP-funded research teams

	Revenue generated from the main innovation in 2015			Expected revenue during the next 3 years
	Share of projects whose main innovation has this revenue	Total revenue generated	Of which: exports	Expected revenue in the next three years
No revenue	81%	n/a	n/a	n/a
Up to EUR 100k revenue/value	6.5%	1.37 billion	0.59 billion	14.8 billion
Between EUR 100k and EUR 0.5 M revenue/value	6.1%	1.28 billion	0.47 billion	17.2 billion
More than EUR 0.5 M revenue/value	6.6%	1.39 billion	0.73 billion	24.8 billion
Total	**100%**	**4 billion**	**1.78 billion**	**57 billion**

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

Almost all the stakeholder consultation respondents agreed (at least to some extent) that Horizon 2020 is contributing to support jobs, growth and investments (94.5%).

62% of the stakeholder consultation respondents think that Horizon 2020 is helping fully or to a large extent to 'implement the Europe 2020 strategy, the EU's strategy for jobs and smart, sustainable and inclusive growth'. Only 2.2% do not share this view at all. In addition, 71.5% of the respondents think that Horizon 2020 is helping fully or to a large extent to build a society and an economy based on knowledge and innovation. For both options, the least positive respondents are umbrella organisations representing research organisations and NGOs. **74% agree (at least to some extent) that Horizon 2020 is contributing to achieve a deeper and fairer internal market with a strengthen industrial base**, **72% to promoting an Energy union with a forward looking climate policy** (25.3% do not share this vision at all, which is the priority with the highest share of full disagreement), and **66% to help to create a Digital Single Market** (29.4% of respondents not to know).

8.5. Key conclusions on the effectiveness of Horizon 2020

In terms of effectiveness even if at a very early stage of implementation and the lack of indicators to track progress across all objectives, Horizon 2020 is on track to achieve its specific objectives – strengthening the science base, tackling the insufficient technological leadership and innovation capability in the private sector, and addressing the insufficient contribution of R&I to tackling societal challenges – thereby contributing to the achievement of its **general objective** – building a society and economy based on knowledge and innovation across the Union while playing a role in the reinforcement of the European Research Area and the implementation of the Europe 2020 Strategy.

It already strengthens the science base by involving the EU's and world's best research institutions and researchers; by training large numbers of EU-based researchers; by producing large numbers of world class open access scientific publications and data; by producing scientific breakthroughs; and by building cross-sectoral, inter-disciplinary, intra- and extra-European research and innovation networks. It is so far difficult to assess the extent to which Horizon 2020 - which only represents a small proportion of total public R&D spending in the EU - is contributing to key performance indicators set to measure progress against the general objective (the 3% GDP target, innovation output indicator and share of researchers as part of the

active population). Nevertheless, Horizon 2020 is expected to have a significant socio-economic impact in the medium to the long term, which are projected to peak towards the end of the next decade, when new product and process innovations enter into the market.

More specifically Horizon 2020 with its focus on excellence is on track towards achieving **scientific impact** through the reinforcement of R&I capacities, the integration of R&I efforts and its contribution to the achievement and reinforcement of the European Research Area. There are early indications of the quality of the knowledge created and circulated, making Europe an attractive destination for excellent researchers worldwide and generating scientific breakthroughs. Research infrastructures are contributing to increase the knowledge base with shared distribution and access to data, materials and tools that are accessible across the EU. Horizon 2020 is also making progress, albeit slowly, on spreading excellence across Europe. The dedicated SEWP actions have mobilised stakeholders at the political level and have shown early signs of structuring effects (notably in preparation for the Teaming actions) but further efforts can still be made.

Horizon 2020 is putting more emphasis than FP7 on supporting closer to market applications and innovation, and there is early evidence of progress towards **innovation and economic impact**. It fosters industrial leadership by successfully involving the private sector and SMEs; by creating networks between the business sector, universities and research institutions; by providing businesses and SMEs with risk finance to carry out their research and innovation projects; by investing in demand-driven innovation; by producing high quality, commercially valuable patents and other intellectual property rights; by generating proofs of concept and demonstrators and supporting the deployment of innovation solutions; by producing new knowledge, strengthening capabilities, and generating a wide range of innovation outputs including new technologies, products and services; and by increasing the competitiveness of beneficiaries. Most of the targeted outputs relate to products and processes, and to a lesser extent to services, although these are becoming increasingly linked to manufacturing. Single-beneficiary projects have been quicker than collaborative projects in applying for IPR. However, a number of potential factors impeding full effectiveness in terms of market uptake have been identified and relate to the capacity of innovation systems to address a range of issues, particularly for SMEs: technological, regulatory, standards, technical and access to finance, as well as lack of customer acceptance of new solutions. The programme has yet to make a significant outreach to young and fast growing innovative companies. On balance, despite positive progress made in coupling research with innovation, it is too early to point to a major impact in terms of breakthrough innovations entering the market.

Whereas FP7 was focused on specific domains, Horizon 2020 puts more emphasis on **societal impact** and aims at contributing through research and innovation to tackling the major societal challenges Europe and the world are facing. The Societal Challenges pillar is already generating publications, patents, prototypes, products, process and methods in domains of relevance for society. The portfolio of projects selected and their progress are in line with the objectives set. Noticeably most Horizon 2020 projects are expected to generate cross-cutting impacts, including from the Excellent Science and Industrial Leadership pillar generating key discoveries and technologies. In terms of achieving the objectives set, stakeholders believe Horizon 2020 is helping relatively less to address societal challenges than other objectives, while the internal framework for systematically identifying impact is lacking. Moreover, results of expenditure tracking for sustainable development and climate change show that the programme falls behind the expenditure target, which is mainly due to the bottom-up (hence unpredictable) parts of Horizon 2020 and methodological problems, which are being addressed. It is still expected that the target will be achieved by the end of the Programme.

A review of the projects selected so far indicates that the progress Horizon 2020 is making in generating science with and for society is in line with expectations. Results are encouraging in terms of the integration of Responsible Research and Innovation, Gender in research content and Social Sciences and Humanities in Horizon 2020, although some data quality concerns exist. Apart from the relatively low budget, the limited lifetime of funding, and the fact that just a handful of projects are funded per topic, which spreads resources rather thinly, factors impeding full effectiveness of projects supporting science with and for society include the lack of clear objectives defined for all topics, the fact that not all lines work clearly towards the SWAFS key performance indicator (number of institutional changes), and the under-representation of some parts of society (particularly private companies and other types of organisations) in the funded actions.

9. HOW COHERENT HAS HORIZON 2020 BEEN SO FAR?

This question involves looking at the extent to which Horizon 2020 actions work together, internally and with other EU interventions/policies and to identify whether there are major complementarities, gaps or overlaps between the initiatives.

Expectations from Horizon 2020 as regards its internal and external coherence

Based on the Horizon 2020 impact assessment - and compared to FP7 - knowledge triangle and broader horizontal policy coordination are expected to be enhanced under Horizon 2020 through the integration of research, innovation, and researcher training and skills development into a single framework, and the explicit definition of links with other policies. In addition, the reduction of the number of programme pillars and funding schemes is expected to facilitate the gearing of all programme components towards the achievement of the objectives.

Summary box: Key findings on the internal and external coherence of Horizon 2020

- ✓ The integration of research and innovation, the three pillar structure, the challenge-based approach, and the use of focus areas contribute to the internal coherence of Horizon 2020 compared to FP7.
- ✓ Outside the 'Excellent science' pillar, Horizon 2020 is increasingly focused on research and innovation at higher Technology Readiness Levels. It should be ensured that this does not come at the expense of lower Technology Readiness Levels collaborative research, which is regarded as one key source of future breakthrough innovations in line with societal needs.
- ✓ The large number of European R&I funding instruments is difficult to understand for potential applicants and may lead to overlaps.
- ✓ Compared to FP7, efforts have already been made to increase the synergies between Horizon 2020 and other programmes, notably ESIF but these can be further strengthened.
- ✓ Given the different rules and implementation structures, promoting synergies at project level (in term of combining different financing sources for the same project) is not always realistic. The difference in state aid rules further leads to legal uncertainty for potential beneficiaries.
- ✓ Horizon 2020 specifically aims to establish synergies with national programmes. Public-public partnerships are creating long lasting collaborations between funding agencies and capacity building benefits but do not seem to really influence the alignment of national strategies and policies.

9.1. To what extent is Horizon 2020 coherent internally?

The sources of evidence mobilised for this interim evaluation point that **the integration of research and innovation into a single programme, the structuring around three pillars and a set of challenges instead of thematic domains improved the overall coherence of the programme compared to FP7**.

Figure 84 provides a quick overview of the different approaches pursued under each pillar and the main target groups.

Figure 84 Main approaches and target groups of Horizon 2020 pillars based on programming documentation

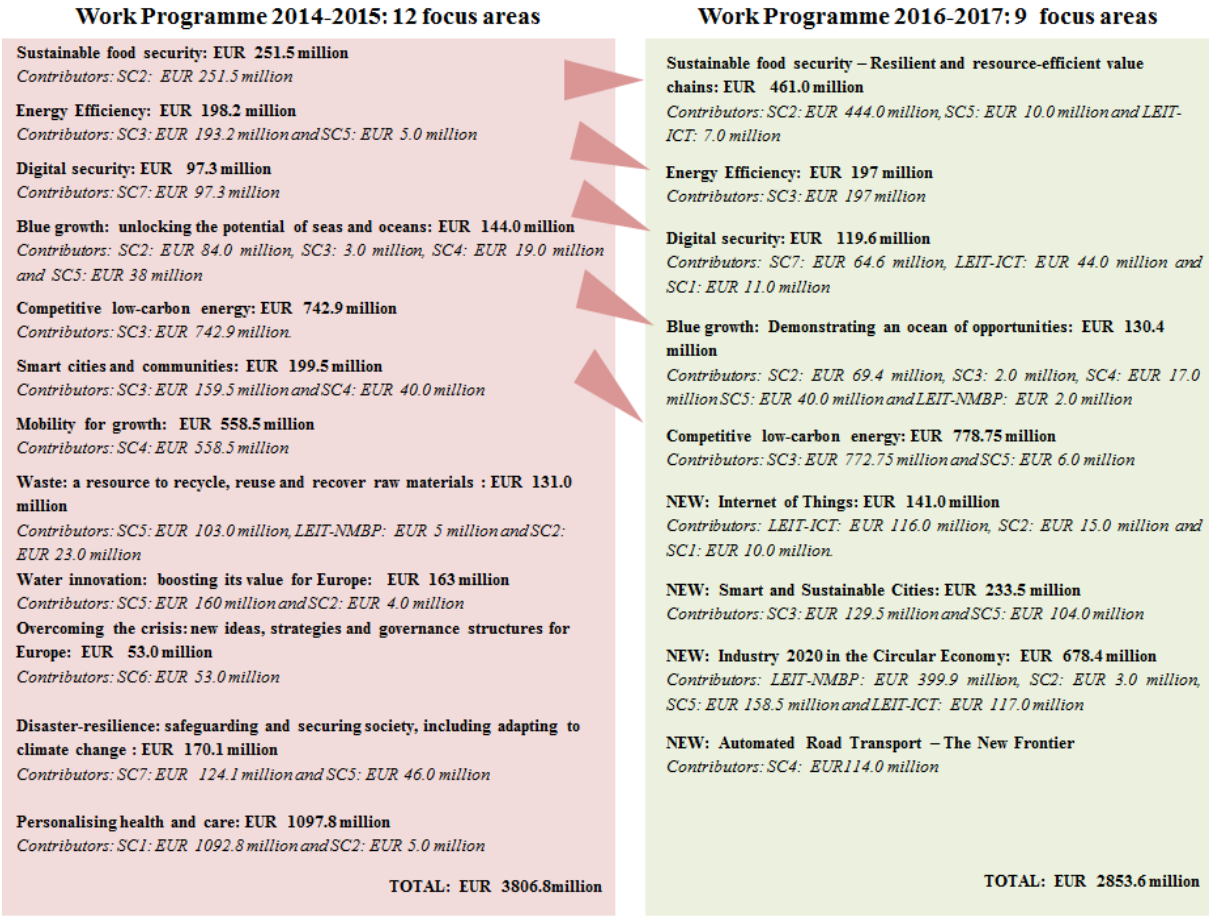
Horizon 2020 pillar	Main approach	Main target group
Excellent Science Excellence-driven[301]	Bottom-up (ERC, Marie Skłodowska-Curie Actions, FET-Open) Top-down (FET Proactive, Research Infrastructures) Either single beneficiary or collaborative projects	Scientific community
Industrial Leadership Technology-driven[302]	Primarily bottom-up (SME Instrument, Access to Risk Finance) Top-down (Leadership in Industrial and Enabling Technologies) Either single beneficiary or collaborative projects	Businesses and industry
Societal Challenges-Challenge-driven[303]	Top-down (priority-based) Collaborative projects (+SME Instrument)	Scientific community, Businesses & Society

Source: European Commission

The internal coherence at programming level is also regarded as reinforced by the use of focus areas - even if their multiplication also results in some confusion - and the fact that many projects are expected to have cross-cutting impacts.[304] Focus areas were introduced where priorities identified from strategic programming cut across the parts of Horizon 2020 e.g. blue growth, circular economy, Internet of Things, Smart and Sustainable cities, Digital Security. They intend to concentrate resources and efforts on key areas of high policy and political relevance and societal concern, alongside increasing industrial competitiveness and providing better solutions and achieving higher impacts through stronger integration across different Horizon 2020 parts, in particular between the Societal Challenges and Leading Enabling and Industrial Technologies (LEITs) thus adding coherence to the programme and avoiding silos. These interdisciplinary solutions are expected to cut across multiple specific objectives, ensuring both coherence and increased cost-efficiency. So far, 21 focus areas were identified (12 in the 2014-2015 Work Programme and 9 in 2016-2017 Work Programme). The choice of focus areas was made following the EU's key priorities and setting these against the R&I activities which could meet these needs.

[301] Based o, Horizon 2020 Specific Programme
[302] Recital 9, Horizon 2020 Specific Programme
[303] Annex I, Part III, Societal Challenges, Horizon 2020 Regulation
[304] For example, the survey run among project coordinators in SC4 found strong evidence (85% agreement overall) of projects simultaneously tackling several challenges and give rise to new competitive businesses and industries (e.g. contribution to decreased CO2 emissions, improved marine environment, while creating increased competitiveness of European paint industry). See more in-depth analysis in Section 8.3.1

Figure 85 Contribution of Horizon 2020 programme parts to focus areas in WP 2014-2015 and 2016-2017



Source: European Commission, DG RTD, based on Horizon 2020 Work Programmes

Stakeholder position papers: The current pillar structure improves the clarity of the programme but linkages across the pillars should be enhanced.

In their position papers, almost half of the stakeholders commented on the current programme structure. Half of those commenting have a positive view of the three pillar structure. They see it as a pragmatic and easy way to clarify the goals of different programme priorities.

However, others pinpointed that the coherence and linkages between activities and projects under the three pillars should be strengthened. In particular, they mentioned a need for better links between the excellent research supported under Pillar 1 and topics in Pillars 2 and 3. To enhance such linkages one representative of academia, for instance, suggested to extend the principle of ERC proof of concept grants across the entire programme. As a further example, one business stakeholder noted that the current "hand off" between Pillar 1 and Pillar 2 hampers in particular the FET projects (more fundamental research) to be advanced to sufficient maturity on the TRL scale to entertain a go-to-market solution by industry which is currently incubated through the LEIT ICT calls. It was suggested that cross-pillar innovation should be enabled and ensured by the Work Programme by for example give a preferential score for proposals that build on previous project results.

A cross-analysis of the thematic assessments performed for this interim evaluation clearly points out to the overall complexity of the EU research and innovation support landscape. Looking at Horizon 2020 only the three pillars of Horizon 2020 consist of around 20 programme parts supporting different areas in different ways (e.g. grants, prizes, financial instruments) in addition to the activities of the EIT (with the KICs), the JRC direct research actions and Euratom. Cooperation networks have been established under 66 active ERA-NET/ERA-NET Plus/ERA-NET Cofund, ten Joint Programming Initiatives (JPI), five Article

185 Initiatives, seven Joint Technology Initiatives (JTIs), ten Contractual Public Private Partnerships (cPPPs). Outside Horizon 2020 but providing inputs to the strategic programming of Horizon 2020 there are also five European Innovation Partnerships (EIP)[305] and 42 European Technology Platforms (ETPs)[306]. In addition, the COSME programme is supporting SMEs, the COST actions support international research actions, and EU programmes such as LIFE+ or the European Structural and Investments Funds also provide support for R&I although with different objectives. This gives potential applicants an array of funding opportunities and/or networking platforms to navigate through, when looking for R&I support at EU level. Stakeholder consultation respondents also suggest that the funding architecture is too complex and may hinder organisations from identifying the calls and instruments that would best fit their needs and create risk of duplication.

To ensure coherence between the different specific objectives and programme parts and mitigate the risk of overlaps, different internal coordination mechanisms across Horizon 2020 were put in place at the programming and implementation level, such as: regular meetings of services interested in a given area; inter-service groups and consultations on the Work Programmes; ex-post consultations on the list of projects retained for funding, informal contacts at project officer level; joint events, joint publications, joint kick-off meetings, etc. Examples of the search for coherence across Horizon 2020 parts are provided in the Box below. Some thematic assessments however report that more systematic tools, channels and processes to ensure access to internal (e.g on R&I activities/results supported by the EU outside of a given area) and external information (e.g. on R&I spending and priorities at national and regional level) are lacking.

Box: Examples of coherence between Horizon 2020 programme parts

In SEWP, since the funding does not cover the cost of R&I, a survey run among beneficiaries showed that 88% of them have already received funding from other Horizon 2020 programme parts such as **ERC, MSCA, Research Infrastructure**s to cover their R&I activities as such.

The newly introduced **SME Instrument** is seen by stakeholders as **complementary to other interventions from Horizon 2020**, in particular the FTI pilot (also new) and collaborative projects, providing a welcomed addition to the Framework Programme toolbox. It supports the efforts towards reaching larger market uptake of innovations from a different angle and in a different manner compared to the other Horizon 2020 instruments.

KIC InnoEnergy provides support to commercially mature concepts which have been developed under the **EU R&I Framework Programmes**. However, activities facilitating the identification of promising concepts and the bridging from Horizon 2020 support to KIC InnoEnergy support could be further developed.

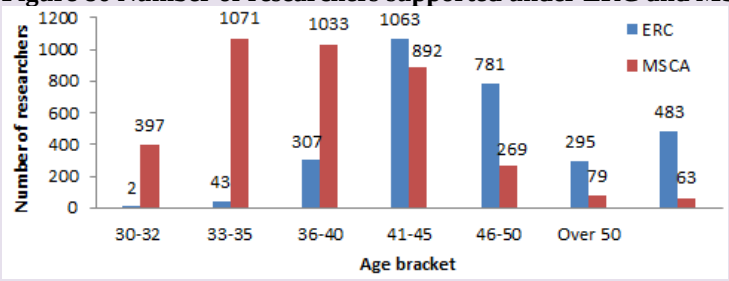
The age profile of the **MSCA** fellows is complementary to **ERC** grantees as they tend to be younger and around 40% of MSCA fellows are doctoral candidates. Furthermore, there is evidence that former MSCA fellows tend to be more successful when applying for ERC grants. An analysis of ERC applicants under Horizon 2020 who were MSCA fellows in FP7 estimates their average success rate at 16%, compared to 12% among all applicants to the same calls.[307]

[305] European Innovation Partnerships (EIPs) act across the whole R&I chain, bringing together all relevant actors at EU, national and regional levels. They were established in order to: (i) step up R&D efforts; (ii) coordinate investments in demonstration and pilots; (iii) anticipate and fast-track any necessary regulation and standards; and (iv) mobilise 'demand' in particular through better coordinated public procurement to ensure that any breakthroughs are quickly brought to market.

[306] European Technology Platforms (ETPs) are industry-led stakeholder fora recognised by the European Commission as key actors in driving innovation, knowledge transfer and European competitiveness. ETPs develop R&I agendas and roadmaps for action at EU and national level to be supported by both private and public funding. They mobilise stakeholders to deliver on agreed priorities and share information across the EU.

[307] For this analysis the study team reviewed ERC applicant data from the following calls for proposals:in 2014: ADG, CoG, PoC, STG; in 2015: AdG, CoG, PoC, STG; in 2016: ADG, COG, PoC, STG; in 2017: STG. Out of 22,784 eligible applicants

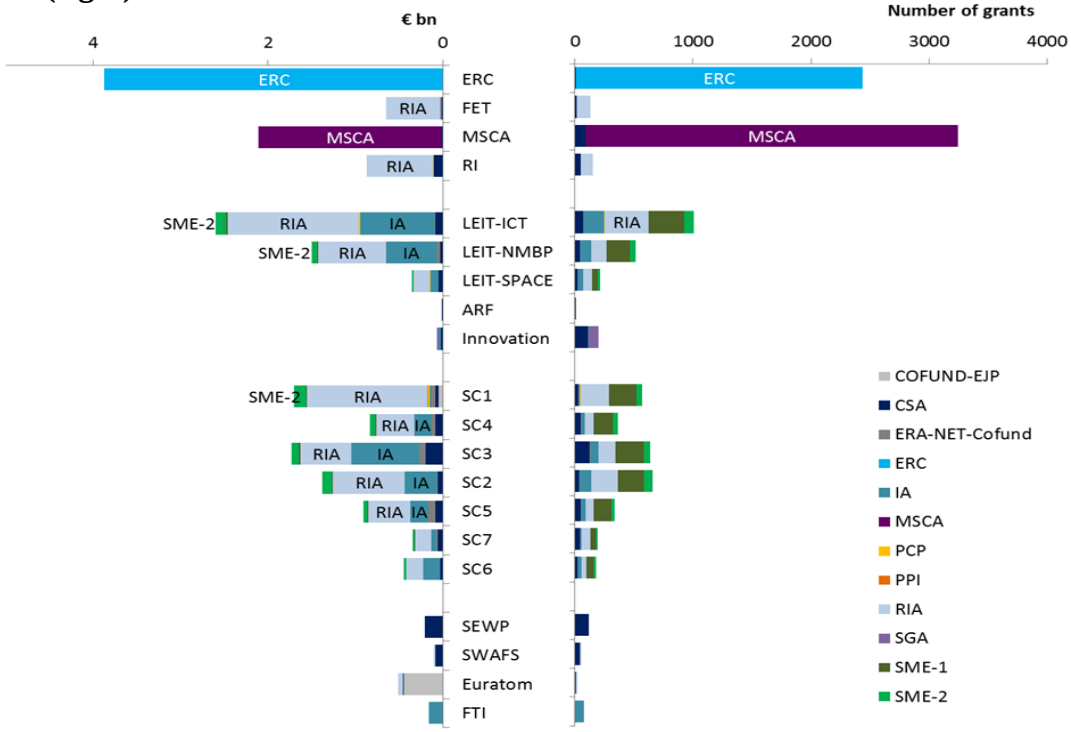
Figure 86 Number of researchers supported under ERC and MSCA by age



Source: European Commission, DG RTD, based on CORDA data.

Horizon 2020 projects are implemented via different actions (policy-mix) that are specified in the Work Programmes depending on the objectives pursued (see Section 5.1 for an overview). Looking at the types of actions **approximately 75% of the funding goes to instruments facilitating collaborative research and innovation**[308] bringing organisations across countries together. This is slightly higher than under FP7 (72% (Cooperation + Capacities)). This represents 39% of the projects under Horizon 2020 whereas this was 40% of the projects under FP7 (the small difference is related to the introduction of the SME instrument). A quarter of the funding is allocated to single beneficiaries to support excellent science (ERC) or R&I projects of SMEs (SME Instrument).

Figure 87 Type of actions per programme part by budget (left) and number of grants (right)



Source: Corda, calls until end 2016, Signed Grants cut-off date by 1/1/2017. European Joint Programme Cofund (COFUND-EJP), Coordination and Support Action (CSA), European Research Council (ERC), Innovation Action (IA), Marie Skłodowska-Curie Actions (MSCA), Pre-Commercial Procurement (PCP), Public Procurement of Innovative Solutions (PPI), Research and Innovation Actions (RIA), Specific Grant Agreement (SGA), SME instrument phase 1 and 2 (SME-1 and SME-2).

overall, 1,591 (around 7%) were MSCA fellows in FP7. For a previous analysis with similar results, see Economisti Associati, Marie Curie researchers and their long-term career development: a comparative study, Final Report, 2014

[308] Research and Innovation Actions, Innovation Actions, MSCA Innovative Training Networks (ITN) and RISE, and Coordination and Support Actions.

Stakeholder position papers: The programme needs to ensure a coherent and simplified policy mix. Several instruments under the Horizon 2020 work particularly well such as the ERC and MSCA grants. Some new instruments could be further improved.

In their position papers, a few stakeholders expressed their concerns with the complexity of the Framework Programme. They believe that the policy mix of the overall programme should be simplified: the number of instruments should be limited, their intervention logic clearly defined and complementary/synergies with other instruments well stated.

Public authorities that commented on the instruments in majority noted that the collaborative projects and grants were preferred over other types of projects and loans. Some of them have a positive view specifically related to the instruments bringing together states and regions such as the P2Ps, cofound schemes and ERA-NETs, others the SME instrument, INNOSUP and MSCA. Some stakeholders from academia and research organisations also depict a very positive view on the current set of instruments fostering excellent science in particular the ERC and MSCA grants. Furthermore some representatives of the business community specifically commented on the Joint technology initiatives (JTIs), Joint Undertaking (Jus) and the (contractual) Private Public Partnerships (c-PPPs). They noted the Horizon 2020 provides a ring fenced budget to PPPs, JTIs and other Industry Initiatives which is in particular beneficial for the industries which are represented by or are member of such initiatives. In addition, few SME and business representatives commented and welcomed the inclusion of innovation activities in Horizon 2020. Finally, a small number of stakeholders discussed the Seal of Excellence (SoE) instrument. A few stakeholders praise the initiative, whereas other pinpointed to the need to review its effectiveness.

As regards the **current balance of the support provided to more science-driven or innovation-driven projects,** 22% of Horizon 2020 budget goes to the Industrial Leadership pillar so far, 36% to Societal Challenges (which is both research and innovation driven depending on the projects) and 37% to Excellent Science (which also include Proof of Concept projects). Looking at the types of actions 21% of the budget goes directly to innovation support through the SME instrument and the Innovation Actions. Under FP7 no dedicated instrument focussed specifically on innovation hence the comparison is not straightforward. However the Entrepreneurship and Innovation Programme (EIP) had a budget of EUR 2166 million (approximately 4% of the FP7 budget but as a separate programme), whereas more than EUR 4.2 billion have already been spent on the SME instrument and the Innovation Actions only under Horizon 2020, after three years of implementation. This does not include the financial instruments that gained in importance under Horizon 2020 compared to the Risk Sharing Finance Facility in FP7.

Due to lack of centralised monitoring data, an overall picture of the current balance between Horizon 2020 grants and financial instrument type of support (e.g loans, equity, guarantees) proves difficult to construct. However, based on data provided in the thematic assessments on Access to Risk Finance, SC1 and SC3 it is estimated that Horizon 2020 currently provides at least EUR 1 in financial instruments for every EUR 12 in grants. [309]

Overall, grants, loans and equity investments are complementary forms of finance for firms and other entities undertaking innovation[310]. Looking at the costs of financing subsequent in-

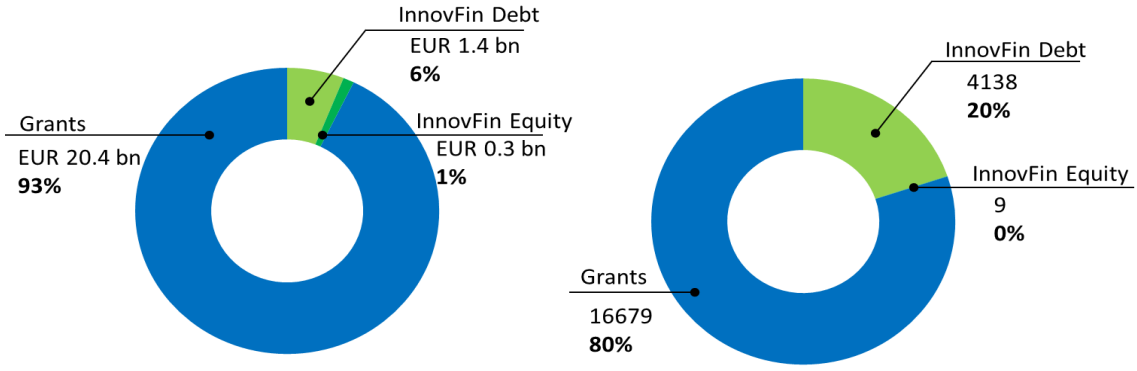
[309] A discussion on the preferred types of support by stakeholders is provided under section 6.3.2 'Programme attractiveness and take-up'.

[310] Investment in innovation by a firm typically covers R&D, capital equipment, design and marketing, and training. The most important item of expenditure in most sectors is R&D, accounting for over half the spend on innovation. R&D investments have three key characteristics that make them different from other investments: most of the R&D expenditure goes towards paying researchers; returns on the R&D investment are highly uncertain; and the capital created from such investment is largely intangible. From the academic literature grants are an essential form of funding when a researcher, research group, public research organisation or very early start-up is at the earliest, most risky and most uncertain phase of the innova-

novation phases from loans or equity, although there is no formula for calculating the appropriate debt / equity mix over time needed by an R&I-intensive firm or project, there are some typical profiles:

- Equity: a company looking for equity investment is usually at the start-up early stage or at a point where accelerated growth is in the offing. All available cash is needed for developing and expanding the firm's means of production and working capital, rather than servicing debt. Such firms have yet to establish the stable pattern of cash-flow required by banks and other lenders, given that they are often breaking new ground.
- Debt is commonly used to fund an R&I project or initiative with a clear business plan or plan of execution, and a clear timetable for implementation. Sufficient cash-flow is needed to repay the loan, and collateral may be required.

Figure 88 Estimated balance between loans, guarantees, grants and other types of support between 2014 and 2017 in terms of budget implementation (left) and number of beneficiaries (right)



Source: EC DG RTD analysis based on Access to Risk Finance thematic assessment state of play as of 31/12/2016 with regards to the EU contribution and as of 30/06/2016 with regard to operations, SC1- Health and SC3- Energy thematic assessment and CORDA, cut-off date by 1/1/2017.

Regarding financial instruments, feedback from the survey of financial intermediaries run in the framework of the interim evaluation of Horizon 2020 financial instruments suggest a clear majority consider that the main financial instruments complement each other and meet the needs of businesses at different stages of the R&I funding cycle 'to some extent' (79.2% of respondents), and 20.8% to a 'great extent'. No respondent said that they do not complement each other at all. Also 45.8% of surveyed entities had no opinion. It should be noted that the survey is still underway.

From an internal coherence perspective, the InnovFin programming architecture is seen as generally consistent with the broader EU policy aim of ensuring that firms can access either debt (guarantees or loan products) or equity through financial intermediaries, irrespective of their stage in the development lifecycle. The four debt-based guarantee and loans instruments appear to be internally consistent and coherent, since investment size / instrument have all been defined in a distinctive way to avoid overlaps. Bringing in the EIB loan scheme for large R&I projects has helped in this regard. Through the SMEG and Midcap Guarantee schemes respectively, there is a funding continuum between EUR 25,000 and EUR

tion process: R&D. Typically, no lender or equity investor can tolerate the risk, nor can offer loans or investments on reasonable terms.

50m which covers a large range of guarantee needs to firms of all sizes. Although micro-credits of less than EUR 25,000 are not available through InnovFin, start-ups and micro-enterprises can take out a guarantee through COSME of less than EUR 25,000 which means that between InnovFin and COSME, all stages of the SME financing lifecycle are addressed.

Compared with the predecessor EIP programme in the 2007-13 period, the InnovFin thematic assessment concludes that there is arguably greater coherence between the design of the programming architecture and evolving EU policy in respect of access to finance. At least for the debt instruments, firms are supported along the "funding escalator" i.e. from SMEs through to mid-caps and large firms. The new 'funding escalator' concept is consistent with the Communication for an Action Plan for the Capital Markets Union (2015)[311], and describes a situation in which EU FI programmes (ideally mirrored in the financial system more widely) are designed to meet the financing needs of all businesses from the smallest micro-firm to the largest listed companies at different stages in their development.

Under InnovFin Debt, banks and other lenders are incentivised to provide loans on reasonable terms to SMEs by the provision of loan guarantees, while the EIB can provide attractive loans to midcaps, large firms, research infrastructures and other bodies through risk-sharing with the EU budget (via a portion of the Horizon 202o 'Access to Risk Finance' budget acting as a first-loss piece). Venture capital, business angel and technology transfer funds, together with funds-of-funds, are encouraged to invest in innovative firms, and to provide follow-on and scale-up funding, through cornerstone investments by the EIF under the InnovFin Equity scheme.

Figure 89 InnovFin debt-based Financial Instruments (guarantees/ counter-guarantees, direct loans)

InnovFin Financial instrument schemes	Type of Financial Instrument	Investment size per beneficiary	Investment duration
SME Guarantee	Guarantee	EUR 25,000-EUR 7.5m	1-10 years
MidCap Guarantee	Guarantee	EUR 7.5-50m (firms with 500-3000 employees)	Maturity from 2-10 years, with a fixed repayment schedule
MidCap Growth Finance'	Loans	EUR 7.5m to EUR25m	Up to 10 years
Large Projects	Loans	EUR 25m-300m	Up to 10 years

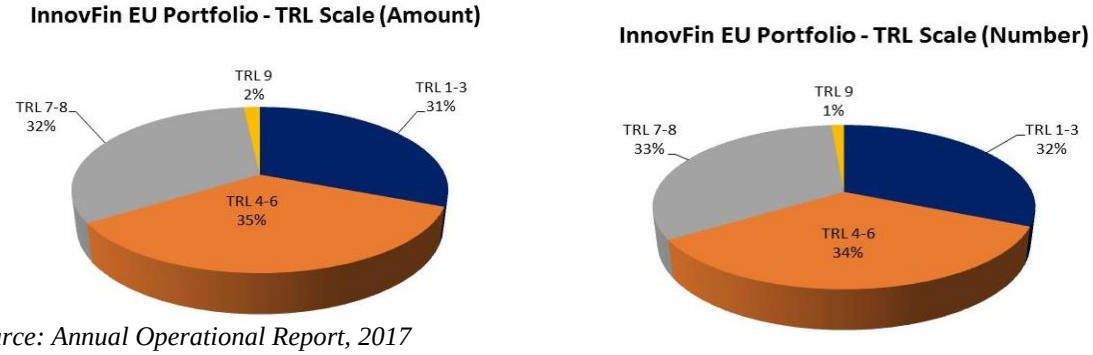
Source: European Commission

The two pie charts below show the Technological Readiness Levels (TRL)[312] of approved projects under InnovFin– a key aspect of Horizon 2020 financing being to finance projects closer to the market. These illustrate a relatively equal share between TRL 1-3, TRL 4-6, and TRL 7-8.

[311] The concept of Europe's 'funding escalator' was mentioned in the Action Plan on Building a Capital Markets Union, COM(2015)468 final.

[312] Technology Readiness Levels are indicators of the maturity level of particular technologies. This measurement system provides a common understanding of technology status and addresses the entire innovation chain: TRL 1 – basic principles observed; TRL 2 – technology concept formulated; TRL 3 – experimental proof of concept; TRL 4 – technology validated in lab; TRL 5 – technology validated in relevant environment; TRL 6 – technology demonstrated in relevant environment; TRL 7 – system prototype demonstration in operational environment; TRL 8 – system complete and qualified; TRL 9 – actual system proven in operational environment

Figure 90 – Technological readiness levels of InnovFin EU portfolio (amount and number)



Source: Annual Operational Report, 2017

An analysis of the TRL supported across thematic areas shows that whereas the Excellent Science pillar focuses on more fundamental research and, with the exception of e-Infrastructures, does not move beyond the stage of an experimental proof of concept, the rest of the programme is rather concentrated on higher TRLs, the majority of which are targeting product demonstration in both the Industrial Leadership and the Societal Challenges pillar. This is notably a result of Horizon 2020 being a combination of research and innovation: what used to be FP7 plus the Competitiveness and Innovation Programme (CIP). FET plays a special role here, building new communities and innovation eco-systems and pushing new technologies up the first steps of the TRL scale towards innovation and impact.

Multiple types of stakeholders (interviewed or surveyed for the thematic assessments or having replied to the Stakeholder Consultation) **regret that Societal Challenges and LEIT do not invest more in lower TRL collaborative research, which is regarded as one key source of future breakthrough innovations, albeit longer-termed, in line with societal needs.** The European Economic and Social Committee (EESC) in its opinion on the interim evaluation of Horizon 2020 also express concerns that collaborative research in the lower TRL 1-5 lost ground to higher TRLs under Societal Challenges, driving many universities and research organisations away from research on societal challenges with the effect that interaction between industry and academia has been reduced rather than strengthened. [313]

Stakeholder position papers on the balance between research and innovation and TRLs: "the importance of basic, collaborative and frontier research should not diminish".

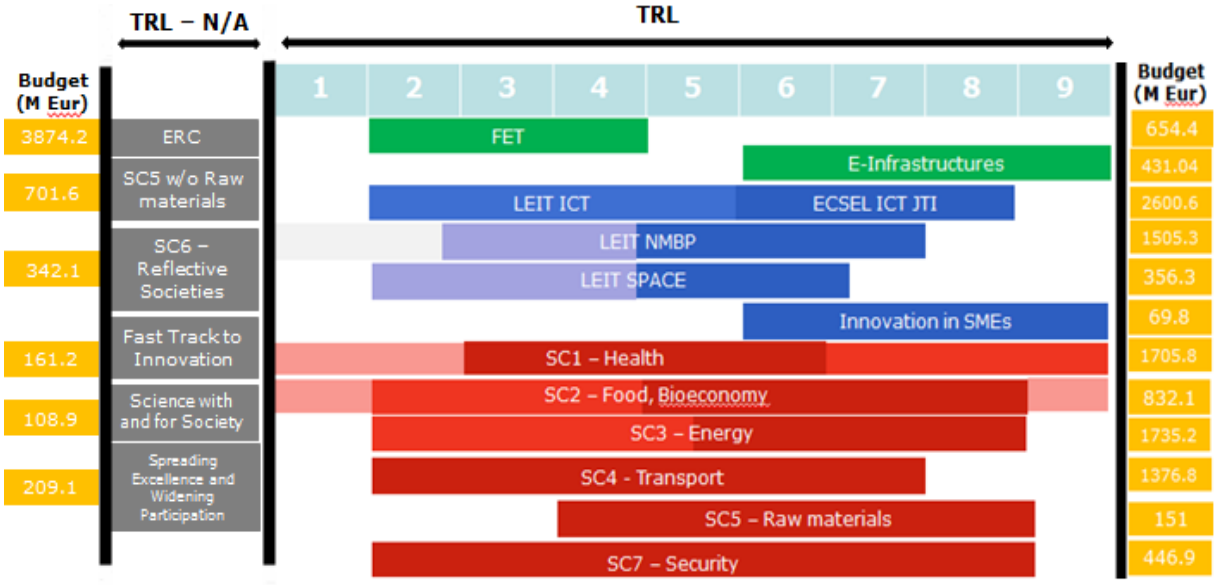
In their position papers, almost half of the stakeholders commented on the balance between research and innovation. The majority of those who commented stated that the programme needs to ensure a better balance. By stakeholder group, the majority of stakeholders from academia, research organisations and public authorities, pinpointed that currently Horizon 2020 seems to be moving away from funding basic, collaborative and frontier research. They believe there is a need to close the gap in funding lower TRL levels to create ground breaking technological foundation for innovation. Only business representatives are positive about the shift towards innovation that took place under Horizon 2020. But still, a few pointed out the current lack of TRL 3-5 projects.

Figure 91 presents an overview of the use of TRL across different Horizon 2020 objectives (alongside their budget) based on the assessments of each programme part performed for this interim evaluation[314]. The information presented is partial and based on diverse methodolo-

[313] http://www.eesc.europa.eu/?i=portal.en.int-opinions.39284
[314] See Annex 2 for the assessments of each Horizon 2020 programme part.

gies such as surveys among project coordinators, projects' mapping by expert groups, external studies, estimates by policy and projects' officers, as well as internal project's reviews[315]. Within each programme part the focus is put more or less on specific TRL – for example, FET-Open is primarily TRL 2, FET-Proactive can be TRL 2-3 while the FET Flagships can be up to TRL 5. From this overview **Horizon 2020 supports R&I on the full TRL-scale, in accordance with the specific intervention logic of each programme part**, which is sometimes operationalised via technological roadmaps. This analysis, however, cannot be conclusive since the data is not comparable nor granular enough (e.g TRL-level at start or at end of the project) . This is an area where further monitoring is needed.

Figure 91 Overview of TRL supported across different Horizon 2020 programme parts based on non-comparable assessment methodologies



Source: European Commission, based on assessmentsof each Horizon 2020 programme part (Annex 2. The stronger the colour, the higher the concentration of projects on those TRLs.)

9.2. To what extent is Horizon 2020 coherent with other EU initiatives?

Expectations: Horizon 2020 shall be implemented in a way which is complementary to other Union funding programmes and policies, including the European Structural and Investment Funds (ESIF), the Common Agricultural Policy, the Programme for the Competitiveness of Enterprises and small and medium enterprises (COSME) (2014-2020), the Erasmus+ Programme and the Life Programme.[316]

9.2.1. Overview

Compared to FP7, Horizon 2020 attaches greater importance to the coherence with other EU instruments, which is illustrated by the legal base.[317] Linkages between Horizon 2020 and other EU initiatives are regarded as important in order to streamline resources, avoid duplications and simplify. It could also provide better and seamless support to the entire dis-

[315] A detailed overview of the approach adopted for this analysis for each programme part is presented in Annex 1.
[316] Article 20 of the Horizon 2020 Regulation.
[317] In the case of ESIF, both programmes include legal provisions to maximise synergies.

covery, research, development and innovation process and ensure better exploitation of projects/programmes results.

It is however difficult to assess to what extent the political willingness to increase the external coherence has been translated in practical implementation. The thematic assessments show that the practical implementation of this approach seems to differ across specific objectives of Horizon 2020.

For example, the assessment of Horizon 2020 financial instruments performed for this interim evaluation suggest that **they are seen as broadly coherent with other EU programmes, although there are some areas of overlap with COSME in respect of the SME-targeting financial instruments.**

In the LIFE Programme Regulation[318] projects that foresee to take up the results of environmental and climate-related research and innovation projects financed by Horizon 2020, mainly under the SC5, or by preceding Framework Programmes are granted one extra point during the evaluation process. An analysis conducted by EASME for the "Nature and biodiversity" theme showed that the number of successful projects linking their activities to the results of EU-funded research projects has increased from a share of 5% in 2014 (corresponding to 2 projects out of 41 funded) to a share of almost 32% in 2015 (corresponding to 13 projects out of 41 funded), without however identifying the quality of this integration so far.

Further examples on the external coherence of Horizon 2020 programme parts with other EU initiatives are provided in the box below. An internal survey among Commission services on the external coherence between EU instruments revealed that **most complementarities/synergies of Horizon 2020 with other EU policies or initiatives are perceived to be with the European Structural and Investment Funds as well as with the EU Industry competitiveness and SMEs policy**. However, **in many cases the coherence with other EU initiatives is limited only to programming level, not followed by concrete actions.** Indeed the programmes might have different scales, scope or follow different implementation structures, intervention logics, timeframes even if focussing on a similar thematic area. More detailed analysis of complementarities, gaps and overlaps with specific EU initiatives are provided in the thematic assessments (Annex 2).

Stakeholders were asked to comment on the coherence between Horizon 2020 and different EU programmes. Illustrating the overall lack of knowledge of the coverage of other EU interventions, most of the stakeholder consultation respondents felt they were unable to assess the level of coherence of Horizon 2020 with other EU programmes because of their lack of familiarity with other initiatives. When they could they indicated that the synergy with other EU programmes is still very limited. More than 27% stakeholder consultation's respondents pointed out that Horizon 2020 and Erasmus + complement each other. 15.6% of respondents said the same about ESIF and 12% judged that they work in synergy.

Box: Example of external coherence of Horizon 2020 with EU initiatives

In case of **Research Infrastuctures** for competitiveness and security reasons there is a major need to develop a more comprehensive approach to underpinning the success of the European Digital Open Market, with a clearer focus on the key areas of the European Open Science Cloud and HPC.

[318] Regulation (EU) No 1293/2013 of the European Parliament and the Council of 11 December 2013 on the establishment of a Programme for the Environment and Climate Action (LIFE) and repealing Regulation (EC) No 614/2007

Societal Challenge 2 shows a high degree of coherence, complementarity and synergies with several other EU policies, particularly the Common Agricultural Policy (in particular with the implementation of the EIP 'Agricultural productivity and sustainability'), the Common Fisheries Policy, maritime and climate policies, but also environment, energy, industry and competitiveness, public health and consumer protection.

Societal Challenge 6 priorities are fully linked to the main EU policies dealing with migration; jobs, growth and investment; the Digital single market; Justice and fundamental rights based on mutual trust; Making the EU a stronger global actor; and fostering a union of democratic change. Though, this coherence is not necessarily based on active coordination and exchanges, which can be further enhanced through more exchanges between relevant services.

9.2.2. Synergies with COSME, Connecting Europe Facility (CEF) and the European Fund for Strategic Investment (EFSI)

In the following table, a comparison is made between the characteristics of the **financial instruments under Horizon 2020 (**InnovFin) and a number of other relevant key programmes that are being implemented in the 2014-20 period in order to assess their coherence, check key differences and assess whether there is a sufficiently clear delineation between EU programmes. It should be noted that the European Fund for strategic Investment (EFSI) is a new financing scheme rather than a new financial instrument.

Figure 92 Comparative overview between InnovFin Financial instruments and COSME

Financial instruments schemes (title, description)	Budget	Type of instruments/ budget	Eligibility criteria	Extent of differentiation with InnovFin
COSME - Europe's programme for small and medium-sized enterprises. Financial instruments strand: **Loan Guarantee Facility (LGF)** **Equity Facility for Growth (EFG)**	Total budget of € 2.5 billion of which 60% (~ € 1.4 billion) supports financial instruments LGF - Guarantees and counter-guarantees for financial intermediaries (e.g. guarantee organisations, banks, leasing companies) to provide more loan and lease finance to SMEs. EFG - Investment in risk-capital funds that provide VC and mezzanine finance to expansion and growth-stage SMEs.	Guarantees with a particular focus on financing of SMEs <€150,000. Risk capital predominantly into SMEs at the growth and expansion stage > € 150,000: for SMEs not eligible in principle under Horizon 2020 (InnovFin)	COSME - all start-ups and SMEs provided financial intermediary can demonstrate market failure InnovFin – 10 criteria that financial intermediary must use to demonstrate market failures apply.	• Funding available for start-ups under COSME, but not InnovFin • Intervention conditional on market failure whereas under InnovFin, improving the conditions of financing for innovative firms, not only market failures are considered sufficient justification for intervention. • COSME focused on micro enterprises - expected that 90% of beneficiaries will have <10 employees with an average guaranteed loan of about €65,000 • COSME focuses on SMEs operating across borders (but not exclusively). • Geographic scope - SMEs, established and operating in one or more EU Member States and COSME Associated Countries. • Applicable state aid rules are de minimis under COSME whereas the state aid rules that apply under InnovFin fall under Art. 21 of the General Block Exemption Regulation.
The Connecting Europe Facility (CEF) **Supports targeted infrastructure investment at EU level. Supports the development of in-**	CEF programme budget - €30.4 billion in total (€22.4 billion for Transport, €4.7 billion for Energy, and €0.3 billion for Telecom).	CEF – Grants, contributions to innovative financial instruments, developed together with entrusted financial institutions such as the European Invest-	CEF – transnational requirement. InnovFin Energy Demo: Only projects of TRL 7-8 are eligible under facili-	• The CEF funds trans-European networks in the fields of transport, energy and digital services. • Unlike the CEF, InnovFin does not fund trans-European energy networks, but instead finances innovative first-of-a-kind energy demonstration projects in the

Financial instruments schemes (title, description)	Budget	Type of instruments/ budget	Eligibility criteria	Extent of differentiation with InnovFin
terconnected trans-European networks in the fields of transport, energy and digital services.		ment Bank, such as: the Marguerite Fund, the Loan Guarantee for TEN Transport (LGTT) and Project Bond Initiative. InnovFin Energy Demo: Loans or loan guarantees between EUR 7.5m and 75m	ty Only projects/companies located in an EU Member State or H2020 associated countries eligible.	fields of renewable energy, sustainable hydrogen and fuel cells. InnovFin Energy Demo focuses on energy only, whereas the CEF focuses on three thematic areas. • However, the CEF focuses on electricity and gas interconnections between different European markets and is not based on demonstrating the market potential of renewable energies unlike InnovFin. • InnovFin doesn't have transnational requirements, whereas CEF projects are by definition transnational.
EFSI SME Window EFSI is not formally a financial instrument itself. Rather, funding will be channelled through existing programmes e.g. SME Guarantee Facility	NA	**Equity and quasi-equity instruments (including guarantees)**	InnovFin SMEG qualifies for additional top-up funding to expand scale	Non-duplicative since EFSI allows InnovFin to simply increase volume effects and leverage. It is not an alternative source of funding.

Source: InnovFin thematic assessment, See Annex 2

The table above shows that there are clear differences between InnovFin and other EU funding instruments (especially the CEF[319]), although there are some areas of possible overlap. This includes a possible overlap between the InnovFin and COSME programmes in respect of SME finance, but the extent to which this is considered a problem varies among financial intermediaries.

9.2.2.1.Coherence with COSME

The InnovFin and COSME programmes were created as a result of a political decision to go ahead with two separate programmes. There was a subsequent need to differentiate the financial instruments supported through InnovFin and COSME respectively as part of the process for developing the detailed programming architecture. This has meant that that the two programmes, which risked being duplicative, have each developed their own intervention logic, programming and policy rationale, which underpins their differentiation at the implementation stage. In particular, coherence between InnovFin and COSME FIs has been achieved by:

- Setting different policy objectives:
  - COSME - supporting start-ups and SMEs, promoting entrepreneurship and addressing clear market failures;
  - InnovFin - promoting access to finance for innovators, improving the terms and conditions for access to innovation finance respectively.
- Defining different targeting strategies, although there is some overlap of targeting in the SME segment.

[319] https://ec.europa.eu/inea/en/connecting-europe-facility

- Drawing up different eligibility criteria – e.g. in the case of COSME, criteria relating to market failure and being an SME, in the case of InnovFin, developing a list of 10 innovation-related criteria.
- Using different State Aid rules – de minimis (COSME) vs. Art. 21 of the GBER (InnovFin).

The fact that the two programmes have evolved in different ways to avoid duplication has led to a reasonably clear delineation emerging, even if there is some blurring of targeting strategies for the SME instruments (i.e. both the LGF and SMEG provide guarantees to SMEs). Whilst InnovFin puts a stronger emphasis on SMEs having to be innovative, the definition of innovative is quite broad and arguably investing in SMEs irrespective of their degree of innovativeness involves a higher risk given the two valleys of death than for other types of lending and equity investment. SME final beneficiaries may be eligible to participate in either programme through a financial intermediary, which has caused some confusion for financial intermediaries as to which FI to apply for until the schemes and their differences became better known.

However, some overlapping may not necessarily a negative in practice since in some Member States, financial intermediaries have only applied to COSME (or only applied to InnovFin). Therefore, SMEs may not be able to participate in both financing schemes through an intermediary in all 28 EU Member States. Moreover, the geographic coverage of InnovFin (EU28 plus 14 associated countries) is wider than for COSME which mainly focuses on the EU although there are a very limited number of COSME- associated countries.

From the InnvFin thematic assessment it appears that start-ups are not explicitly targeted through InnovFin. Given the central importance of start-ups from a jobs and growth perspective, and in light of the Europe 2020 strategy, this could be seen as a gap from an internal programming architecture perspective. However, it could be argued that start-ups and very early stage SMEs can already be funded through the COSME Loan Guarantee Fund (LGF) given the focus on market failures and the decision to focus on loans below the €150,000 threshold. It could also be argued that there is adequate provision for access to finance for start-ups in at least some Member States through national funding schemes, such as BPIfrance's start-up scheme, BPI Prêt d'amorçage[320], although micro-loans made are not backed by a guarantee.

There is a good level of coherence between the SME Instrument and the COSME programme, with synergies created by making use of the Enterprise Europe Network (EEN) to ensure access to the SME Instrument business innovation coaching and mentoring services. Also the thematic assessment of the Innovation in SMEs programme part points that concerning the INNOSUP call under "Innovation in SMEs", there is room for a stronger coordination with the COSME financial instruments.

9.2.2.2.Coherence with the European Fund for Strategic Investment (EFSI)

According to an ad-hoc audit, EFSI contributes mainly to the R&D (45%), energy (21%) and ICT (17%) sectors.[321] The European Investment Bank (EIB)'s evaluation finds that there are

[320] http://www.bpifrance.fr/Toutes-nos-solutions/Prets/Prets-sans-garantie/Pret-d-amorcage

[321] Ad-hoc audit of the application of Regulation 2015/1017 (EFSI Regulation) https://ec.europa.eu/priorities/sites/beta-political/files/ey-report-on-efsi_en.pdf The EU-15 received 91% and EU-13 received 9% of EFSI support. Reasons mentioned for the lower support in EU-13 are the competition from ESIF, less capacity to develop large projects, less experience with PPPs, less developed Venture Capital market and small size of projects.

both risks and opportunities in the relationship between the EIB and Horizon 2020 and the Connecting Europe Facility (CEF). The risk is that EIB privileges EFSI operations over Horizon 2020/CEF operations. Opportunities could reside in the fact that EC could use Horizon 2020/CEF funds to finance the First Loss Piece (FLP) of operations, while the EIB would finance mezzanine tranches under EFSI. Stakeholders indicated that there is competition with other EU funds such as certain financial instruments under CEF and Horizon 2020 or financial instruments and grants under ESFI.

The ad-hoc audit recommends to further structure and enable complementarity with and avoid overlap with Horizon 2020, ESFI, and other funds. This is more urgent in certain countries (EU-13) and sectors.

From the InnovFin thematic assessment (Annex 2 Part H) the availability of supplementary financing through the European Fund for Strategic Investment (EFSI) has not caused any problems relating to coherence, because the funding will be used to top up the InnovFin SMEG rather than to create new rival, alternative financial instruments.

However, **efforts are currently underway to refocus some of the InnovFin instruments partly because since the set-up of EFSI in** 2015, it has proved challenging to reach InnovFin's objectives, as a significant part of the products deployed overlap with EFSI in terms of both risk spectrum and eligibility. Indeed, the introduction of EFSI has arguably slowed down the deployment of InnovFin. In 2016, the Bank signed only EUR l.5 billion of InnovFin transactions, reaching just 56% of the annual objective, while EIB signed EUR 2.4 billion of EFSI financing under the RDI EFSI objective. This modest 2015 InnovFin activity confirmed a declining trend since the launch of the initiative: EUR 2.5 billion signed in 2014, followed by EUR 2.0 billion in 2015, the year EFSI was launched. In cumulative terms, as at 31 December 2016, the EIB had deployed EUR 5.9 billion of financing under the InnovFin programme across 96 operations spread between the EU and EIB windows. The budgetary contribution from the EU to date to support the existing portfolio amounts to about EUR 0.8 billion. In total, over the first three years to December 2016, only 73% of the target of EUR 8.1 billion for the period was achieved, representing a cumulative shortfall of EUR 2.2 bn. InnovFin was expected to make up for this shortfall in the period 2018-2020 in the period following the deployment of EFSI as originally conceived; but in the context of discussions on the extension of EFSI to 2020 (''EFSI 2.0'), this assumption is no longer valid.

Given the above, the EIB and DG RTD of the Commission have concluded that the current approach is no longer sustainable and that **changes are necessary to re-focus InnovFin's deployment in the post-EFSI context**. The aim is to improve cooperation with EFSI through better complementarity and to combine InnovFin and EFSI financing where needed, building on the success achieved under EFSI's SME window (implemented with the European Investment Fund (EIF)) for both equity and debt joint InnovFin/EFSI products.

Work is underway to transform InnovFin into two portfolios — one for debt, one for quasi-equity —covering a wider range of risk profiles and underpinning a suite of products that more closely target, in marketing terms, a variety of constituencies. This approach will, in turn, make it possible to build on the experience of the current thematic pilots - 'InnovFin Energy Demo Projects', 'InnovFin Infectious Diseases' - and open up possibilities for crafting risk- finance products for other sectors.

Currently, the EIB InnovFin product portfolio is composed of two high-risk thematic products (see above) and three non-thematic products, which represent the main overlap with EFSI:

InnovFin Large Projects has a very similar eligibility to the debt financing under EFSI Infrastructure and Innovation Window (IIW); InnovFin MidCap Guarantee has an equivalent product offering as EFSI's Risk Sharing; and equity-type operations under InnovFin Midcap Growth Finance have already been fully transferred under EFSI with the European Growth Finance Facility.

Two new facilities are envisaged with minimal overlap with EFSI: InnovFin Research Institutes, Universities, Research Organisations Facility (RIURO), and InnovFin Moderate & Modest Innovator Countries and Associated Countries Facility (MMI). RIURO will strengthen the InnovFin focus on research organisations, including public entities. MMI will target regions which are currently underserved by InnovFin operations, in particular in Associated Countries, but also in EU countries indicated as less innovative in the 2016 Innovation Scoreboard.

The possibility of combining InnovFin and EFSI finance is also being explored, with InnovFin used as a junior tranche to credit-enhance EFSI equity-type deployments. This would potentially unlock new financing options in the fields of risk-sharing for corporate R&I and corporate venture. Besides this refocusing, the equity side of operations, implemented by EIF, has been remodelled to improve its relevance to a wider range of constituencies.

9.2.3. Synergies with European Structural and Investment Funds

Horizon 2020 shall also contribute to the closing of the research and innovation divide within the Union by promoting synergies with ESIF. Where possible cumulative funding may be used.[322]

Synergies between Horizon 2020 and the European Structural and Investments Funds (ESIF) aim at maximising the quantity and quality of R&I investment and their impact. In doing so, synergies seek to bring together research and business communities as well as relevant national and regional policy designers and implementing bodies, thus ensuring a higher impact of the funds for a knowledge-based economic transformation.

The Commission has taken specific measures to facilitate the coherence between Horizon 2020 and ESIF through the publication of guidance for policy-makers and implementing bodies and a specific brochure for interested parties with examples of synergies[323]. Even though it is possible for the first time to combine Horizon 2020 and ESIF support in a single project in this programming period and a strong focus and political importance are put on synergies, Horizon 2020 is implemented under central management by the Commission whereas ESIF is under shared management, with joint responsibility of the Member State authorities and the Commission. This leads to differences in implementation rules and procedures, as the commitment of actors as well as the application and project execution requirements differ.

[Horizon 20202 should]…focus on areas that national funders don´t support and synergies with ESIF- good practices- are needed; Foster clustering and sharing experience in Widening projects (Teaming, ERA chair).

Czech Republic,CEITEC

Under ESIF the selection of specific type of R&I intervention can vary among regions (research infrastructure, industry academia cooperation, etc.) and Member States,

[322] Article 21 of the Horizon 2020 Regulation.

[323] Guidance: "Enabling synergies between European Structural and Investment Funds, Horizon 2020 and other research, innovation and competitiveness-related Union programmes" . Brochure: "EU Funds working together for jobs and growth" with examples of synergies between Horizon 2020 and ESIF was published in 2016.
https://ec.europa.eu/research/regions/index.cfm?pg=synergies

according to the strategic choices made in each territorial context. ESIF supports the **same type of beneficiaries** for several Horizon 2020 areas: Research Infrastructures, LEIT NMBP, Innovation in SMEs, SC1, SEWP and SWAFS and has similar objectives compared to Horizon 2020's specific objectives (LEIT NMPB, SC1, SC3 and SWAFS) in terms of TRL covered. However, the overlapping between the two programme is seen as not possible due to the different **geographical coverage** of the two instruments, i.e. the ESIF fund **national or regional initiatives**, while Horizon 2020 is based on trans-national partnerships and networking and hence helps strengthen scientific collaboration at the EU and international scale.

According to an external study,[324] the development of synergies between both programmes is still at the early stage and their development is limited. **Although a clear legal basis for synergies is in place and overall implementation guidance have been compiled by the Commission, the study concluded that communication, coordination and support to the synergies between all the institutional actors involved is not optimal.** The enhancement of the coherence between Horizon 2020 and ESIF is rather incidental which is confirmed by the thematic assessments. During the project phase, there are notably discrepancies that hinder a combined use of funding means. These include different funding rates and eligibility rules, which are not always coherent with each other. The difference in State Aid rules under ESIF and Horizon 2020 further leads to legal uncertainty for potential beneficiaries.

Over the last years Smart Specialisation Strategies (S3) have taken their place as a key programming tool for R&I in Member States and regions. S3 are the ex-ante conditionality underpinning R&I funding through ESIF. The now over 120 existing S3 at national or regional levels provide a framework for synergy action with Horizon 2020 as they identify priority areas and activities. Smart specialisation can provide a framework to develop complementarities through "upstream actions" to prepare regional R&I stakeholders to participate in Horizon 2020, and "downstream actions" to exploit and diffuse R&I results, developed under Horizon 2020 and previous programmes, into the market. A pilot project Stairway to Excellence (S2E) was launched to support EU-13 Member States and their regions in this regard.[325]

In order to build up on the evaluations of high quality proposals under Horizon 2020 SME Instrument and MSCA actions, **the Seal of Excellence (SoE) initiative has been launched by the Commission to support synergies with national/regional initiatives by highlighting high quality projects for further public or private funding**. The 'SoE' certificate is an official recognition of the value of proposals that have succeeded the evaluation by independent experts run by Horizon 2020. The regional and national authorities, who decide to fund the 'SoE' proposals (with national or ESIF resources), select them on the basis of eligibilities and ways to achieve the objectives if their regional or national their smart specialisation strategies. This is expected to result is an operation with a clear added value in terms of maximising the impact of investments in R&D, with the national and regional authorities also benefitting from a technical evaluation already performed. While comprehensive data is not yet available on the exact number of proposals for which these quality labels allowed applicants to secure other sources of public or private funds, there is currently evidence of an increasing number of national and regional funding schemes that offer support to SME Instrument pro-

[324] "Synergies between Framework Programmes for Research and Innovation and the European Structural and Investment Funds" *[forthcoming]*

[325] Stairway to excellence (S2E) is a European Parliament Pilot Project executed by DG-JRC together with DG-REGIO. It assists EU-13 Member States and their regions in closing the innovation gap, in order to promote excellence and to stimulate the early and effective implementation of national and regional Smart Specialisation Strategies http://s3platform.jrc.ec.europa.eu/stairway-to-excellence

ject proposals awarded with a SoE[326]. It is however recognised that **the SoE initiative has not yet tapped into its full potential, which would be possible with alignment of rules, for example in the case of State Aid rules[327]**. According to the Innovation in SMEs assessment, **opinions are divided when it comes to the usefulness of the SoE to effectively influence funding decisions**. While agencies indicate a limited influence of the SoE so far, there are signs that this may change in the nearby future. SoE holders display a strong confidence that the SoE makes and will make a difference in funding decisions, be it implicitly or explicitly.

The following Box provides examples of the coherence of Horizon programme parts with the European Structural and Investment Funds.

Box: Examples of coherence of Horizon 2020 programme parts with ESIF

In the **LEIT ICT** area a number of cases have been identified where research activities under national programmes act as stepping stones to Horizon 2020 projects and, conversely, where FP/Horizon 2020 projects have led to research being funded by national or regional sources. However, survey results suggest that respondents had limited knowledge or experience regarding the synergies that could be developed by combining Horizon 2020 and other sources of funding. Survey findings also suggest that participation in Horizon 2020 does not seem to offer any competitive advantage for securing funding from other sources.

An analysis of FP7 in the **LEIT NMBP** areas[328] showed that most regions have participated as much as one would expect from their level of activity: regions with more R&D resources tend to participate more. The main factors for high performing regions are the track record and level of specialisation, but also the level of regional expertise. In this context, the creation of regional research centres, some of which were established in the 80's and 90's to diversify incentives to innovation, appears to pay off.

The **SC5** Work Programmes 2014-15 and 2016-17 underline the possibility of complementing Horizon 2020 support with private or public funding, "*including for relevant national/regional schemes under the European Structural and Investment Funds (ESIF), in particular under the European Regional Development Fund (ERDF)*". The procedures to access to this complementary ESIF financing further to the Horizon 2020 funding are explained in the Work Programme. Until end 2016, looking at a sample of 75 proposals, 29 mentioned synergies. Amongst the 75 proposals, 19 have been granted, of which 15 referring to complementarity with ESIF. Interestingly, proposals arguing their potential synergies have a higher success rate. There is however no strong commitment to deliver on synergies as a project outcome and the actual complementarity between Horizon 2020 and ESI Funds may not be reflected in the annual ESIF reporting.

In case of **SEWP** the design of the programme entails synergies with cohesion policy in particular for Teaming where applicants are obliged to ensure appropriate co-financing for the infrastructure and equipment component of the centres of excellence from the ESIF or other sources. Beyond the mere financial dimension, the programme is well aligned with the overall objectives of cohesion policy notably to help less developed European countries and regions in order to catch up and to reduce the economic, social and territorial disparities that still exist in the EU.

In **MSCA**, ESIF investments can be in support of COFUND, for instance in the form of investment in infrastructures, large equipment (European Regional Development Fund) or training and networking (mainly European Social Funds).

[326] SoE friendly funding schemes for SME Instrument Phase 1 and/or Phase 2 proposals are operational at a national or regional level in Spain, Italy (8 Southern regions, plus Lombardy, Piedmont, Friuli-Venezia Giulia), France (Ile-de-France), Sweden, Norway, Czech Republic (Brno), Cyprus, Slovenia, Hungary and Finland. Moreover it is expected that more seal schemes will be soon launched in other EU counties and/regions. In the case of MSCA, Cyprus and the Czech Republic have already introduced funding schemes using ESIF to support recipients of the Seal of excellence while Croatia, Greece, Lithuania, Poland, Slovenia, Sweden have initiatives in the pipeline.

[327] For further information about the state aid implications of the Seal of Excellence, see: European Commission (2017), Commission Staff Working Document - Explanatory note of the Commission services on the application of State Aid Rules to national and regional funding schemes that offer alternative supp support to SME Instrument project proposals with a Horizon 2020 'Seal of Excellence', SWD(2017) 11 final

[328] Study "Mapping the regional embeddedness of the NMP programme", INNOVA et al., 2016. No significant differences between NMBP areas were detected, therefore these results are considered relevant also for Horizon 2020.

9.3. To what extent is Horizon 2020 coherent with other initiatives at national, regional and international level?

With the aim of achieving the greatest possible impact of Union funding, Horizon 2020 should develop closer synergies, which may also take the form of public-public partnerships, with international, national and regional programmes that support research and innovation. In that context, Horizon 2020 should encourage the optimal use of resources and avoid unnecessary duplication.[329]

9.3.1. Overview

At the international level, the establishment of Sustainable Development Goals (SDGs), the successor of the United Nations' Millennium Development Goals, and the COP21/22 **paved the way for developing a more coherent approach within Horizon 2020 to address these objectives.** Research and innovation policy and related implementation measures are seen as engines of a transformative agenda built around universally applicable SDGs.[330] Examples of coherence between Horizon 2020 and international initiatives can be found in LEIT-Space and the European Space Agency (ESA)[331] or in case of SC5's strong alignment at international level e.g. through the Belmont Forum, GEO, IPCC, Transatlantic Research Alliance. In addition, in SC3 the Commission's active role in Mission Innovation is expected to improve coherence with regard to similar initiatives of the main global actors outside the EU.

With regard to the alignment of national research strategies and programmes, Horizon 2020 further strengthens instruments already developed under FP7 – for instance, ERA-NET Co-Fund and Article 185 initiatives – to pool resources across Member States, define common strategic research agendas, avoid duplication, implement joint calls, etc. Furthermore, the Policy Support Facility under Horizon 2020 aims to assist Member States to implement effective reforms, in line with the priorities of the European Research Area.

It follows from the thematic assessments that **the scope and scale of coherence between Horizon 2020 and other non-EU initiatives depends on the policy domain**. Complementarity between Horizon 2020 and national activities is often seen by Member States as crucial. Duplication, on the other hand, is not always perceived by default as a negative aspect, especially taking into account the global character of Horizon 2020 Societal Challenges. However, in some countries it is difficult to ensure national coordination with Horizon 2020, notably in R&I systems where the bottom-up approach dominates. In general, in the context of coordination with R&I activities carried out at national level, the Horizon 2020 Programme Committees plays a special role, and the involvement of Member States in its activities is of special interest and often underlined by Member States.

Horizon 2020 aims to improve the coherence with national programmes through support to Public-to-Public Partnerships (P2Ps) including Joint Programming Initiatives (JPIs), the ERA-NET Cofund instrument and the Art.185 initiatives[332]. Efforts from Member States towards coordination in the field of P2Ps are core components of the ERA Roadmap and national ERA

[329] See recital 39 of the Horizon 2020 Regulation.
[330] Report "Follow-up to Rio+20, notably the Sustainable Development Goals (SDGs)" of an independent expert group. https://ec.europa.eu/programmes/horizon2020/en/news/role-science-technology-and-innovation-policies-foster-implementation-sustainable-development
[331] The Delegation Agreement for Galileo R&D has represented a major achievement in this regard.
[332] Article 185 of the Treaty on the Functioning of the European Union (TFEU) [ex Article 169 of the Treaty establishing the European Community (TEC)] enables the EU to participate in research programmes undertaken jointly by several Member States, including participation in the structures created for the execution of national programmes.

action plans, notably for priority 2a of the ERA Roadmap ('Jointly addressing societal challenges").

EU support for P2Ps was introduced under FP6 (mainly with the notion of networking of national programmes) and financed with EUR 380 million (2.1% of the FP6 budget). Support under FP7 reached EUR 802 million (1.4% of the budget) and will reach approximately EUR 2.500 million in Horizon 2020 (around 3.1% of the budget). In parallel, the EU contribution mobilised around EUR 1.250 million of national funding under FP6 and around EUR 2.900 million under FP7, whereas the EU contribution in Horizon 2020 is expected to mobilise EUR 6.000-8.000 million of national funding. Since 2004 more than 5,500 projects with a cumulative budget of about EUR 5.000 million from national sources have been implemented through P2Ps.

Box: Examples of coherence of Horizon 2020 with the regional and national levels

In the **LEIT NMBP** area, links between activities at European level and national or regional strategies and programmes were developed through previous framework programmes and there are now examples of follow-up investments made by regions to take the results of successful projects further. Regions with more R&D resources tend to invest more; the track record of regions and their degrees of specialisation, as well as the level of regional expertise, are key factors. This support is indispensable to the NMBP strategy of developing pilot lines as a means of supporting innovative SMEs in validation and scale-up activities. Out of the projects financed by the InnovFin Large Projects scheme of the EIB, at least 40% are KETs-related.

SC1 has set encouraging precedents of associating EU regional partners to the definition and implementation of roadmaps and strategic agendas. However expanding this would require some additional work.

Several actions of **SC2** have supported the links with the national or regional plans and smart specialisation strategies using ESIF, for instance those targeting development of new bio-based industries. The ERA-NET cofund actions included in the calls are potentially highly effective strategic investments in ERA, with structuring effect and ensuring coherence between EU and national research programmes in the bioeconomy.

In **SC3** the situation has improved in Horizon 2020 thanks to the progress achieved in the SET-Plan which rallies national programme owners and managers from 32 European countries around common priorities

9.3.2. ERA-NET Cofund under Horizon 2020

ERA-NET Cofund is a policy instrument across all priorities of Horizon 2020 to catalyse joint calls and other joint activities of national R&D programmes through additional Horizon 2020 top-up funding. The joint activities of Member States and Associated States contribute to increasing the quality of national research, to increasing the level of national funding and to avoiding the duplication of research. Mobility is promoted through the transnational research projects resulting from the joint calls and additional mobility and staff exchange schemes. As the selection of topics for ERA-NET Cofund actions is part of the Horizon 2020 Work Programmes, a high coherence between national and EU programming can be ensured via the responsible Programme Committees.

The Horizon 2020 Work Programme 2014-2015 included calls for proposals for ERA-NET Cofund actions, resulting in a total of 27 proposals selected for funding by the European Commission. The direct leverage effect of the 27 actions is 2.31, i.e. for each euro invested by the EU, the participating states invest an additional amount of 2.31 €. The average budget per co-funded call is around EUR 21.6 million while the average number of countries participating in each co-funded call is 16.

In addition, over 30 topics are included in the 2016-2017 Horizon 2020 Work Programmes. Funding from Horizon 2020 for these is expected to reach about EUR 280 million and leveraging budgets from national sources of about EUR 700 million. The overall leverage effect for the period 2014-2017, adding the national funding for the co-funded calls and the unfunded calls (only financed by national sources) is expected to exceed the leverage effect measured for the period 2014-2015. Based on the planning of the current ERA-NET Cofunds and past experience, an overall leverage effect of 3-5 can be expected.

Figure 93 Calls for ERA-NET Cofund actions published in the WPs 2014-2017

	2014		2015		2016		2017	
	€M	no	€M	no	€M	no	€M	no
Excellent Science								
Future and Emerging Technologies					18,0	2	5,0	1
Industrial Leadership								
ICT			6,0	1				
Nano, Materials, Biotech and Manufacturing			12,5	1	30,0	3		
Societal challenges								
Health, demographic change and wellbeing	27,4	4	15,0	3			5,0	1
Food security, agriculture, marine, bioeconomy	5,0	1	15,0	3	35,0	5	15,1	3
Secure, clean and efficient energy	36,8	3	36,3	4	45,8	5	33,5	4
Smart, green and integrated transport					10,0	1		
Climate action, environment, resource efficiency and raw materials	18,2	2	51,0	3	13,0	3	30,0	3
Europe in a changing world – inclusive, innovative and reflective Societies	5,0	1	5,0	1	5,0	1	5,0	1
Science with and for society					5,0	1		
Total	**92,4**	**11**	**140,8**	**16**	**161,8**	**21**	**93,6**	**13**

Source: Horizon 2020 Work Programmes

The evaluation of the ERA-NET Cofund scheme[333] highlights that the main added value of the ERA-NET scheme is the lasting collaboration between and learning among funding agencies as well as capacity building. ERA-NET Cofund actions are relatively **less perceived as strategic instruments that can influence national strategies and lead to alignment of national policies among participating states and/or EU R&D policies**. With respect to efficiency, the evaluation concluded that a number of simplification measures have been introduced under Horizon 2020 that are appreciated by the ERA-NET community. The lack of clear understanding of the financial aspects of the ERA-NET Cofund instrument was however highlighted as an area for improvement. While the relevance of the ERA-NET Cofund instrument has been confirmed, **coherence among ERA-NETs but also between the ERA-NETs and other joint initiatives is clearly underdeveloped**. ERA-NET Cofund actions contribute effectively to strengthening transnational cooperation and creating a critical mass of resources to tackle EU societal challenges. The instrument has facilitated widening participation of lower performing countries. ERA-NET Cofund actions are also gradually increasing the participation of third countries.

9.3.3. Article 185 initiatives

Public-public partnerships may be supported though Union participation in Article 185 initiatives where the participation is justified by the scope of the objective pursued and the scale of the resources required.[334]

[333] https://bookshop.europa.eu/en/analysis-of-era-net-cofund-actions-under-horizon-2020-pbKI0116995/
[334] See Article 26 (b) of the Horizon 2020 Regulation.

Article 185 initiatives are jointly implemented Member States programmes.[335] They include Associated Countries and, in some cases, extend the collaboration towards third countries. They are implemented on the basis of Annual Work plans of research activities that receive EU funds from Horizon 2020[336]. Horizon 2020 currently implements four Article 185 initiatives.[337] The following table summarises the financial contribution of the EU and Participating States to the four Article 185 initiatives.

Figure 94 Financial contribution of the Union and the Participating States to the Article 185 initiatives under Horizon 2020

Article 185 initiatives adopted under Horizon 2020	EU (max) [EUR million	Participating States (min) [EUR million]
European & Developing Countries Clinical Trials Partnership 2 (EDCTP2)	683	683
EDCTP (FP6)	**200**	**200**
European Metrology Research Programme (EMPIR)	300	300
EMRP, FP7	**200**	**200**
Eurostars2 (for SMEs)	287	861
Eurostars1 (FP7)	**100**	**300**
Active and Assisted Living R&D Programme (AAL2)	175	175
AAL (FP7)	**150**	**200**

Source: European Commission, (in bold: contributions for the predecessor programmes FP6/FP7)

On 18 October 2016 the Commission adopted a proposal to establish a new public-public Partnership for Research and Innovation in the Mediterranean Area (PRIMA) under Article 185, currently under negotiation in the Council and European Parliament, and expected to start implementation in 2018. PRIMA would focus on two key socioeconomic issues that are important for the region: food systems and water resources.

As foreseen in their respective basic acts, the Article 185 initiatives are currently being evaluated with the assistance of independent experts, with results to be reported to the Council and the European Parliament by end of 2017.

9.3.4. Joint Programming Initiatives (JPIs)

In July 2008, the Commission presented joint programming as a Member State-led process, designed to coordinate research in Europe and to address major societal challenges. Member State participation in the Joint Programming Initiatives (JPIs) follows the principle of variable geometry and open access. Currently there are 10 JPIs (see Figure below), which all have Strategic Research Agendas (SRAs) as one Key Performance Indicator (KPI) of Horizon 2020.

All JPIs have received support to their initial preparation phase (Coordination and Support Action (CSA) under FP7) that has been or will be extended by a second CSA under Horizon

[335] Art.185 initiatives can only be proposed in cases 'where there is a need for a dedicated implementation structure and where there is a high level of commitment of the participating countries to integration at scientific, management and financial levels'. See Art 26 of Horizon 2020 Regulation.

[336] The origin of the name stems from the legal basis, Art.185 of the Treaty on the Functioning of the European Union

[337] European and Developing Countries Clinical Trials Partnership 2 (EDCTP2): new or improved treatments for poverty-related diseases in sub-Saharan Africa; European Metrology Programme for Research and Innovation (EMPIR): new measurement solutions for industrial competitiveness and societal challenges; Eurostars 2: support to transnational collaboration of R&D performing SMEs; Active and Assisted Living Research and Development Programme (AAL): innovative ICT-based solutions for active and healthy ageing.

2020. In addition all but one JPI received additional EU funding from both FP7 and Horizon 2020, for the implementation of joint calls. From the currently planned 61 ERA-NET Cofund actions, 16 are in support of the JPIs.

Figure 95 Support from the Framework Programme for the JPIs via Coordination and support actions (CSA), ERA-NET-Plus (EN+) and ERA-NET Cofund (EN-CF)

Joint Programming Initiatives	FP7	Horizon 2020			
	Until 2013	2014	2015	2016	2017
Antimicrobial Resistance	CSA		EN-CF	CSA	
Climate	CSA		EN-CF		EN-CF
Cultural Heritage	CSA, EN+		CSA		
Agriculture, Food Security & Climate Change	CSA, EN+	CSA, EN-CF	EN-CF	EN-CF	
A Healthy Diet for a Healthy Life	CSA		CSA, EN-CF	EN-CF	
Neurodegenerative Diseases	CSA	EN-CF	CSA		
More years better lives	CSA	CSA			
Oceans	CSA		CSA	EN-CF	
Urban Europe	CSA	EN-CF	EN-CF	CSA, EN-CF	EN-CF
Water	CSA	EN-CF	EN-CF	CSA	EN-CF

Source: European Commission

The Joint Programming evaluation[338] highlights in particular that the societal challenges of the JPIs were selected by Member States but **the overall level of ambition does not meet the initial expectations**; the level of co-investment so far in joint calls and actions is no greater than for some ERA-NETs and there is no indication that Member States will increase their contributions significantly; most countries are not adapting their national research activities towards the SRA/SRIAs; inter-ministerial structures to support the joint programming process is rather mixed. Some demonstrate high level commitment but too many have not really made any progress; financial support through CSAs and the ERA-NET instruments has been vital to the development of the JPIs. The Commission also plays an important role in helping the JPIs to position themselves within both the European and international societal challenge landscape. **There is a risk that the joint programming process is not sustainable, without a stronger role for the Commission**; too many resources seem to be devoted to securing financial support from the Commission, while not sufficient resources are invested in ensuring the overall socio-economic impact of JPIs.

9.4. Key conclusions on the coherence of Horizon 2020

The integration of research and innovation into a single programme, the three pillars structure of Horizon 2020 and its focus on finding solutions to challenges (notably through the use of focus areas) rather than being domain-oriented improved its **internal coherence** compared to FP7. In such an integrated programme, there is however a need to ensure an appropriate balance between funding basic, collaborative and frontier research and higher Technology Readiness Levels, in order to maintain a link between industry and academia and to create groundbreaking technological foundation for innovations. An analysis of the Technology Readiness Levels supported across thematic areas shows that whereas the Excellent Science pillar focus-

[338] http://bookshop.europa.eu/en/evaluation-of-joint-programming-to-address-grand-societal-challenges-pbKI0416204/?CatalogCategoryID=7QwKABstDHwAAAEjK5EY4e5L

es on more fundamental research and, with the exception of e-Infrastructures, does not move beyond the stage of an experimental proof of concept, the rest of the programme is rather concentrated on higher TRLs, the majority of which are targeting product demonstration in both the Industrial Leadership and the Societal Challenges pillar. Multiple types of stakeholders regret that Societal Challenges and LEIT do not invest more in lower TRL collaborative research, which is regarded as one key source of future breakthrough innovations, albeit longer-termed, in line with societal needs.

The different types of action of Horizon 2020 appear coherent to address the different objectives of the programme, but the large number of instruments at EU level and complex funding rules are difficult to understand for potential applicants and may lead to overlaps.

In terms of **external coherence** there is a clear strategic willingness to ensure complementarity and synergies of Horizon 2020 with other EU programmes, in particular the European Structural and Investment Funfs (ESIF) and the European Fund for Strategic Investments (EFSI). Compared to FP7, efforts have already been made to increase the synergies between Horizon 2020 and other programmes, notably ESIF. However, strong evidence is lacking on how far this has materialised in practice yet. Given the different rules and implementation structures, promoting synergies at project level (in term of combining different financing sources for the same project) still appears difficult. The difference in state aid rules further leads to legal uncertainty for potential beneficiaries.

Member States' support to public-public partnerships has significantly increased over the past years. Although generating lasting collaborations between entities and improved capacities, the public-public partnerships are not seen as influencing the alignment of national strategies and policies. The Member States-led joint programming process is regarded as unsustainable, without Union intervention, especially during times of economic austerity in many countries.

10. WHAT IS THE EU ADDED VALUE OF HORIZON 2020 SO FAR?

This question aims to assess the value resulting from Horizon 2020 that is additional to the value that could result from interventions which would be achieved by Member States at national and/or regional levels.

Expectations on the European added-value of Horizon 2020

Based on the Horizon 2020 impact assessment, compared to a renationalisation of R&I policies, Horizon 2020 is expected to allow for the orientation of European research and innovation programmes to commonly agreed objectives, as well as for the fostering of initiatives that fundamentally restructure the European R&D landscape. The programme is also expected to allow for research that only takes place through EU-funded collaborative research projects and to produce more scientific, technological and innovation impacts, which should translate into higher economic and competitiveness, social, environmental and EU policy impacts.

Summary box: Key findings on the EU added value of Horizon 2020

- ✓ 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 excellence through competition, the creation of international, trans-national, multidisciplinary networks; pooling of resources; creating a big leverage effect and creating critical mass to tackle global challenges.
- ✓ Horizon 2020 increases the EU's attractiveness as a place to carry out R&I.
- ✓ Horizon 2020 is seen as improving the competitive advantage of participants for example through international multi-disciplinary networks, the sharing of knowledge and technology transfer and access to new markets.
- ✓ The additionality of Horizon 2020 is very strong – support is given to fund distinctive projects, which are unlike those funded at national or regional level.
- ✓ The impacts of discontinuation are difficult to quantify, but are likely very large.

10.1. Additional value compared to national and/or regional levels

In the field of R&I the application of the concept of EU Added Value (EAV) has expanded along with successive Framework Programmes (FPs). The basic principle underlying the FPs has been from the start the undisputed justification for public intervention in R&I, which is linked to well-studied and important market and systemic failures[339].

Figure 96 The evolving character of European Added value through successive FPs

Dimensions of European Added Value	FP1 1984-1988	FP2 1987-1991	FP3 1990-1994	FP4 1994-1998	FP5 1998-2002	FP6 2002-2006	FP7 2007-2013
Scale too big for Member States (MS) to handle alone	X	X	X	X	X	X	X
Financial benefits: a joint approach would be advantageous	X	X	X	X	X	X	X
Combines complementary Member States efforts to tackle European problems	X	X	X	X	X	X	X
Cohesion	X	X	X	X	X	X	X
Unification of European science & technology across borders	X	X	X	X	X	X	X
Promotes uniform laws and standards	X	X	X	X	X	X	X
Mobilising EU potential at European and global level by co-ordinating national and EU programmes				X	X	X	X
Contributes to implementing EU policy					X	X	X
Contributes to societal objectives (later 'grand challenges')					X	X	X
Exploits opportunities for the development of European science, technology and industry					X	X	X
Structures the EU R&D community and 'fabric'						X	X
Improves quality through exposure to EU-wide competition							X

Source: Technopolis, Science Metrix, Understanding the Long Term Impact of the Framework Programme, 2012

The design of earlier FPs had taken up considerations such as scale, complementarity of efforts, trans-national interaction, standardisation, implementation of EU policy, achievement of societal objectives and structuring effects on the European research and innovation ecosystem. FP7 introduced the concept of EAV derived from EU-wide competition for excellence

[339] See the Horizon 2020 Impact assessment for an extensive list of studies, evaluations and publications http://ec.europa.eu/research/horizon2020/pdf/proposals/horizon_2020_impact_assessment_report.pdf

(notably used when introducing the ERC). Horizon 2020 was designed to address all these considerations and also added a focus on coordination with respect to 'internationalisation'.[340]

Much of the EU support to R&I is unique compared with national funding. In the case of MSCA, which is a mobility programme, evidence shows for example 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[341]. Furthermore, the full value and impact of opportunities is often revealed after many years, illustrated by the number of Nobel Prize winners who had previously benefited from the MSCA (see Section 8.1.1.4).

A key aspect of EAV for EU support to R&I is the synergy it creates across Europe (and beyond) through trans-national collaborations of systemic importance. This collaboration brings the R&I effort closer to the critical mass required to tackle challenges of a societal scale. This is most evident in challenges of such a scale and complexity that no single Member State can provide the necessary resources to tackle them. Several examples of such areas are provided below (on Antimicrobial resistance) and in Annex 1 (EAV case studies). These examples highlight the Framework Programme response to European (and global) policy challenges (e.g. Antimicrobial Resistance, Climate Change) whose resolution is increasingly dependent on the establishment of a common scientific base leading to harmonised laws and standards that can support innovation.

Box: European Added Value Case Study – The fight against antimicrobial resistance

Antimicrobial Resistance (AMR) is the ability of microorganisms to resist antimicrobial drugs. Various pathogens, including bacteria, viruses, fungi and parasites can evolve to be resistant to antimicrobial drugs due to gene mutations over time. Excessive and inappropriate use of antimicrobial medicines on humans and animals, and poor infection control practices, are both speeding up the evolution of resistant strains of microbes and transforming AMR into a worldwide public health threat. A subset of multidrug-resistant bacteria in Europe are responsible for about 25 000 of human deaths annually.[342]

In addition to the avoidable deaths, this also translates into extra healthcare costs and productivity losses of at least EUR 1.5 billion each year. In 2007, infections caused by antibiotic-resistant bacteria resulted in approximately 2.5 million extra hospital days, which translated into EUR 900 million hospital costs. According to a report commissioned by the UK Government in collaboration with the Wellcome Trust, 700 000 people die of resistant infections every year.[343]

In order to tackle Antimicrobial Resistance, the EU employed a "One Health" approach and also initiated coordination efforts between countries and international organisations. In 2011 the Commission adopted an action plan against the rising threats of Antimicrobial Resistance.[344] Through its research framework programmes (e.g. FP7, Horizon 2020) the Commission contributed to several of these areas by funding research activities in the fields related to antimicrobial resistance.

Research projects directly or indirectly related to Antimicrobial Resistance were conducted under different themes, including Health, Nanosciences, Nanotechnologies, Materials & New Production Technologies (NMP), Knowledge Based Bioeconomy (KBBE), Information and communication technologies (ICT) and others.

[340] Technopolis Group, Empirica, European Added Value of EU Science, Technology and Innovation actions and EU-Member State Partnership in international cooperation, Report for the European Commission, 2014

[341] 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."

[342] EMEA and ECDC Joint Technical Report. The bacterial challenge: time to react. 2009.

[343] Tackling drug-resistant infections globally: final report and recommendations. The review on Antimicrobial resistance chaired by Jim O'Neill. (2016).

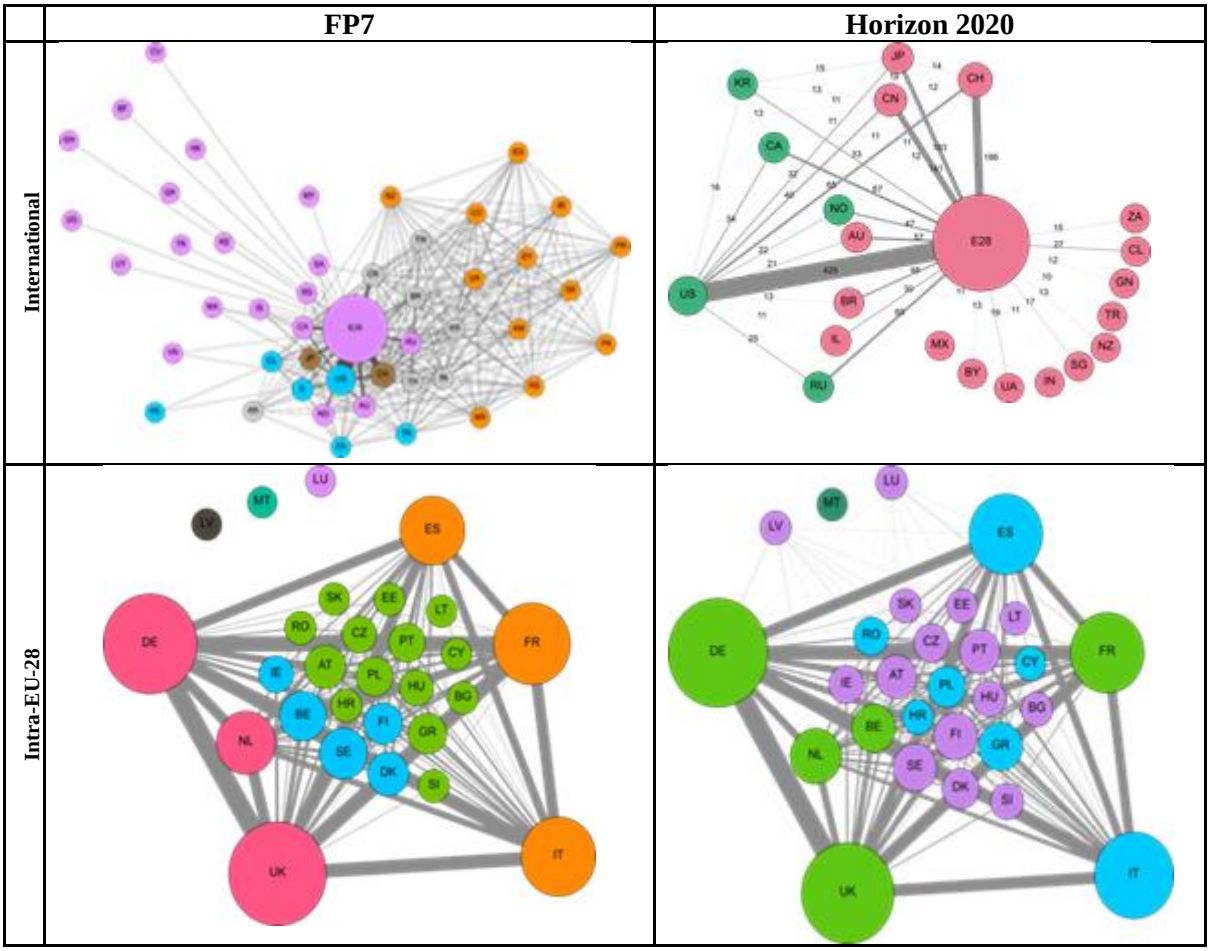
[344] Communication from the Commission to the European Parliament and the Council - Action plan against the rising threats from Antimicrobial Resistance. COM (2011) 748 final.

In order to promote adequate use of antimicrobial drugs, the Commission launched in 2015 a EUR 1 million challenge prize to develop a rapid diagnostic test for upper respiratory tract infections that can be safely treated without antibiotics. The prize was awarded to MINICARE HNL for a finger prick test that can diagnose in less than ten minutes a bacterial infection and identify if a patient can be treated safely without antibiotics.

To foster the engagement of industry in antibiotic research, several Antimicrobial Resistance related projects were launched under the Innovative Medicines Initiative. The Innovative Medicines Initiative was launched in 2008 and is currently one of the largest public-private partnership between the EU and the European Federation of Pharmaceutical Industries and Associations. Overall, the EU has contributed more than EUR 1 billion towards combating Antimicrobial Resistance over the years.

A direct outcome of the R&I trans-national networks built as a result of participating in the FPs is the trans-national co-publication of research articles. A study carried out by Elsevier[345] observed similar patterns when comparing FP7 and Horizon 2020 co-publication networks, despite the lower number of publications at this early stage of Horizon 2020. The following figures displays the intra-European and international co-publications networks under FP7 and Horizon 2020.

Figure 97 Co-publication networks in FP7 and Horizon 2020 – inside the EU and internationally



Node colour is determined algorithmically to designate clusters. Nodes that have similar collaborations and volume of collaborations have the same colour. Node size is number of publications. Edge thickness is number of collaboration publications between entities. Source: Scopus.

[345] Elsevier, Study of FP7 and Horizon 2020 publications (forthcoming), see details in Annex 1.

From this analysis, in terms of intra-EU 28 collaboration as reflected by co-publications, the most frequent collaborations occurred between the larger and more R&D intensive countries. Collaboration frequencies are highest between these countries, but the countries with smaller R&I domestic ecosystems collaborate often with each other and with at least one of the R&D intensive nations. Germany, the Netherlands and the UK continue to collaborate largely with each other, as was observed in FP7, however in Horizon 2020 Belgium and France also joined this trend. Spain and Italy remain part of their own group but are now collaborating more with smaller Member States (compared to FP7), including Cyprus, Romania, Croatia and Greece. While the Nordics and Ireland formed their own group under FP7, they now collaborate more with the eastern European countries.

Another key aspect of EAV concerns the concept of project additionality - i.e. the capacity of the project beneficiaries to carry out the same or very similar projects without EU funding. The underlying finding of a recent external study[346] is that **EU FPs fund distinctive projects which are unlike the projects funded at national or regional level**. More than 4 in 5 Horizon 2020 projects (83%) would not have gone ahead without Horizon 2020 funding, and particularly in Research Infrastructures (100%) Space (95%) and FET (95%). On average, only around 14% of Horizon 2020 projects would have gone ahead without EU funding; the actual size of this potential crowding-out is likely to be even lower[347]. A disaggregation by participant type of the survey data is not possible, but indicatively, in the LEIT and FTI parts (where private sector participation is high) additionality would be even higher (92% of projects would have gone ahead only with significant changes or not at all). **Overall, this points to a high additionality of the EU FPs, which results from the distinctive characteristics of EU-funded research projects**.

Figure 98 Continuity of Horizon 2020 projects had they not received EU funding.

	The project would have gone ahead with none or minor modifications.	**The project would have gone ahead with significant modifications.**	**The project would not have gone ahead.**
Excellent Science			
Future and emerging technologies	4,9%	29,0%	66,1%
Research Infrastructures	0,0%	29,7%	70,4%
Industrial leadership			
NMPB	12,9%	35,8%	51,3%
Subtotal within NMPB: PPP projects	*19,0%*	*81,0%*	*100,0%*
Information and Communication Technologies	19,5%	30,0%	50,5%
Space	5,6%	27,6%	66,8%
Innovation in SMEs	13,4%	16,2%	70,4%

[346] PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming. Several novel quantifications of EAV are drawn from this study, which performed a counterfactual analysis (based on a regression discontinuity with propensity matching) of FP7 top-scoring applicants who happened to be just above (intervention group) and below (control group) the funding threshold. This FP7 evidence is corroborated with a survey of Horizon 2020 beneficiaries (for which it was not possible yet to carry out the same design analysis) and in-depth case studies of EAV.

[347] Idea Consult (2009), Assessing the behavioural additionality of the Sixth Framework Programme, European Commission, Brussels; or PPMI (2013), Interim evaluation of FP7 Marie Curie Actions, European Commission, Brussels

	The project would have gone ahead with none or minor modifications.	The project would have gone ahead with significant modifications.	The project would not have gone ahead.
Societal Challenges			
Societal Challenge 1	12,3%	39,6%	48,0%
Societal Challenge 2	25,6%	32,9%	41,5%
Societal Challenge 3	14,9%	30,6%	54,5%
Societal Challenge 4	7,3%	43,7%	49,0%
Societal Challenge 5	17,7%	39,5%	42,8%
Societal Challenge 6	6,7%	29,2%	64,1%
Societal Challenge 7	11,2%	33,4%	55,3%
Spreading Excellence and Widening participation + Science with and for Society + other programmes			
Spreading Excellence and Widening Participation	8,7%	25,0%	66,4%
Science with and for Society	8,4%	29,7%	61,8%
Fast Track to Innovation Pilot	20,0%	60,0%	20,0%
Euratom	0,0%	23,0%	77,0%
Total	**13,7%**	**33,2%**	**53,2%**

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

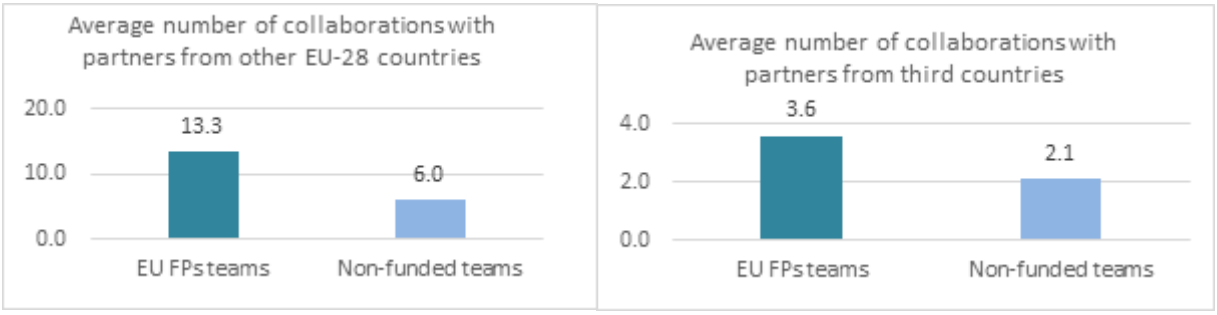
Both the Horizon 2020 and FP7 surveys provide consistent evidence that the FPs did not duplicate national R&D efforts and supported distinctive research activities. The lack of alternative funding for the type of activities funded in Horizon 2020 projects (92%) was mentioned as a key reason for not going ahead with their projects had Horizon 2020 beneficiaries not received EU funding.

Very similar data were obtained in the survey of unsuccessful FP7 applicants, where the lack of similar national or regional funds meant that **4 in 5 FP7 applicants who did not receive EU funding had to cancel their projects**.

Even though in some analysed EAV areas (e.g. anti-microbial resistance, Fuel Cell research) some Member States funded similar research activities, the national projects were in most cases less ambitious in size and scope. Importantly, EU funding opened avenues for cross-country research and data collection, leading to faster and better quality research results and impacts. The area of large-scale data gathering, omics research and biobanks is an exemplary area where the research performed greatly benefitted from the collection and analysis of cross-country patient cohort data coupled with a large quantity of omics, clinical, lifestyle and imaging information. The multi-centre and inter-disciplinary approach practised in EU-funded research projects strongly contributed to the development of personalised medicine approaches.

Following the counterfactual analysis, the PPMI study established that the EU FPs teams had, on average, 13.3 collaborations versus six collaborations in the control group. The beneficiary teams also built almost two times more collaborations with partners from outside the EU (on average, 3.6 partners from third countries versus 2.1 partners in the control group). Overall, these data point to the substantial structuring effect of the EU FPs and provide a quantification for the additionally built collaborations both across the EU and outside of it. Consistent results were found among Horizon 2020 beneficiaries.

Figure 99 Number of partners from other EU28 countries and third countries with which the analysed teams collaborated in 2015

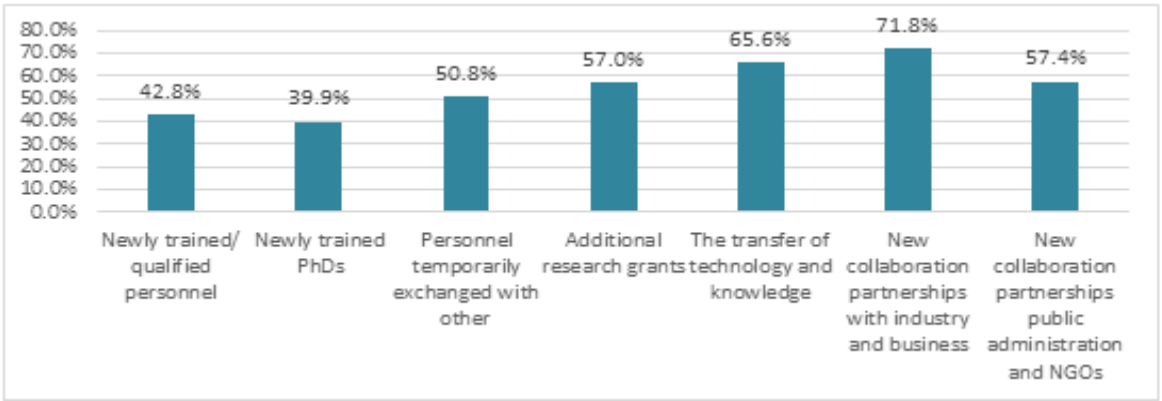


Source: PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming

The underlying trend is that there would be a significant decrease in the research capacities, particularly with respect to the transfer of knowledge (63%) and collaboration with industry and business (70%).

On average, a researcher produced 1.9 publications in 2015 in both the FP and control groups[348]. However, the publications produced in FP7 projects were published in higher impact journals (average SJR[349] of 2.4) than non-FP publications (average SJR of 1.9) published by the same authors who participated in EU-funded projects during 2007-2015. Based on the PPMI estimates, the SSH (estimated difference of 115%), Energy (56%) and Health (52%) programmes produced the largest positive difference in SJR values. The **substantial difference in SJR values shows the benefits of the networking opportunities created in FP-funded projects** to gain access and exposure to higher scientific impact.

Figure 100 Share of the project and consortium partners for whom their research capacity outputs would have decreased had they received national/regional instead of Horizon 2020 funding



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

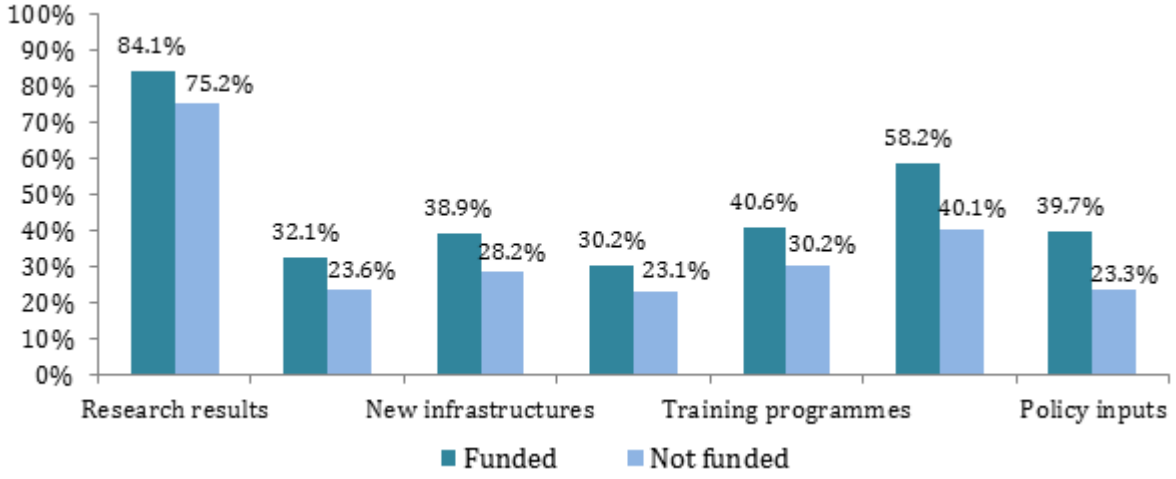
[348] This finding (i.e. no concrete evidence of the research teams becoming more productive or economical because of their participation in the FPs) is similar to assessments done elsewhere large-scale international research programmes, notably for the NIH (National Institutes of Health in the USA): Brian A. Jacob, Lars Lefgren, Corrigendum to "The impact of NIH post-doctoral training grants on scientific productivity" [Res. Policy 40 (2011) 864–874], Research Policy, Volume 41, Issue 2, March 2012, Page 497

[349] SCImago Journal Rank (SJR indicator) is a measure of scientific influence of scholarly journals that accounts for both the number of citations received by a journal and the importance or prestige of the journals where such citations come from

Moreover, as regards wider availability and dissemination of knowledge between sectors, Horizon 2020 seems to be more effective than similar national or regional research support schemes, as shown by two thirds (66%) of Horizon 2020 coordinators who answered that transfer of technology and knowledge as an output of their project would have decreased if their projects had been funded by national/regional programmes.

The analysis showed that the distinctive research activities and the better results subsequently lead to better addressed pan-European/societal challenges. Around 3 in 4 Horizon 2020 project coordinators thought that the capacity to address the needs of EU citizens (74%) and tackle global challenges (73%) would have decreased if the project had been funded with national or regional funds instead of Horizon 2020. A similar share (71%) thought that their Horizon 2020 projects addressed pan-European issues that could not be addressed solely at national level. The beneficiaries of large projects exceeding EUR 5 million in budget size were particularly likely to report this finding, which suggests that sufficient scale of the research activities was a key factor in addressing pan-European challenges.

Figure 101 Share of research units that produced outputs in open access



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

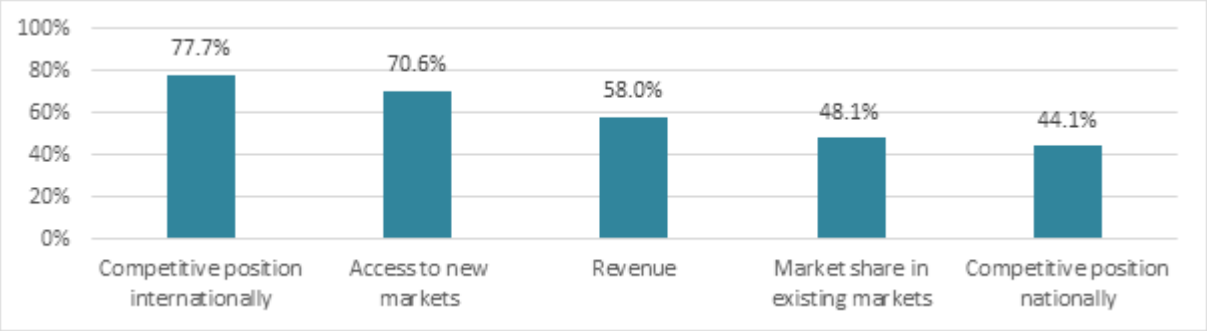
The study also found that the EU FPs helped achieve results faster in almost half of the projects (i.e. 45%). In some analysed EAV areas such as food waste, the Horizon 2020 and FP7 allowed research results to reach the market 3-5+ years faster than national projects. This suggests that time reduction was a universally perceived impact of Horizon 2020 across different types of beneficiaries and projects. Regarding the wider impact of European projects, an especially large proportion of Horizon 2020 projects are expected to have an effect on 'Climate action, environment, resource efficiency and raw materials' (51%) and 'Health, demographic change and wellbeing' (47%), followed closely by 'Secure, Clean and Efficient Energy' (42%).

Horizon 2020 primarily brought about benefits by improving the beneficiaries' competitive position internationally (78% expected a decrease in this area and access to new markets (71%). Revenue would have decreased for 58% of survey respondents had their projects been implemented at national level. Overall, this evidence points to the international/intra-national dimension of Horizon 2020 and the commercial advantages this programme aspect brings as opposed to national or regional research activities. The Horizon 2020 and FP7 survey findings consistently show that the EU FPs were substantially more effective in producing economic

and innovation outputs, and particularly large-scale demonstration initiatives, prototypes/testing activities, new/improved commercial products, business models and IPR.

Lastly, the **improvement of the quality of R&I through exposure to EU-wide competition** is another important element of EU added value. This is evident in the individual thematic assessments (Annex 2), notably in those where mono-beneficiaries are possible, like the SME Instrument and the ERC. The EU added value of the ERC from its exclusive focus on excellence-has been proven beyond doubt; it has become a global beacon of excellence; the number of ERC-grantees hosted by academic institutions is now a badge of honour comparable to Nobel prizes or Fields medals. An in-depth evaluation study of the SME Instrument carried out by Technopolis positively assessed it's EU Added Value; it is unique compared to similar support schemes at national/regional level (which are only focusing on certain priority domains; do not have rolling submissions; have significantly smaller project volumes; require project collaboration with other SMEs or universities). Moreover, the EU Added Value at individual project level is assessed in the evaluation process.

Figure 102 Share of the project and consortium partners to whom their commercial advantage would have decreased had they received national/regional instead of Horizon 2020 funding



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

The issue of the EAV of R&I is complex, and different views are taken by stakeholders, EU institutions, EU Member States. For example, the European Economic and Social Committee "believes that trans-national cooperation between academia, industry, SMEs and research organisations is the main added value of Horizon 2020. The EESC believes that this transnational collaboration and networking is more important than the absolute amount of funding"[350]. Similarly, the report of the High Level Group chaired by M. Monti[351] found research and innovation to be one of the two areas consensually identified as having a high potential added value (together with internal and external security). The report also noted "that EU research and development accounts for a much more modest share of the EU budget than agriculture and cohesion policies. In a global context where EU research is compared to American, Indian or Chinese research, this should be one of the essential policy priorities in the future."

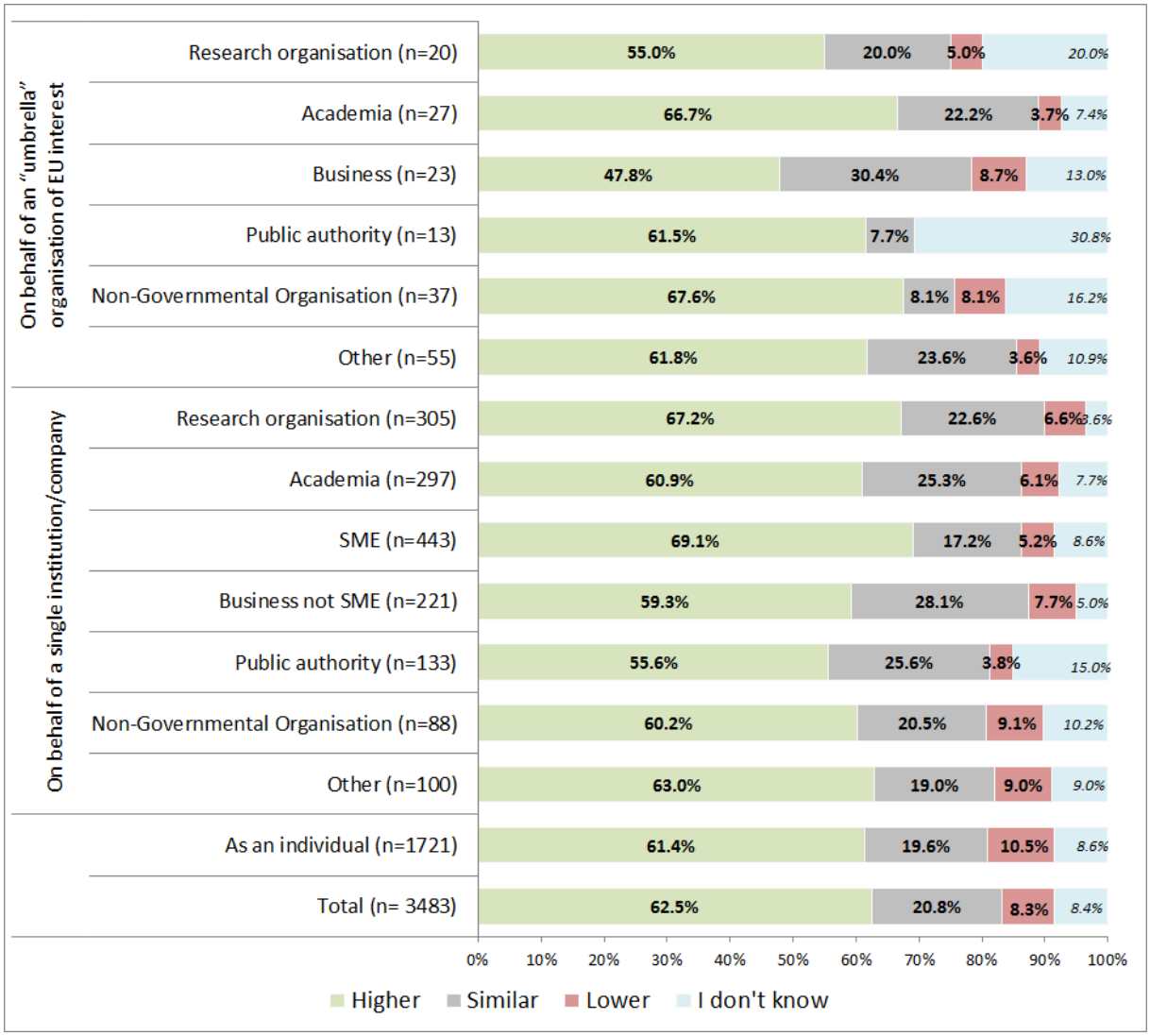
In the public stakeholder consultation, 62.5% (2,176) of the respondents rate higher the added value of Horizon 2020 compared to national and/or regional programmes for research and in-

[350] EESC information report INT/807
[351] High Level Group Own Resources report, http://ec.europa.eu/budget/mff/hlgor/library/reports-communication/hlgor-report_20170104.pdf

novation (see below). Research organisations and business respondents are the group with the highest percentage of respondents agreeing that the programme to be of higher value (respectively 66 and 65%), while public authorities are the group with the lowest percentage (56%).

Furthermore, out of the 835 respondents who did not participate in Horizon 2020, a rather low number prefer participating in other regional/ national programme (63 respondents) or in other European or international programmes (30 respondents). The consultation results also show that **cooperation with partners from other countries is the main added value** for respondents that participated or are expecting to participate.

Figure 103 How do you rate the overall added value of Horizon 2020 compared to national and/or regional level research and innovation programmes in EU Member States?



Source: Replies to stakeholder consultation questionnaire launched in the framework of the Interim Evaluation of Horizon 2020, October 2016-January 2017, N=3483

In terms of effectiveness, the respondents strongly agree with statements suggesting that Horizon 2020 strengthened the quality and visibility of research in the EU. For 1908 respondents, it contributes to improve international visibility and 1,357 are confident it improves excellence in research and innovation. In their open comments, respondents also outline the visibility and reputation they gain from being selected. Horizon 2020 is qualified as a "prestig-

ious" programme that set high standards for R&I in Europe and could lead to career development or help organisations attract top researchers.

In terms of efficiency, for 1,076 (31%) stakeholder consultation respondents, the programme strengthens critical mass to address pan-European challenges. In their open comments, respondents go as far as saying that Horizon 2020 promotes trust between partners and a more coherent and integrated Europe through shared goals and joint work. 1,574 respondents highlight that it finances projects which otherwise could not be supported at national or regional level. European funding is all the more important that the reimbursement of costs is higher than national/regional programmes for 788 respondents. In open responses, some respondents also outline that 100% cost funding for SMEs is a main incentive to participate (although it should also be noted that a few comments are against full reimbursement).

> *I see in Horizon 2020 an added value in potentially increasing the relevance of social sciences. The effort to embedding social science research into specific challenges forces us - social scientists - to put in place a dialogue with other disciplines - both inside and outside social sciences - and to critically reflect on the impact the social sciences might have, and should have, in making this world a better place to stay.*
>
> Italy, University Bologna, E. Mollana

In terms of synergy, Horizon 2020 is said to have contributed to strengthen interdisciplinary cooperation (by 1,147 respondents, 33%) as well as cooperation between academia and the private sector (873 respondents, 25%). Additional comments provided by respondents suggest that the programme offers opportunities (qualified by some respondents as "unique opportunities") to access new partners and new expertise, to work with the best and internationalise their activities. It promotes a more integrated vision of the research and innovation system, one that links together business, academy, industry and SMEs. Working with different types of organisations and across different countries fosters cross-cultural experiences (to the benefits of young researchers more particularly), thus encouraging the confrontation of different points of views, stimulating ideas and fostering creativity and the emergence of disruptive ideas.

> *Horizon 2020 is a big sandpit. If you are lucky you find toys and somebody to play and spend a great time with you. If you fail you […] only watch all others play.*
>
> Germany, Emschergenossenschaft

To provide a further analysis of the programme added value and additionality, stakeholder consultation's respondents were asked what would be the impact if the EU support to research and innovation (Horizon 2020 and its possible successor) were to be discontinued. Very few of the respondents judge that a discontinuation of the framework programme would only have a limited impact on their organisation and most of the ones who do are NGOs and public authorities (a few businesses, very few academics). Overall, **the discontinuation of the programme would be judged as "catastrophic", "devastating" "a nightmare", or a significant "drawback"**.

Potential negative impacts are numerous and vary based on the dependence of the organisation to Horizon 2020 funding. The impacts are worst for businesses whose activities are very much dependent on EU funding – the programme's discontinuation would result in a reduction in scope or even in a stop to research and innovation activities, slower product development and reduced business activities).

For academia and research organisations, it would mean: less funding for fundamental, interdisciplinary, risky and disruptive research; less drive to cooperate; less international contacts; less exposure to new knowledge; and more limited capacity to anticipate new trends – in short, losing the ability to create critical mass at the European level. It will lead to the disappearances of existing network since a stable framework would no longer be available to support joint work.

Ultimately, since without an EU Framework Programme for R&I most of the strategically important research and innovation actions would simply not take place or be far less ambitious, discontinuation of Horizon 2020 will be a drawback for research and innovation in the EU, affecting the ability of Europeans to carry out top research and to address global challenges, thus resulting in a loss of competitiveness, loss of social, environmental and economic and EU policy impacts and loss of international visibility of the EU on the international research and innovation stage.

The economic costs of discontinuation can be considered to be the foregone growth and employment benefits of Horizon 2020. These are detailed in section 8.4: over EUR 27 billion per year until 2030 (or a lost cumulative GDP of over EUR 400 billion).

10.2. Key conclusions on the EU added value of Horizon 2020

Horizon 2020 produces demonstrable benefits compared to national and regional-level R&I support in terms of **scale, speed and scope**, notably through the creation of trans-national, multidisciplinary networks; pooling 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.

Stakeholders feel that a possible discontinuation of the programme would have strong negative impacts, which would extend far beyond a simple reduction of R&I funding for their organisations. Costs of discontinuation (foregone economic benefits) are estimated to be over EUR 400 billion until 2030.

11. IMPACT OF PREVIOUS FRAMEWORK PROGRAMMES

11.1. Results from FP7

The Ex-Post Evaluation of FP7[352] was published in 2016 - approximately two years after the end of the programme and after the start of Horizon 2020.

Figure 104 presents updated data on the state-of-play of FP7.

Excellence was one of the overarching goals of FP7. Figure 105 shows the average number of citations per publication. Publications funded in FP7 are more often cited than Member States publications. On average, EU funded FP7 publications are cited 21.4 times per publication, 7 times more than the Netherlands, 12 times more than the EU average number of citations per publications, and also higher than the world, United States and Japan's averages. Further findings on FP7 publications are:

[352] https://ec.europa.eu/research/evaluations/index_en.cfm

- A higher impact (Field-Weighted Citation Impact)[353] compared to that for all Member States, the USA and Japan.
- Strong support for international collaboration defined as international co-authorship in publications, which resulted in significantly more publications co-authored compared to those at international level (54.5%) as well as EU and world averages (34.4% and 17.3% respectively).
- A high score in terms of share of academic-private sector publications, which indicates publications with both academic and corporate affiliations. FP7 funded publications have a 3.9% share of publications that are co-authored, which is higher than the EU (2.2%), US (3.2%) and world averages (1.7%).[354]

Figure 104 State of play on outputs from FP7 projects

	FP7 output
Signed Grants in FP7	25 289
Finalised projects[355]	15 612
Publications[356]	207 501
Share of open access publications[357]	61.8%
Patent applications[358]	2 669
Commercial use of R&D results[359]	10 260

Source: eCORDA, 21/12/2016

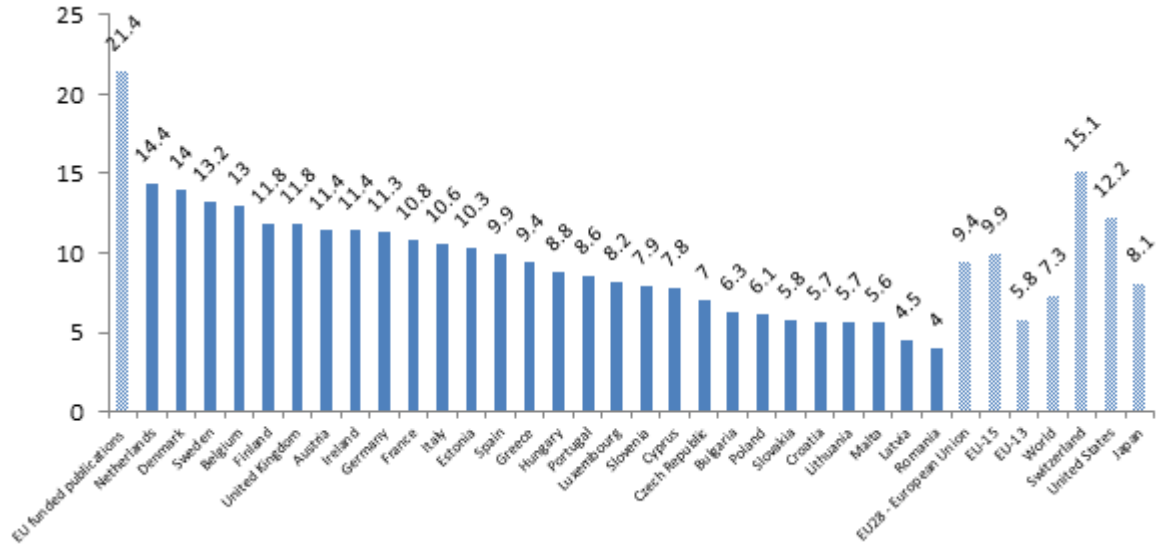
According to an external study on EAV, FP7 funded research units tended to grow 11.8 percentage points (p.p.) more than similar non-funded units. This implies an increase of at least 40000-94,000 researchers due to the implementation of FP7. Similarly, FP7 had a positive effect on the R&D budget of high-quality European research units. The R&D budget of FP7 beneficiaries tended to grow around 24.6 p.p. more than similar non-funded units (i.e. a high leverage effect). An estimated 8-17.5 billion euros of R&D funding were attracted to European high quality research units because of FP7. FP funding also helped to attract more private R&D funding into EU-13 research organisations.

FP7 funding increased research collaborations of funded organisations with research teams in other EU countries by 120%. FPs also increased collaborations of beneficiaries with non-EU based research units by of 60% (at least 100,000 collaborations).

At least 7000-15,500 European researchers would have moved from one EU country to another as a direct consequence of FP7.

[353] It divides the number of citations received by a publication by the average number of citations received by publications in the same field, of the same type, and published in the same year, thus adjusting it for field and year.
[354] To see all details please see Horizon 2020 Annual Monitoring Report 2015, pp 66-68
[355] 13341 from Sesam-Respir extraction date 22/2/2017 and 992 from ERC and 1279 from DG CONNECT.
[356] The number of publications and open access rate is calculated using OpenAire on FP7 publications: https://www.openaire.eu/fp7-stats extraction date 21/12/2016
[357] The number of publications and open access rate is calculated using OpenAire on FP7 publications: https://www.openaire.eu/fp7-stats extraction date 21/12/2016
[358] Excluding ERC, 2374 from Sesam-Respir 22/2/2017 and 295 from DG CONNECT.
[359] Excluding ERC, 9006 from Sesam-Respir extracted on 22/2/2017 and 1 254 from DG CONNECT.

Figure 105 Citations per FP7 publication, average (2007-2016)



Source: SciVal based on Corda-Sesam-Respir data, 9/8/2016

11.2. Longer term impact of previous Framework Programmes

As for Horizon 2020, the longer-term impact of FP7[360] was simulated using the Nemesis macro-economic model in order to estimate economic impacts, in particular in terms of GDP and job growth, compared to a reference scenario in which FP7 was not implemented. Similarly, the economic impacts of FP7 are non-linear and follow three main phases (Figure below):

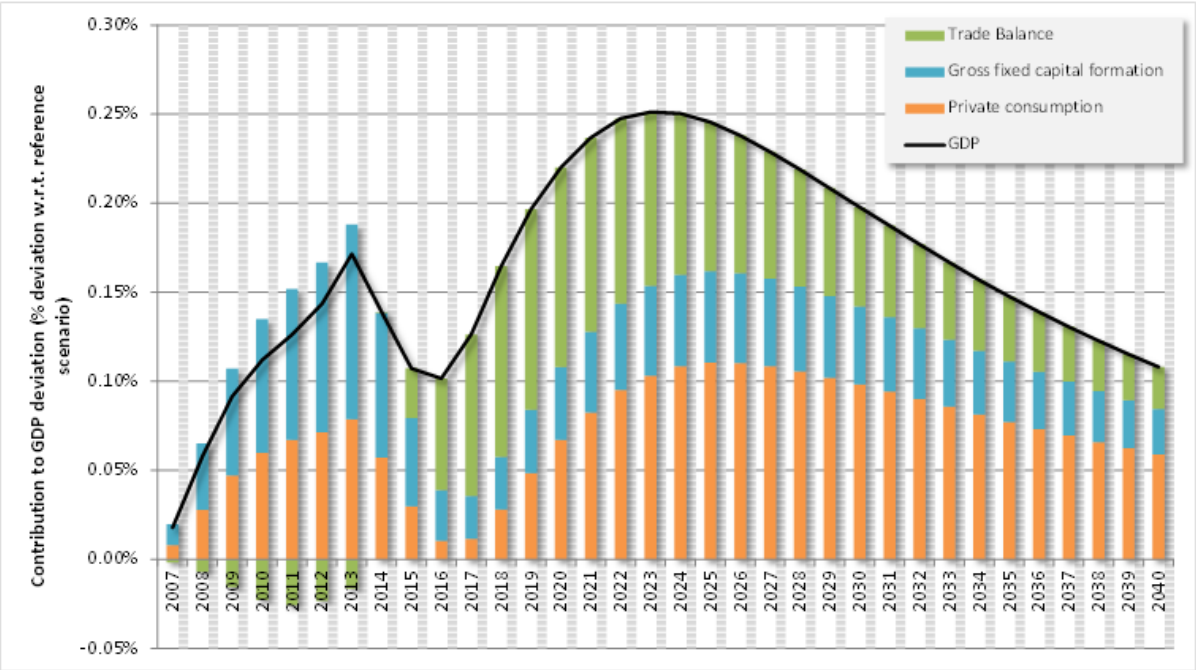
- The first phase (maturation) from 2007 to 2016, where GDP gains (compared with the reference scenario) are mainly due to the R&D investment flows and the private consumption favoured by FP7 investment whereas the external balance, penalised by the inflationary pressure and by the raise of the internal demand, is contributing negatively to EU GDP.
- During the "Innovation" phase (i.e. 2017-2023), the GDP gains are resulting from the acceleration of the arrival of process and product innovations, with a peak in 2023 where the GDP increases by 0.25% compared to the reference scenario.
- Finally in the Obsolescence phase (i.e. 2024-2040), where, under the progressive obsolescence of the new innovations, the GDP gain declines progressively to reach an increase of 0.09% in 2040 compared to the reference scenario.

On average, the GDP gain is estimated to amount to EUR 22.4 billion (in 2014 prices) per year during 2007-2023. Over the same period of 17 years, the total GDP gain is EUR 380 bil-

[360] The analysis (PPMI, "Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)", forthcoming) quantified also the effect of FP7 on the EU economy and employment, simulating FP7 socio-economic impacts up to 2040 compared to a situation in which the Framework Programme would have ceased in 2007, after the end of FP6. The estimations are based on similar assumptions as those used for Horizon 2020, except for the amount of financing which is based on historical contributions from 2007 to 2014 and the related direct leverage effect.

lion: each EUR of FP7 direct budget (EUR 42.6 billion in 2014 prices) brought an estimated GDP increase of about EUR 9.[361]

Figure 106 The impact of the FP7 funding on EU GDP (in % deviation from reference scenario)



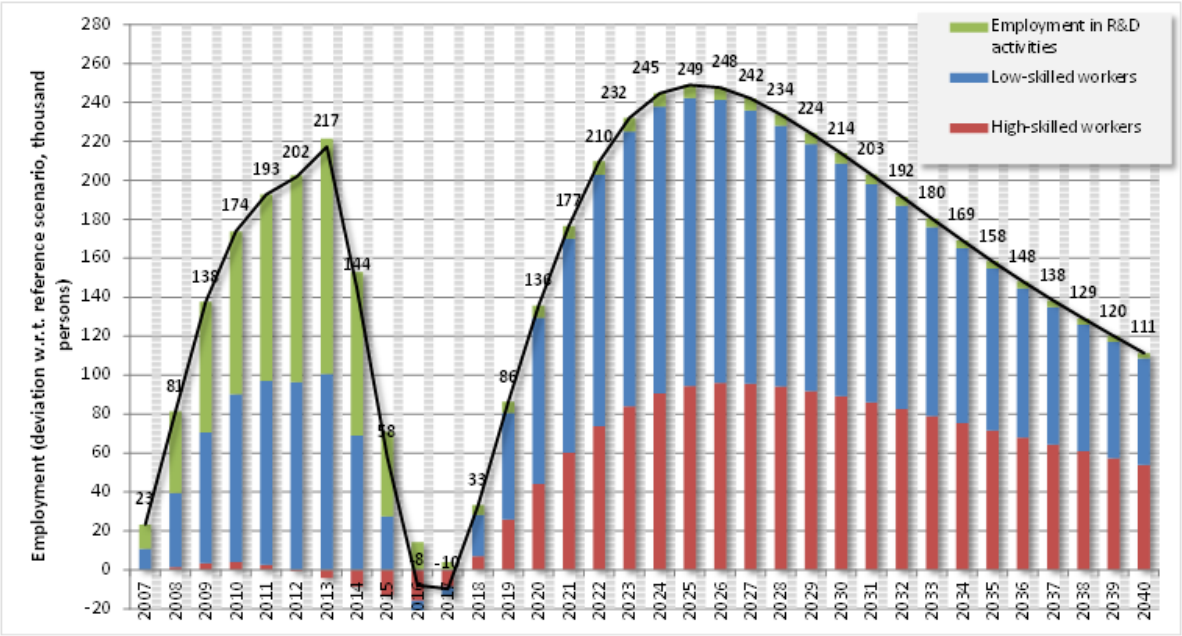
Source: NEMESIS model

In terms of employment, as in the Horizon 2020 simulations, two phases can be distinguished:

- In the first phase, up to 2016, the total employment at EU level was positively impacted by the FP7 (job creation peaks at 217 000 units in 2013 compared to the reference scenario in the same year) with a strong contribution at the beginning of the period coming from the employment in R&D activities (up to 121 000). With the decline of the FP7 funds after 2013, the total employment started falling, due to the inflationary pressures of the first period.
- In the following phase, the total employment gains increase again as a result of new innovations entering into the market. Job creation peaks in 2025 (with 249 000 more jobs compared to the reference scenario) and declines progressively. On average, during the period 2007-2023, the EU contribution through FP7 has increase the level of employment by 123 000 units, including 42 000 in research.

[361] These estimates are based on a crowding-in factor of 0.64 (each EUR of Commission contribution leading to an additional R&D expenditure of EUR 0.64 from other public and private actors) as observed in the real data extracted from CORDA (January 2017).

Figure 107 Impact of the FP7 on total employment (difference in thousand from reference scenario)



Source: NEMESIS model

12. KEY FINDINGS AND ISSUES FOR FUTURE CONSIDERATION

The results of this interim evaluation will help improve the implementation of Horizon 2020 in its last Work Programme 2018 – 2020, to provide input to the report of the High Level Expert Group on maximizing the impact of EU Research and Innovation programmes and to inform the design of future Framework Programmes. This section summarizes the key findings and outlines issues for future consideration.

12.1. Limitations of the interim evaluation exercise

Key findings

- Few projects are finalised to date, limiting the data availability on the programme's performance. Projects already started have not had the time yet to produce the full set of outputs, results and impacts, in line with the usual and widely acknowledged long time lags in research and innovation.

- Research and innovation programmes are notoriously difficult to evaluate because the pathways to impact are not linear.

- It is difficult to capture all direct and indirect results and impacts of a comprehensive programme like Horizon 2020, which operates in a multi-faceted policy context, raising the challenge of the attribution of the changes observed.

- The Horizon 2020 interim evaluation has been hampered by data availability, measurability and reliability challenges and by the lack of a clear pre-defined intervention logic.

- Most monitoring indicators are focussing on input and output, and not on results and (societal) impacts.

- There are monitoring gaps, including lack of data beyond the life-time of a project.

Areas for improvement

Short term:

- Make the calls more specific by clarifying how projects are expected to contribute to the objectives through their expected outputs, results, and impacts.

- Ensure the availability/reliability of data to monitor progress.

- Solve monitoring problems with the flagging of cross-cutting issues and understanding of certain notions, e.g. with the notion of "gender dimension in research content".

- Track longer term impacts beyond the project's life time.

Longer-term:

- Develop a clear intervention logic at the beginning of a new Programme, starting with the expected impacts (longer term) and link them to results (medium term) and output (short term).

- Set clear indicators that are understandable by the wider public and suitable to monitor in real time short-term output, results and longer-term impact on the economy and society.

- Ensure the availability of data on results and impacts beyond the project's life time.

12.2. Relevance

Key findings

- Horizon 2020's original rationale for intervention and objectives remain valid also in light of the Juncker priorities and the implementation of the Sustainable Development Goals.

- Horizon 2020 has proven fairly flexible to respond to new emerging needs.

- Horizon 2020 is broadly in line with stakeholders' needs and is attractive for newcomers.

- The strategic programming process improved the intelligence-base underpinning programming choices and helped better define the focus in line with stakeholder needs.

- Emerging priorities and new developments need to be scouted continuously and the right balance has to be found between being too prescriptive or not prescriptive enough.

- The 2-year programming is at times seen as too rigid to swiftly respond to emerging needs dictated by disruptive and counter-intuitive technologies and business models.

- The translation of high level challenges and objectives into specific calls and topics is not always clear.

- The involvement of civil society organisation remains low and there is a gap in society in understanding the benefits of publicly-funded research and overall room for improvement in bringing research closer to the general public.

Areas for improvement

Short term:

- Improve the transparency and understandability of the Work Programme through improved 'impact' statements.

- Better communicate on the projects' results and their scientific, technological, economic and societal impacts to the citizen and the wider scientific community.

Longer-term:

- Find ways to further increase the flexibility of the Framework Programme through an appropriate balance between top-down and bottom-up approaches.

- Establish an impact-focused mission-oriented approach to deliver on the implementation of the Sustainable Development Goals.

- Reconsider the length of the programming cycle and stakeholder involvement processes (e.g. more inclusive and transparent).

- Involve end-users and citizens in co-designing the R&I agenda and co-create solutions, which should also stimulate user-driven innovation.

12.3. Efficiency

Key findings

- Based on macro-economic projections, Horizon 2020 is as cost-effective as FP7 and comparable to the expected cost-effectiveness of public spending in research.

- Compared to FP7, Horizon 2020's efficiency is positively influenced by the extensive externalisation of programme implementation to new management modes including Executive Agencies.

- Simplification reduced administrative burden for participants and led to large decreases in the time to grant.

- Current administrative expenditure is below the target and is particularly low for the executive agencies.

- The new funding model is attractive for stakeholders and did not led to a significant change in funding rates compared to FP7.

- Horizon 2020 suffers from underfunding resulting in large-scale oversubscription, much larger than under FP7, which constitutes a waste of resources for applicants and a loss of high quality research for Europe.

- The proposal evaluation process is generally highly regarded but some aspects such as the feedback to applicants could be improved.

- Despite the low success rates, and cost of proposal writing, the costs on stakeholders seem to be proportionate given the (expected) benefits of participation, which go beyond the financial contribution received.

- The balance in project size did not change significantly compared to FP7 and does not seem to have a negative impact on newcomers in the programme.

- Horizon 2020 funding reaches a wide range of stakeholders, including SMEs and a high share of newcomers, but is also rather concentrated.

- Horizon 2020 is open to world and has a broad international outreach but funding of participants from third countries has decreased compared to FP7.

- Horizon 2020 promotes intensive collaboration between different types of organisations, scientific disciplines and sectors.

Areas for improvement

Short term:

- Address the issue of oversubscription; e.g. by expanding the use of two-stage procedures and improving proposal evaluations (for example the quality of feedback provided to applicants) and expand the use of the Seal of Excellence.

- Reinforce international cooperation activities for the remainder of the Horizon 2020 Programme.

- Continue with the externalisation of the implementation of the Framework Programme.

- Aim for further simplification and reduction of administrative burden for participants (e.g. via piloting output-based funding).

- Maintain the balance in project size.

Longer-term:

- Pursue further simplification and efficiency gains, for instance by assessing certain aspects of the proposal evaluation process could be further improved.

- Seek alternative ways to increase participation of international partners.

12.4. Effectiveness

Key findings

- Horizon 2020 is on track towards achieving its general objective of building a society and economy based on knowledge and innovation - based on its early progress towards achieving scientific, economic and societal impact.
- Horizon 2020 is projected to produce large-scale economic impacts.
- Horizon 2020 makes an important contribution to the Commission's policy on "Budget for Results"[362] because investing R&I in one area is expected to generate multiple impacts in various domains. All Horizon 2020 pillars are also expected to produce scientific, economic and societal impacts.
- Horizon 2020 is attracting the best universities, research organisations, researchers and many of the top "established" innovative companies but has not been able to reach out young and quickly growing innovative companies worldwide.
- Horizon 2020 builds cross-sectoral, inter-disciplinary, intra- and extra-European research and innovation networks.
- Horizon 2020 projects already produce numerous outputs like publications, patents, prototypes, new or improved products, processes and methods, including in domains of societal relevance with the potential to generate scientific breakthroughs.
- Technological, regulatory, standards, technical and access to finance, as well as lack of customer acceptance of new solutions may impede Horizon 2020's full effectiveness in terms of market uptake.
- Horizon 2020 is making progress, albeit slowly, on spreading of excellence and widening participation, with noticeable performance differences and heterogeneity among the EU-13 countries and across Horizon 2020 programme parts.
- Progress is made with respect to promoting gender equality under Horizon 2020 but data quality concerns remain.
- The expenditure targets for sustainable development and climate change are not achieved yet.
- Results are encouraging in terms of the integration of social sciences and humanities (SSH) in Horizon 2020, even if highly uneven across the programme.

[362] http://ec.europa.eu/budget/budget4results/index_en.cfm

Areas for improvement

Short term:

- Identify and support in particular SMEs that are developing breakthrough technologies at the intersection of different sectors, and support companies to scale up rapidly at EU level in order to stimulate market-creating disruptive innovation.
- Further strengthen feedback from R&I projects to policy-making.
- Ensure gender balance in terms of representation on Horizon 2020 advisory groups and project evaluation panels.
- Step up efforts to reach the sustainable development and climate expenditure target by the end of Horizon 2020.
- Deepen and broaden the embedding of SSH across the Horizon 2020 work programmes (contributions from certain SSH disciplines are relatively well-represented, while others are hardly present at all).
- Continue progressing with making scientific publications and data it generates openly accessible to the wider scientific community and the public.

Longer-term:

- Better support market-creating disruptive innovation, e.g. by identifying and supporting companies, in particular SMEs, that are developing breakthrough innovations at the intersection of different sectors and technologies and supporting their scale-up at EU level.
- Pursue further reinforcement of the R&I systems of low-performing R&I countries through a better policy coordination at EU, national and regional level stimulating national reforms e.g. through the European Semester, the Policy Support Facility and smart specialisation strategies.
- Ensure a complementarity/a better connection between all types of funding instruments across the EU, in particular between grants and non-grants, to facilitate scaling up of young innovative firm.
- Engage future users in the agenda-setting and development of market-creating innovations.
- Focus investments in areas of strategic interest for the EU and that are relevant to society, where multiple impacts are expected, for example through focus areas.
- Better address the barriers to innovation (regulations, standards, access to finance, customer acceptance) and support the creation of the right framework conditions for full market-uptake, including by developing approaches to identify the dual-use potential of projects' results.

12.5. Coherence

Key findings

- The integration of research and innovation, the three pillar structure, the challenge-based approach, and the use of focus areas contribute to the internal coherence of Horizon 2020 compared to FP7.

- Outside the 'Excellent science' pillar, Horizon 2020 is increasingly focused on research and innovation at higher Technology Readiness Levels. This has to be ensured that this does not come at the expense of lower Technology Readiness Levels collaborative research, which is regarded as one key source of future breakthrough innovations in line with societal needs.

- The large number of European R&I funding instruments is difficult to understand and may lead to overlaps.

- Compared to FP7, efforts have already been made to increase the synergies between Horizon 2020 and other programmes, notably ESIF but these can be further strengthened.

- Further coherence with other EU funding programmes is hampered by the different intervention logics and complexity of the different funding and other rules such as State Aid rules.

- Horizon 2020 specifically aims to establish synergies with national programmes. Public-public partnerships are creating long lasting collaborations between funding agencies and capacity building benefits however do not seem to really influence the alignment of national strategies and policies.

Areas for improvement

<u>Short term:</u>

- Improve internal coherence further, for example through the use of a limited number of focus areas.

- Ensure an appropriate balance between fundamental research, applied research and innovation support across all pillars in line with societal needs.

<u>Longer-term:</u>

- Rationalise the R&I funding landscape.

- Strengthen coherence, by integrating different EU funding schemes/programmes with the same intervention logic and further harmonisation of rules for participation in EU funding programmes.

- The alignment of the programme with policy priorities and the challenge-based approach need to be strengthened further and the work programme fragmentation needs to be reduced in order to maximise the impact of the supported activities.

- Focus on enhancing synergies between the EU Framework Programme for research and innovation and other EU funding programmes by ensuring complementary intervention logics at the design stage.

- Ensure a coherent approach at EU level for policies supporting research, education and innovation.

12.6. EU added value

Key findings

- 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 excellence through competition, the creation of international, trans-national, multidisciplinary networks; pooling of resources; creating a big leverage effect and creating critical mass to tackle global challenges.

- Horizon 2020 increases the EU's attractiveness as a place to carry out R&I.

- Horizon 2020 is seen as improving the competitive advantage of participants for example through international multi-disciplinary networks, the sharing of knowledge and technology transfer and access to new markets.

- The additionality of Horizon 2020 is very strong – support is given to fund distinctive projects, which are unlike those funded at national or regional level.

- The impacts of discontinuation are difficult to quantify, but are likely very large.

Areas for improvement

<u>Longer-term:</u>

- Consider an impact-focussed mission-oriented approach to continue to deliver on global challenges at a scale, speed and scope that adds value compared to what can be done at national or regional level.