European Commission

Interim Evaluation of HORIZON 2020

Commission staff working document

Research and Innovation

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FOREWORD

Horizon 2020, the EU Framework Programme for Research and Innovation (2014-2020), is unique in the world in terms of its scale, duration and scope. It pursues ambitious objectives, including jobs, growth and better lives for Europe's citizens, through stronger science, technological leadership and the tackling of societal challenges.

The interim evaluation of the programme presented here shows, based on a wide range of evidence, that Horizon 2020 is already a huge success. It is well on track to produce the scientific and technological results and outputs and wider societal impacts needed to effectively achieve its objectives.

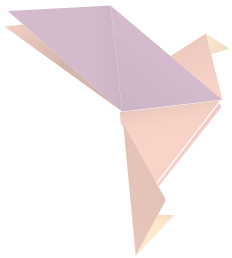
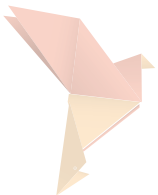
It is doing so through actions that are subject to processes and procedures that have been simplified substantially compared to the previous programme and have made the programme much more attractive. More than half of the participants are newcomers, and Horizon 2020 receives 65% more applications per year than FP7 did.

Horizon 2020's actions have clear European added value (over 80% of projects would not have gone ahead without its support) and are managed in a highly cost-efficient manner.

This is not to say that there are no issues to be addressed in the remainder of the programme. More can be done to support much needed breakthrough market-creating innovation, for instance. And the involvement of end-users and citizens in co-designing the programme and implementing it can be increased.

This interim evaluation of Horizon 2020 provides a rich and comprehensive evidence base for understanding the impacts of the projects, improving the programme and for preparing its successor - while at the same time demonstrating the importance of research and innovation as an investment in the future we want for Europe.

Carlos Moedas
European Commissioner for Science, Research & Innovation

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1 EXECUTIVE SUMMARY

This publication presents the interim evaluation[1] 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 contribute to drafting the last Work Programme for 2018-2020, provide the evidence-base for the report of the High Level Expert Group on maximising the impact of EU R&I programmes and will inform the design of future Framework Programmes. Since the first projects only started three years prior, an interim evaluation obviously has limitations. Science and innovation are long-term and risky endeavours creating an impact that can only be partially captured after such a short period. A monitoring system with indicators to systematically track impact (in particular for societal challenges) is found 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** even in light of new political priorities. The EU still spends too little on R&I (the 3 % expenditure target has not been met) 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 surge in migration. However, the right balance has yet 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 each year, compared to 20 000 for the **Seventh Framework Programme for Research and Technological Development** (FP7). A third of proposals came from newcomers. However, more can be done to bring R&I closer to the public and further improve its 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 has increased **efficiency** compared to FP7. It has 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 programme's attractiveness has led to very low success rates (11.6 % compared to 18.5 % in FP7), leaving some parts strongly underfunded: only 1 in 4 proposals evaluated as being of high-quality were retained; an additional EUR 62.4 billion would have been needed to fund them all. 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 declined compared to FP7.

Looking at its **effectiveness**, 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, although this expenditure represents a considerable

1 The interim evaluation package: http://ec.europa.eu/research/evaluations/index_en.cfm?pg=h2020evaluation

increase compared to FP7. It has succeeded, albeit slowly, in spreading excellence and widening participation, and compared to FP7 is making slight progress in generating science with and for society.

Even though Horizon 2020 only represents a small proportion of total public research and development (R&D) spending in the EU, macroeconomic models estimate significant socio-economic impact from the programme (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.

With its three pillars, Horizon 2020 has a more **coherent** structure than FP7. In particular, the use of focus areas to promote interdisciplinary solutions to multiple societal challenges is 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 (TRL) in some parts of the programme is creating concerns about 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 (ESIF), further coherence is hampered by the different intervention logic and complexity of various funding and other rules, such as state aid rules. Although the Public-to-Public Partnerships (P2P) supported by Horizon 2020 co-funding are building lasting collaborations, they do not seem to have been influential on Member State 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 transnational, multidisciplinary networks, pooling resources, and creating critical mass to tackle global challenges. This is enhancing 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, such as 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 for different proposals
ARF	Access to risk finance
Associated Country	Third countries that are party to an association agreement with the EU. They participate in Horizon 2020 under the same conditions as EU Member States. As of 1 January 2017, 16 countries were Associated[2]
CEF	Connecting Europe Facility
CIP	Competitiveness and Innovation Framework Programme
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
CSC	Common support centre
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 RTD	European Commission's Directorate-General for Research and Innovation
EASME	Executive Agency for Small and Medium-sized Enterprises
EC	European Commission
EESC	European Economic and Social Committee
EFSI	European Fund for Strategic Investments
EIB	European Investment Bank
EIF	European Investment Fund
EIP	European Innovation Partnership
EIT	European Institute of Innovation and Technology
ERA	European Research Area
ERC	European Research Council
ERCEA	European Research Council Executive Agency

2 see list here http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/3cpart/h2020-hi-list-ac_en.pdf

NAME OR ABBREVIATION	DESCRIPTION
ESIF	European Structural and Investment Funds
ETP	European Technology Platform
EU	European Union
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
EUA	European University Association
FET	Future and Emerging Technologies
FI	Financial instrument
FPA	Framework Partnership Agreement
FP7	Seventh Framework Programmes for Research and Technological Development
FTI	Fast track to innovation
FWCI	Field Weighted Citation Index
High-quality proposal	A proposal that scores above the set evaluation threshold, making it eligible for funding
IA	Innovation action
ICT	Information and communication technologies
INEA	Innovation and Networks 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
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
OECD	Organisation for Economic Co-operation and Development
P2P	Public to public partnership

NAME OR ABBREVIATION	DESCRIPTION
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 partnership
Project	Successful proposals for which a Grant Agreement is 'signed'
PPS	Purchasing power standard
PSF	Policy Support Facility
R&D	Research and development
REA	Research Executive Agency
RI	Research infrastructures
R&I	Research and innovation
RIA	Research and Innovation Actions
RRI	Responsible research and innovation
RSFF	Risk-sharing Finance Facility
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 and medium-sized enterprise
SME-1 and SME-2	SME instrument phase 1 and 2
SSH	Social sciences and humanities

NAME OR ABBREVIATION	DESCRIPTION
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
TFEU	Treaty on the functioning of the EU
Third Country	A state that is not an EU Member State of the EU. "'Third Countriescountries" ' 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 readiness Levels 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
WP	Work programme

3 INTRODUCTION

3.1 PURPOSE OF THE EVALUATION

This report 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[3] and the Commission's Better Regulation Guidelines[4].

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 maximising 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 Horizon 2020 and with other instruments, and its EU added value.

3.2 SCOPE OF THE EVALUATION

The interim evaluation covers the entire Horizon 2020 programme and its specific programme, including the European Research Council (ERC), 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 has been done without prejudice to the forthcoming separate dedicated interim evaluations of those initiatives[5].

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 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.

3 See Annex 2 for an overview of the elements covered by this provision.

4 More information here: http://ec.europa.eu/smart-regulation/guidelines/toc_guide_en.htm

5 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.

4 BACKGROUND TO THE INITIATIVE

4.1 DESCRIPTION OF THE INITIATIVE AND ITS OBJECTIVES

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 (seven 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; cross-border, transnational, in-ter-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'; 'in-dustrial leadership'; 'societal challenges' and two additional priorities;
- 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; and
- Wide range of instruments and actions.

Research is a shared competence between the European Union (EU) and Member States[6]. Framework Programmes are the EU's main instruments for the funding of R&I in Europe. Horizon 2020 is the eighth EU Framework Programme for Research and Innovation for the period 2014-2020 with a budget of nearly EUR 80 billion, bringing together EU-level R&I funding into a single programme, covering the scope of 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.

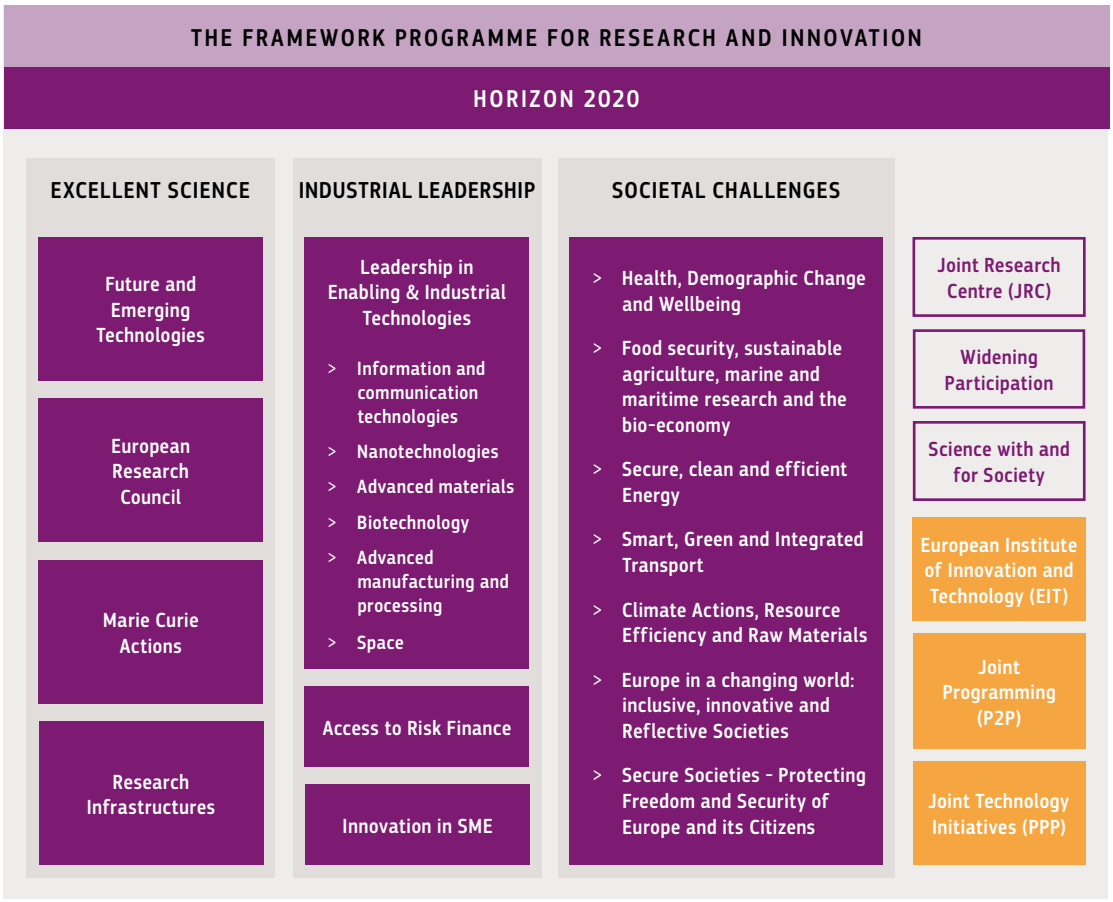
Its general objective is "to contribute to building a society and economy based on knowledge and innovation across the Union by leveraging additional research, development and innovation funding and by contributing to attaining research and development targets, including the target of 3 % of gross domestic 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)" [7].

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.

6 Article 4(3) Treaty on the Functioning of the European Union.

7 Article 5, Regulation 1291/2013/EC establishing Horizon 2020.

FIGURE 1: Structure of Horizon 2020



When Horizon 2020 was adopted, this single framework integrating research, education[8] and innovation 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.

SMEs were expected to benefit in particular from administrative simplification and closer knowledge triangle coordination, especially concerning R&I 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 both the European Commission and for applicants. A set of cross-cutting issues (such as gender equality, social sciences and humanities, international cooperation, responsible R&I, 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[9].

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

8 A large part of the European action related to education is covered by ERASMUS+ and is thus outside Horizon 2020.

9 Annex 1 Regulation (EU) No 1291/2013.

transnational 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 R&I 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 R&I networks (knowledge triangle players, enabling and industrial technologies, in areas of key societal challenges);
- Support the development and implementation of R&I agendas through public-private partnerships (PPP);
- Strengthen public-public partnerships (P2P) in R&I;
- 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 R&I;
  - Promote world-class research infrastructures and ensure EU-wide access for researchers;
  - Ensure adequate participation of SMEs;
  - Promote international cooperation with non-EU countries.

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[10]. 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[11].

10 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 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.

11 http://ec.europa.eu/research/evaluations/index_en.cfm?pg=h2020evaluation

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 transnational 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 in supporting policymaking in line with citizen needs and the acceptance and take-up of R&I results by society (also based on the broader involvement of society in R&I).

FIGURE 2: can be found as a stand-alone leaflet at the end of the present publication.

4.2 BASELINE

When Horizon 2020 was conceived, Europe was facing a series of major challenges that centred around low growth rates, a diverse set of environmental, social and technological challenges, declining 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[12].

The three-pillar structure of Horizon 2020 reflects the set of issues identified as underlying Europe's innovation gap: the insufficient contribution of R&I to tackling societal challenges; insufficient technological leadership and innovation capability in the private sector; the need to strengthen the science base; and insufficient transnational 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 CIP, and the EIT), with different rules and implementation modalities. The box below provides an overview of the main changes from FP7 to Horizon 2020 as well as the key expectations resulting from the change 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.

FROM FP7 TO HORIZON 2020

RECOMMENDATIONS FROM FP7 *EX-POST* EVALUATION[13]	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 R&I and new digital technologies
Align R&I 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 R&I strategies > identifies obstacles to R&I > 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 R&I 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 socio-economic impacts > improves feedback loop from project results to policymaking

12 Introduction to Horizon 2020 Ex-Ante Impact Assessment Report (COM/2011/808).

13 European Commission, Commitment and Coherence – Ex-Post Evaluation of the EU's Seventh 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 R&I 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 facing Europe and the world. 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 paperwork 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 both the private and public sector 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 (ERC) and transnational collaborative projects.

MAIN ELEMENTS OF CONTINUITY/ STRENGTHENING OF SUCCESSFUL ELEMENTS FROM FP7

- The **ERC** which, in just a few years, has become the point of reference for excellent frontier research in Europe and 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 under Horizon 2020 have been 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 have been shown to be particularly valuable in a period when 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 Horizon 2020 strategy, the *EIT* 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 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 enable greater flexibility;
- Administrative costs for applicants and participants are expected to fall drastically, which should significantly improve accessibility, in particular for SMEs, and increase 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 greater downstream economic and competiveness, and 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 Horizon 2020 objectives are still relevant and how well they match 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 making progress towards its objectives;
- **Coherence:** how well or otherwise 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 that which could result from interventions that 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 adaptations 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 progress has been made towards achieving scientific impact? - What progress has been made on strengthening R&I capacities, reputation and scientific excellence? - What progress has been made on improving R&I integration? - What has Horizon 2020 contributed to the achievement and functioning of the ERA? > What progress has been made towards achieving innovation and economic impact? - What progress has been made on advancing knowledge, IPR and knowledge transfer? - What progress has been made on reinforcing framework conditions for R&I? - What progress has been made on delivering close-to-market outputs and diffusing innovation in products, services and processes? > What progress has been made towards achieving societal impact? - What progress has been made on tackling societal challenges? - What progress has been made on generating science with and for society? - What progress has been made on generating science for policy? > What is the overall progress of Horizon 2020 towards its general objective?

MAIN EVALUATION QUESTIONS	SUB-QUESTIONS PER EVALUATION CRITERIA
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 ESIF and the 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 that of 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 European Commission's (EC) Directorate-General for Research and Innovation, with the support of a Working Group and an Inter-Service Group comprising several Commission services. The interim evaluation started in April 2016 and has been guided by the 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[14]:

- Monitoring reports of Horizon 2020 and statistical data, mainly from the Commission's internal IT tools as well as Eurostat/Organisation for Economic Co-operation and Development (OECD) data;
- Extensive analysis carried out by the responsible Commission services on the different programme parts of Horizon 2020 (thematic assessments[15]), on the 15 cross-cutting issues, on the Horizon 2020 funding model and various Horizon 2020 instruments/actions (initiatives from Articles 185/187, Fast Track to Innovation, SME Instrument EIT), on participating companies' profiles (OECD, ORBIS data), on the new management modes (based on external evaluations of agencies and internal data), and on participants' networks (with the Joint Research Centre). Most internal assessments benefitted from 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, 2017), the financing of participating companies (Grimpe et al., 2017); on the EU Added Value and economic impact of the Framework Programme (PPMI, 2017) – which included a representative survey of Horizon 2020 project coordinators, counter-factual analysis and macroeconomic 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[16];
- Data from other EU institutions such as the Conclusions on the Interim Evaluation of the Council, work of the European Parliament's Committee on Industry, Research and Energy (ITRE), relevant Court of Auditors' reports and reports/evaluations of the European Economic and Social Committee (EESC).

Input from various stakeholder consultations was used to contextualise the findings, in particular the

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

15 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 and social network analysis. All 'thematic assessments' are available in Annex 2.

16 European Commission Expert Group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020, 'Applying relevance-assessment methodologies to Horizon 2020' (2017).

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 3500 stakeholders replied and more than 300 stakeholder position papers were submitted[17].

LIMITATIONS – ROBUSTNESS OF FINDINGS

The main limitation of this interim evaluation concerns its timing: it is taking place just three years after the beginning of Horizon 2020, when most projects have only just started (projects completed at the time of this evaluation represent 0.6 % of funding allocated so far). Whereas for some actions, the 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 to 30 years) and have effects more difficult to capture through the 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, for example, reducing CO_2 emissions, or improving the health of citizens, or their security, often in the longer term. Other limitations include aggregation (for example, monitoring data covering the entire programme comes from various data sources, which are difficult to aggregate) and the reliability of certain data (for example, data on patents and publications, which in many parts of the programme are based on self-reporting by project coordinators; data on cross-cutting issues like gender and social sciences and humanities are based on flagging up by project officers). It has also not always been possible to validate findings from external studies/expert groups, for example, with respect to macroeconometric modelling results.

Another limitation is the lack of benchmarks to compare performance. There is no other programme in the world 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, countries' R&I performance is influenced by many factors other than just Horizon 2020. The programme's performance 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) national and regional policy initiatives.

To overcome/mitigate these limitations, the interim evaluation is transparent in its data sources; all underlying data sources are made publicly available. The analysis of the evidence by Commission services has allowed the identification of data availability/quality problems that could already be overcome during 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.

17 A full analysis of the stakeholder consultation (both the questionnaire and the position papers) is provided in Annex 2. This report only summarises key stakeholder input on dedicated topics.

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 each Work Programme (WP). While the Horizon 2020 legislation sets out the broad lines of action and the budget envelope, the WPs define the priorities for each year, as well as details of the calls for proposals. The priority-setting process and the topics covered under the WPs for each programme part are discussed in depth in Annex 2.

Compared to FP7, the Commission has taken a **new approach to implementing Horizon 2020.** The strategic programming is the process of shaping Horizon 2020's WPs so that they are forward-looking, respond to new developments, cover the full R&I cycle, and contribute significantly towards the EU's overall policy objectives[18]. The programming 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, comprising Member State representatives, the WP has been 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 are expected to give researchers and businesses more certainty on the direction of EU R&I policy. At the same time, the strategic programming is expected to allow flexibility in the redefinition of priorities and response to pressing needs. To make funding flexible and to counterbalance the possible rigidity of the two-year work programmes, there is room for WP updates to be issued if necessary and, as in this case, to activate an emergency procedure to swiftly allocate funds to a particular purpose[19].

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[20]. The management of specific parts of the programme is carried out through different forms of partnership – PPP and 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 both the market and to end-users (e.g. prototyping, testing, demonstrating, piloting, product validation and market replication) and demand-side approaches. To this end, 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 (RIAs) and Innovation Actions (IAs)), support to individual applicants is provided under the 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), P2P (including ERA-NET Co-funds, Article 185), PPP (including Joint Technology Initiatives (JTIs), contractual public-private partnerships), inducement prizes and financial instruments. Coordination, support and other actions are used for studies, expert groups, conferences, as well as for disseminating and exploiting results. Such grants are also used to underpin R&I policy initiatives (e.g. Policy Support Facility (PSF), Belmont Forum and Innovation Deals). There is also support

18 OJ, L 347, p. 974.

19 As happened during the Ebola crisis, see section 6.2.

20 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 communication measures, including to the public at large. Furthermore, a special type of collaborative projects is being piloted – the Fast Track to Innovation is focusing on industrial actors and rapid turn-around. Also, the Commission is undertaking direct actions in the form of R&I activities through the JRC.

FIGURE 4: Types of actions in Horizon 2020[21]

TYPE OF ACTION AND OBJECTIVES PURSUED	TARGET GROUPS	CHANGES TO FP7
COLLABORATION-BASED GRANTS		
Research and Innovation Actions (RIAs): Actions primarily comprise 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. **TRLs covered**[22]**: defined in the WP 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 (IAs): Actions primarily comprise 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 in areas where scientific and technology insights are available and the focus shifts to turning these into applications. **TRL covered: defined in the WP 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

21 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 will be limited to a maximum of 70 % for innovation actions and programme co-fund actions [what does this mean?] (except for non-profit legal entities where 100 % rate applies). Indirect eligible costs shall be determined by applying a flat rate of 25 %.

22 The definition of technology readiness levels (TRLs) is not a precondition for most of the actions, except if mentioned in the WP (and then only for RIAs and IAs).

TYPE OF ACTION AND OBJECTIVES PURSUED	TARGET GROUPS	CHANGES TO FP7
European Joint Programme Co-fund (COFUND-EJP): support to coordinated national R&I programmes in implementing a joint programme of activities (ranging from R&I 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-Co-fund: support public-public partnerships in their preparation, establishment of networking structures, design, implementation and coordination of joint activities, as well as EU topping-up of a transnational call for proposals.	Independent legal entities from Member States or Associated Countries owning or managing national R&I programmes	-
Pre-commercial procurements (PCPs): 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 (buyers group) to undertake one joint PCP/PPI procurement together	-
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 one joint PCP/PPI procurement together	-
Coordination and Support Actions (CSAs): 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. These may also include complementary activities on networking and coordination between programmes in different countries.	Single entities or consortia of partners from different countries	-
MSCA ITN: The Innovative Training Networks (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 R&I staff exchanges, and sharing 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)	

TYPE OF ACTION AND OBJECTIVES PURSUED	TARGET GROUPS	CHANGES TO FP7
MONO-BENEFICIARY GRANTS		
Marie Skłodowska-Curie Actions (MSCA): Individual Fellowships (IF)): support experienced researchers undertaking mobility between countries, and where possible 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 small and medium-sized enterprises (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 (FPAs) for long-term partnerships and associated specific grant agreements. FPAs and SGAs have been used in a limited way when in line with the objectives of the programme sections.		-

TYPE OF ACTION AND OBJECTIVES PURSUED	TARGET GROUPS	CHANGES TO FP7
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 may pursue more radically new concepts than large, institutionalised 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.	Whoever can meet a defined challenge most effectively	New action
Public-Public Partnerships (P2Ps) also provided via the Article 185 initiatives: Article 185 of the Treaty on the Functioning of the European Union (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 Parnerships (PPPs): these support the development and implementation of R&I activities of strategic importance to the EU'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. Contractual PPPs are also supported.	Partnerships between public and private sector	-
Public procurement: this is the supply of assets, execution of works or provision of services against payment.	By means of tenders and subject to special procurement procedures	
Financial instruments (FIs): Equity or quasi-equity investments; loans; guarantees; other risk-sharing instruments. Horizon 2020's FIs operate in conjunction with those of the European Union Programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME). Strong synergies will be ensured with the EFSI to create the maximum possible impact. This will be the main form of funding for activities close to market under Horizon 2020.	FIs are not directly implemented by the Commission (nor via the WP), but via the European Investment Bank/European Investment Fund	Replacing the Risk-Sharing Finance Facility (RSFF)

Source: European Commission

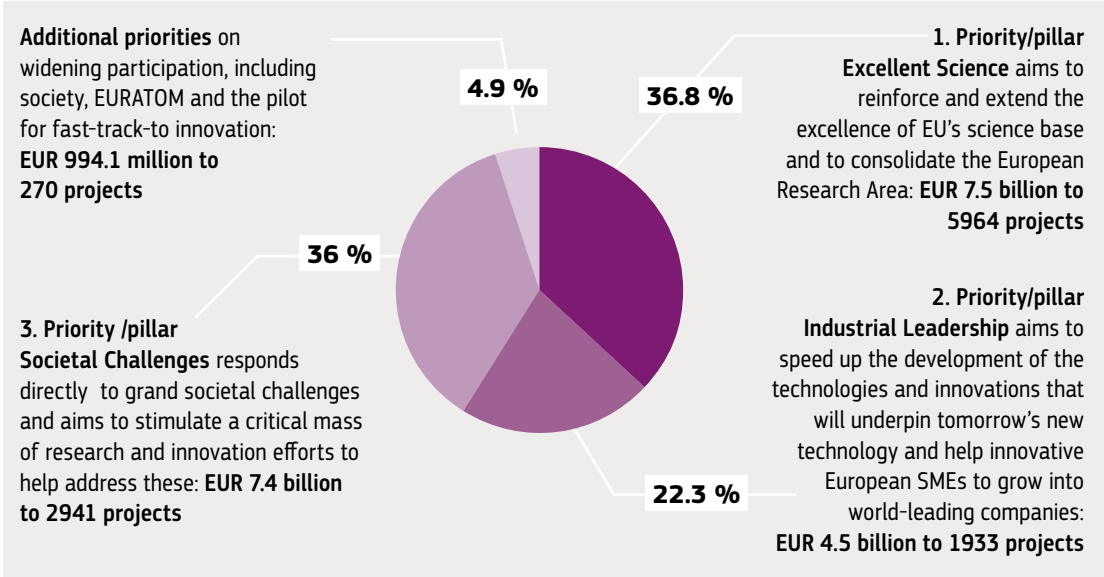
5.2 OVERVIEW OF IMPLEMENTATION STATUS AFTER THREE YEARS

The Commission monitors the implementation of Horizon 2020 through annual monitoring reports[23] based on Horizon 2020 key performance indicators (KPIs)[24]. The overall budget of Horizon 2020 is EUR 74.8 billion[25]. As of 1 January 2017, EUR 20.4 billion has been allocated to 11 108 signed grants[26]. As shown in the following figure, EUR 7.5 billion was allocated to 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[27].

Most of the Commission funding has been allocated through RIAs (39.3 % of the funding), followed by frontier research grants awarded by the ERC (19.0 %), IAs (17.2 %) and MSCA (10.3 %). MSCA accounts for the highest number of grants signed (3246) followed by ERC (2440) and RIA (1680). The programme surpassed the 20 % SME target (almost 24 % of the total budget for Leadership in Enabling and Industrial Technologies (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) have so far not been met (27.0 % and 53.3 %, respectively).

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 in the section on Coherence.

FIGURE 5: Funding allocation and number of projects per programme part



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

23 Available at: https://ec.europa.eu/research/evaluations/index_en.cfm?pg=monitoring

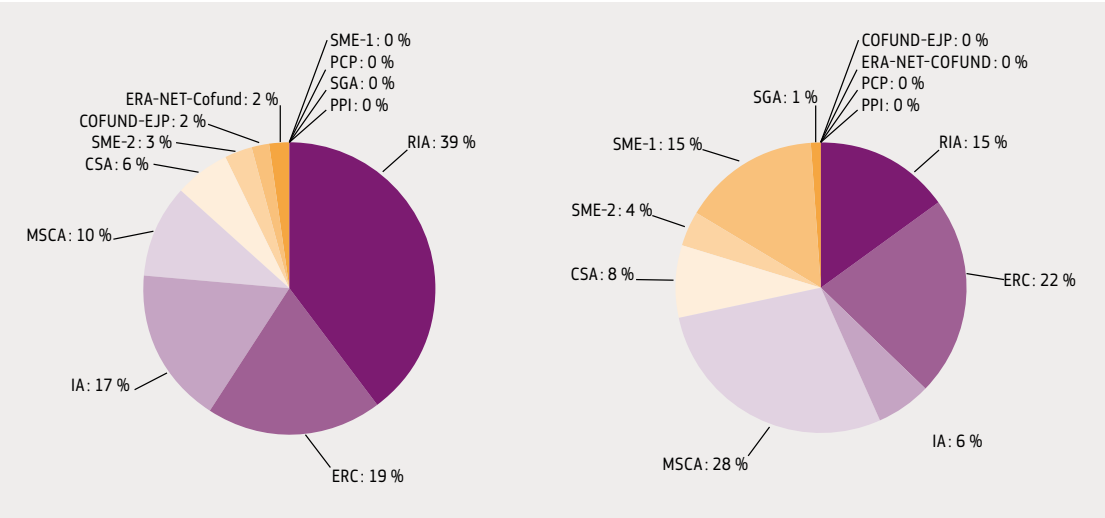
24 https://ec.europa.eu/programmes/horizon2020/en/news/horizon-2020-indicators-assessing-results-and-impact-horizon

25 Regulation (EU) 2015/1017 of the European Parliament and of the Council of 25 June 2015.

26 Including EUR 0.5 billion in grants under Euratom.

27 Detailed implementation data can be found in Annex 1.

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



Source: Corda, calls until end of 2016, signed grants cut-off date: 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's financial contribution that is climate-related (Rio-Markers methodology)	27.0 %
Sustainable development target: 60 % of EC's financial contribution that is sustainability-related (RIO-Markers methodology)	53.3 %
SME target: 20 % of EC's financial contribution going to SMEs (only LEIT and societal challenges)	23.9 %
SME Instrument target: 7 % of EC's 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 the key indicators used for benchmarking purposes for FP7 and Horizon 2020.

FIGURE 8: FP7 vs. Horizon 2020 benchmarking

KEY INDICATORS		FP7 2007-2013, EUR 55 BILLION	HORIZON 2020 2014-2020, EUR 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-reviewed 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 %	↑ 4 pps
Time to grant in number of days (excl. ERC)		303 days	192.2 days	↓ 110.8 days
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	4 332	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 %

KEY INDICATORS		FP7 2007-2013, EUR 55 BILLION	HORIZON 2020 2014-2020, EUR 74.8 BILLION STATUS AS OF 01/01/2017	DIFFERENCE
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	~33 000	↑ 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 database

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 remain relevant and how well they still match the current needs and problems of stakeholders. It also addresses the question of the programme's flexibility in light of 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 researchers' training and skills development). Horizon 2020 is expected to have the support of all types of stakeholders who agree on the need to orientate EU R&I 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 focusing EU R&I funding on three objectives: tackling societal challenges, strengthening competitiveness, and raising the excellence of the science base. By strengthening bottom-up schemes and making WPs less prescriptive, Horizon 2020 is also expected to provide for more programme flexibility than FP7, being more open with both curiosity-driven and agenda-driven activities working in tandem.

KEY FINDINGS ON THE RELEVANCE OF HORIZON 2020

- Horizon 2020's original rationale for intervention and objectives remains 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 is still 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 explored continuously and the right balance found between being too prescriptive and not prescriptive enough.
- The strategic programming process improved the intelligence-base underpinning the 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.
- At times, the two-year programming is 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 R&I and the involvement of civil society in Horizon 2020 can be further improved.

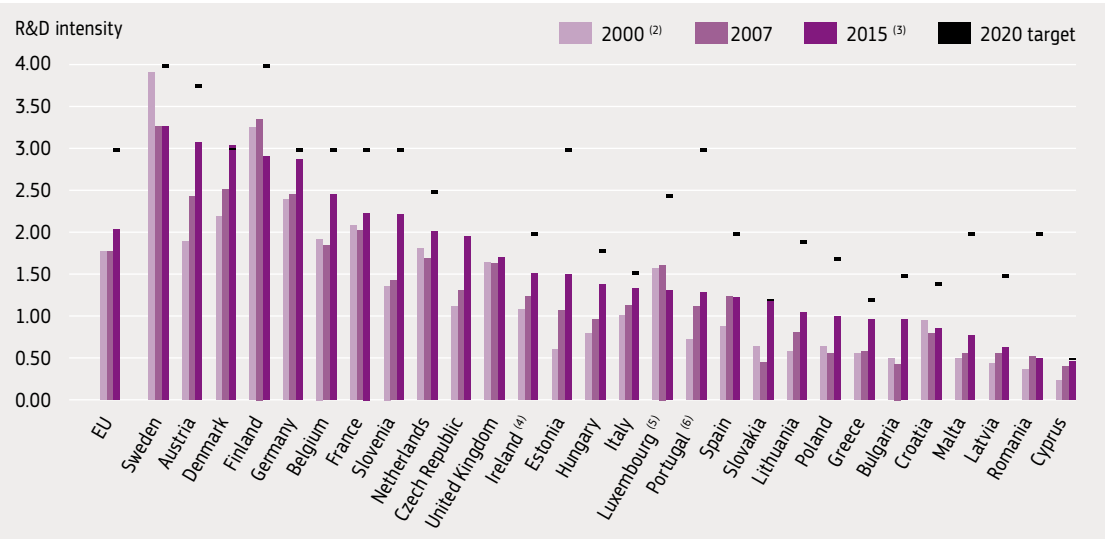
6.1. IS HORIZON 2020 TACKLING THE RIGHT ISSUES?

6.1.1 THE RELEVANCE OF HORIZON 2020 GIVEN THE CHALLENGES TO BE ADDRESSED

When Horizon 2020 was conceived, Europe was suffering from a number of critical weaknesses in its R&I system, which contributed to problems of low productivity, declining competitiveness, inadequate response to societal challenges, and the inability to move to a new sustainable economic model[28]. 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 from R&I to tackle societal challenges; and insufficient transnational coordination. Horizon 2020 was adopted to tackle these 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 among young people, remained the biggest socio-economic 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 Union still faces strong productivity and innovation challenges – for example, those emerging from the most recent economic forecasts[29]. Actions in the R&I area are central to a coherent response to these overarching challenges[30]. In terms of investment in 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: 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. (8)Values in italics are estimated or provisional.

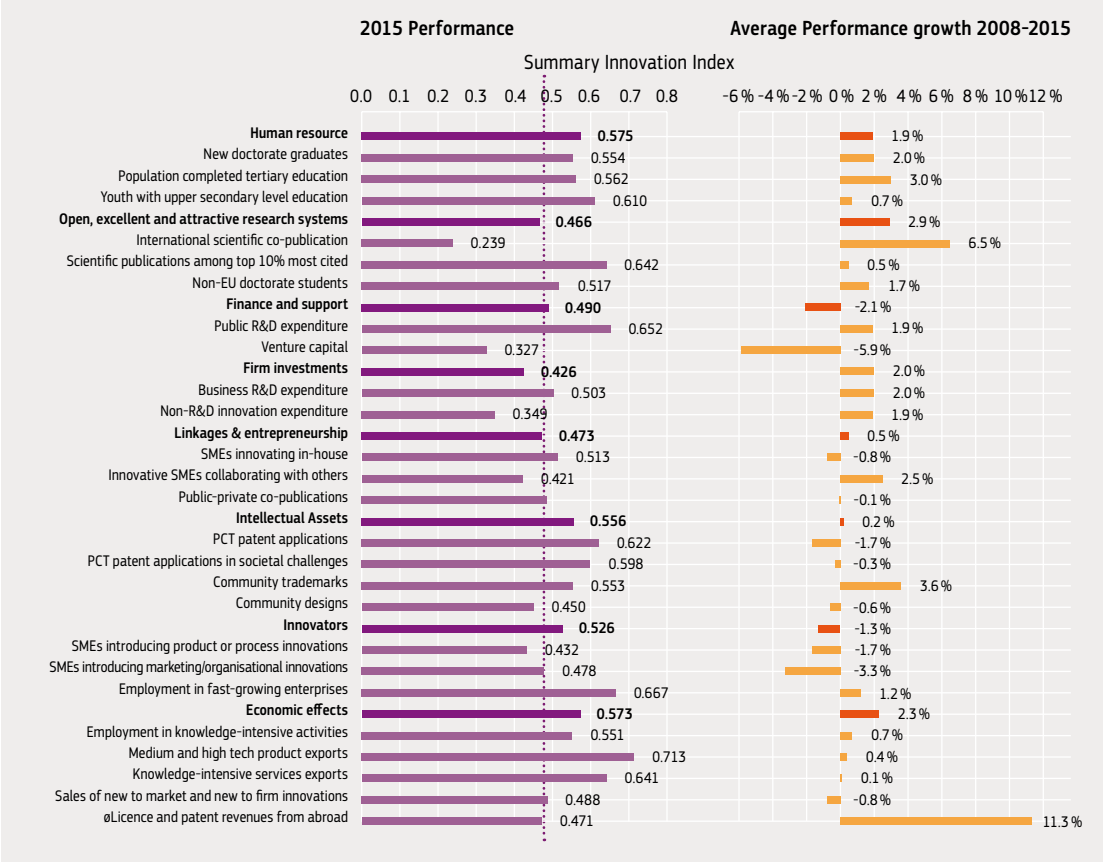
28 European Commission, SEC(2011) 1427, Impact Assessment Accompanying the Communication from the Commis-sion Horizon 2020 – *The Framework Programme for Research and Innovation* (COM(2011) 808).

29 European Commission (2016), European Economic Forecast Autumn 2016. Institutional Paper 038.
30 Ibid.

Figure 10 provides a snapshot of European R&I performance in 2015 as well as the evolution over the period 2008-2015. Overall, **EU R&I performance increased** at an average annual rate of 0.7 % between 2008 and 2015, although growth was not 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[31]. It has been strengthening its educational knowledge base to turn 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 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.

Furthermore, within the EU, **R&I performance amongst European Member** States is significantly **unequal**[32]. The need for transnational coordination was identified as needing to be addressed through Horizon 2020. Optimal circulation and transfer of

FIGURE 10: EU-28 R&I performance per dimension, 2015, and average performance growth over 2008-2015



Source: European Innovation Scoreboard 2016, European Commission

31 European Commission (2016), European Innovation Scoreboard 2016.

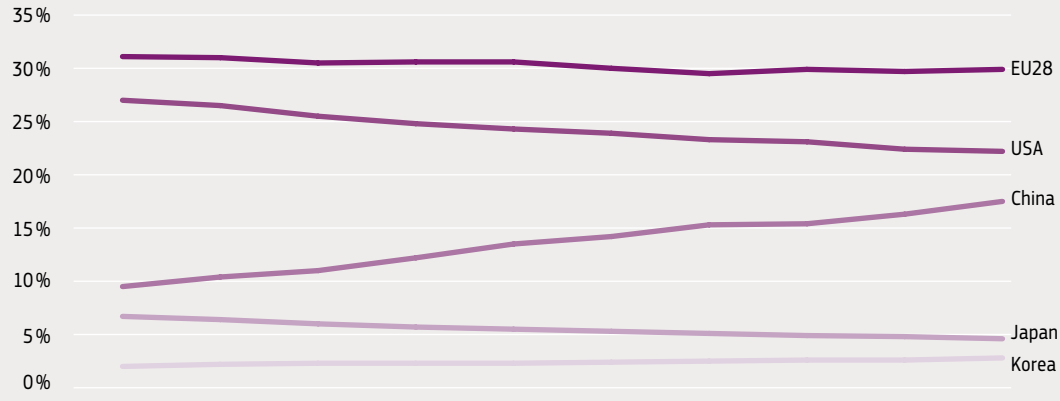
32 Ibidem.

knowledge (across countries, sectors and disciplines) is one of the key prerequisites for relevant research with societal or economic impact[33], and is addressed throughout Horizon 2020 via transnational 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 EU in accordance with the principle of excellence. The thematic assessment validates the objectives of the SEWP programme but highlights that "widening countries" are not all affected by the same problems and to the same extent, showing that the current dichotomy of "widening"-"non-widening" and EU-13 versus EU-15 can be considered as a simplification of the reality.

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[34] – 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 the top 1 % most-highly-cited publications (Figure 11) **the EU-28 caught up with the USA in 2014, each accounting for about 40 % of the world's top-cited publications**. In 2014, for the first time, EU-based authors appeared in more

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)



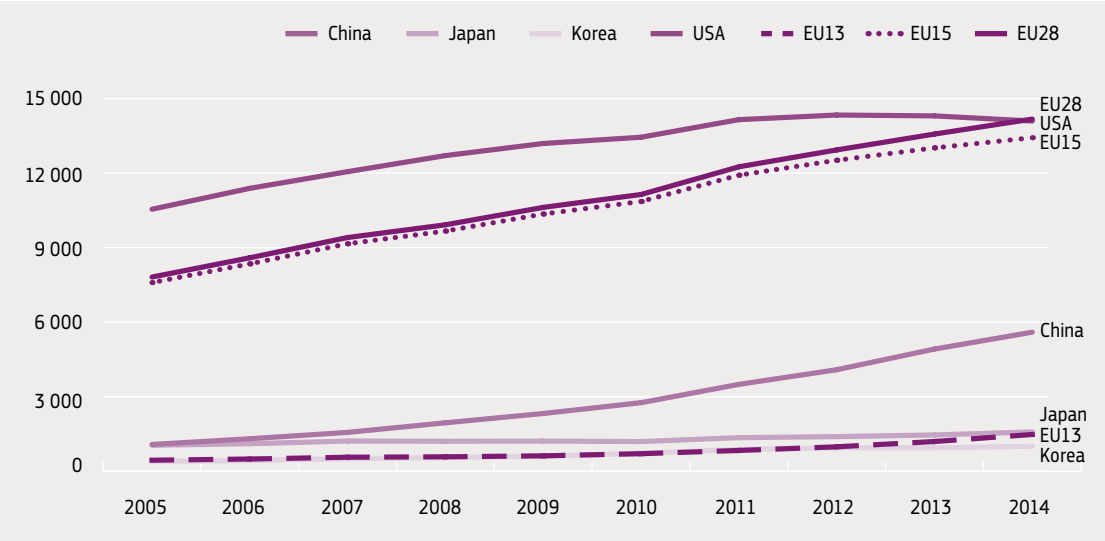
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EU28	31.1 %	31.0 %	30.5 %	30.6 %	30.6 %	30.0 %	29.5 %	29.9 %	29.7 %	29.9 %
USA	27.0 %	26.5 %	25.5 %	24.8 %	24.3 %	23.9 %	23.3 %	23.1 %	22.4 %	22.2 %
China	9.5 %	10.4 %	11.0 %	12.2 %	13.5 %	14.2 %	15.3 %	15.4 %	16.3 %	17.5 %
Japan	6.7 %	6.4 %	6.0 %	5.7 %	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 %

Source: Scopus database, ERCEA elaboration

33 OECD (2015), Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society.

34 OECD (2015), Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society.

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



Source: Scopus database, ERCEA elaboration

top 1 % cited publications (14 172) than USA-based authors (14 093) in absolute numbers.

However, worldwide, the EU is lagging behind in university rankings. In the 2016 Leiden rankings[35], only two EU universities are in the top 25 (US has 19) and seven in the top 50 (all from the UK; the US has 38)[36]. Within the EU, **scientific quality is concentrated in a group of leading countries predominantly** in north-west Europe while southern, eastern and Baltic countries still rank at the bottom despite progress in recent years. Figure 13 shows the evolution of the number of top 1 % highly-cited publications by EU country.

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[37]. The number of researchers increased in the EU over 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). However, there are still large differences between EU Member States in how researchers' careers are structured and how professional development and career planning is supported at the institutional level[38]. A growing number of PhD candidates in the EU are finding career opportunities outside traditional academic research careers[39].

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

35 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, are ranked in the top 10 % most frequently cited.

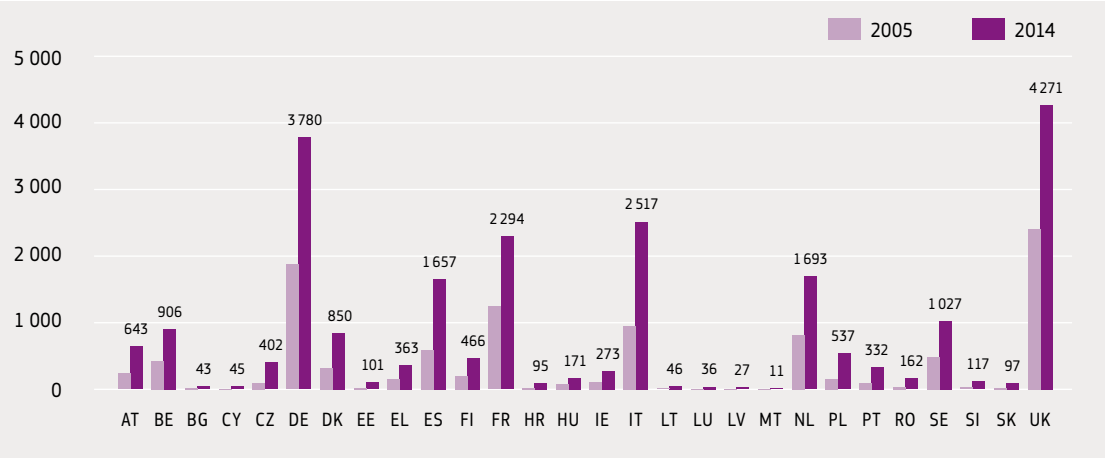
36 The US has 58 universities in the top 100 while the EU has 30 (including 17 from the UK, 7 from the Netherlands) with another 7 from Switzerland and Israel combined.

37 European Commission (2016), Science, Research and Innovation Performance of the EU, 2016.

38 IDEA Consult (2013), MORE2 study final report.

39 The non-academic sector here does not necessarily focus on industry, but could encompass public sector organisa-tions, the voluntary sector and non-profit organisations.

FIGURE 13: Number of top 1 % highly-cited publications, 2005 and 2014, EU countries



Source: Scopus database, ERCEA elaboration

top researchers[40]. Horizon 2020 allocates a budget of EUR 24.4 billion (31 % of its budget) to actions to raise the excellence of Europe's science base, in particular through actions which have proven to be a huge success, including the ERC, with the view to generating the ground-breaking R&I needed to sustain Europe's competitiveness in the long term.

THE NEED FOR REINFORCED TECHNOLOGICAL LEADERSHIP AND INNOVATION CAPABILITY IN THE PRIVATE SECTOR

Low consumer demand in Europe, uncertainties about the economic outlook, the relatively high prices of raw materials and energy, as well as difficulties for SMEs to access finance were weighing down on business confidence when Horizon 2020 was designed[41, 42]. **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. 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 the EU's business sector employment). While business expenditure on R&D (BERD) in the EU-28 rose from 1.13 % GDP in 2007 to 1.30 % GDP in 2014[43], 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 the **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[44]. It has been estimated that up to 1 million new jobs could be created and up to EUR 2.000 billion

40 See Annex Part 3 for in-depth assessments of each Horizon 2020 specific objective.

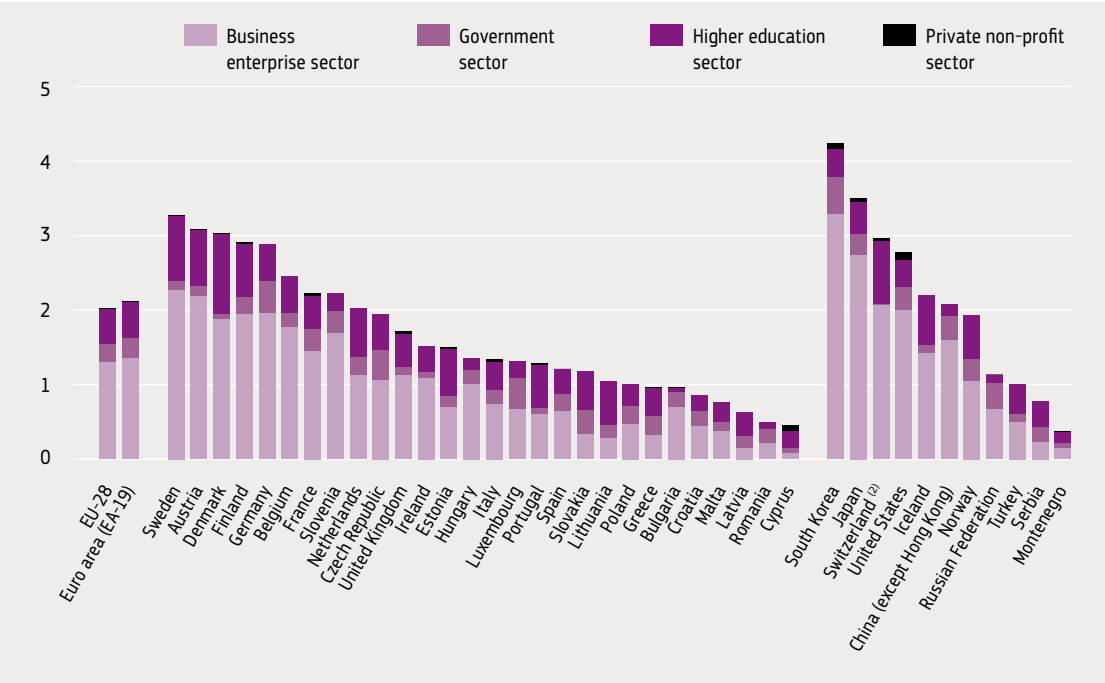
41 European Commission, Industrial Policy Communication and Staff Working Document No 297, 2012.

42 Impact Assessment. Commission Staff Working Paper. SEC(2011) 1427 final.

43 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 US companies at 5.9 % and Japanese companies at 3.3 %.

44 High-growth enterprises tend to be younger than the average enterprises (Innova, TNO, Framework Conditions for High Growth Innovative Enterprises, 2016). Among the USA's 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 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).

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



Source: European Commission, Data: Eurostat, OECD.

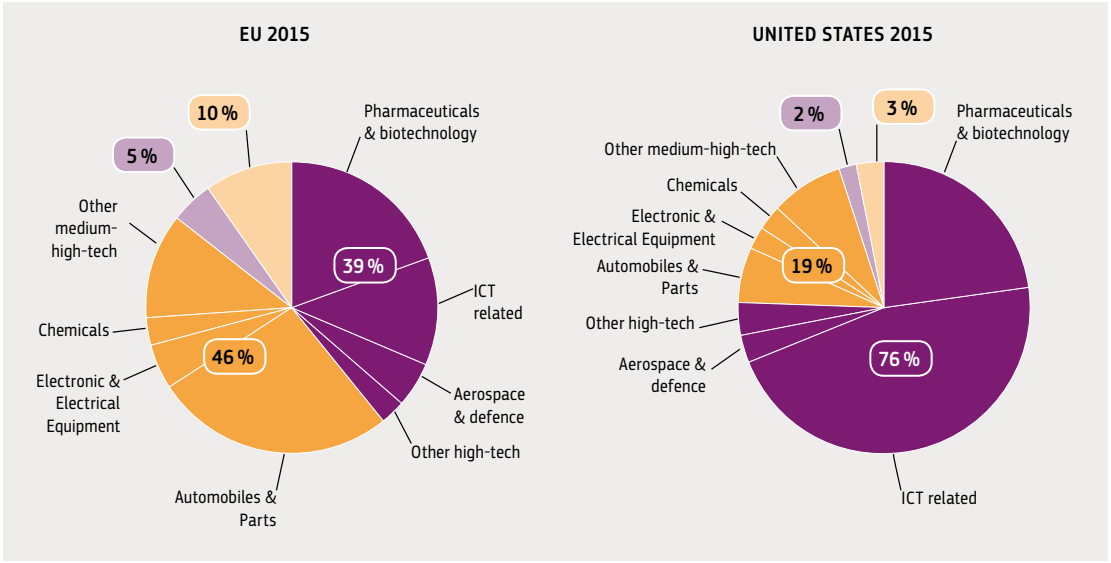
Notes: (1)Switzerland: 2012; Ireland, Turkey, Serbia, Montenegro: 2014. (2) Switzerland: government expenditure on R&D refers to federal or central government only.(3)United States: most or all capital expenditure is not included.

added to GDP in the EU over the next 20 years if the share of scale-ups matched that of the USA[45]. 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[46, 47]. Whereas the volumes of venture capital investment in the USA experienced a slight decline of around 3 % in terms of GDP from 2007 to 2013, **while 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.

Compared 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, **it 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).

45 Europe's next leaders: the Start-up and Scale-up Initiative, COM(2016) 733 final.
46 EIB (2015). Investment and Investment Finance in Europe 2015: Investing in Competitiveness.
47 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 USA, 2015



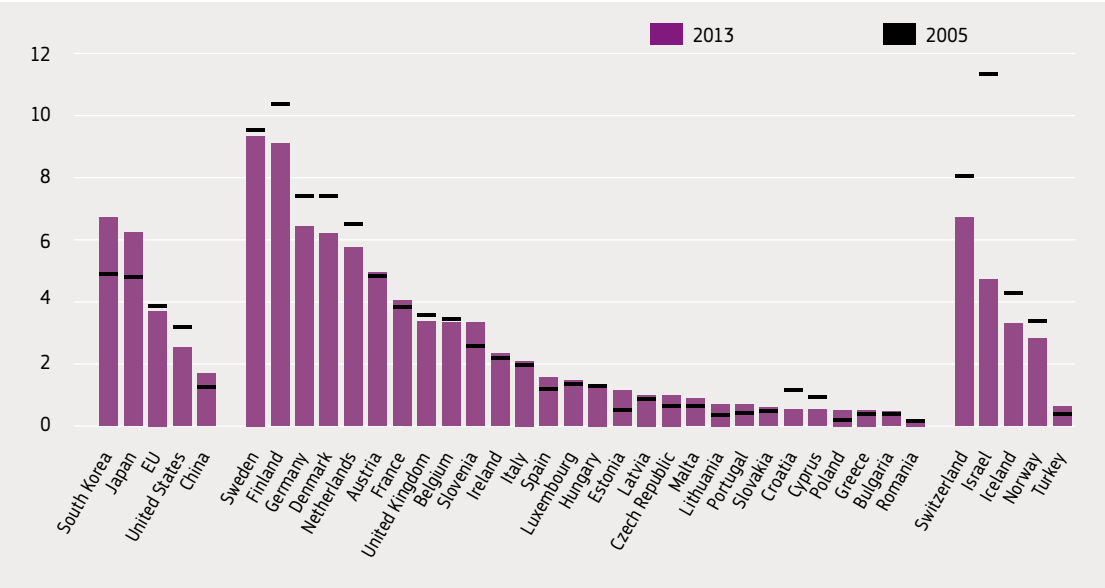
Source: EU Industrial Scoreboard, 2016

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 %[48] of manufacturing on private R&D investments and over 80 % of all exported goods). The strongest sectors which are also 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[49]. More than 19 % of the EU-28 production volume is highly dependent on key enabling technologies[50, 51]. The ICT sector also plays a key role in 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.

48 Latest Eurostat data, October 2016.
49 EU Industrial Structure Report 2013.
50 Eurostat-based figures from 2015.
51 KETs Observatory, European Commission, December 2015.

FIGURE 16: Patent applications (WIPO-PCT) per GDP (billion EUR), 2005 and 2013



Source: European Commission, Data source: Eurostat, OECD

As regards patenting activities, the EU performs at a similar level as the USA in international patent applications, but is outperformed by Japan and South Korea[52]. In many European countries, **the number of international and national patent applications has declined in recent years**, while patenting is expanding quickly in East Asian countries. As a result, Asian countries, especially China, are catching up in world patent shares, while the EU's share is declining and that of the USA, long in decline, has stabilised.

> *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 on the market.*
>
> D'Appolonia SpA, Italy

Against this overall background, the second priority of Horizon 2020 is to foster industrial leadership with the aim of speeding up the development of the technologies and innovations that will underpin tomorrow's new technology, keeping leading industries at the forefront of global competition and helping innovative European SMEs to grow into world-leading companies. **The technology-driven approach adopted under the LEIT programme, the provision of risk finance and support for innovation in SMEs based on a demand-driven, bottom-up logic are all assessed as still being relevant given current challenges**[53].

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

52 European Commission, Science Research and Innovation performance of the EU, 2016.

53 See Annexes Part 2 for in-depth assessments of Horizon 2020 specific objectives, including each societal challenge.

THE NEED FOR R&I TO CONTRIBUTE TO TACKLING SOCIETAL CHALLENGES

'Societal challenges', the third pillar of Horizon 2020 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 in contributing to tackling societal challenges further increased with the adoption of the UN's Sustainable Development Goals[54] and the Paris Climate Change Agreement (COP21)[55]** in 2015, providing a global framework for 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 raise public and private R&D investment in line with the universal 17 SDGs[56]. In 2016, the Commission published its Communication on the Sustainable Development Goals ('Next Steps for a Sustainable European Future'[57]) which ensures that all EU policy measures take SDGs on board at the outset. R&I are mentioned as crucial to implementing certain SDG targets, with a particular reference to FOOD 2030[58].

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 regarded in several cases 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 citizen science and user-led innovation**. The EESC, however, questioned whether the programme sufficiently involved real 'societal' stakeholders and requested clarification as to whether all societal groups can and should participate in SWAFS[59].

Horizon 2020 allocates the highest share of its budget to tackling societal challenges (EUR 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 European 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 into R&I can help the EU to exit the crisis successfully while addressing citizens' concerns. These amounts are complemented by those dedicated to support the EIT (EUR 2.7 billion), which receives 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 ADDRESSING EUROPEAN OBJECTIVES

Strengthening the EU's scientific and technological bases, notably in support of its industrial competitiveness, is enshrined as an objective in the EU Treaty[60]. While Horizon 2020 was adopted in late 2013, before the new European Commission came into office in 2014, 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

54 vailable at: http://www.un.org/sustainabledevelopment/sustainable-development-goals/

55 Available at: http://unfccc.int/paris_agreement/items/9485.php

56 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.

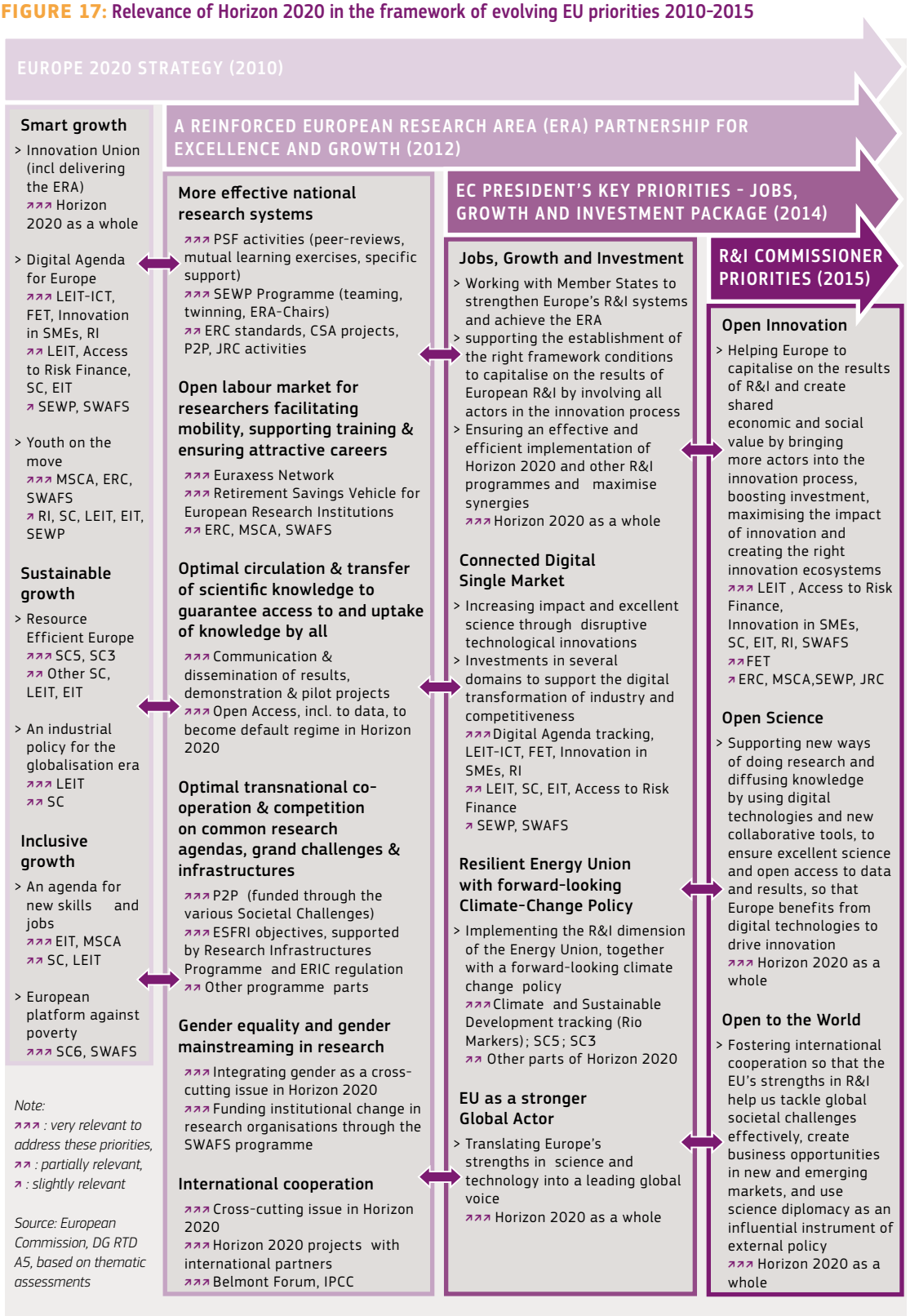
57 Available at: http://europa.eu/rapid/press-release_MEMO-16-3886_en.htm

58 European Commission, Staff Working Document (2016)319, European Research and Innovation for Food and Nutrition Security, 2016.

59 European Economic and Social Committee, Information report on Interim evaluation of Horizon 2020, 2016.

60 http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:12012M/TXT&from=en

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



Europe 2020 Strategy[61]. This strategy seeks to achieve smart, sustainable and inclusive growth in Europe, including by devoting 3 % of the EU's GDP to R&D by 2020. The Juncker Commission's 10 priorities[62] provided an update and focus for these goals whereas the '3 Os', put forward by the Commissioner for R&I, which call for open science, open innovation and openness to the world[63], complement the research policy objectives since 2015.

Evidence collected within the thematic assessments, as well as the work of an Expert Group[64], 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[65].** 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 contributing to 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 stronger global actor (see Figure 17 for a detailed overview of how Horizon 2020 aligns to each of these key EU priorities).

STAKEHOLDER POSITION PAPERS

HORIZON 2020 IS ADDRESSING EUROPE'S POLICY PRIORITIES

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 facing Europe by contributing directly to Europe's competitiveness which leads to jobs and growth; a few position papers highlighted the contribution of Horizon 2020 to realisation of the ERA by funding collaborative research, transnational infrastructure and mobility; position papers from businesses that addressed this point specifically noted that the (societal) "challenge driven" R&I 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 of a global nature.

61 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF

62 https://ec.europa.eu/priorities/publications/president-junckers-political-guidelines_en

63 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

64 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). A text-mining approach was developed to investigate whether keywords from key EU and international documents are present in the Horizon 2020 Regulation and the first WPs. This approach was not applicable in the case of the excellent science pillar because of its bottom-up nature.

65 Investment in R&I is also recognised as an important aspect of the EU's comprehensive response to harnessing globalisation, COM(2017) 240.

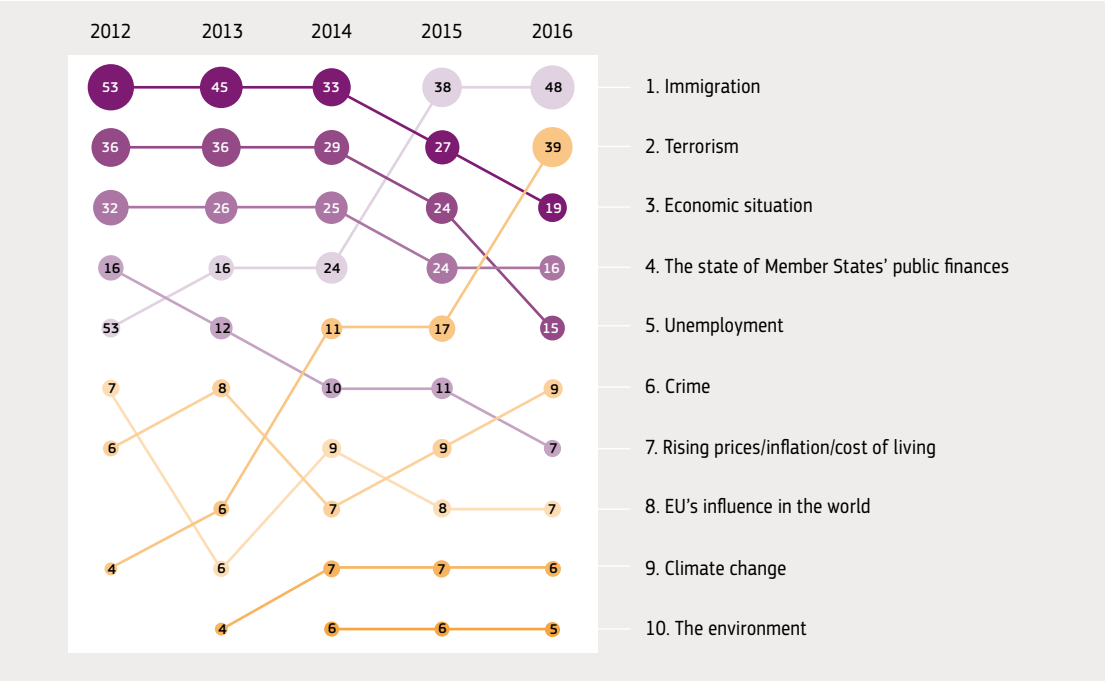
6.2. DOES HORIZON 2020 ENABLE ADAPTATION TO NEW SCIENTIFIC AND SOCIO-ECONOMIC DEVELOPMENTS?

Whereas in 2016 high (youth) unemployment remains the biggest socio-economic concern and challenge in many Member States associated with 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)[66]. More specifically, the greater threat of terrorism, with major incidents occurring in several Member States, the increase in 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 just some of the developments impacting the programme's context.

Horizon 2020 has built-in flexibility[67] to tackle new and unexpected challenges and thus allows for a more flexible approach to respond to the new emerging challenges compared to FP7[68]. The strategic programming approach (see previous section) involving advice, evidence and foresight aims to support flexibility in its implementation[69].

So far, **the Horizon 2020 WPs 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

FIGURE 18: What issues are Europeans most concerned about?



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

66 This shift is observed across the Union with the exception of Portugal, where fears about public finances and unemployment rank second and third after immigration, and Romania, where crime comes third.

67 See Articles 12 and 15 of Horizon 2020 Regulation.

68 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.

69 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 WPs.

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 migration. However, thematic assessments under societal challenges 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 R&I, but also highlights the **scope for better coordinating the various stakeholders to ensure a stronger alignment of basic/fundamental research with future needs**. In the SC6 assessment, it appears 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 'Brexit'.

HORIZON 2020 REACTING TO THE OUTBREAKS OF EBOLA AND ZIKA

The **outbreak of Ebola** in West Africa was *the* major international public health emergency in recent years. SC1 promptly supported urgent research on Ebola by launching – for the first time – two fast-track procedures completed in a very short time frame[70]. A sum of EUR 24.4 million from Horizon 2020 was mobilised despite not having been foreseen in the WP. In parallel, the IMI-Ebola+ call (a PPP between EU and the European Federation of Pharmaceutical Industries) was launched in record time taking into consideration the dual nature of the Innovative Medicines Initiative. In turn, this Horizon 2020 SC1 research response, which was very significant in scale, with a total of EUR 140 million, 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 three 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 in a timely manner and with due respect to all H2020 and international ethical standards[71]. These actions have placed the Commission second only to the US Government in terms of commitments made[72]. 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 to future outbreaks.

Horizon toto has taken the lead in establishing, via Societal Challenge 1, the Global Research Collaboration for Infectious Disease Preparedness (GloPID-R) that links research funders, the scientific community, industry, patient groups and public health actors. Its goal is to build up 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 WP was updated to include an emergency 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. In addition, from other WP 2016 calls, EUR 15 million were allocated for research on Zika vaccines and for infrastructures for mosquito research.

70 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.

71 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5240928/

72 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[73] allowed for flexible adaptation as needs arose, channelling funds to new and promising research areas, including on multidisciplinary research and effectively integrating 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, the complexity of socio-economic (e.g. financial) and socio-technological systems, or in the extremely competitive emerging industry areas such as graphene, quantum technologies and biotechnology. FET-Open is explicitly non-topical and non-prescriptive 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 the scouting of developments**. Since the adoption of Horizon 2020, evolutions in the socio-technological framework include the greater 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 developments in distributed computing, and overall computer power and high-volume data transmission have combined to produce an **explosion of data-driven science**, giving scientists in many disciplines interoperable access to research data of a hitherto-unimagined scale and diversity[74,75]. 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 blurred product-service boundaries**. Firms which previously focused on straight manufacturing are positioning themselves as 'solution providers', often based on using advanced technologies in their products and digital and data-based services – for example, customisation or after-sales services. While this approach has been taken up in the LEIT-NMBP Work Programme, selected projects have yet to reflect the importance of these developments in terms of their planned activities.

Based mainly 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 WP (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[76]. Moreover, an external study looking at the keywords of FET project abstracts highlights the high number of **FET projects that focus on technologies which are expected to have significant potential to drive economic impact and disruption by 2025**[77]. The **ERC is also reinforcing 25 of 28 key fronts of research** (Figure 19).

73 Under this pillar, research proposals tend to be less constrained by policy objectives set out in a WP established years earlier, and as such can target topical issues using the latest scientific and technological approaches.

74 See thematic assessment of research infrastructures (RIs).

75 Riding the wave. How Europe can gain from the rising tide of scientific data. 2010.

76 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).

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

FIGURE 19: Key hot and emerging research fronts in which ERC grantees are working

HOT RESEARCH FRONTS	
1. Outbreak, prevention and control of microbial contamination of fresh produce	11. Phosphors for white LEDs
2. Mechanism of plant innate immunity	12. Sodium-ion batteries
3. Microplastic pollution in the marine environment	13. Galactic center gamma-ray excess
4. Biodiversity loss and its impact on ecosystem functions and ecosystem services	14. Property and application of monolayer/few-layer black phosphorus
5. Global warming hiatus	15. Observations of the cosmic microwave background (CMB) by Planck
6. Carbon cycle of inland waters and the ocean	16. Baryon acoustic oscillation (BAO) related research based on sky survey missions like SDSS
7. Clinical trials of direct-acting antivirals (DAAs) for hepatitis C infections	17. The internet of things, cloud manufacturing and related information technology services
8. Immune checkpoint inhibitors anti-PD-1 antibodies in melanoma immunotherapy	18. Research on measurement-device-independent quantum key distribution
9. The molecular mechanism for origin, development and differentiation of macrophage	19. DEA (Data Envelopment Analysis) based assessment of environmental and energy efficiency
10. Differentiation, function, and metabolism of T cells	

EMERGING RESEARCH FRONTS	
1. Effects of systemic insecticides (neonicotinoids and fipronil) on non-target organisms and environment	4. Research fronts on perovskite
2. Elemental composition of the North Atlantic Ocean and Southern Ocean	5. Experimental realisation of fractional Chern insulators
3. Principles of chromatin looping and evolution of chromosomal domain architecture	6. Studies of Comet 67P/Churyumov-Gerasimenko by Rosetta

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

FIGURE 20: Word cloud of frequency of keywords from Horizon 2020 projects

Source: Horizon 2020 Corda, date: 01/01/2017. The size of the word depends on its frequency in project keywords

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'.

The flexibility of Horizon 2020 to adapt to new scientific and socio-economic developments is nuanced by the results of the stakeholder consultation. With reference to its thematic coverage, 36 % of respondents agreed fully or to a large extent that Horizon 2020 is flexible enough to cope with changing circumstances, 41 % agreed to some extent, and 12.4 % totally disagreed. NGOs tended to disagree more than the other categories of respondents (16 % rate of total disagreement). Also, a high percentage of respondents agreed, at least to some extent, that Horizon 2020 supports the latest developments in R&I at the national/ European and international level (93 % agreement). 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 EU (e.g. migration, terrorism, ageing population), only 35 % of the consultation respondents thought that the programme does fully or to a large extent, 42 % to some extent while 8 % judged that this was 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'S FLEXIBILITY TOWARDS 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's flexibility to changing priorities, although 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 represented a good practice example of the programme's flexibility which could be applied to other parts of Horizon 2020.

6.3. IS HORIZON 2020 RESPONDING TO STAKEHOLDER NEEDS?

6.3.1. INVOLVEMENT OF STAKEHOLDERS IN PROGRAMME DESIGN

> *"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 poses a challenge for newcomers to navigate through."*
>
> Italy, European Academy of Bolzano

Compared to FP7, stakeholders are much more closely involved in the programme design through the 19 Horizon 2020 Expert Advisory Groups[78] which have been set up as consultative bodies for the individual programme elements of Horizon 2020[79], targeted and open public consultations on future research themes[80], European Technology Platforms (ETPs), which develop R&I roadmaps for action at EU and national level in some sectors, and Programme Committees composed of representatives from Member States and European Innovation Partnerships (EIPs). The priorities and activities under contractual Public-Private Partnerships (cPPPs) build on an agreed relationship between the European Commission and the private sector in defined areas, and on specific roadmaps with KPIs and a commitment to additional investments on the private side. In addition, the Citizen and Multi-Actor Consultation on Horizon 2020 ('CIMULACT') project[81] began in 2015 to improve the engagement of citizens and provide concrete input to the European R&I agenda.

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. However, the translation of high-level challenges and objectives into specific call topics is not always clear to external stakeholders. Moreover, it has been difficult to establish clear links between high-level policy objectives and the related quantitative targets and the specific contribution expected from some topics[82]. 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 of SEWP also highlights that supporting world-class excellence requires long-term commitment, as well as continuity 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 WP (67 %) and the ease of finding the right call for their proposal. However, there are also high levels of dissatisfaction with 26 % finding these "poor" or "very poor".

78 The Expert Advisory Groups produce reports and recommendations that contribute towards defining the WP. A full list and open call for expression of interest can be found here: http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=h2020-experts. The selected experts' mandate is for a two-year period with the possibility of renewal for a further maximum two years.

79 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.

80 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.

81 http://www.cimulact.eu/

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

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 as contributing to a comprehensive and widely supported programme. Several others, however, noted the current design of the WPs is not transparent. In general, organisations found lacking the involvement of stakeholders in their particular field. For instance, among others, the following issues were highlighted: inadequate coordination with the Member States was specifically mentioned by Germany and France but also by stakeholders in academia; Estonia and one SME noted that larger players seem to have more influence on the research programme and call topics; and a few stakeholders commenting on this issue from the industry and business community noted they are not well represented in 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 over its seven-year duration (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[83] and the health societal challenge[84]. In FP7, the private sector submitted 25.4 % of the applications, which has increased to 37.4 % in Horizon 2020.** On average, each higher or secondary education institution (HES) applies more often to Horizon 2020 compared to private companies. In the first three years of Horizon 2020 implementation, each HES applied 28 times on average compared to 2.6 times for private companies (SMEs applied 1.2 times on average).

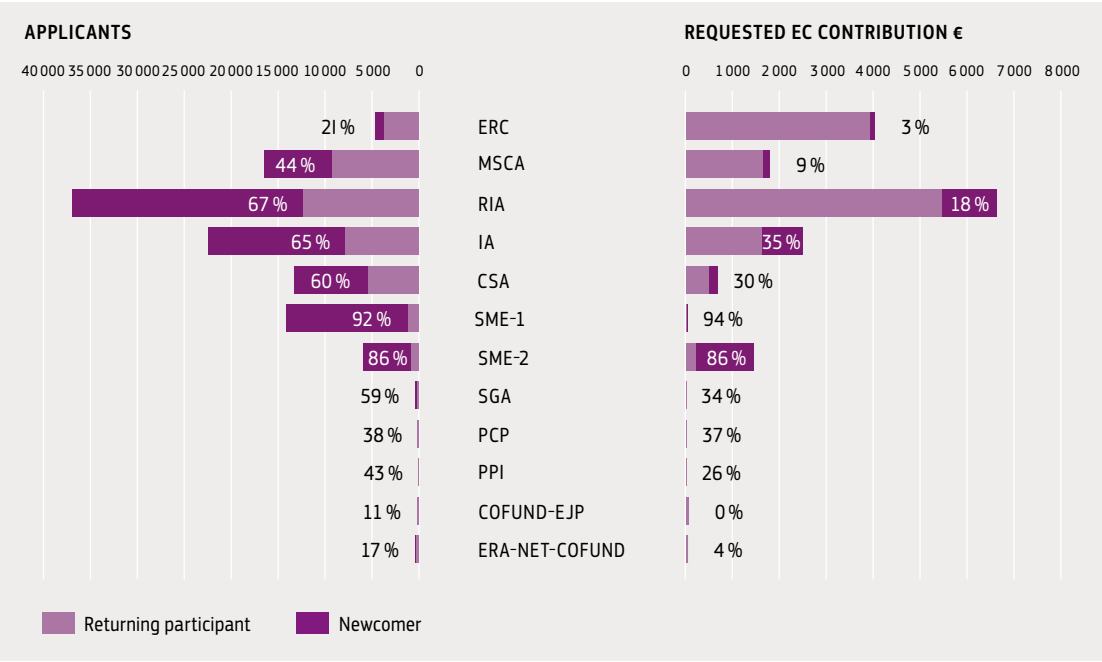
Greater interest is prominent thorough Horizon 2020, but especially for the SME Instrument which has generated more than 30 000 proposals compared to around 5000 in FP7 (under Research for the benefit of SMEs). Overall, in Horizon 2020, SMEs submitted 99 434 applications in eligible proposals, which is around 26.2 % of the total for Horizon 2020 (against 23.7 % in FP7).

Significantly, **78 % of all organisations applying for 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 from the private sector. More specifically, the programme generated the interest of 35 288 new SMEs, representing more than half of the new applicants from the private sector (55 296) as well as 5022 new higher or secondary education institutions, 5150 new research organisations and 3925 new public bodies, and 5376 'other' organisations (which include most of the civil society organisations). These figures indicate the continued relevance of the programme for new players, including those organisations representing citizens' interests. In particular, the majority of applicants (91.3 %) for the SME Instrument are new to the Framework Programmes.

83 This includes Open Disruptive Innovation projects implemented through the SME Instrument.

84 An in-depth discussion on oversubscription is presented in Section 7 'Efficiency'.

FIGURE 21: Proposals submitted and funding requested per type of instrument



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

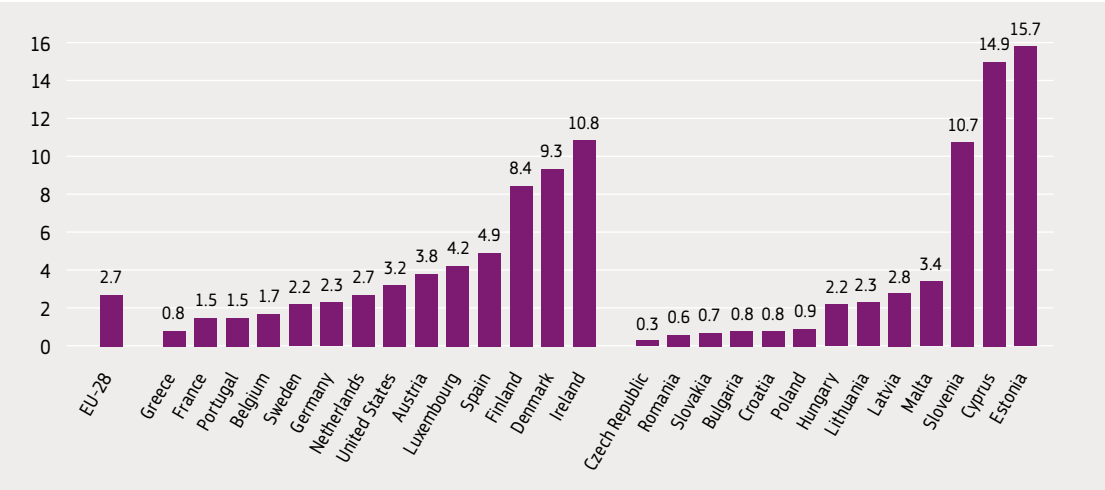
FIGURE 22: Number of distinct applicants and applications per type of organisation

	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	5022[85]	*3024*	140 900	*7973*
Research organisations	5150	*2464*	68 346	*5341*
Public bodies	3925	*2815*	13 551	*5480*
Other	5376	*4309*	14 492	*8460*
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)

85 This covers e.g. universities, academies, colleges, technical schools and high schools.

FIGURE 23: Penetration rates of the SME Instrument per Member State (SMEs reached per 1000



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

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 outreach 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 EU-28 average is 0.27 %[86].

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[87]. 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 form of funding through Horizon 2020, followed by co-funding, prizes, financial instruments and public procurement**[88]. Collaborative grants and the ERC stand out as being particularly relevant to respondents. Almost 7.5 % of those who did not participate in Horizon 2020 emphasised the lack in adequate financial support for their work and 14.6 % mentioned that the programme did not include an area/topic relevant for their needs.

86 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 1000 of the target population.

87 Respondents also refer to products, solution 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.

88 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.

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

A dedicated survey asked SMEs and intermediary 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 topics. In particular, SMEs are very positive about the possibility to resubmit proposals, as well as about the time period from application to grant.

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 R&I, perceiving it as an *"attractive" and "successful"* method and *"the backbone"* of Horizon 2020. However, one SME was particularly critical noting there is already enough emphasis on interdisciplinarity and that insisting on it makes research lose its focus.should fund the extra costs that comes with keeping data open (for example for the ICT tools).

As regards the openness of the calls, the right balance must be found between being too prescriptive and not sufficiently so. The FET assessment points out that the open and non-prescriptive nature of the calls leads to a dispersal of approaches and solutions which may result in imbalances in the number of proposals across topics impeding the cross-fertilisation of experience. However, 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 from 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 has been identified regarding the focus in the programme design on the specific needs of each segment, thereby 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 should 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[89].

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

In general, **Horizon 2020 covers topics responding to stakeholders' needs;** stakeholders only mentioned a few examples of topics not covered in Horizon 2020. However, a majority of those responding to the stakeholder consultation pointed out that social sciences and humanities (SSH) 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 as natural sciences. In their opinion, SSH needs to be better integrated from the WP design, description of calls to project evaluation (i.e. ensuring that at least one evaluator has SSH expertise).

6.3.3.2. ADDRESSING CITIZENS' NEEDS

From the thematic assessments, it appears that **innovations arising from Horizon 2020 are likely to benefit all types of stakeholders – including citizens** – 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 TRLs, and depending on the specific challenges addressed, the projects involve different types of partners from the 'triple helix' – i.e. industry, academia and governments – and, less frequently, society (e.g. citizens, civil society organisations – CSO). Based mainly on a keyword text-mining approach (including phrases and topics), which compares the degree of matching between keywords extracted from the Horizon 2020 establishing act (Council Decision 2013/743/EU) and WPs (2014-15 and 2016-17) against keywords identified by the experts as pertaining to EU citizens' needs, an expert group concluded that EU citizens' needs are broadly covered in all pillars. They revealed a 50-75 % correspondence between keywords in both WPs and the Horizon 2020 establishment act and those identified by the experts as pertaining to EU citizens' needs[90].

As part of MSCA, the European Researchers' Night attracts up to 1 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. However, the thematic assessments highlight the **gap in society in understanding the benefits of publicly funded research and the overall room for improvement in bringing research closer to the general public and encouraging young people to embark on research careers**. **The involvement of civil society representatives 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[91].** 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).

90 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)

91 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 SWAFS part of the programme is a key way in which Horizon 2020 responds to citizens' needs[92]. 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 EESC (83 %) either agree or strongly agree that there is a **lack of knowledge exchange between the scientific community and civil society**. Responsible Research and Innovation (RRI)[93] 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[94] found that **CSO participation in FP6, FP7 and Horizon 2020 was/is marginal**. CSOs' share in funding is even lower than their share in institution numbers and project participations, even if – as of April 2015 – Horizon 2020 exhibited a low-level increase (2.3 % compared to 1.4 % in FP7). This contrasts with the monitoring data which suggests 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*". Furthermore, the network analysis performed in this study points out that **CSOs which do participate generally take on non-core roles in project consortia**.

In the stakeholder consultation, 49 % (1706) of the respondents agreed fully or to a large extent that Horizon 2020 priorities address the main citizens' needs, whereas 37 % (1302) agreed to some extent and 5 % judged that it is not the case at all. The most negative respondents were NGOs. Further, 48.5 % (1698) of respondents agreed that greater citizen involvement in priority setting is needed to maximise the socio-economic impact of the EU's Framework Programme for Research and Innovation, whereas 37.9 % (1320) disagreed (13.6 % (473) did not know). The most positive were the NGOs. Whereas business umbrella organisations were more negative, a slight majority of individual SME respondents agreed, together with individual research organisations, academia and public authorities.

> *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

92 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

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

94 WU Vienna in collaboration with FAS Research and De Montfort University (forthcoming), April 2015 data.

EXAMPLES OF PROMOTING 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 WPs. 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** projects, citizens, CSOs and other societal actors contribute to the co-creation of scientific agendas and contents[95]. 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, and they also play an active role in the definition of personalised medicine.

Under **Societal Challenge 2**, a large number of funded projects implement the multi-actor approach which aims at more demand-driven innovation through the involvement of various actors throughout 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 to develop 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. This approach is implemented as part of the EIP 'Agricultural productivity and Sustainability'[96].

Within **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[97] explicitly targeting citizens, consumers and/or local stakeholders with the aim of raising awareness, building capacities and increasing their involvement to facilitate the uptake of innovative energy solutions.

A chapter dedicated to the societal dimension has been included in the WPs for **Societal Challenge 4** Smart, green and integrated transport since the start of Horizon 2020. Among the activities, the Mobility4EU[98] project brings together the civil society and 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, giving them the tools to measure and share, through apps, environmental parameters like air quality, noise, alien invasive species, etc. – in collaboration with a very active European Citizen Science Association (ECSA)[99].

Societal Challenge 6 projects make efforts to reach specific stakeholders as well as the general audience with web-based platforms, social media and communication resources. For example, the Dandelion project (Promoting EU-funded projects of inclusive, innovative and reflective societies) aims to support the uptake and valorisation of research in inclusive, innovative and reflective societies and improve its dissemination to citizens, policymakers, academia and the media. This will be achieved through a series of innovative and creative communication activities targeting a range of audiences.

Under **Societal Challenge 7** a number of projects (CITYCoP, ICT4COP, INSPEC2T, TRILLION, Unity) share the 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.

95 Data on this cross-cutting issue is provided by EC project officers during grant agreement preparation.
96 http://ec.europa.eu/eip/agriculture/

97 Such as: FosterREG, TOPTEN ACT, SMART-UP, STEP_BY_STEP, DOMINO, Digi-Label, RESCOOP Plus
98 Available at: http://www.mobility4eu.eu/
99 Available at: http://ecsa.citizen-science.net/

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 was 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 remains. 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 demonstrates 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 which 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 have even been reinforced by the SDGs/COP21 framework and 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 WPs, calls, and projects is not straightforward (lack of clear pre-defined intervention logic). In several cases, the programme objectives, as currently articulated in the legal basis, are 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 has been 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 for flexible adaptation as needs arose, channelling funds to new and promising research and training areas, including multidisciplinary research. However, at times the two-year WP may be too rigid to adapt to new and 'urgent' topics dictated by disruptive and counter-intuitive technologies and business models. Evolution of the socio-technological framework (including digitisation, servitisation, data revolution, social conflict, violence and security concerns, SDGs) is expected to profoundly impact the Horizon 2020 context in the coming years, calling for a constant review of priorities and scouting for developments. The right balance must also be found between being too prescriptive or not prescriptive 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 the available funding. 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 programme's focus in line with stakeholder needs. However, the transparency in the WP 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 will consider the relation between the programme inputs (i.e. resources, budget, selection processes) and the outputs and impacts achieved. Since this is a mid-term review, the assessment mainly refers to the efficiency of 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 Horizon 2020 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 R&I funding simpler to access, not only for established players but also for newcomers. Administrative costs for applicants and participants are expected to decline drastically, which should 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 Commission implementation costs), and externalisation. Together with the increased benefits expected from Horizon 2020 compared to FP7, this is expected to result in greater efficiency.

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

KEY FINDINGS ON THE EFFICIENCY OF HORIZON 2020

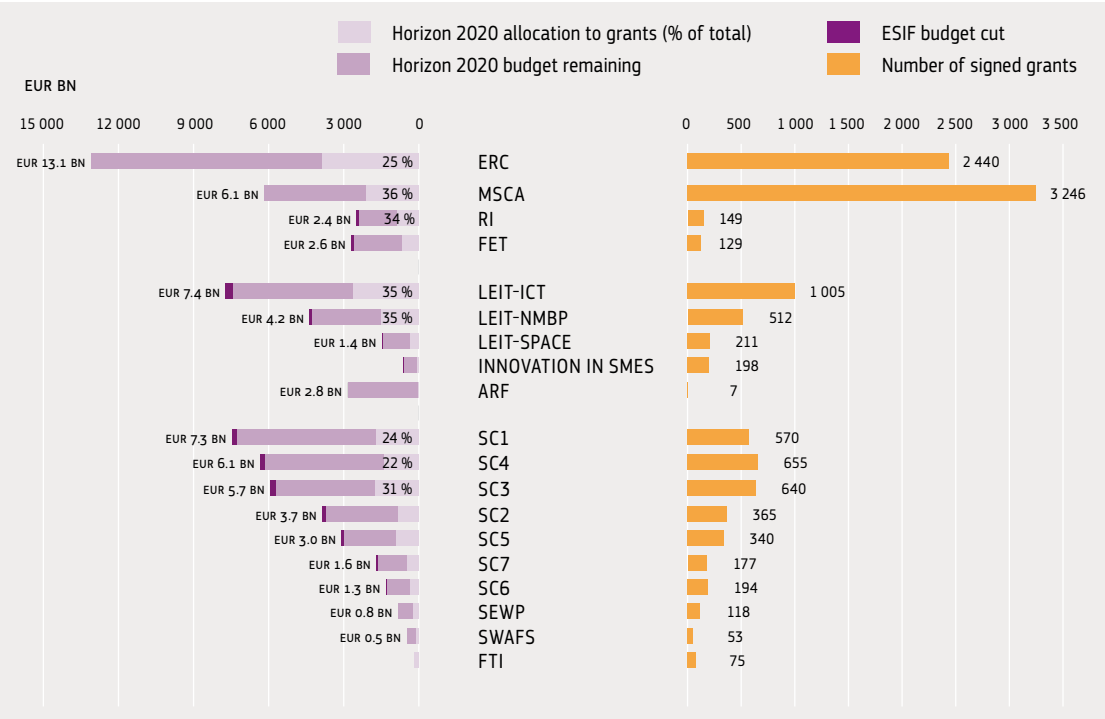
- Based on macro-economic projections, Horizon 2020 is as cost-effective as FP7 and comparable to the expected cost-effectiveness of public spending in research.
- Compared to FP7, Horizon 2020's efficiency has been positively influenced by the extensive externalisation of programme implementation to new management modes, including executive agencies.
- Simplification has reduced the administrative burden for participants and led to large reduction 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 has not led to any 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 feedback to applicants, could be improved.
- Despite the low success rates, and cost of proposal writing, the costs for stakeholders seem to be proportionate given the (expected) benefits of participation, which go beyond the financial contributions received.
- The balance in project size has not changed 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 on a few players.
- Horizon 2020 is open to the world and has a broad international outreach but the funding of participants from third countries has declined 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 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) was allocated to grants[100].** 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[101].

100 Based on Corda data, excluding grants under Euratom, cut-off date by 1/1/2017, and Regulation (EU) No 1017/2015.
101 For further information on the budget allocation, see Section 5 Implementation State of Play.

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).

Horizon 2020 grants are implemented through 12 different types of actions[102]. Four types 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 (IAs) (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 in Section).

In the second year of programme implementation, the overall Horizon 2020 budget was cut by 2.9 % (EUR 2.2. billion) to contribute to the creation of the 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 parts of the programme. These activities are being implemented by the European Investment Bank (EIB) and the European Investment Fund (EIF).

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 through the use of external bodies (e.g. executive agencies, joint undertakings) with the aim of increasing the programme's efficiency and effectiveness[103]. The Commission services are expected to focus on core institutional tasks, such

102 Implementation data for other non-grant based instruments is currently not tracked in a comparable way.

103 European Commission

as policymaking, implementation and monitoring of the application of EU law, and strategic management, whereas the NMMs aim to deliver the effective and efficient implementation of Horizon 2020.

Horizon 2020 grant management has been delegated to four executive agencies[104]. Already in FP7, two executive agencies (REA and ERCEA) implemented almost 30 % of the budget. However, in the first three years of Horizon 2020, almost 60 % of the budget has been implemented by four executive agencies – REA, EASME, ERCEA and INEA.

The agencies' governance structures 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, a single set of rules was established for participation and dissemination in Horizon 2020 across all the actors implementing the programme.

Based on the cost benefit analysis[105], the 'Communication to the Commission on the delegation of the management of the 2014-2020 programmes to Executive Agencies'[106] published prior to the launch of Horizon 2020, noted that delegation of programme management tasks to external agencies is a fully relevant solution to improving 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 to foster knowledge spillover.

- **The agencies' existing communication and outreach channels**: Over time, these have developed to keep them close to beneficiaries were they are expected to provide greater levels 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.

- **Lower cost:** Fewer full-time equivalents (FTEs) are 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 at 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 outlined above, was larger Horizon 2020 grants compared to FP7[107].

Recent external evaluations of REA and ERCEA[108] demonstrated that executive agencies improve the cost-effectiveness of grant management and that both agencies exceed even the positive estimates made in the cost-benefit analysis. In the three 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 by both agencies are due to lower-than-

104 The division of labour between the Commission and the executive agencies is defined and documented in Delegation Acts.

105 DG GROW 2013 Cost Benefit Analysis (CBA). The report is referred to extensively in SEC(2013) 493 final Accessed at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52013SC0493(01)

106 Ibid.

107 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

108 Public Policy and Management Institute, Evaluation of the operation of REA (2012-2015), 2016, and Evaluation of the operation of ERCEA, 2016.

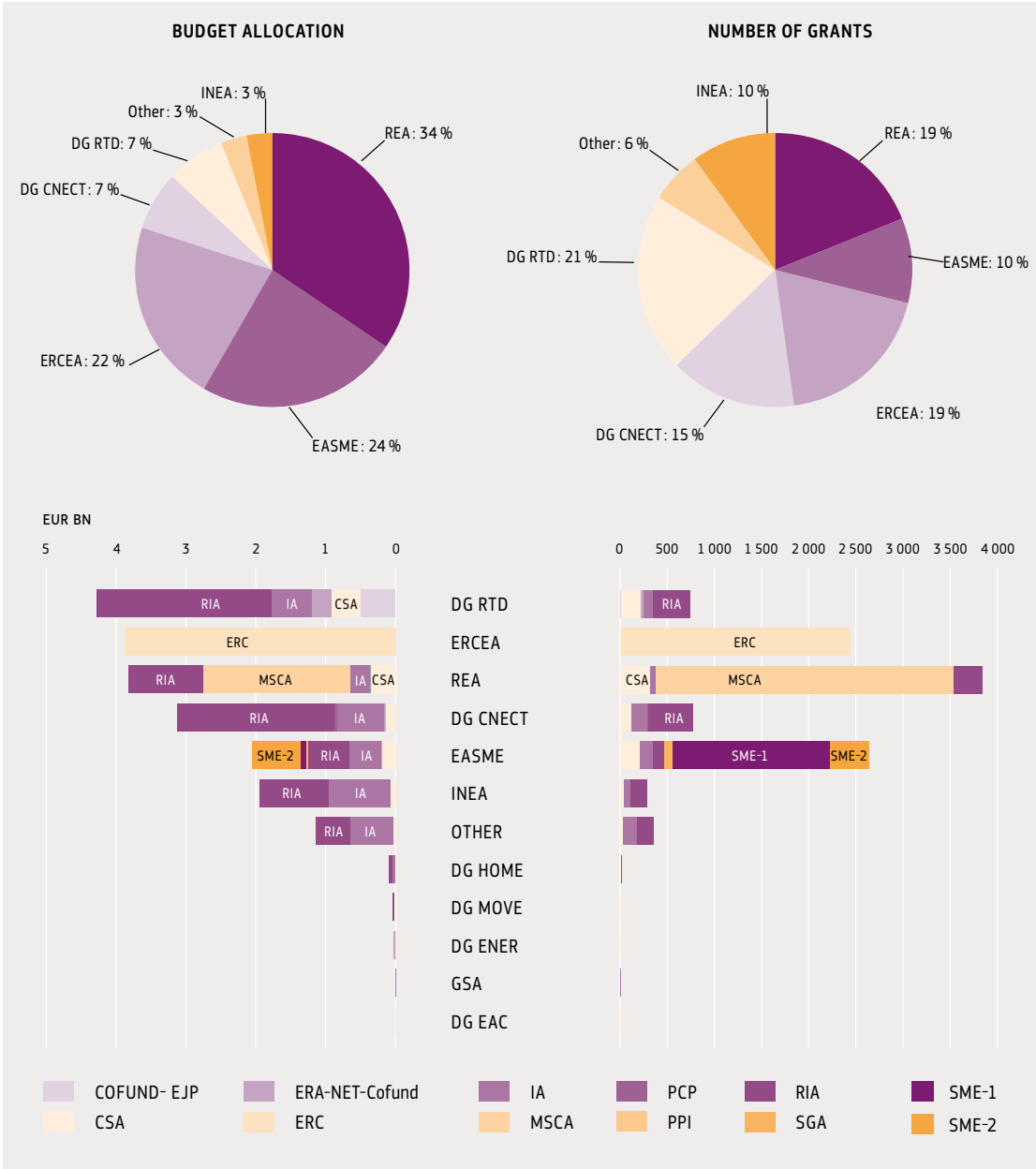
estimated staff costs and cheaper overheads[109]. At the same time, the evaluation concluded that the performance of ERCEA and REA reached very high levels of satisfaction among their beneficiaries and independent experts: 82 % in the case of REA and 93 % for ERCEA.

To help coordinate and deliver the programme, a common support centre (CSC) has also been set up in the Commission to centralise services which were previously decentralised. The CSC 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 under way 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) have been externalised: the Commission implements larger but fewer collaborative grants (EUR 7.6 billion allocated to 1550 grants)[110]; the executive agencies implement smaller and more numerous grants, a large part of which are single-beneficiary[111] (EUR 11.7 billion allocated to 9207 grants)[112]. 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[113]. The overall budget of Horizon 2020 is managed by nine different Commission DGs[114] and implemented by 23 different bodies[115].

109 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.
110 Such as the LEIT-NMBP, RIs and SC1 programme parts are fully managed by the Commission.
111 Such as the SME Instrument, ERC and MSCA actions.
112 The remaining 351 grants (EUR 1.1 billion) are managed by other bodies.
113 The CBA study on executive agencies (2013) assumes more resources are need to manage smaller and numerous grants compared to larger and fewer grants: the FTE days per EUR 100 000 are higher for smaller projects – 7 to 10 FTE man-days per EUR 100 000 (project size from EUR 50k to 1 million, such as SME Instruments, MSCA-ITN, MSCA-Cofund) compared to 4 FTE man-days per EUR 100 000 for larger projects (project size from EUR 5-6.8 million security, ICT, H2020 – food agriculture).
114 DG RTD, DG CONNECT, DG Education, Youth, Sport and Culture (DG EAC), DG Energy (DG ENER), DG Internal Markets, Industry, Entrepreneurship and 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 JRC.
115 Six Commission DGs, four executive agencies, four P2Ps, seven PPPs, the EIT and the EIB.

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: Centralisation measures under Horizon 2020

CENTRALISATION MEASURE	DESCRIPTION
Centralisation of the proposal evaluation process	REA takes care of the logistics of the evaluation and management of the evaluation experts (except for ERCEA and EASME) as well as the validation of legal entities for the entire Horizon 2020
Common Support Centre	DG RTD hosts the CSC which provides support for 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

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

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 on Horizon 2020 is below the 5 %[116] allowed in the legal base and is estimated at below EUR 1131 million (excluding EIT, JRC and Euratom) in the first three years of programme implementation. This figure includes the administrative costs of all DGs, including the CSC and executive agencies[117]. The agencies' administrative expenditure is particularly low at 2.75 % for ERCEA, 2.6 % for REA, 0.77 % for INEA and 2.7 % for EASME. As previously noted, based on the existing evidence from external evaluations[118] and cost-benefit analysis[119], this is mainly the result of lower staffing costs (agencies are mainly staffed by contractual agents) and lower overhead costs, thanks to a high degree of specialisation in each agency and the lower number of employees overall. In comparison, the level of administrative expenditure for FP7 was 5 % for its specific Ideas programme and 6 % for FP7 cooperation, capacities and people specific programmes[120].

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[121], it is estimated that, on average, 76 % more proposals are evaluated per year under Horizon 2020 compared to FP7 (19 340 proposals under FP7 compared to 34 025 under Horizon 2020)[122]. On average, proposals under Horizon 2020 are evaluated by more evaluators compared to FP7[123]: the average number of evaluators per proposal was between three and four for most programme parts in FP7, while it ranged mainly between four and five in Horizon 2020. However, each evaluator spends less time per proposal compared to FP7: on average, 0.7 days under Horizon 2020

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

compared to 0.8 days under FP7. The average cost per evaluation per day has also fallen (from EUR 606 under FP7 to EUR 568 under Horizon 2020). The observed reduction 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 around EUR 65 million under Horizon 2020. The increase in total costs is mainly due to the higher number of eligible proposals submitted to the programme.

In general, the stakeholders consulted are content with the current support provided by the Commission services (including agencies). The support provided by the Commission services during grant preparation and implementation was considered by 73 % (1927) of consultation respondents as 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, the majority of respondents who commented on this relationship underlined the delays they experienced in receiving answers to their request from the project officers while some asked 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[124].

Compared to FP7, Horizon 2020 was constructed from the outset around a simplification[125] **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 to technological development to close-to-market activities. 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.

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 two-stage approach** in parts of the programme, with

124 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).

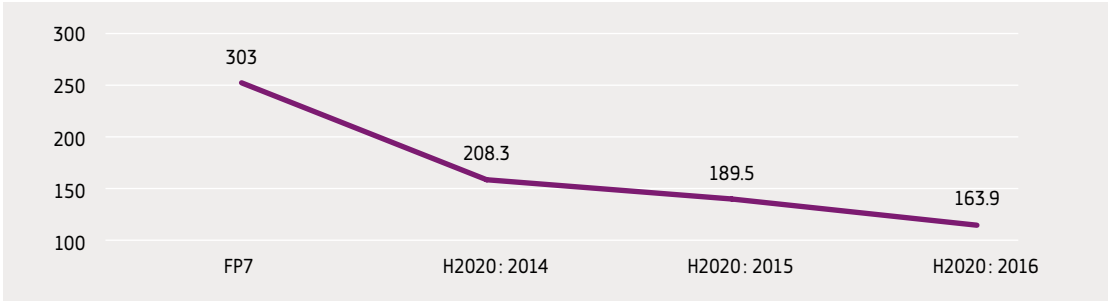
125 The use of simplified forms of grants under the MSCA (unit costs), streamlined ex-ante checks, reduced requirements for work-time recording, reduced audit burden, an acceleration of the granting processes, and fully paperless proposal and grant management. For further details, please see Horizon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

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 RIAs and up to 70 % for IAs (with one exception: non-profit organisations are reimbursed 100 % 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 of 25 % of the direct costs[126].	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

FIGURE 29: Time-to-grant in days



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

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 in the time elapsing between the closure of a call and 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 (six months for phase 2 and three 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, with the 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".

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

The new funding model is based on two main features: a single reimbursement rate and a single flat rate, which represents a major simplification compared to FP7 (Figure 28). This new funding model puts the focus on those costs directly related to the project. It was expected to simplify the financial management of projects, by reducing the 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**[127]**.**

IMPACT OF THE HORIZON 2020 FUNDING MODEL AGAINST SPECIFIC CRITERIA

As noted in the legal base[128], the interim evaluation should assess the Horizon 2020 funding model against specific criteria. The following provides a summary[129] of this assessment:

- **The participation of participants who have at their disposal high-end research infrastructures or have a history of using full costing in FP7:** Participation of research organisation and higher or secondary education institutions in Horizon 2020 is similar to FP7 and has not been influenced by the funding model (22 % versus 24 % participation rate for research organisations and 34 % versus 37 % for higher or secondary education institutions)[130].

- **The simplification for participants who have at their disposal high-end research infrastructures or have a history of using full-costing in FP7:** 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 about the single flat rate for indirect costs. Until January 2017, 13 entities[131] lodged a request for an *ex-ante* assessment of the methodology for LRI[132]. This confirms that the number of applicants for the LRI scheme remains modest.

- **The acceptance of beneficiaries' usual accounting practices:** 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 for personnel, as referred to in Article 27 of Regulation (EU) No 1290/2013:** The feedback received from Member States' representatives and stakeholders indicates that 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 the availability of external funding. Under those remuneration schemes, project-triggered remuneration may count, for example, for as much as two-third of the employee's total salary. That leads to situations where the cap of EUR 8000 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 an Horizon 2020 action than in an FP7 project.

127 See in particular the thematic assessments for MSCA, FET, ICT, LEIT-NMBP, LEIT-SPACE, SC1, SC2 and SC4.
128 See Article 32 of the Horizon 2020 Regulation.
129 A more detailed assessment is included in Annex 1.
130 Based on Corda, cut-off date by 1/1/2017.
131 Nine research organisations, three higher education establishments, and one enterprise
132 Four entities (research organisations) have received a positive ex-ante assessment while two (research organisations) have been found non-compliant. For five entities, the work is ongoing; two entities have voluntarily withdrawn their application.

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. Around 90 % of universities and more than half of research organisations which have used the FP7 60 % flat-rate method for indirect costs, the Horizon 2020 funding model has brought little change compared to FP7 in terms of funding rate[133]. Therefore, it has 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 "LRI scheme which, as intended, is now being used for a selected number of large research organisations with expensive research infrastructure which are doing research as their core business. For industry and other organisations using the real indirect cost option in FP7, 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 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[134]. As a result, **the overall funding rate between FP7 and Horizon 2020 has not changed and remains 70 % of total costs.**[135]

The additional remuneration scheme, another feature of the Horizon 2020 funding model 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 overall the new funding model has 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 have been submitted and no *ex-post* audits have been 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 with their usual accounting system. In particular, this concerns obligations on staff time recording, accounting for the depreciation of equipment and for internally provided consumables and services, handling personnel costs outside closed financial years, and some accounting details for beneficiaries outside the euro zone. The Commission has already reacted to these concerns and has 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 be opened 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).

However, stakeholders find that the costs of participating in Horizon 2020 have fallen – but insufficiently. Further simplification and more flexibility appear to be required. In the simplification

133 The funding rate is expressed as a percentage of the Commission's contribution to the total project costs.

134 The methodology identifies a coefficient (funding intensity) for each type of organisation (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 by their direct cost.

135 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 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.

survey[136], 77.5 % of responding project 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 thought that the cost of participating in Horizon 2020 compared to FP7 has lowered with the simplification measures[137]. Still, out of the 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 have acknowledged 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 % (1732) of the survey respondents felt that the acceptance of organisations' accounting practices in the programme was "good" or "very good" while 17.9 % (475) viewed it as "poor" or "very poor").

136 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.

137 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 concerning FP7.

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 can be assessed at an overall governance level involving DG RTD, the EIF and the EIB; at a more operational level, using financial intermediaries (in the 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, assessment of the efficiency of managing the instruments is fairly positive[138]. Even if it might be difficult for financial intermediaries and other

138 Interim evaluation of financial instruments under Horizon 2020 (2017), see Annex Part 3.

stakeholders to distinguish between the different financial instruments under the EIB Group, the fact that they are under the same organisation helps the EIF to guide financial intermediaries to identify and apply for the most appropriate instrument.

Results of a survey of intermediaries carried out 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 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 those that must be fulfilled manually. Some intermediaries also highlight that reporting and monitoring costs seem to be growing.

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, which were mainly organised by the executive agencies: In 2015, EASME held three 'infodays' attended by close to 2000 participants; the agency is also using social media and participating in major events[139]. ERCEA is also active on social media – its website attracts more than half a million visitors yearly, and the agency organises stands at three to five selected scientific conferences every year. The REA oversaw the evaluation activities; in 2015 alone, it 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 the 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"[140]. Within the projects, a large number of communication activities are also undertaken to disseminate and communicate the results of the knowledge generated. Validated periodic reports from the first 726 projects show that they have spent EUR 57.6 million on communication and dissemination covering many different types of activities, including 308 brokerage events, 3451 communication campaigns, 270 conferences, 1626 workshops, 2385 press releases and 8938 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 and social media channels as a way of reaching the general public. However, it is only in cases where consumer engagement is 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 procedures for writing,

139 For example, the EU Sustainable Energy week, Green Week, SME – instrument Innovation Summit.

140 As an illustration, the mapping of SC2-funded projects shows that they target a broad range of stakeholders as poten-tial users of their outputs but dissemination and communication efforts largely target stakeholders expected to be "immediate users" of project results.

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[141].

Three quarters (75 %) of those responding 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 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 ranges from EUR 10 000 to EUR 100 000. It applies these numbers to the overall number 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[142].

From FP7 to Horizon 2020, the bureaucra-cy 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

Based on the EUA's approach, **it is estimated that it costs Horizon 2020 applicants EUR 1908.9 million or EUR 636 million annually to write proposals[143]. 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**.

TIME SPENT ON PROPOSAL PREPARATION

- 52.3 % of coordinators in a multi-partner project say that they spent more than 30 days, and 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, and 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[143]

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

142 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, and the information required by the proposal template.

143 See detailed methodology in Annex 1.

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

FIGURE 30: Estimation of costs of proposal writing

	ELIGIBLE PROPOSALS (EXCLUDING RESUBMISSIONS)	COST OF WRITING PROPOSALS (EUR MILLION)
High-expense level: EUR 50 000[145]	22 267	1 113.4
Medium-expense level: EUR 20 000[146]	24 572	491.4
Low-expense level: EUR 10 000[147]	18 774	187.7
Very-low-expense level: EUR 5000[148]	23 292	118.9
Total	88 905[149]	1 908.9

Source: Corda per 1/1/2017, excluding resubmissions, estimation by Commission services

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 given to applicants is an area for improvement.** This is also reflected in the stakeholder consultation results, where 62.2 % (1647 of 2648) respondents who participated in Horizon 2020 assessed the quality of the feedback from the evaluations as "good" or "very good", while 34 % (905) judged it as "poor" or "very poor". (This was the highest score reached by the "poor" and "very poor" categories compared to the other items relating to the implementation aspects of Horizon 2020 which were submitted to the respondents' opinion). The numbers show that NGOs are least positive (55.6 % "very good" or "good"), followed by academia (59.2 % "good" or "very good").

In the open questions in the stakeholder consultation, some respondents asked for more transparency and better quality evaluation feedback. Respondents have complained that not enough details are provided, that the quality of the feedback varies greatly from one evaluation panel to the other, meaning that discordant views may 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 BE IMPROVED

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. Various issues were highlighted, in particular: the evaluation summary reports are reportedly too short and provide generic rather than 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. A few business representatives further noted the selection rules concerning 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.

145 Instruments included: RIA and IA, COFUND-EJP/PCP/PPI/ERA-NET.
146 Instruments included: CSA, ERC ADG/COG/LVG/ POC/STG, MSCA Cofund/ITN/RISE.
147 Instruments included: MSCA-IF and SME-2.
148 Instruments included : SME-1 and Stage 1 applications in two-stage applications.
149 Including Stage 1 proposals.

7.4. HOW EFFICIENT IS THE DISTRIBUTION OF FUNDING?

7.4.1. SUCCESS RATES AND OVERSUBSCRIPTION

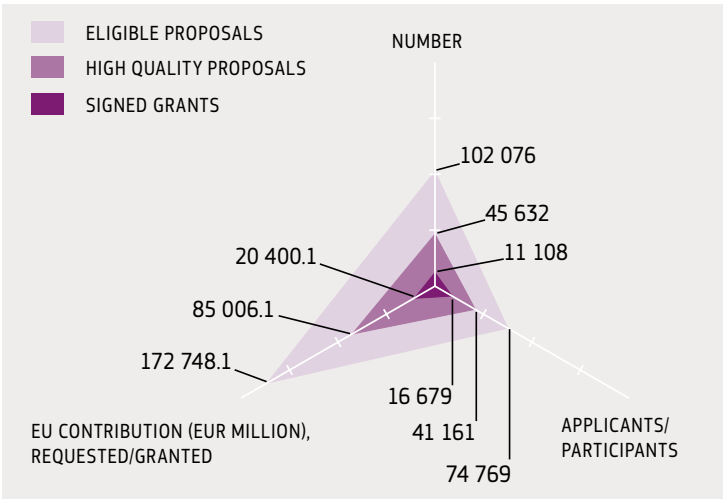
The surge in interest in Horizon 2020 means that demand vastly outstrips supply, leading to oversubscription. An additional EUR 62.4 billion would have been needed to fund all the proposals evaluated as high quality. The average success rate of Horizon 2020 dropped to 11.6 % compared to FP7, which had an overall proposal success rate of 18.4 %. While the popularity and high demand for parts of the programme show that they are providing 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 as of high quality (44.7 % of total eligible proposals); and 11 108 grants were signed[150,151].

However, **oversubscription is distributed unequally 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 Figure 31 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 success rates are found in FET, the SME Instrument and SC6[152].

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. FET has the lowest rate of high-quality proposals funded, where less than 1 in 10 is retained for funding. **This indicates an underfunding of substantial parts of the programme where the budget is not sufficient to support even 1 in 5 high-quality proposals.** 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 recent years will also help to alleviate this.

FIGURE 31: Overall proposal and grant data

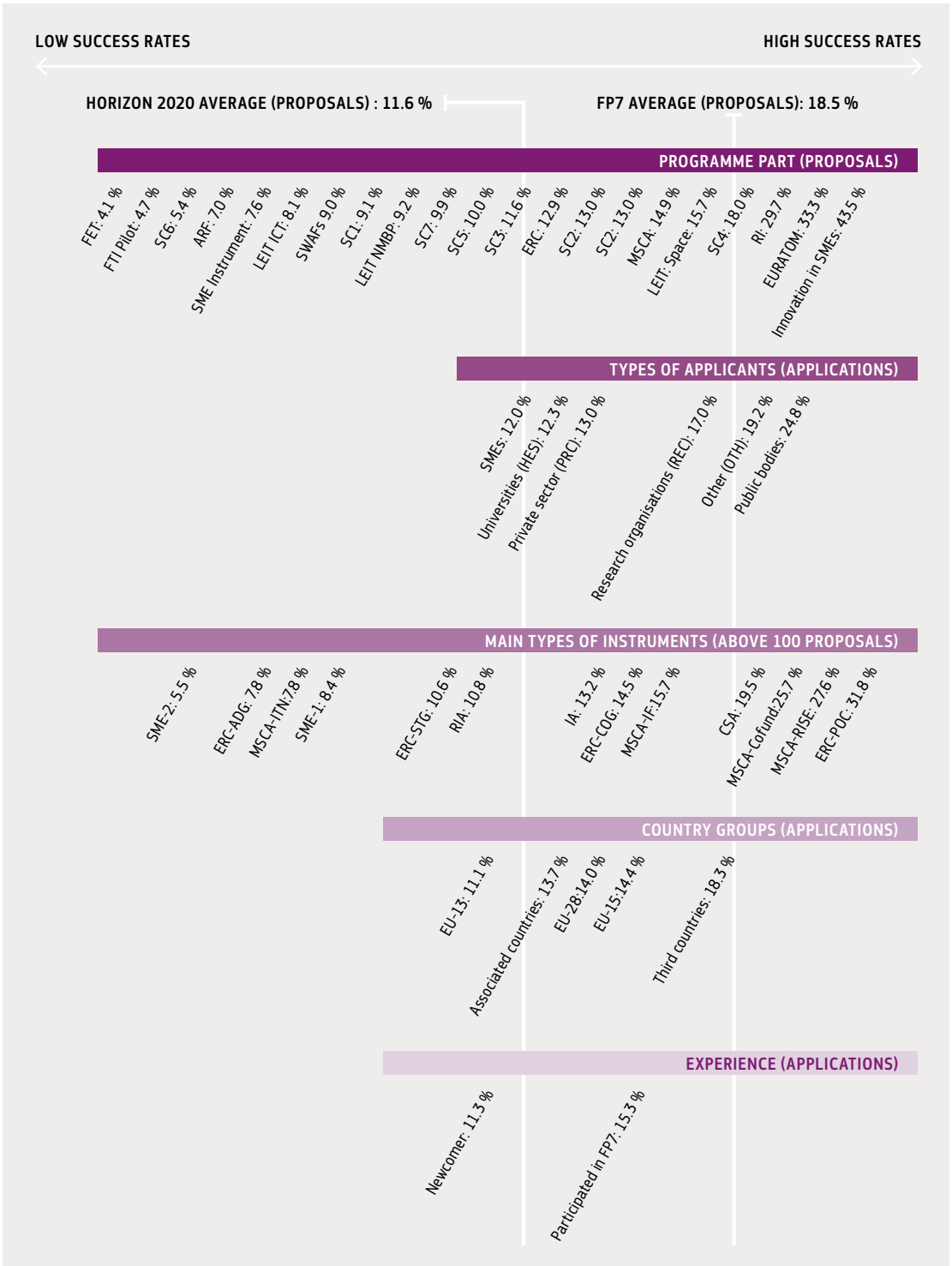


Source: Corda, cut-off date by 1/1/2017

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

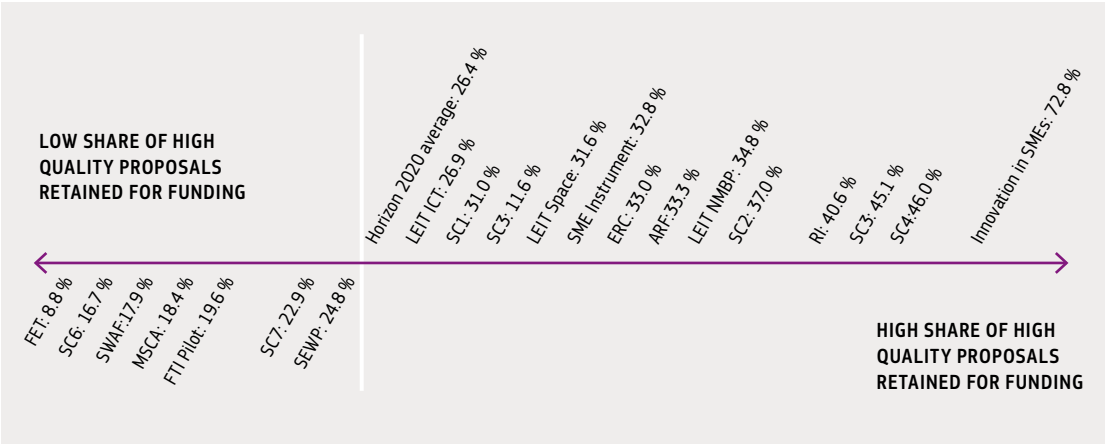
152 The calculation of success rates is based on full proposals, i.e. one proposal is counted only as second stage of a two-stage proposal, not including the proposals which are excluded in stage 1. This means that some parts of Horizon 2020 success rate actually report higher success rates than would 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 32: Success rates (programme part, Types of applicants, type of instrument, country groups and level of experience)



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

FIGURE 33: Share of high-quality proposals retained for funding per programme part



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

In some of parts of Horizon 2020, two-stage calls were used to cope with oversubscription. In the first stage, the applicants submit a short project description for evaluation. Successful applicants are then invited to submit a full proposal in stage 2[153]. In total, by 1 January 2017, 10 001 proposals had been submitted to Horizon 2020 in this staged approach, which represents a share of 9.8 % of the total number of full proposals submitted. Of these 3144 were invited to submit a full proposal[154]. Of the full proposals submitted, 19.6 % were 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 WP for two-stage proposals which 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 the first stage, their quality, and the budget they request. For two-stage calls, which closed in 2016, as a result of the new rule , out of 1112 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 proposals is 38.9 %, almost doubling the success rate of all two-stage calls (19.6 %). The introduction of this new rule has so far proved effective.

Following a pilot in FP7 (XTrack), FET-Open (which previously used a two-stage call) now applies a single-stage call with very short proposals (up to seven 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 with the programme raised during the stakeholder consultation, leading to calls for the budget for those areas to be increased. The majority of respondents (89 % or 3099) "strongly agreed" or "agreed" that a bigger budget is needed to finance R&I at EU level.

153 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 required to develop a stronger proposal.

154 Including 166 proposals that were invited but for various reasons decided not to submit.

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 stress 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 the oversubscription rate: more budget especially for the bottom-up calls to better meet the demand; reduce the scope of the narrower calls and improve and expand the two-stage proposal procedure with the success rates at the second stage reaching 30-50 %. Increase the time between the first and the second step so that proposers receive negative feedback before preparing their submission for the second step. Make step one lighter. A few noted that the current introduction of the two-stage proposal procedure to manage oversubscription in certain calls is welcome, 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. UK participants coordinate almost one in five projects.

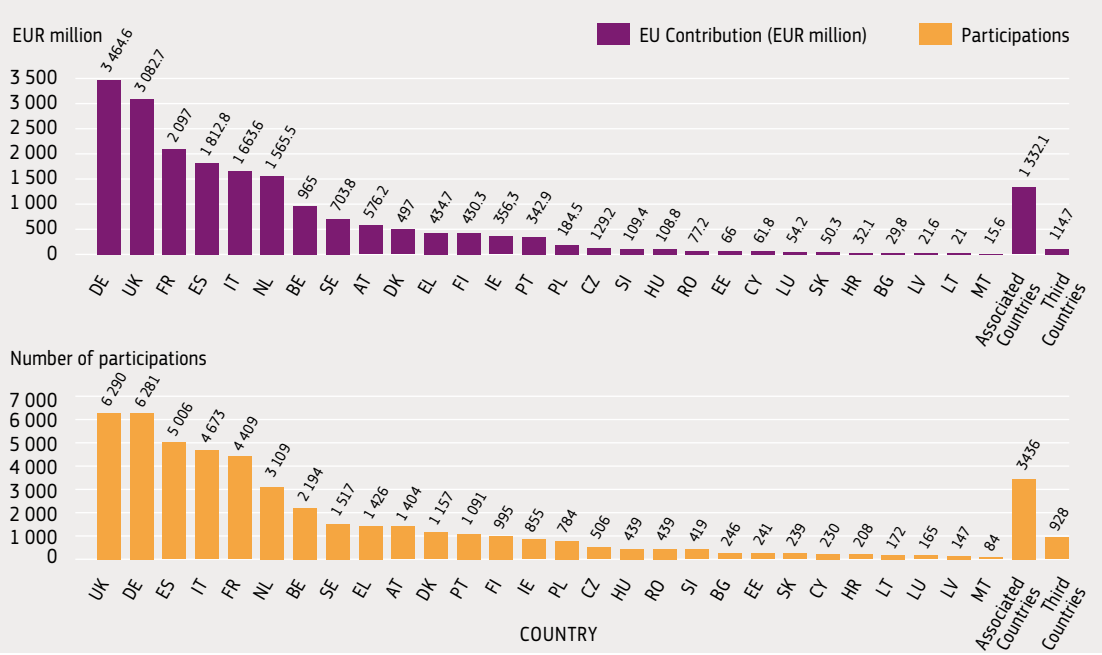
To date, the funding disbursed under Horizon 2020 is concentrated. **Participants from five countries received 59.4 % of the overall funding**, with participants from Germany receiving 17 % of the overall funding, while participants from Bulgaria, Latvia, Lithuania and Malta receive 0.1 % each. The five 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 are all below 20 %. In total, the EU-13 countries have a lower success rate of 11.1 % compared to the EU-15 which register 14.4 %. In total, third countries have the highest success rate of 18.3 %. A total of 133 countries participated in Horizon 2020. Their detailed performance is provided in Annex 1.

Participants from EU-13 Member States represent 8.5 % of participations in Horizon 2020 and receive 4.4 % of the overall funding, which is slightly more than under FP7 (7.9 % and 4.2 %, respectively). Overall, the EC contribution to participants from EU-13 countries has increased from approximately EUR 270 million per year in FP7 to EUR 300 million per year under Horizon 2020. In spite of overall lower Horizon 2020 contributions, some EU-13 countries are outperforming the EU-15 average. For example, 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 outperform EU-15 Member States by 6.7 % on average. Thus, to a large extent, variations in Horizon 2020 funding can 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 those from the EU-13 (11.6 %).

We observe strong "old boys clubs" cooperation patterns, poorer visibility of EU13 excellence but also week involvement of EU13 in testing new technolo-gies 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

FIGURE 34: Summary graphs (EU contribution and participation per country)



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

FIGURE 35: Key data on participation per country group

		HORIZON 2020			
KEY INDICATORS	**FP7, EU-13**	**EU-13**	**EU-15**	**EU-28**	**OVERALL**
Share of EC contribution	4.2 %	4.4 %	88.5 %	92.9 %	100 %
Average EC contribution per year (EUR million)	272	302	6015	6318	6800
Annual EC contribution per inhabitant (in EUR)	3	3	15	12	n.a
Annual EC contribution per researcher FTE (in EUR)	1321	1271	3808	3475	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 participation	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 newcomer participation	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 project coordinators 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

FIGURE 36: Horizon 2020 contribution normalised per inhabitant, researchers 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

Noticeably, EU-13 countries record a higher share of SME participation than under FP7 (from 18.2 % to 21.8 %) which is above the performance of EU-15 countries. Private-sector participation also increased compared to FP7 (from 28.7 % to 31.1 %). **However, there are 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 varies greatly, comparing 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 as against 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 receive EUR 11 423 and EU-13 receive 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 receive **EUR 67 524 from Horizon 2020 compared to the EU-15 which receives EUR 63 277. This is 6.7 % higher for the 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[155].

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. **However, some programme parts register better EU-13 participation than others – 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 %).** In spite of overall lower Horizon 2020 contributions, some EU-13 countries are outperforming the EU-15 average. For example, 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, on average, EU-13 Member States outperform EU-15 Member States with 6.7 %. This implies that, to a large extent, the variations in Horizon 2020 funding can be explained by differences in national investments in R&I.

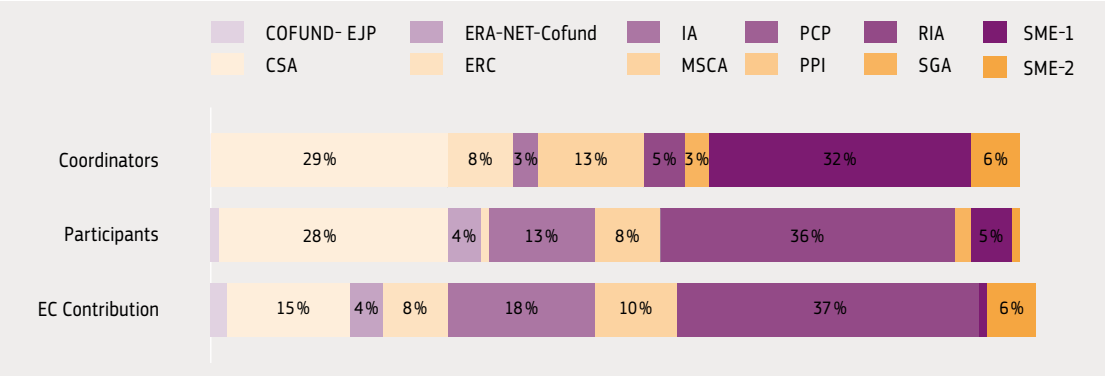
Most of the EC contributions received by participants from EU-13 countries come under IAs (37 %) and RIAs (18 %), followed by CSAs (15 %), Marie Skłowdowska-Curie Actions (10 %) and ERC (8 %).

By 1 January 2017, higher or secondary education institutions (HES) and research organisations together attracted 64.9 % of the funding, the private sector 27.7 %, and public authorities and others 7.3 %. Each HES participates 11.4 times on average and receives EUR 5.5 million; each company participates 1.6 times on average and receives 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, SMEs receive 23.9 % of the funding and recorded 26.9 % of the participation – exceeding by far the 20 % target of funding in LEIT and societal**

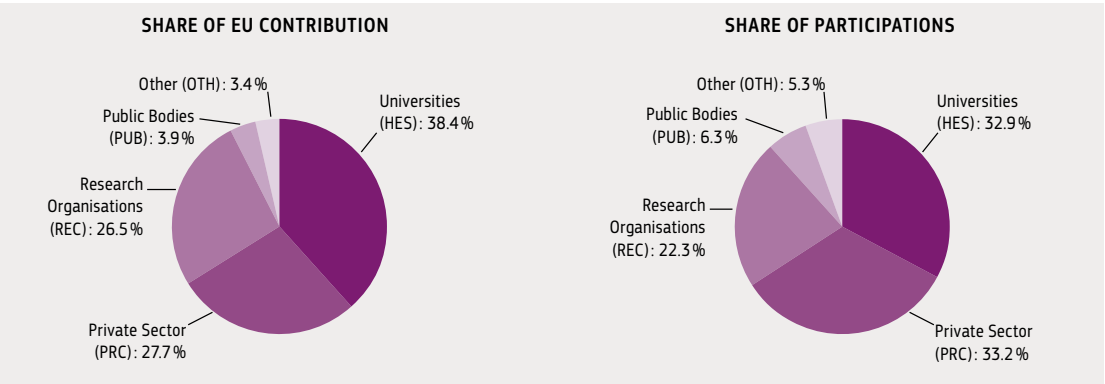
155 Commission analysis of September 2011, at the request of the Polish Presidency, see http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2014728%202011%20INIT. This has been confirmed by other studies, analysis and public discussions, for instance the FP7 MIRRIS project.

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

FIGURE 38: Share of participations and EU contribution per type of organisation



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

challenges allocated to SMEs[156]. The share of EC funding allocated through the SME Instrument between 2014 and 2016 is 5.6 % of the total budgets of the specific LEIT objectives and the priority societal challenges, representing EUR 881.7 million[157]. This share increased 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 %[158].

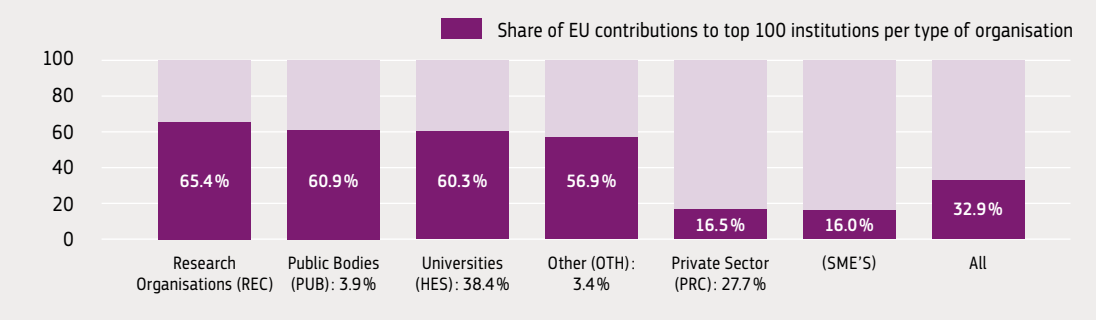
Overall, in Horizon 2020, the 100 institutions receiving most funding received 32.9 % of the total budget. Among research organisations and higher or secondary education institutions, this concentration of funding is particularly strong. The 100 research organisations getting the most funding received two-thirds (66.2 %) of the funds, while higher or secondary education institutions in the top 100 received 60.5 %. The centralisation is less pronounced for the 10 367 private companies which 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 getting the most funding received 34.6 % of the funds, 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.

156 More information available at: https://ec.europa.eu/programmes/horizon2020/en/area/smes

157 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 for the SME Instrument in the WPs.

158 Regulation (EU) No 1291/2013 establishing Horizon 2020, Annex II.

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 more than 20 projects and over 20 collaborations.

FIGURE 40: Horizon 2020 network at country level – based on project participations

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

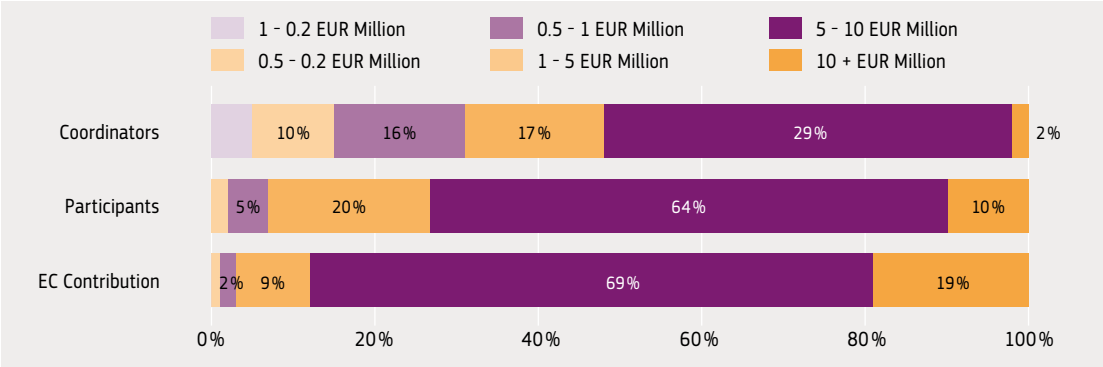
7.4.3. DISTRIBUTION OF FUNDS PER PROJECT SIZE

Horizon 2020 is expected to provide an appropriate balance between small and large projects[159]. The RIAs and IAs involve, on average, 11.6 partners which is only a 3 % decrease compared to FP7 collaborative projects (12.0).

Based on a methodology developed by the Commission services combining budget and participation data[160], **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, with reference to IAs and RIAs only: 36.4 % of the Horizon 2020 projects are regarded as large if they have more than three participants per EUR million, while 63.6 % are small. In terms of funding, and based on this approach, 24.8 % of Horizon 2020 funding (IA and RIA) goes to large projects and 75.2 % to small projects.

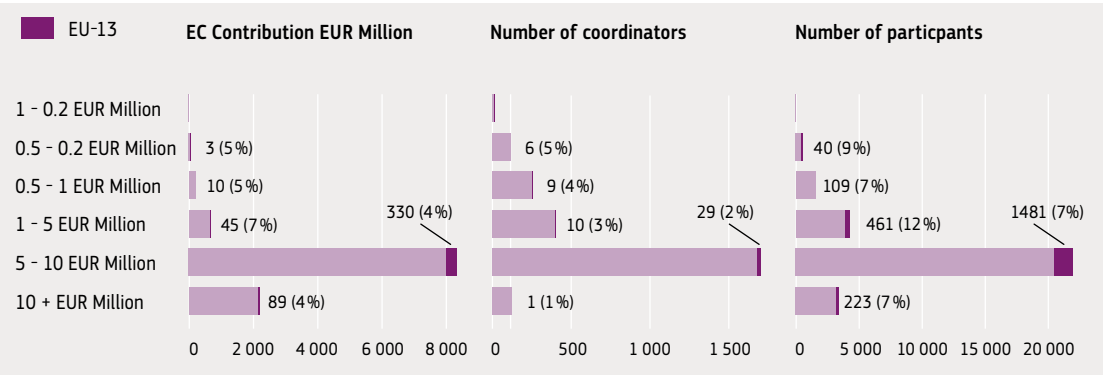
In terms of participation, large projects seem to attract a higher share of newcomers and EU-13 participants into the programme compared to smaller projects.

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 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.
160 See Analysis 2, Annexes Part 2/3 Section 7 for more information.

Most of the EC contribution is currently allocated to projects worth over EUR 5 million (92 %). A closer look at EU-13 participation patterns by budget categories shows that most EU-13 participants are in projects with budgets higher than EUR 5 million, and 88 % of the EC contribution received by EU-13 participants is currently from these large projects (Figure 41). The EU-13 participants seem to coordinate and lead more if the projects are smaller (although the current sample size is too low to draw conclusions). At the same time, the EU-13 seem to participate best in the EUR 1-5 million bracket[161]. A full discussion on project size is available in Annex Part 2.

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 (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 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 a balance should look. 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. A few others stated smaller projects allow for the higher participation of SMEs and newcomers into the programme and can be as effective as large projects.

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

7.4.4. PARTICIPATION OF NEWCOMERS

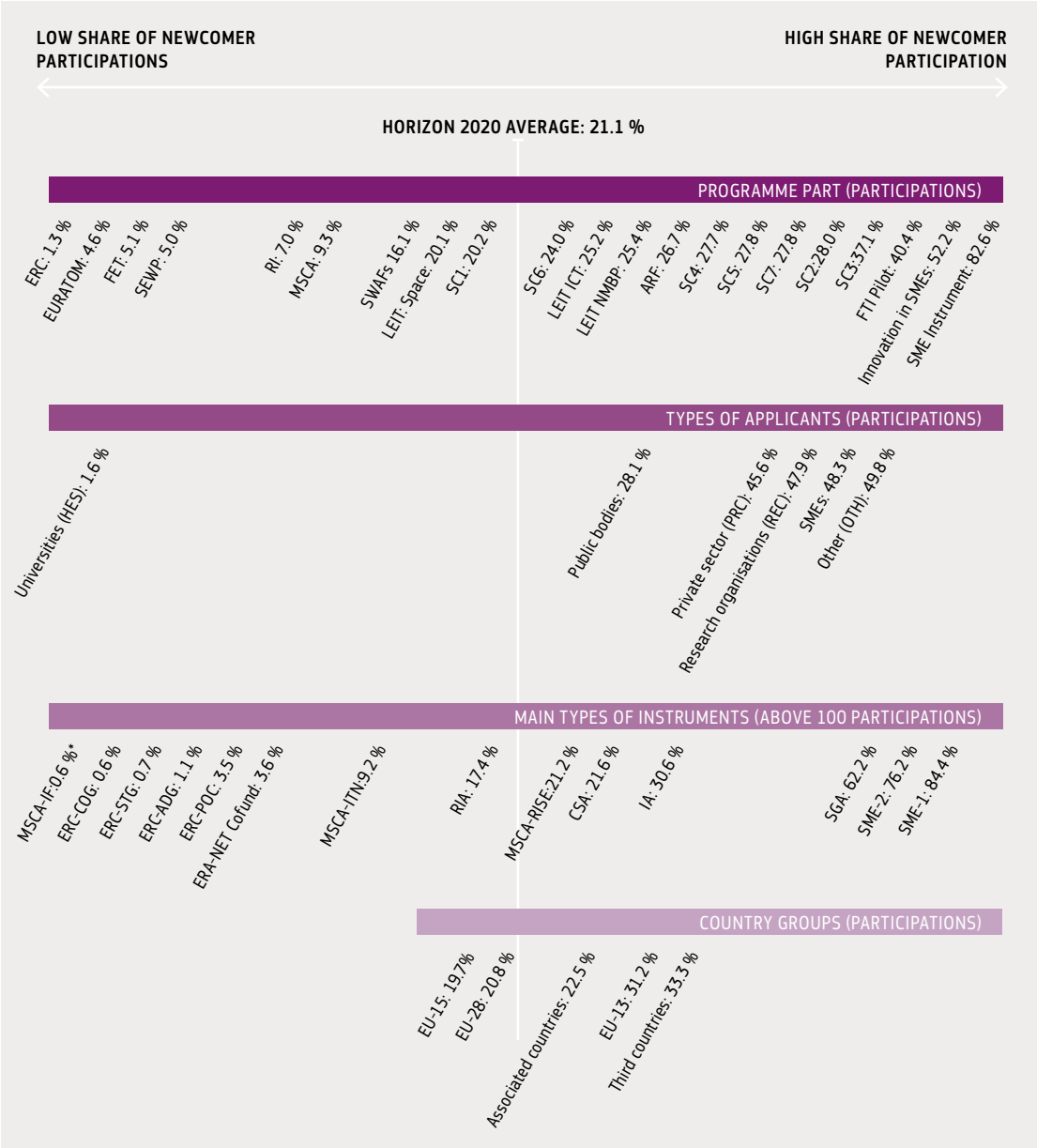
The ability to attract newcomers (not participating to FP7) is essential to the openness of Horizon 2020: 78 % of all organisations applying for Horizon 2020 funding in the first three years of programme implementation where newcomers. But their success rate is considerably lower when compared to returning 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 (on average, newcomers 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 IAs and RIAs (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 organisations participating were newcomers at the programme end[162]. Horizon 2020 needs to continue attracting newcomers to reach a comparative share by the end of the programme.

There are vast differences between programme parts, country groups, sectors and types of instrument in attracting and selecting newcomers. **In spite of the majority of newcomers originating in the 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'.** As regards the instruments, the SME Instrument and IAs have above-average shares of newcomer participations compared to other funding instruments.

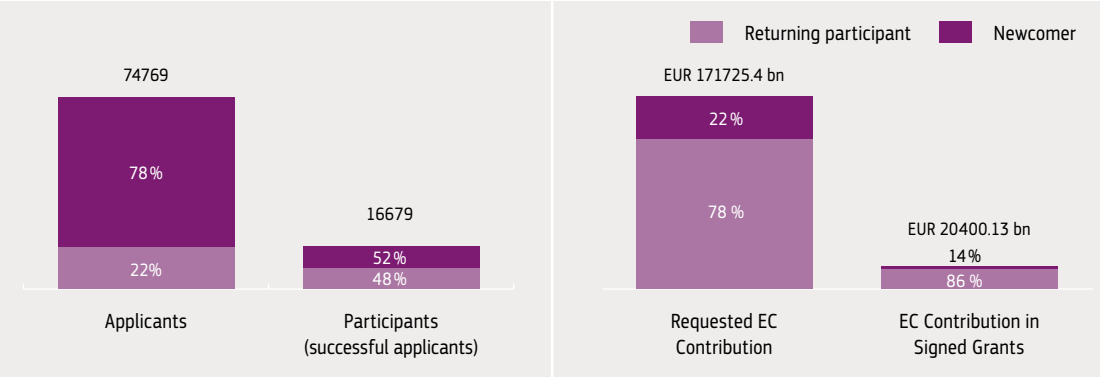
162 Several studies (including the ex-post evaluation of FP7) have shown the share of newcomers to be over 70 %, although this information was not obtained in a structured way during FP7.

FIGURE 44: **Share of newcomer 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.*

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

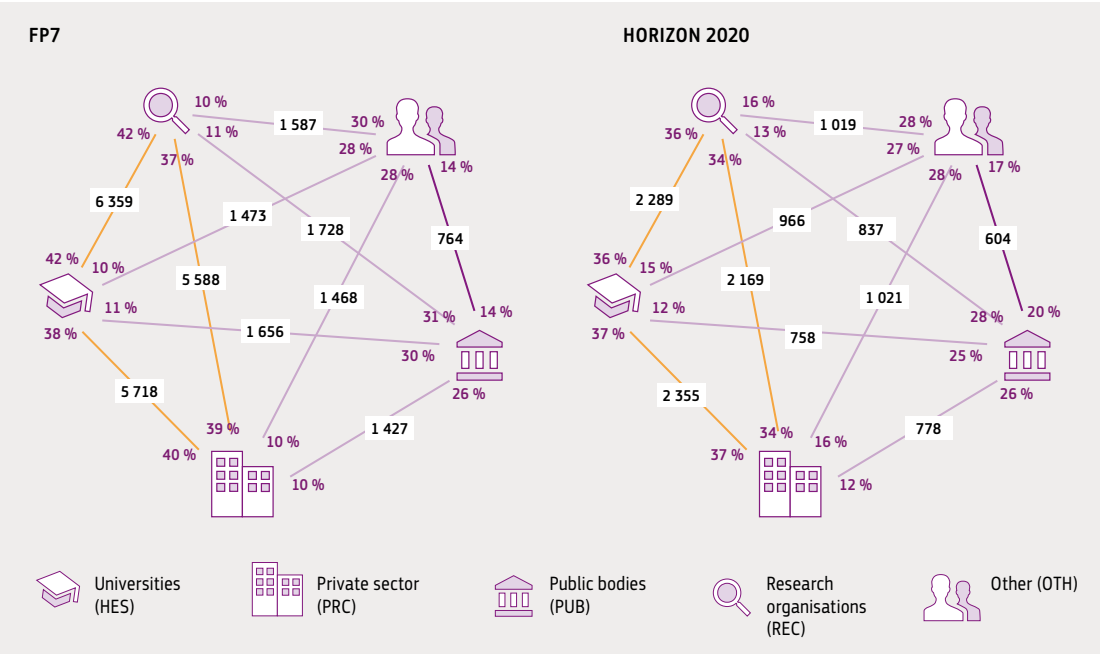


Note: The percentages refer to newcomers. The figures above the bar refer to total numbers for the programme as a whole.
Source: Corda, cut-off date 1.1.2017

7.4.5. INTERSECTORALITY AND PROFILE OF PARTICIPATING COMPANIES

Based on a review of the participations in collaborative projects, the main collaborations to date occur between the higher education sector and private firms (2355 collaborative projects), the higher education sector and research organisations (2289 collaborative projects) and between the private-for-profit sector and research organisations (2169 collaborative projects). Private companies have become the academic sector's main partner under Horizon 2020 projects, as opposed to research organisations in FP7.

FIGURE 45: Number of collaborative projects between types of institutions



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 produced by participants in Horizon 2020 projects (independently of their Horizon 2020 project) it appears that **Horizon 2020 projects are supporting interdisciplinary networks** (see Figure 46 below)[163]. However, only a few unusual interdisciplinary collaborations are observed, such as that 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, decision sciences, economics, econometrics, finance and nursing; and
- Computer science, engineering and energy fields.

THE VALUE OF INTERSECTORALITY FOR BREAKTHROUGH INNOVATION – THE SPIRE EXAMPLE

Among the cPPPs, SPIRE is on track to achieve a reduction in fossil energy intensity of up to 30 % by 2030, a 20 % reduction in non-renewable primary raw material intensity, and a 40 % reduction in 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 generated by 20 % compared to the current situation across the manufacturing sector.

Looking more closely at industry participation, Figure 47 shows companies participating in Horizon 2020 according to the number of employees and EC contribution received (grants only). Companies involved in Horizon 2020 have a number of characteristics[164]:

- **In terms of employees, SMEs represent more than 75 % of all Horizon 2020 companies and receive almost 60 % of EC contributions**. 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 receive the highest grants[165].

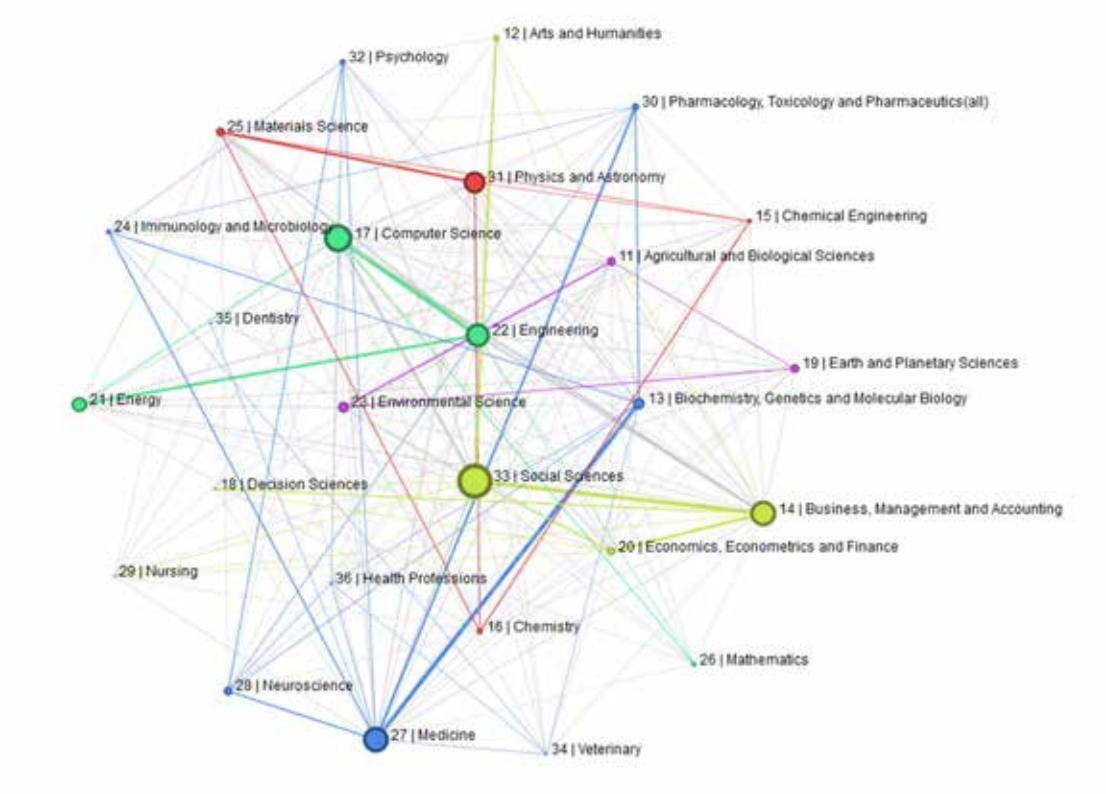
Looking at sectoral patterns, 80 % of total grants to Horizon 2020 companies go to the three biggest sectors: 35 % to manufacturing, 30 % to professional, scientific and technical activities, and 16 % to the information and communication sector. The amount of grants awarded to each sector is roughly proportionate to the number of companies in that sector: **the Horizon 2020 allocation seems not to be sector-specific** (chart below). The only slight exceptions are manufacturing (relatively more grants) and professional, scientific and technical activities (relatively less grants), which may be because of equipment costs in manufacturing and relatively smaller grants to consultancy companies. In terms of companies' intersectoral collaborations, the wholesale trade sector and the digital sector tend to collaborate more with other sectors.

163 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 European Commission's JRC.

164 For full analysis, see Annex 2.

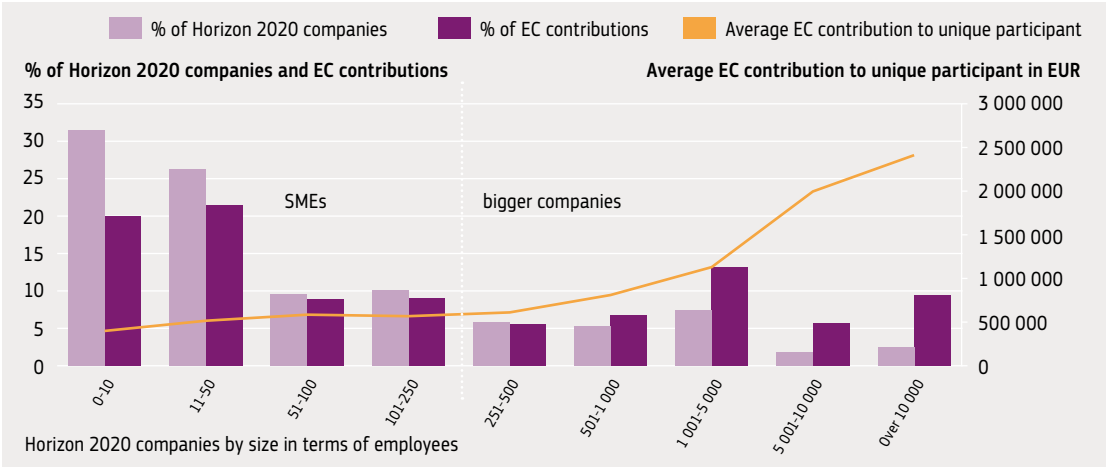
165 The scope of this analysis varies from the scope in Corda. For example, for SMEs in Corda, these are mainly (except for the SME Instrument) based on self-declaration, where as in this analysis of companies, the data in ORBIS were filtered on two SME criteria (less than 250 employees and less than EUR 50 million in turnover) to identify SMEs..

FIGURE 46: Collaboration networks in Horizon 2020 projects between different academic fields



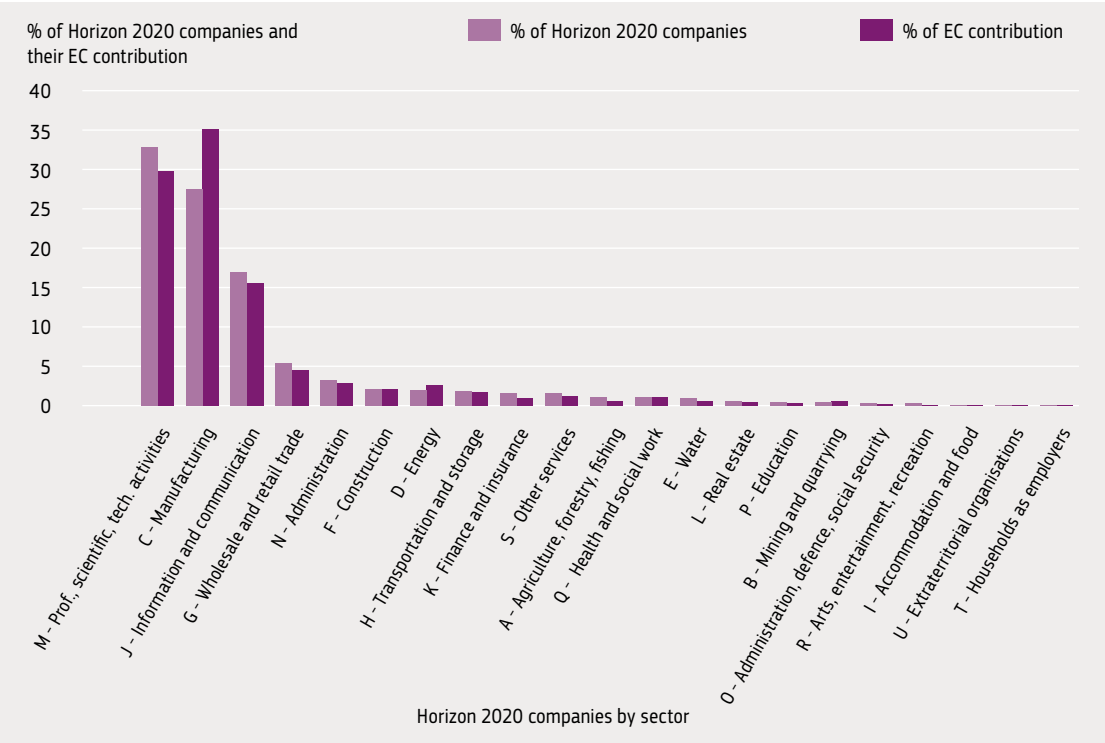
Source: JRC Technology Innovation Monitoring. Based on Corda data, cut-off date: 01/01/2017

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[166].

Horizon 2020 has a broad international outreach: applicants from 188 countries in total 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 has not led to a transversal increase in international participation across the programme. **The share of third-country participations and funding going to third-country beneficiaries has declined when compared to FP7**, mainly due to the discontinuation of the dedicated schemes in FP7 and a change in the eligibility conditions for funding participants from Brazil, Russia, India, China and Mexico[167]. **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); 1.9 % of beneficiary participations (compared to 3.6 % in FP7)[168]; 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 in FP7). Among those countries which are not automatically eligible for funding from Horizon 2020, the most active in terms of participation are the USA, China, Canada, Australia

166 See Recital 41 of the Horizon 2020 Regulation.

167 See Performance Analysis of International Participation in Horizon 2020, European Commission, 2016.

168 Taking the considerable share of international partner organisations in MSCA into account, third-country participations are 3.9 % of Horizon 2020 participations (compared to 5.3 % in FP7).

[The discontinuation of Horizon 2020 would be] an absolute catastrophe. 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

and Brazil, compared to the 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.

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 PPPs have either no or very few international participants (except for the Innovative Medicines Initiative) whereas PPPs 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 participation from 14 African countries. Participations in MSCA account for more than half of all third-country participations in Horizon 2020. **There is also a higher level of investment in multilateral initiatives compared to FP7.** During 2014-2015, around EUR 114 million were invested in health-related initiatives, 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 is close to EUR 200 million, while the total investment by all partners is estimated to be around three to four times this amount. In this context, another relevant example relevant is the developing international maritime research component, notably across the Atlantic (Galway Declaration).

In terms of associations to Horizon 2020, 16 countries have now signed an association agreement[169], some countries (Switzerland, Norway, Iceland, Israel and the Faroe Islands) have a long-standing participation in the EU Framework Programmes and a very strong performance. For others (e.g. countries from the European Neighbourhood, like Armenia, Georgia, Moldova, Tunisia and Ukraine) the association has contributed to the integration of their R&I systems in the ERA even though several still lack the national capacity needed to fully benefit from their association.

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 were established in 2014 with the US and Canada. Their activity has triggered an improved cooperation and the decision to invest in a consistent package of Arctic research activities in the WP 2016-17 focused on climate change issues, which has attracted further US and Canadian investments.

STAKEHOLDER POSITION PAPERS

THE SHARP DECLINE IN THE PARTICIPATION OF INTERNATIONAL PARTNER COUNTRIES IS A CONCERN

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

169 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.

7.5. TO WHAT EXTENT IS HORIZON 2020 COST-EFFECTIVE?

It is too early to compare the costs and benefits of Horizon 2020, particularly as the benefits are still emerging. **The benefits of R&I investments are the outcome of a complex set of interactions and investments made today which are expected to bring return over a much longer time frame.** 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 resources required to get the programme up and running. This includes, for instance, the administrative costs of the Commission and the various implementing bodies, the application costs (i.e. cost of writing proposals), proposal evaluation costs and the cost of managing the projects by the project coordinators. The efficiency section provides some estimates of such costs, although costs incurred by participants are difficult to estimate based on existing data.

As detailed 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 not have been implemented, the results of a macro-econometric modelling analysis are that every EUR 1 spent under Horizon 2020 will bring an estimated benefit in terms of GDP increase of between EUR 6-8.5 by 2030[170]. Applying this formula to the total Horizon 2020 direct budget of EUR 69.3 billion between 2014 and 2020[171], 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 Horizon 2020 will be 30 % by 2030**. This is in line with the expected return on public spending in research; based on the economic literature, this is estimated at between three and eight times higher than the initial investment[172]. 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 since it is still at a very early stage of implementation and only partial effects can be measured (see 'Effectiveness' assessment). However, based on the macroeconomic modelling exercise, using projections up to 2030, the estimated rate of return for Horizon 2020 is 30 % and its expected benefit is in the range of EUR 400 to EUR 600 billion over the period 2014 to 2030[173]. 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 **externalisation and simplification**. Compared to FP7, externalisation has increased efficiency since almost 60 % of the budget is outsourced to the NMMs such as executive agencies which are more efficient in grant management compared to in-house Commission Services. There is evidence this has resulted in increased administrative efficiency. Current administrative expenditure remains below the 5 % mentioned in the legal base. It is particularly low

170 This is based on projections up to 2030 of the NEMESIS macroeconometric 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 reduced co-funding rate.

171 These figures include only the first, second and third pillars of Horizon 2020 – hence excluding the specific objectives SEWP and SWAFS, as well as Euratom, EIT and JRC non-nuclear direct actions.

172 The internal rate of return was calculated as the actualisation rate that equates the actualised sum of GDP gains to the actualised sum of the Horizon 2020 contribution. It increases slightly over time as annual GDP gains stay positive in most countries up to 2050 while EC contributions stop 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).

173 NEMESIS econometric model.

for the executive agencies mainly due to their higher specialisations and lower staff costs. Simplification of participation rules has reduced costs for the participating stakeholders. Simplification efforts have had other positive effects, in particular on the time-to-Grant (on average 192 days, 100 days faster than in FP7).

Overall, the new **funding model** has 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 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 8 000 cap.

In terms of the efficiency of funding distribution, greater interest from stakeholders has resulted in lower **success rates** than in FP7. Many high-quality proposals have not been funded. At the same time, the higher number of proposals has resulted in the higher cost of proposal evaluation and might have an impact on the quality of the feedback given to applicants, which is of concern. There is scope for a further reduction in the 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 the costs to stakeholders are proportionate, given the expected benefits of 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 be assessed yet as very few financial reports have been submitted and no ***ex-post*** audits have been completed.

In terms of **participation**, 52 % of all organisations participating in Horizon 2020 are newcomers (and almost half of them are SMEs), but they have only received 14 % of the total budget. The majority of newcomers are participating in IAs and RIAs, followed by the SME Instrument. Although 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 the 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 lower level of participation from international partners in the programme is a cause for concern. The decline was mainly caused by 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 which have affected 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. A detailed assessments of progress for each specific objective are provided in Annex 2. This aims to provide a synthetic overview of the overall progress being made according to key expected impacts, which are not mutually exclusive and, in each case, cover the whole programme**: scientific impact, innovation/ economic impact and societal impact**. The following analysis is structured according to these key impact strands, results and early outputs, and identifies factors that might affect progress either positively or negatively.

Overall, it should be kept in mind that R&I are long-term and risky endeavours creating knowledge, spillovers and ground-breaking results that can only be captured very partially after such a short period of programme implementation[174]. The figures presented in the subsequent analysis are therefore a very small fraction of the output to be expected (projects completed at the 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 counter-factual analysis), project reviews, and expert groups gathered for the 18 in-depth thematic assessments carried out for each programme part (see Annex 2) to provide a picture of the progress to date. Results from the stakeholder consultation contextualise the findings.

174 "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

8.1. WHAT PROGRESS HAS BEEN 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 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

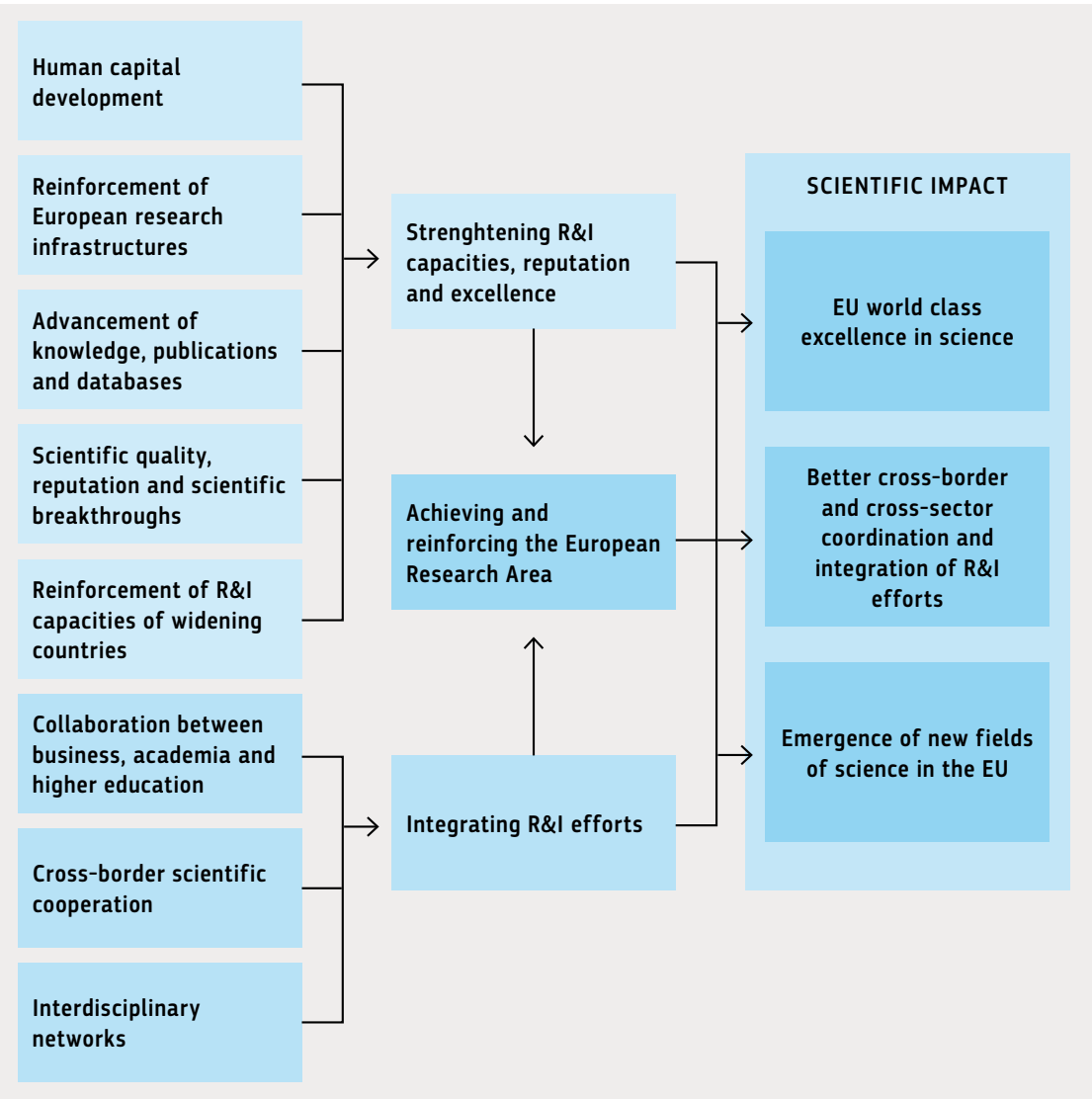
Based on the Horizon 2020 impact assessment, **excellence remains the main guiding principle in Horizon 2020, as it did in FP7.** Scientific excellence continues to be promoted through the pan-European competition for funding, as well as screening for excellence in all project proposals. Therefore, all 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 more in the programme. Horizon 2020 includes a specific programme part dedicated to 'spreading excellence and widening participation' (SEWP), in addition to making it a cross-cutting issue in the whole programme. The objective is to ensure that participants from all EU countries can take part in the programme by reinforcing the excellence base and more R&I-conducive policy frameworks.

Figure 49 provides an overview of the approach used for analysing progress towards achieving 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 transnational 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, transnational and interdisciplinary collaboration). Progress on these strands is expected to support the consolidation of the ERA.

FIGURE 49: **Approach towards analysing progress towards scientific impact**



Source: European Commission

KEY FINDINGS ON 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 is succeeding 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 provide support for training large numbers of researchers and are contributing to Europe's human capital development, which in turns makes the 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. To a large extent, these are already 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, interdisciplinary, intra- and extra-European R&I networks.
- Horizon 2020 is also making progress, albeit slowly, on spreading excellence in Europe.
- The Horizon 2020 funding measures are crucial to accompany realisation of the ERA, 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 enabling 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 all these fronts.

8.1.1.1. HUMAN CAPITAL DEVELOPMENT

Horizon 2020 is already supporting human capital reinforcement throughout its activities, the most direct way being through the 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 who participate in FPs strengthen almost all their skills and capacities[175]. The Research Infrastructure programme also plays a major role in promoting research mobility, within the EU and more globally, not only due scientists moving to work at different sites but also due to the synergistic development of common standards, research protocols, tools and platforms. These are engendering a greater portability of skills, data and knowledge across the European scientific community.

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

FIGURE 50: Horizon 2020 KPIs related to human capital development

KEY PERFORMANCE INDICATORS	PROGRESS SO FAR/TARGET
HUMAN CAPITAL DEVELOPMENT	
MSCA - number of researchers undertaking international mobility under the Marie Skłodowska-Curie actions	27 000 (9 000 per year)[175] Target: 65 000 researchers (including 25 000 PhD candidates)
MSCA - number of researchers undertaking mobility between academic and non-academic sectors	4 000 Target: 65 000 researchers (including 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

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 has increased each year since 2010 to reach 1.87 million FTE researchers in the EU-28 in 2015 (1.73 million in 2013).** An external study[177] identifies between **300 000 to 340 000 researchers in EU Framework Programme teams 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**. Furthermore, the study indicates that, on average, the FP7 research teams had 24.4 % more researchers in 2015 compared to the year when application for 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 participating in the EU FPs. This difference translates into some 45 000 to 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 individuals involved in the collaborative projects (e.g. through their DOI[178]), which is not available.

176 To be funded under the budget of the MSCA Calls for the years 2014-16.

177 PPMI study, 'Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)', 2017.

178 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. To date, this information is not available for individual researchers in Horizon 2020.

EXAMPLES OF THE 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 between 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.

European Research Council (ERC): In 2014, an analysis of over 7000 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 evidence already 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 6500 ERC projects currently running, 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 project** participants foresee 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** which help to 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 KPIs related to the reinforcement of European research infrastructures [179]

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 EU support)	By the end of 2015, 363 national research infrastructures were networked thanks to Horizon 2020 support. The target for the end of Horizon 2020 is 900.
Number of researchers who have access to research infrastructures through support from Horizon 2020	33 741[179] Target: 20 000 additional researchers during Horizon 2020

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

179 This amount is calculated on FP7 grants as data from H2020 grants is not available yet.

Joining forces to boost the ERA (best brains, the best solutions, the best research infrastructures); Horizon 2020 focuses on areas where regional/national programmes are not sufficient and the EU level is vital; excellent research infrastructures must be strongly sup-ported 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

Thanks to Horizon 2020 support, 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[180]. According to the RIs thematic assessment, the development of EU RIs has raised awareness of the burgeoning potential and stimulated scientific communities across the EU. In close conjunction with the ESFRI[181], this 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 under development. These include world-leading infrastructures across all the science disciplines. They are all 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.

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 to create the European Open Science Cloud (EOSC) vision put forward in the European Cloud Initiative[182]. To date, 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.

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 has stimulated scientific communities across Europe into cooperation - creating a solid basis for EU-level research. As none of the Horizon 2020 projects on RIs has been concluded so far, it is not possible to provide information on the users being supported. The number of researchers with access to RIs through FP7 support until 2015 is 33 741[183].

180 A detailed assessment of progress made under the RI programme is provided in Annex Part 3.

181 European Strategy Forum on Research Infrastructures: http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri

182 European Cloud Initiative - Building a competitive data and knowledge economy in Europe, COM(2016) 178 final.

183 This amount is calculated on FP7 grants as data from Horizon 2020 grants is not yet available.

ELIXIR-EXCELERATE[184], AN HORIZON 2020 INFRASTRUCTURE PROJECT

The project is aiming to accelerate 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 three European priority RIs. With 41 partners in 17 countries, this grant is coordinating and enhancing existing resources into a world-leading data service for academia and industry, growing bioinformatics capacity and competence across Europe, and completing the management processes needed for a large distributed infrastructure. Four use cases – rare diseases, human data, plant genotype-phenotype and marine metagenomics – will help to better tune the services.

Project type: INFRADEV; budget: EUR 19 million; September 2015 - August 2019

8.1.1.3. ADVANCEMENT OF KNOWLEDGE, PUBLICATIONS AND DATABASES

FIGURE 52: Horizon 2020 KPIs related to the advancement of knowledge, publications and databases

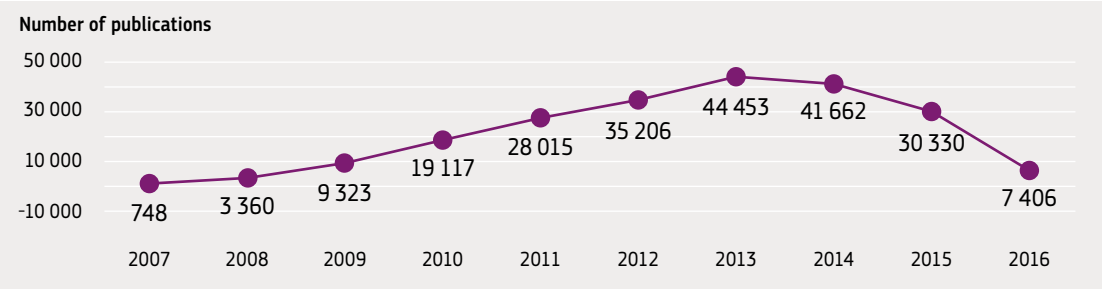
KPIS	PROGRESS SO FAR/TARGET
ADVANCEMENT OF KNOWLEDGE, PUBLICATIONS AND DATABASES	
Number of peer-reviewed publications	4 043 Target: FET: 25 publications/EUR 10 million; societal challenges: 20 publications/EUR 10 million
Chapters in books	373
Number of publications in conference proceedings/ workshops	3 138
Number of books/monographs	49
Number of theses/dissertations	78
Other publications	548
Total number of publications Peer-reviewed in open access	8 246 60.8 % to 68.7 %[185]
Number of projects making scientific data accessible and reusable and number of scientific datasets made accessible and reusable	65 % of the projects covered by the scope of the pilot (2014-2015 figures) participate in the pilot while 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

184 https://www.elixir-europe.org/news/elixir-accelerates-major-horizon-2020-funding

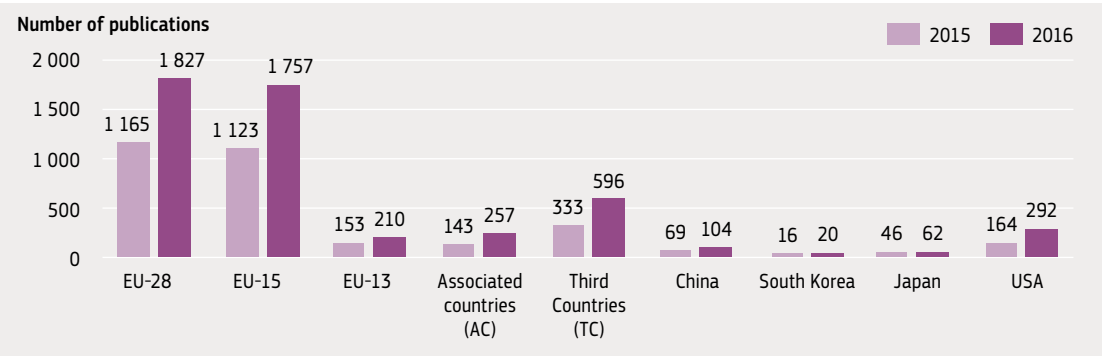
185 The lower limit is based on OpenAire (22/02/17) while while the upper limit is based on Corda.

FIGURE 53: FP7 yearly peer-reviewed publications – total output 2007-2016



Source: Scopus (study by Elsevier)

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



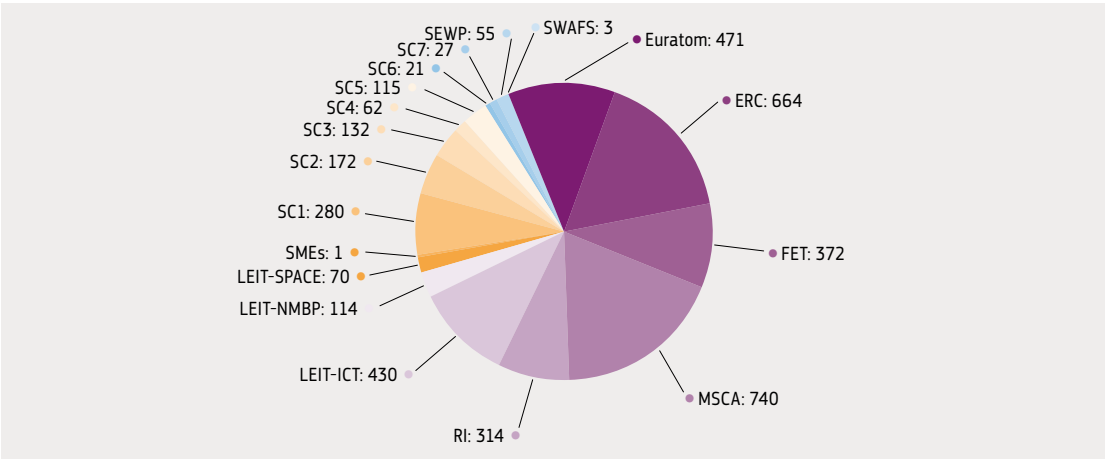
Source: Scopus [study by Elsevier]

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 8246 publications[186], around half of which (4043) 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 volume in the first three years of FP7 (13 431 – see Figure 53 below), the apparent decline in the 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 programme end. Thus, the current figures are a small fraction of the total output expected. The remaining publications are mainly those related to workshops, books or chapters in books, theses or dissertations, or other publications.

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 recorded in FP7.

186 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 55: **Number of peer-reviewed publications from Horizon 2020 projects per programme part**



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

Not surprisingly, a slight majority (52 %) of the peer-reviewed publications come from the excellent science pillar (mostly MSCA, followed by ERC and FET)[187]. In addition, 15 % of the peer-reviewed publications in Horizon 2020 derive from more industry-focused LEIT projects, of which 70 % come from LEIT-ICT projects. Furthermore, 20 % derive from projects in societal challenges, mainly from the health societal challenge (SC1).

Horizon 2020 aims to open up as much of the data from EC-funded research to the wider scientific community to maximise 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**[188]. 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 reusable. 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, although 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 as well as academia, pinpoint that an open access to data requires strict conditions to be met, such as the waterproof Intellectual Property protection system which must be put in place. Open access should be voluntary and evaluated by the beneficiary on a case-by-case basis – opting out should remain a possibility, a sustainable model should be ensured, involving all relevant stakeholders in the transition, and governments should fund the extra costs that come with keeping data open (for example, for ICT tools).

187 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 on 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.

188 As calculated using OpenAire, 22/02/17.

8.1.1.4. SCIENTIFIC QUALITY, REPUTATION AND SCIENTIFIC BREAKTHROUGHS

FIGURE 56: Horizon 2020 KPIs related to progress towards scientific impact

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 %[189] Target: 1.8

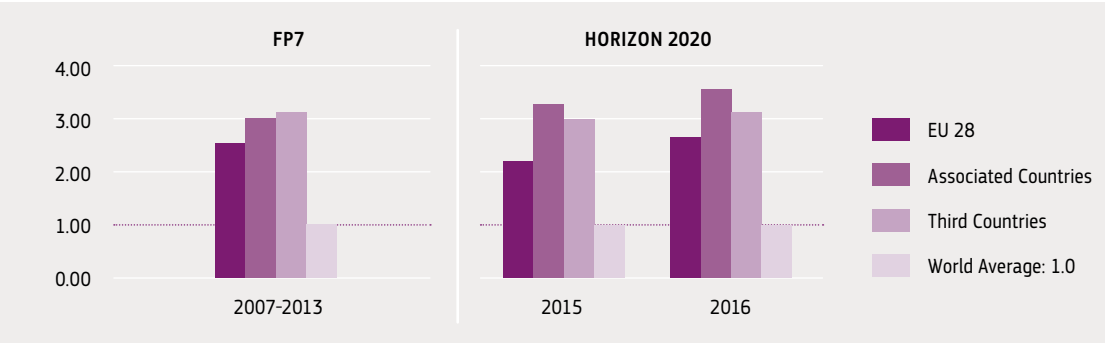
Source: Corda, Signed Grants cut-off date by 1/1/2017

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. The proxy indicator on the quality of the publications produced, the preliminary assessment of the FWCI[190] of the 4043 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 at more than twice the world average (FWCI of 2.46).** For 2015 and 2016, the EU-28 group's Horizon 2020-funded output was represented 3.74 times more in the world's top 1 % of cited research than the overall EU-28 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**.

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 with authors based in the EU and the Associated Countries were ERC-funded publications. ERC funding has gone from contributing less than 0.1 % of the EU's top 1 % publications in 2007 (2) to nearly 7 % in 2014.

Although it is too early to identify major scientific breakthroughs for most of the Horizon 2020 projects, there are already

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



Source: Scopus (Elsevier study, forthcoming)

189 Preliminary estimate based on ERC publications from FP7 projects.

190 Field-weighted Citation Impact normalises citation differences between research fields, with a world average set to 1.0.

early indications of potential breakthroughs. Qualitative analysis of ERC-funded work, since its creation in 2007, confirms the breakthrough nature of the work being performed[191]. **The ERC, MSCA and FET, together with collaborative research themes, have supported at least 17 Nobel Prizewinners prior to or after the award of their prize, and four ERC grantees have been awarded the Fields Medal having been funded by the ERC.** As an illustration, the 2016 Nobel Prizewinner in Chemistry – Professor. 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, and 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!

Horizon 2020 beneficiaries have also contributed to major scientific discoveries, including the Higgs Boson at CERN[192], the detection of gravitational waves[193], and the discovery in 2017 of a planetary system composed of seven Earth-like worlds (exo-planets) located relatively close to Earth[194]. 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.

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)	

191 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 the 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 ad-vances in the study of a topic, and the elaboration of theoretical principles.

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

193 See https://ec.europa.eu/research/mariecurieactions/news/20160615-eu-research-gravitational-waves_en

194 See https://erc.europa.eu/sites/default/files/press_release/files/SPECULOOS_Highlight.pdf

NAME OF AWARDEE	AWARD, YEAR OF AWARD	SUPPORT GRANTED BEFORE HORIZON 2020	SUPPORT UNDER HORIZON 2020
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

NAME OF AWARDEE	AWARD, YEAR OF AWARD	SUPPORT GRANTED BEFORE HORIZON 2020	SUPPORT UNDER HORIZON 2020
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

RESULT OF ERC PROJECT AMONGST TOP 10 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[195].

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[196].

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.

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

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

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 largest ever funded research initiatives. It comprises 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 by 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. This can help us 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 ultra-high-sensitivity graphene infra-red detectors (key for security screening).

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 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 EU in accordance with the principle of excellence.

Although EU funding from Horizon 2020 to EU-13 countries remains at a low level, it is slowly increasing (4.2 % in FP7, 4.4 % in Horizon 2020). All programme parts must 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 SEWP. Based on the information collected, by extrapolation, **it is expected that SEWP projects will achieve their targets and contribute to the SEWP objectives**[197]. 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**.

197 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 in the financial reporting because the grant agreements have not been signed yet, will allocate an additional 17 % of the SEWP budget (10 phase 2 projects of a maximum EUR 15 million each) which is a significant investment for the selected institutions and countries.

SUPREME, A TWINNING PROJECT FOR POLISH ENERGY INFRASTRUCTURE

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 from 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 of 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 the required 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.

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

As regards Teaming phase 1, Twinning and ERA Chairs, 112 projects are contributing to the SEWP's objectives in the 19 widening countries. To date, of a total of EUR 254 million allocated, 73 % has gone 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**[199]. Equally, countries have taken the initiative to link the actions with their Operational Programmes in the ESIF (e.g. Poland, Czech Republic). **The aim of strengthening framework conditions for R&I is pursued primarily by the PSF**[200] **providing on-demand advice to policymakers on national R&I systems**[201]. Bulgaria, Czech Republic, Hungary, Latvia, Slovakia and Slovenia are currently combining widening actions with the PSF and will also benefit from investments in Teaming 2.

Together with Teaming, Twinning and ERA Chairs, COST[202] (promoting networking and connecting pockets of excellence) also plays a role in improving the international positioning of the R&I stakeholders in each country, Currently, there are 3234 ongoing participations in projects in widening countries within the COST programme.

Of the stakeholder consultation respondents, 64.7 % 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, while 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 NGOs.

198 http://cordis.europa.eu/project/rcn/200260_en.html
199 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.
200 Available at: https://rio.jrc.ec.europa.eu/en
201 It has so far provided/is providing support to 11 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 from significant investments for Teaming 2.
202 Available at: http://www.cost.eu/

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 RIs to boost regional cooperation and collaboration in different fields (active ageing, transport and connectivity, education, R&I) and support scientists from low R&I performing countries to access research infrastructures.

The **European Institute of Innovation and Technology** widened the geographical coverage of its Knowledge and Innovation Communities (KICs) by mainstreaming the EIT Regional Innovation Scheme (RIS) actions into KIC activities and earmarking a dedicated budget for 2016 activities. The RIS initiative is targeted at countries which have no participating organisations in 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[203] in 2016 between the Bio-based Industries Joint Undertaking (BBI JU), its private member, the Bio-based Industries Consortium (BIC), and eight Polish regions for cooperation and awareness raising in the regions. The Lodz Bioregions Declaration[204] aims to establish a Central and Eastern European Bioregions Forum for development of the 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** is also taking measures to enhance awareness of the ERC grant 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 wishing to set up fellowship programmes to fund short-term visits of potential ERC applicants to current ERC grantees' teams. So far, five countries – Czech Republic, Estonia, Hungary, Poland and Slovenia – as well as the Belgian region of Flanders, have set up such fellowship programmes.

STAKEHOLDER POSITION PAPERS
WIDENING PARTICIPATION IS CRUCIAL, BUT SHOULD NOT COME AT THE EXPENSE OF EXCELLENCE

In their position papers, some stakeholders representing different stakeholder groups comment-ed on the need for a more balanced participation among different stakeholders within the Hori-zon 2020 programme and, in general, welcomed the programmes SEWP activities. Stakeholders mentioned most often the low participation rates of the EU-13 due to their lower R&I capacities. However, there seems to be an agreement that this issue should not be addressed 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 R&I or for financial incentives to catch up with research systems, follow-up and opening of the twinning and teaming mechanisms, introduction of a milestone prize mecha-nism, extension of the ERA Chairs to early-stage researchers; and introduction of a bottom-up networking instrument for experienced researchers across Europe.

203 European Bioeconomy conference, Lodz/Poland, 6-7/10/2016.
204 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 transnational 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 in five (21.5 %) so far is based on the cooperation between academic and private organisations.** Going beyond traditional R&I projects, MSCA feature non-academic sector partners playing a strong role in joint researcher training projects, while 25 % of its publications are public-private co-publications. Also based on their thematic assessment, FET projects – involving high-tech research-intensive SMEs, too – 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 to 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[205]. Also, while the involvement of industry (including SMEs) in RI activities and projects is still limited, a number of targeted measures have been launched to increase their interaction with industry, particularly as regards the supply of high-tech components.

8.1.2.2. INTEGRATING THE KNOWLEDGE TRIANGLE OF HIGHER EDUCATION, SCIENCE, AND INNOVATION THROUGH THE EIT

As part of Horizon 2020, the 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 KICs[206], which bring together higher education institutions, research organisations, industry and other stakeholders to create the 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[207] has found that, even though it has contributed to progress in addressing specific structural weaknesses in the EU's innovation 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[208] included a set of recommendations which are in an advanced stage of implementation. Further recommendations have been made through the report by the High-Level Group

205 For example, in the Graphene Flagship, this is key for advancing technology through different TRLs and for completing value chains needed to achieve tangible societal and industrial impact.

206 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 supported by a market study; (ii) education: a set of postgraduate (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 referred to 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.

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

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

FIGURE 59: Key Performance Indicators for the EIT

INDICATOR 1: ORGANISATIONS FROM UNIVERSITIES, BUSINESS AND RESEARCH INTEGRATED IN THE KICS		2014	2015	2016
	Target	240	450	500
	Actual results	550	800	1 052*
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	1 500
	Actual results	1 184	2 145	3 565*

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

FIGURE 60: Key Performance Indicators in the innovation KPI (2013-2015) [209]

INDICATORS	2013-2015 ACTUAL	2013-2015 TARGET
Number of eligible applicants for EIT-labelled PhD and Masters programmes	12 783	11 577
Number of available seats for EIT-labelled PhD and Masters 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 a direct output of a KIC activity	429	326
Number of knowledge transfers (from one KIC partner to another or to third parties) that are a direct output of a KIC activity	308	260
New or improved products/services/processes launched	212	290

Source: EIT

appointed by Commissioner Navracsics[210]. In particular, an amended EIT legal basis, revising its funding model, is expected to be tabled to the European Parliament and Council at the beginning of the second quarter of 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 in Figures 59 and 60.

The number of start-ups and spin-offs set up by the KICs is slightly below the target, even though

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

210 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

KICs continue to generate new ventures at a faster pace. Business ideas are screened by the KICs and only the most promising 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 require a longer incubation period before being translated into a marketable proposal. Figures related to support for innovation show that such activities are producing outcomes beyond initial expectations, as evidenced by the adoption and transfer of knowledge within the KICs and towards external partners. The only indicator that falls behind is that related to the new products/services/processes launched; 73 % of that target has been achieved. According to the survey of KIC partners, 70 % 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[211].

8.1.2.3 TRANSNATIONAL COOPERATION

Most of the EU-funded projects are collaborative with at least three organisations from different EU Member States or Associated Countries, which is reflected in the transnational 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 breadth of networks at the international level is declining, 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 often collaborate with each other and with at least one of the R&D-intensive nations. The countries most represented in Horizon 2020 publications are Germany, the Netherlands, the UK, France, Italy and Spain. While Germany, the Netherlands and the UK continue to co-publish largely among themselves, as observed in FP7, Belgium and France have 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 the world average**[212]. The most frequent co-publications occur between the EU-28 group, the USA, Japan, Canada, China, Russia and Switzerland, just as in FP7. In addition, in FP7, many countries collaborated in publications with only one other EU-28 Member State, which 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[213].

211 http://ec.europa.eu/dgs/education_culture/more_info/consultations/european-institute-innovation-technology_en.htm

212 Elsevier, Study on the overall output of select geographical group comparators and related FP7- and Horizon 2020-funded publication output, forthcoming.

213 For more information, see section on EU Added Value.

TRANSNATIONAL CIRCULATION OF KNOWLEDGE – EXAMPLES 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's top 1 % highly-cited publications this rate is 46 %. Collaboration with third countries is most intense with US-based authors: 22 % of all ERC-reported publications have at least one US-based author and 64 % of ERC-reported publications are written in a non-ERA collaboration (75 % if only the top 1 % of 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. Furthermore, 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 postdocs in ERC teams came from outside Europe, the largest numbers coming 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 collaborative 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 – see box above.

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[214], **the share of Horizon 2020 publications which are interdisciplinary is relatively high and increasing slightly compared to FP7.** For the EU-28, out of their total number of Horizon 2020 publications, 7.55 % are interdisciplinary (compared to 7.45 % in the first three years of FP7). The EU-15 share is 7.29 % (compared to 7.53 % in the first three years of FP7). For the EU-13, the share is 10.19 % (compared to 5.87 % in the first three years of FP7). This means that **the EU-13 produces more interdisciplinary publications when compared to the EU-15** and that the share of such publications among the EU-13 countries in Horizon 2020 has doubled compared to their interdisciplinary publications in FP7.

To date, in the Future and Emerging Technologies programme there are 1278 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.

So far, when looking only at interdisciplinary Horizon 2020-funded research, the FWCI for the period 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 yearly basis. As already highlighted in section 8.1.1.4, compared to the world average, the FWCI of all Horizon 2020 publications is currently 2.46, which indicates that to date Horizon 2020 interdisciplinary publications have a relatively lower scientific impact than Horizon 2020 field-specific publications.

214 Study on the overall output of select geographical group comparators and related FP7- and Horizon 2020-funded publication output, Elsevier, 2017.

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). For example, to achieve their objectives and technology development targets, each of the two FET Flagships is seeking 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 have started to create an unprecedented level of collaboration and community building in Europe. For instance, 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.

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 ERA[215].

According to the Treaty, it is the EU's objective to strengthen its scientific and technological bases by achieving a European Research Area 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 as regards its industry. **The Horizon 2020 funding measures are crucial to supporting 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 or remove the legal and practical obstacles to achieving the ERA.

As discussed earlier and summarised in Figure 61 below, Horizon 2020 supports the ERA policy priorities (e.g. researcher mobility and careers, research infrastructures, knowledge transfer, etc.), the monitoring of progress and fostering 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 researchers remain in or return to Europe, 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 being pursued in Horizon 2020. New initiatives, such as the 'Teaming Competition for Excellence' and a more

"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 geograph-ical levels, instead of looking for only one possible European approach, the total European added value might increase further."

Denmark, Copenhagen Business School

215 Article 5 of the Horizon 2020 Regulation.

focused strategy of international cooperation have been introduced in Horizon 2020 to better serve the objectives of ERA to promote the EU's scientific and technological. **Horizon 2020 provides support to Member States and the main stakeholders in implementing the ERA reform agenda** across six key priorities, the progress of which is summarised below.

Among the respondents to the stakeholder consultation, 75 % 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. 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[216]
More effective national research systems	New Policy Support Facility tool[217]	Most countries have made progress in the field of research excellence (average increase of 6.4 % over the period 2010-2013 and almost all of them have adopted national strategies for R&I). Several Member States are redefining their national R&I strategies further based on a broad concept of innovation, encompassing education, R&I to achieve greater efficiencies
Optimal transnational cooperation and competition on common research agendas, grand challenges and infrastructures	P2Ps, European Strategy Forum for Research Infrastructures	Since FP6, the Framework Programmes have provided 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 achieving ERA: 10 JPIs have been launched to date, all of which 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 ESFRI, the major result of this work being the ESFRI Roadmap. First published in 2006 and updated in 2008, 2010 and 2016, the Roadmap identifies vital needs for new European RIs for the next 10-20 years. It is doing so in various scientific macro-domains, ranging from health and environment to social and cultural domains. .

216 European Commission, 3rd ERA Progress Report: The European Research Area: time for implementation and monitor-ing Progress, 2016

217 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 feed-back 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[216]
		Currently, the Roadmap comprises 21 ESFRI projects that are well advanced from a maturity point of view and 29 projects that have already reached their implementation phase, the so-called ESFRI Landmarks. Thirteen pan-European facilities are already based on the new EU Regulation – the European Research Infrastructure Consortium – which entered into force in 2009, and it is expected that at least four more ERICs will be launched in 2017. Horizon 2020 funding aims to support the different phases of the RI life cycle from the preparation, implementation and long-term sustainability to the efficient operation and transnational access and use of RIs. Preliminary results indicate that the number of national RIs (networked thanks to Horizon 2020 support) was 363 at the end of 2015. The target for 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 (at November 2016) comprised 278 518 job vacancies and 64 777 fellowships .The number of EURAXESS posts increased by 7.8 % a year in 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	Since 2017, open access to peer-reviewed scientific publications resulting from Horizon 2020 is mandatory. 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 while 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 PROGRESS HAS BEEN MADE TOWARDS ACHIEVING INNOVATION AND ECONOMIC IMPACT?

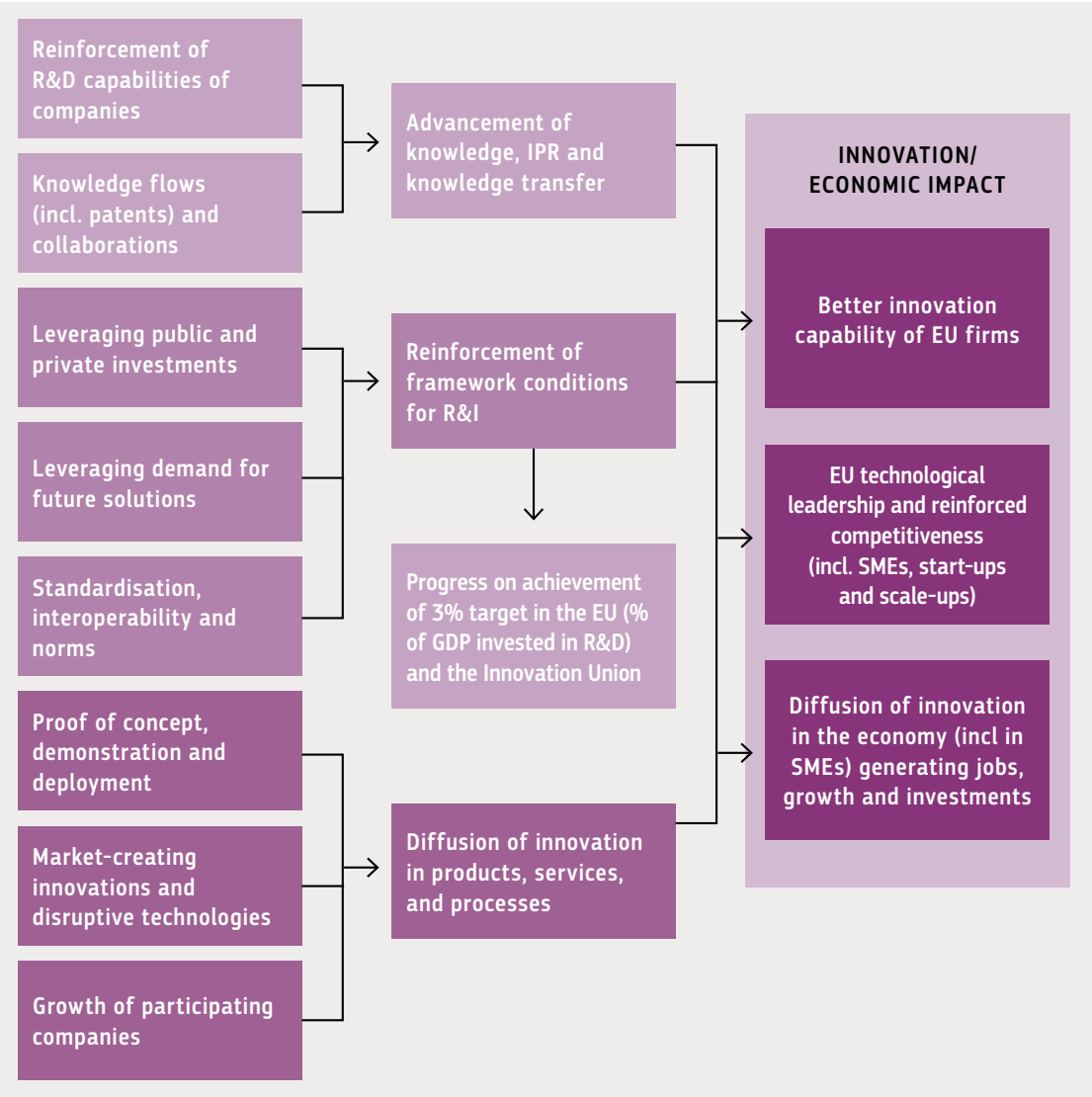
The objective of Horizon 2020 is to speed up development of the technologies and innovations that will underpin tomorrow's businesses and help innovative European SMEs to grow into world-leading companies.

EXPECTATIONS FROM HORIZON 2020 FOR ACHIEVING INNOVATION AND ECONOMIC IMPACT

Compared to FP7, Horizon 2020 is putting 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 allow for supporting all stages in the innovation chain through, in particular, more support for closer-to-market activities and an improved framework of PPPs.

Figure 62 provides an overview of the approach used for analysing progress towards achieving innovation and economic impact. Overall – from the review of the programming documentation – it is expected that this will lead to a better innovation capability among EU firms; a stronger competitive position for European industry; 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 companies' R&I capabilities, 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 to analysing progress towards innovation and economic impact



Source: European Commission

KEY FINDINGS ON PROGRESS TOWARDS ACHIEVING INNOVATION AND 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, although such support can be strengthened substantially.
- Technological and regulatory barriers as well as lack of access to finance or 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 by reinforcing companies' R&D capabilities, the creation of collaboration networks and PPPs. Early evidence indicates that the programme is making progress on these fronts.

8.2.1.1 REINFORCEMENT OF COMPANIES' R&D CAPABILITIES

Under all programme parts, **the development of new knowledge and related learning effects are among 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 so 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 oppor-tunity 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 KPIs related to knowledge flows and collaborations

KPIS	PROGRESS SO FAR/TARGET
KNOWLEDGE FLOWS AND COLLABORATIONS	
Patent[218] applications	153 Target: 3 patent applications per EUR 10 million funding
Patents awarded	39

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

> *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

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**. Thanks to the creation of networks and partnerships, the flow of knowledge between the stakeholder communities, as well as the transfer of technology, data and information among the participants and with the broader community, constitute key elements for the creation and diffusion of innovation. To illustrate, a survey of LEIT-Space industry participants indicates positive progress especially in improved positioning in the international community and a strengthening of their international partnerships (45 %) and better 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[219] also foresee a high impact from 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 as having 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.

Regarding the KPIs related to knowledge flows through Intellectual Property Rights (IPRs), to date, **beneficiaries of Horizon 2020 projects have declared 187 IPR applications[220], of which 69 were awarded**. These are very early indications, and the numbers will rise significantly as projects are completed. The vast majority comprise patents (153 applications and 39 awards[221]) and trademarks (24 applications which have all been awarded). The limited number of applications from Horizon 2020 projects so far is related to the short time span under consideration and thus cannot be compared to FP7[222].

218 Based on beneficiary reporting.

219 Survey performed within the thematic assessment of ICT projects under Horizon 2020 (CARSA, forthcoming).

220 Beyond patents and trademarks, this category includes also Utility models, Registered designs and other.

221 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.

222 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.

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 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 enable them 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, an HIV nanovaccine, and a drug for treating 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 pilot line operator, an SME, two university institutes developing the nanopharmaceuticals, and a specialist institute on nanosafety.

RIA; EUR 6.3 million; January 2015 - December 2018

Not surprisingly, given the higher TRL supported (TRL of 6, demonstration level) and the shorter duration of projects (phase 1 runs for up to half a year, phase 2 up to two years), two-thirds of patent applications and trademark 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 of a 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, so far a limited number of IPRs are attributable to IAs and to RIAs, despite the fact that these actions absorb more than half the Horizon 2020 funding.

Since in FP7 18 % of projects in the Cooperation theme reported at least one IPR protection[223], these elements would suggest that, while single-beneficiary projects (SME Instrument phase 2 and ERC Proof-of-Concept) have proved more successful to date than collaborative projects in applying for IPR, it seems likely that IPR applications deriving from projects in IAs and RIAs will take a more significant share in the near future. According to an external study based on counter-factual analysis[224], **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**.

8.2.1.3. SPECIFIC FOCUS ON PUBLIC-PRIVATE PARTNERSHIPS, INCLUDING JOINT TECHNOLOGY INITIATIVES AND CONTRACTUAL PPPS

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

The Joint Undertakings (JUs)[225] are PPP[226] in industrial research at European level. Currently, seven

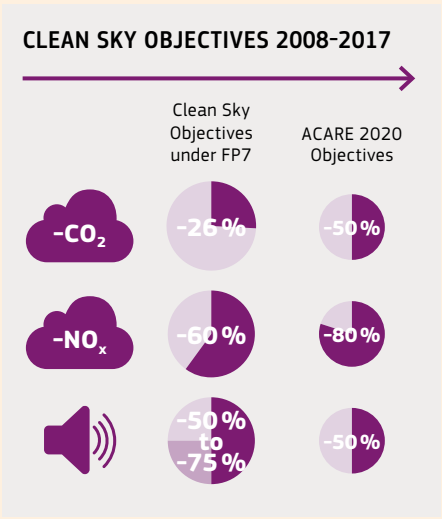
223 RESPIR-SESAM Research Performance and Impact Reports (FP7). Report generated on: 2017/02/03.

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

225 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".

226 In addition to the institutionalised PPPs, the cPPPs also 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.

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 CO_2, gas emissions and noise levels produced by aircraft. Funded equally by the EU R&I Framework Programmes (FP7 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. Furthermore, 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 CO_2 emissions and noise by 2020.

Clean Sky 2 is larger in scope than the initial Clean Sky programme with a total budget of nearly EUR 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 EUR 90 million available in indicative call value per year.

JUs organise their own R&I agendas[227] 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 cPPPs involve dedicated arrangements between the Commission and private associations representing the interest of industrial technologies. On the basis of mutually prepared roadmaps, cPPPs provide direct input into the preparation of priorities for Horizon 2020 WPs in pre-defined areas of significant industrial relevance[228]. There are currently 10 contractual PPPs[229] set up directly under 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 EU contribution of EUR 6.6 billion[230].

227 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.

228 Moreover, depending on the cPPP, they can:
- 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;
- provide a platform to link towards other sectors, especially in the context of identification of use cases.

229 The first four take forward PPPs established under FP7.

230 Excluding the budget for the Cybersecurity cPPP.

THE ECSEL JOINT UNDERTAKING – A PUBLIC-PRIVATE COLLABORATION KEEPING EUROPE AT THE FOREFRONT OF TECHNOLOGY DEVELOPMENT IN ELECTRONIC COMPONENTS AND SYSTEMS

ECSEL implements pilot lines which are large projects (IA) at high TRLs. They are providing a means for producing realistic research demonstrators in an industrial environment, thereby bridging the gap between R&I in the area of electronic components. This is a game changer as regards increasing the economic and innovation impact of EU funding in the strategic electronic components field. Similar actions are now being implemented in the Photonic contractual Public Private Partnership with similar results and impact on the R&I 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.

MONITORING DATA FOR THE JOINT UNDERTAKINGS (FEBRUARY 2017)

- 35 JU calls launched and concluded;
- 1 677 eligible proposals, involving 11 719 applications;
- 473 proposals (28 %) retained for funding with a total EU financial contribution of EUR 2 162.1 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 → SPIRE	5G, HPC, PHOTONICS, ROBOTICS, BIG DATA
> 27 calls launched and concluded	> 6 calls (16 topics) launched and concluded
> 1704 eligible proposals, involving 19 466 applicants	> 1 030 eligible proposals, involving 8 986 applicants
> 231 signed grants totalling EUR 1 217.5 million of EU funding	> 154 signed grants totalling EUR 713.3 million of EU funding
> Among the participants: 15.8 % HES, 58.8 % PRC and 20.3 % REC.	> 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 29.9 % of the total	> The number of SME participations is at least 21 % of the total

More in-depth evaluations of Joint Undertakings and 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 has a substantial influence on the type, size and/or composition of the entities that can become members and thus 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 to becoming a JU member. Openness to membership may also impact participation in the programme and 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 are 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 of them. Instead, they prefer to participate in the open calls as 'beneficiaries' rather than 'members'. As regards SMEs, in addition to financial considerations that in themselves constitute a barrier to membership, they sometimes face difficulties in participating in open calls. Poor networking capacities that stop them from participating in strong and competitive consortia are a frequently cited. 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 on 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 JUs' membership composition and the top-ranking beneficiaries in open calls, it can be concluded that all JUs are attracting prominent players in their respective fields of activity, not only in terms of size and position on the market but also in R&D intensity and innovation potential.**

The content of roadmaps agreed in the context of cPPPs also feeds into calls in the Horizon 2020 WP, 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 ETPs to develop their strategies and roadmaps. These platforms are also open to new members and do not require a financial commitment, thereby opening up participation in particular to SMEs. SME participation varies across cPPPs and ranges from 11 % to 35 %[231]. **The strong participation of non-members, as well as highly innovative and research-intensive industrial players, shows that the cPPPs' priorities are highly attractive to a vast range of stakeholders**.

231 cPPPs are not comparable with each other since they have not all been active for the same period of time.

OPENNESS OF JOINT UNDERTAKINGS IN FIGURES

- Overall, 27 % of all JU beneficiaries are newcomers;
- Overall, 23.3 % of JU 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 Part 2.

PARTICIPATION IN CALLS FOR CONTRACTUAL PUBLIC PRIVATE PARTNERSHIPS

CPPPS[232]	FoF	EeB	EGVI	SPIRE	5G	HPC[233]	PHOTONICS[234]	ROBOTICS[235]	BIG DATA[236]
% 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 the participations	>35	>33	>15	>27	>17	>11	>28	18	>25

Source: European Commission

The cPPPs are included in the Horizon 2020 WP 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, participation of above 75 % is observed. The level of funding also demonstrates this significant participation from outside the cPPP association. **The average success rate in the cPPPs[237] 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 are major variations in EU-13 participation between the different cPPPs. At the same time, consortia involving participants from the EU-13 are considerably more likely to be selected than quality projects that do not include members from the EU-13. For 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

232 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.

233 Approximate figures from 29 projects that started in 2015.

234 Calculated for all funded projects in 2014-2016. The non-membership participation and funding is based on the 100 members of the PPP's board of stakeholders.

235 Relating to 2014-2016 calls.

236 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'.

237 13.6 % in the case of the calls for FoF, EeB, SPIRE and EGVI for three call years, 2014-2016.

participation of EU-13 partners (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 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 in the programming under LEIT-NMBP.

(B) TRANSPARENCY

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

All the JUs have put in place a wide range of mechanisms to ensure an open and non-discriminatory attitude towards their wider stakeholder community, including the general public. These mechanisms include various communication tools, such as 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 as well as other mechanisms that aim to enhance 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.

JUs use a variety of tools to disseminate project results as widely as possible. Most of them reserve a dedicated space on their website for the dissemination of project results and publishable project summaries, while some also provide 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 about the existing common support services and IT tools provided to facilitate access to both project results and research data sets. However, to date, only a few beneficiaries seem to be 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 programming level, the process involving industrial stakeholders includes publicly available strategic research agendas and roadmaps. There are also partnership boards between Commission services (DG RTD/DG CONNECT) 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 various parts of Horizon 2020 provide direct technical input on WPs and are formally invited to support the work programme on the basis of a vote. Thus, national administrations have a major say on the WP contents.

At 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

Progress towards achieving the common Horizon 2020 and JU-specific objectives is measured by a set of KPIs common to all JUs[238] and a set of JU-specific KPIs[239]. 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 their Annual

238 Based on Annex II (PERFORMANCE INDICATORS) to Council Decision 2013/743/EU).

239 With the exception of SESAR JU that is not subjected to a predefined set of KPIs.

FIGURE 64: Contractual Public Private Partnerships today

	FIRST CALL YEAR	MAXIMUM EU FUNDING (EUR MILLION)
Factories of the Future (FoF)	2009	1 150
Energy-efficient Buildings (EeB)	2009	600
Green Vehicles (EGVI)	2009	750
Future internet (5G)	2014	700
Sustainable Process Industry (SPIRE)	2014	900
Robotics	2014	700
Photonics	2014	700
High Performance Computing	2014	700
Big Data	2015/2016	534
Cybersecurity	2017	450

Source: European Commission

Activity Reports. Overall, on the basis of early and partial data available on the KPIs and on the expected results from projects already funded (no project reports are available yet), **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 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 must report on the development of new types of high-skilled jobs and new curricula. **Projects within the NMBP cPPPs have reported a wide range of results regarding new types of high-skilled jobs, the highest average being in FoF (Factories of the Future), with 3.5 new job profiles per project. EeB (Energy-efficient Buildings) projects currently report 0.8 jobs per project, with 1.6 in FP7. EGVI also helped 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**.

First estimates (see Annex 1) demonstrate that the **JUs are well on track to achieving and, in some cases, exceeding their foreseen legally minimum leverage effect**[240]. In the case of the cPPPs in the NMBP thematic area, the current leverage factors range between 1.5 and 3.5[241].

On the basis of 2014 estimates, additional private investments in EGVI projects are expected to lead to a leverage factor of 3. In the Photonics PPP, the industrial investment has been estimated at 4.3. This is based on confidential information received from 80 companies on their investments in 2014-2015. For the other cPPPs, given their recent start, it is too early to give figures based on project results. However, there are no indications that the leverage factor is deviating from the commitment

240 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

241 On the basis of a methodology accounting only for current investments and discounting future investments.

laid out in the contractual arrangements. As with the JUs, the overall leverage effect of each cPPP can only be assessed beyond programme end.

8.2.2. PROGRESS ON REINFORCING FRAMEWORK CONDITIONS FOR R&I

One objective of Horizon 2020 is to help reinforce the framework conditions for performing R&I in Europe via standardisation and interoperability efforts, the leveraging of demand for future solutions and for 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 of and/or compliance with international standards is a critical factor in competitiveness. The progressive evolution of the programme's focus towards higher TRLs makes greater attention to developing standards and/or stronger requirements to comply with existing standards even more important for commercialisation success. **To support the commercialisation or diffusion of innovation in the economy, some projects aim to develop standards and norms, in particular under the LEIT programme, although progress seems 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 LEIT-NMBP projects. LEIT-Space interviewees have criticised the **limited attention to the issue of standardisation in products and services**, despite the fact that interoperability is considered as the key to success overall. In LEIT-ICT, where the contribution to standards is part of the expected impact from a number of topics, a specific action was introduced in the WP 2016-17 to reinforce EU presence in the international ICT standardisation scene.

8.2.2.2. LEVERAGING DEMAND FOR FUTURE SOLUTIONS

The use of new instruments, such as pre-commercial public procurement (PCP), public procurement for innovation (PPI) and inducement prizes, clearly aim to leverage demand for future solutions. However, to date, **evidence of outputs is still lacking on the effects of the PCP and PPI** since the first projects were only signed in 2015[242].

Given the current lack of information and the small scale of PCPs and PPIs so far, the main actions supporting more user-driven innovation and leveraging demand for future solutions in Horizon 2020 are coming from inducement prizes. These provide alternative opportunities to develop innovative solutions by offering a reward for completing a specific technological challenge[243]. The first ones were launched in 2015: five inducement prizes with a budget of EUR 6 million[244] were selected together with three recognition prizes with an overall budget of EUR 1.33 million[245]. Up to the end of 2016, 12 Horizon 2020 inducement prizes have been launched and six more will follow in 2017. They target challenges such as sharing the spectrum, breaking the optical barrier, an ageing population, mother and child health, CO_2 reuse, clean car engines, cyber security, materials for clean air, etc. For example, EUR 1 million under the 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 antibiotics[246]. However, **more could be done overall to support demand for innovative solutions and user-driven innovation.**

242 In 2015, six projects were signed that are implemented through PCP or PPI (total EC contribution of EUR 18.5 million). Of those, three PCPs are procuring in early 2017, while two other PCPs have finished the open market consultation and will start procuring soon. The PPI has not started procuring yet as the 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 in this batch are preparing for procurement. In the second semester of 2016, another five PCPs and one PPI project from 2016 call deadlines were signed (EC contribution of EUR 25.2 million).

243 They are only awarded based upon achieving the target set and solving the challenge defined.

244 No budget executed to date.

245 EUR 0.15 million of the budget has been executed so far.

246 Available at: http://ec.europa.eu/research/horizonprize/index.cfm?lg=en&pg=prizes

8.2.2.3. LEVERAGING PUBLIC AND PRIVATE INVESTMENTS

FIGURE 65: Horizon 2020 KPIs related to leveraging public and private investments

KPIS	PROGRESS SO FAR/TARGET
LEVERAGING PUBLIC AND PRIVATE INVESTMENTS	
Total investments mobilised via debt financing	EUR 29 600 million (2014-2016) Target: EUR 25 billion
Total investments mobilised via venture capital investments	No data available yet Target: EUR 25 billion [247]
Number of organisations funded and amount of private funds leveraged	5 700 organisations funded & EUR 13 235 million of private funds leveraged (2014-2016) Target: 5 000 organisations funded & EUR 35 billion of private funds leveraged

Source: Data from European Investment Bank

One key element for reinforcing the framework conditions for performing R&I in Europe is to ensure public and private funding is 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 have yet to secure additional funding.** However, early evidence shows that **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**[248]. Under this programme, a total of 5700 organisations have been funded – which is above the target of 5000 – and EUR 13.235 million of private funds leveraged (2014-2016) (target: EUR 35 billion). Total investments mobilised via debt financing in 2014/2015 is EUR 29 600 million, which is above the target of EUR 25 billion).

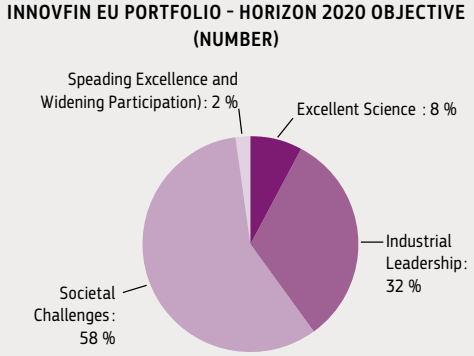
Stakeholders interviewed for the InnovFin interim assessment see the **effectiveness of InnovFin as particularly strong with regard to the objective of increasing private investment in R&I as well as greater risk financing (number of entities and volume of funds). They are more cautious about InnovFin's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

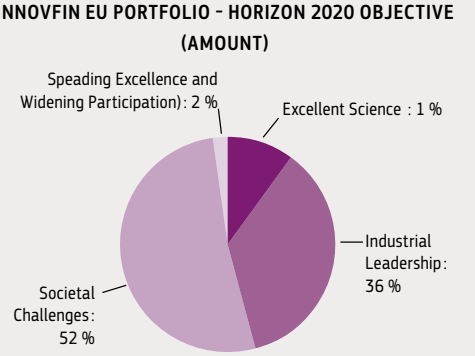
The two pie charts below show the shares of the InnovFin EU portfolio going to different parts of Horizon 2020 in terms of numbers of projects and amount of funding. In terms of both amounts and number of projects, most are going to societal challenges, followed by industrial leadership and excellent science.

247 The instrument has been implemented as from 2015 following an amendment to the Delegation Agreement between the Commission, the EIB and the EIF.

248 Source: European Investment Bank, data per January 2017.

FIGURE 66: InnovFin portfolio spread across Horizon 2020





Source: Annual Operational Report, 2017

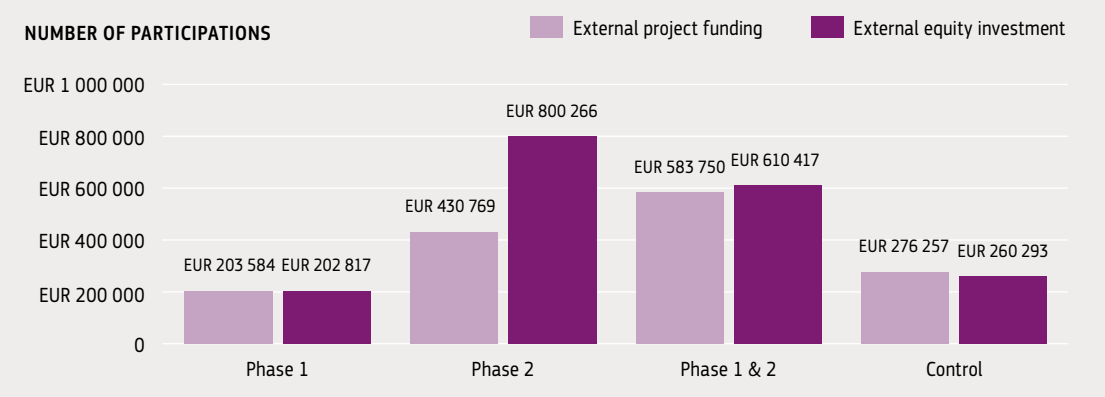
THE INNOVFIN INFECTIOUS DISEASES (INNOVFIN ID) LOAN FACILITY

The InnovFin Infectious Diseases (InnovFin ID) loan facility, launched in 2015, being carried out with the EIB, aims to facilitate the development of innovative vaccines, drugs, medical and diagnostic devices and 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 a Swedish SME for the further development of a diagnostic device for HIV viral load testing[249]. The second loan was secured by the French biopharmaceutical company Transgene SA to develop new treatments for hepatitis, HPV-induced cancer and tuberculosis[250]. 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[251].

Furthermore, of the 2236 SMEs taking part in the SME Instrument at the end of 2016, 88 companies had secured a total of EUR 481 million venture capital either during or after the project[252]. These numbers are expected to increase in the years to come when more projects start delivering results. Indeed, based on the thematic assessment, SME Instrument funding 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 which have participated in phase 2 projects, although the volume of public funding is rising. 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 taking up the Access to Risk Finance offer in their growth phase points to a **potential lack of integration/interconnection between the grant- and non-grant-based instruments available to firms at different stages of the innovation cycle.**

249 Available at: http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2015&na=na-130715
250 Available at: http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2016&na=na-280116-2
251 Available at: http://www.eib.org/infocentre/press/releases/all/2016/2016-175-finland-innovfin-european-support-for-innovation-in-finland.htm
252 Source: Dealroom

FIGURE 67: How much funding have you attracted since you first applied or were first awarded an SME Instrument grant (excluding SME Instrument funding)?



Source: Technopolis, based on SME survey data; sample size: 284 - 293 (Phase 1) 91 - 94 (Phase 2) 20 - 24 (Phases 1&2) 1229 - 1293 (control)

The specific LEIT-NMBP survey of project coordinators also gives positive signals regarding additional investments, in particular in the exploitation of results. 26 % of LEIT-NMBP projects indicated they have already invested additional funds – not initially budgeted – to continue exploiting their objectives – mainly from private sources, but also from 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 in 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.

The PPPs and cPPPs aim to leverage private investment in key industrial sectors – but with 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[253].

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, particularly in SC2, SC5, LEIT ICT, LEIT-Space and Fast Track to Innovation Pilot. Although this 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 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.

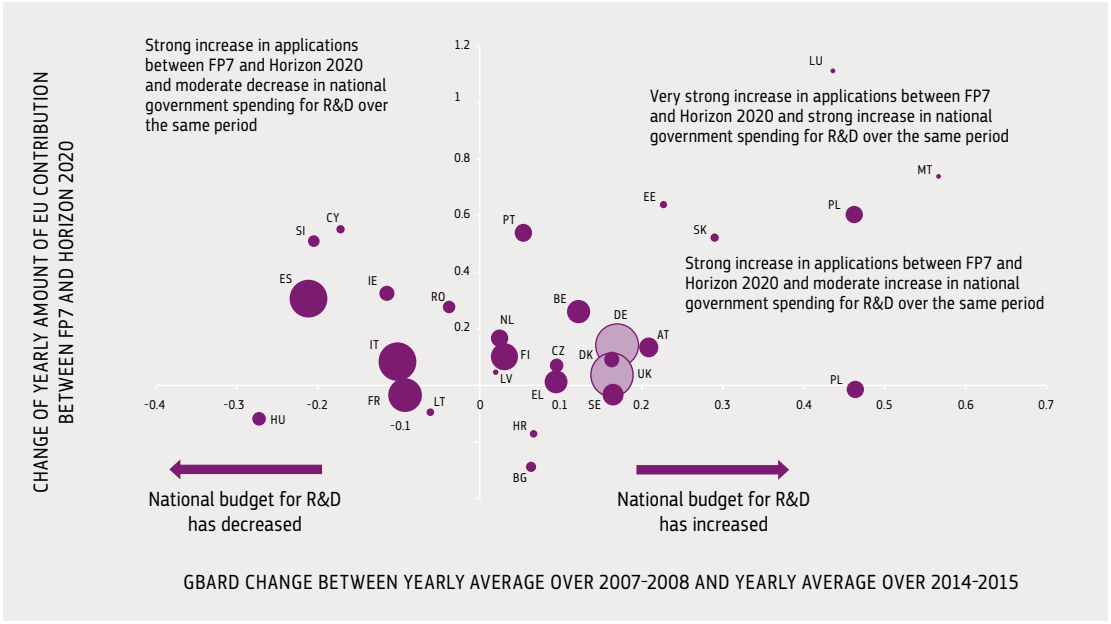
253 See dedicated section 8.2.1.3 on PPPs.

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 %
Sub-total 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= 31)	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= 2)	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

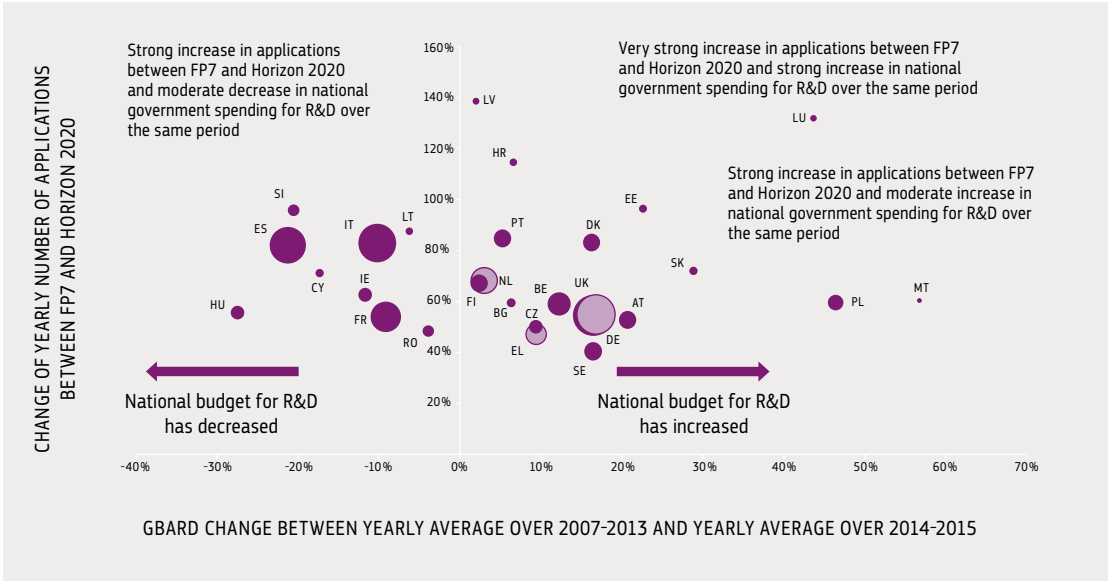
Note: This table shows the percentage of respondents who chose the 'yes' option. N shows the maximum number of valid responses received to these questions in each Horizon 2020 programme part. – Source: Survey of representative set of Horizon 2020 project coordinators, PPMI, 2017

FIGURE 69: Change in GBARD and in the 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: Change in GBARD and 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

Looking more closely at the relationships between the different levels of R&I support, there is little statistical evidence about any complementarity or substitutability between funding received in the context of the FPs and the level of public funding for research at national and regional level. However, comparing data on participation in the FPs at the country level with national budgets for R&D over the same period still provides insights into the extent to which their evolution does or does not correlate.

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 FPs[254]. Countries on the left side of the graph have experienced budget cuts between the two periods, while those on the right have increased their national R&D budget. Participants from countries in the upper part of the graph receive more funding in total from the EU under Horizon 2020 than under FP7, while countries in the lower part receive less.

While simultaneously some countries show a decline in their national budget for R&D and an increase in the EU contribution their participants receive from the FPs, 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 it even indicates countries that have seen both funding measures increase strongly over the period.

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

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**.

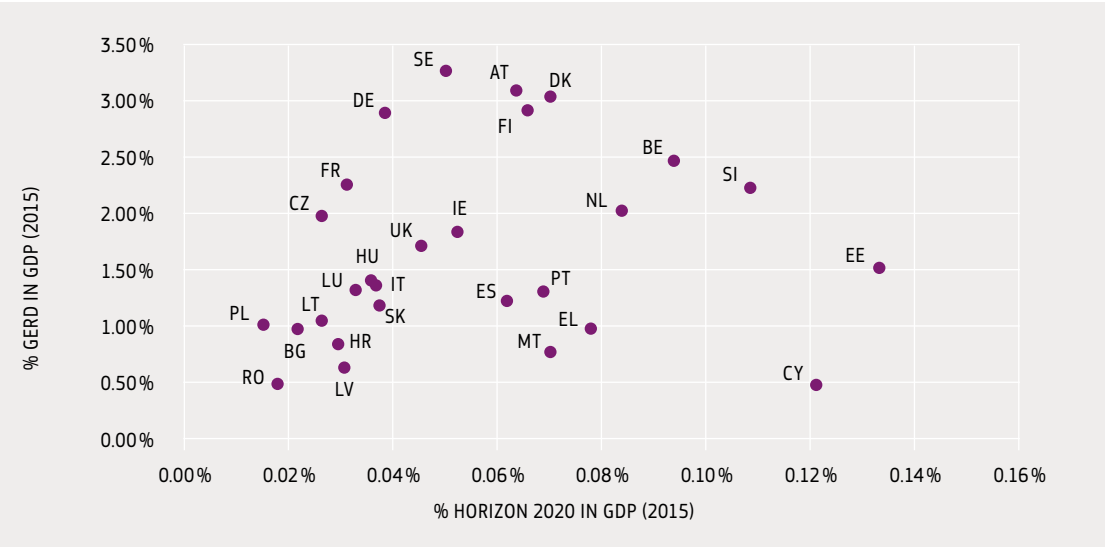
However, Horizon 2020's contributions to this target can only be limited given that, based on Eurostat statistics for 2015 and Horizon 20202's average annual allocations, the Horizon 2020 investment in 2015 represented less than 3 % of the overall R&D spending[255] in the EU and approximately 10 % of its public R&D allocations[256]. 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 its public and private investment in R&D by an additional EUR 150 billion per year. In addition, quantifying the contribution of Horizon 2020 to this indicator would require a further breakdown of programme spending between R&D and innovation, which is not available.

The figure below puts into perspective the direct Horizon 2020 contribution (excluding in-kind contribution and indirect leverage effect) as a 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 correlate directly to higher R&D intensity in Member States.

254 To measure the change in GBARD over the two 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 allocated to participants from each Member State under FP7 and the yearly average under Horizon 2020.

255 Gross Expenditures on Research and Development (GERD).
256 Government Budget Appropriations and Outlays on R&D (GBARD).

FIGURE 71A: 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 which is the Innovation Union. Horizon 2020 implements the Innovation Union by bringing together all existing EU R&I funding, providing support in a seamless way from idea to market, through streamlined funding instruments and simpler programme architecture and participation rules. The programme implements a number of the specific commitments made in the Innovation Union, notably: focusing on societal challenges, simplifying access, involving SMEs, strengthening the ERC, strengthening financial instruments, supporting public procurement of innovation, facilitating collaboration, and supporting research in public and social innovation.

In the context of the Innovation Union, the 2016 edition of the **Innovation Output Indicator**[257] **shows progress compared to the start of 2011 and the year before. On average, the indicator has progressed by about one percentage point per year during the reference period.** National performance varies significantly compared to the respective baselines. For this indicator, too, it is not possible to establish a clear correlation between Member State performance in terms of the Innovation Output Indicator and the share of Horizon 2020 funding in their GDP.

Having noted a definite shift towards innovation, Horizon 2020 has contributed significantly to this flagship. The Innovation Union was evaluated in 2015[258] to take stock of the progress and set out the 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. Commitments requiring greater Member State involvement appear to have progressed to a

257 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, and innovativeness of fast-growing enterprises).

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

FIGURE 71B: 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

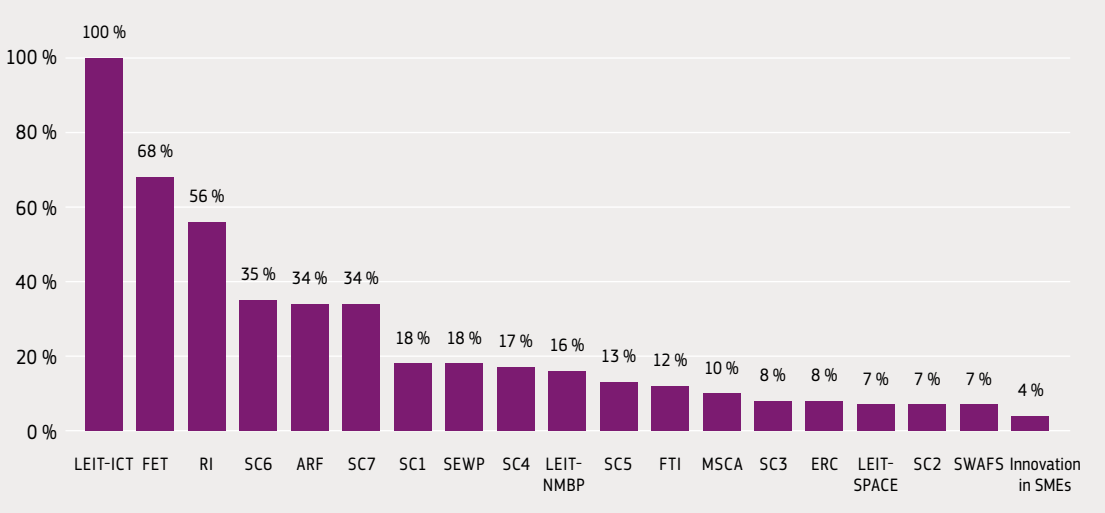
lesser extent, either because of the long legislative procedures (e.g. ratification of directives), or because they are less binding in nature.

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.

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[259], 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 to bring those technologies 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 spending related to digital R&I to be tracked throughout Horizon 2020. Preliminary data – based on an indicator[260] aimed at estimating the ICT component of projects – for calls up to January 2017 show that about EUR 5.3 billion (30 % of overall EC funding in Horizon 2020) are contributing to ICT R&I, thereby providing important input to the progress towards the Digital Single Market objectives. This budget goes beyond that allocated through dedicated topics to ICT and signals the cross-cutting nature of digital technologies and their societal relevance.

FIGURE 72: EC contribution to the Digital Agenda, share of EC contribution (%), by programme part



Source: Corda data, extraction 1 January 2017

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

260 '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 at 40 %, indicating that 40 % of the project budget contributes to ICT R&I. This indicator has been recently introduced and may be subject to further refinement.

8.2.3. PROGRESS ON DELIVERING CLOSE TO MARKET OUTPUTS AND DIFFUSING INNOVATION IN PRODUCTS, SERVICES AND PROCESSES

One key Horizon 2020 objective 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 projects completed and the review of a set of ongoing projects. However, there are also indications already 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

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, although but this could be reinforced further.** 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). Notably, Internet of Things (IoT) large-scale pilots launched in 2016 will make use of the portfolio of technologies and tools developed and demonstrated in reduced and controlled environments and extend them to real-life use case scenarios. The aim is to validate advanced IoT solutions across complete value chains with actual users and prove its enormous socio-economic potential.

Not surprisingly, given their shorter-term nature and their higher TRL, **to date, projects within the SME Instrument (phase 2) are producing 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 have introduced innovations new to the market and 3.0 % 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 beneficiaries. Positive effects were also created on 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, for example, fine-tuning the business plan, and better networking. **Phase 1 SME Instrument beneficiaries display a steeper growth path than unsuccessful applicants, also in their capacity to take a strategic approach to risk identification and management.** Other areas seeing major improvements were 'innovation project formulation', 'idea management and involvement of staff, clients, and suppliers in innovation' and the 'overall innovation strategy' (30 % of respondents).

LEIT projects are also on track to deliver innovations (output involves demonstrators, pilots, and advancing on the TRL scale) and bring clear market orientation. Nevertheless, with reference to the emphasis on higher TRLs, **experts raised some concerns on an apparent trend in reducing 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 are causing concern. Notwithstanding the impact orientation, for NMBP, there are concerns regarding the limitations on the lower TRLs (between blue sky research and TRL 3-4, e.g. FETs).

261 The remaining 5% of the projects are not classified.

FIGURE 73: Horizon 2020 KPIs related to proof-of-concept, demonstration and deployment

KPIS	PROGRESS SO FAR/TARGET
PROOF OF CONCEPT, DEMONSTRATION AND DEPLOYMENT[262]	
Within the innovation actions, share of EU financial contribution focused on demonstration and first-of-a-kind activities	86.5 % was focused on demonstration and 7.7 % on first-of-a-kind activity
No. of prototypes	229
No. of testing activities	801
No. of clinical trials	81
No. of projects with innovative products	160
No. of projects with innovative processes	73
No. of project with innovative methods	76
Number of participating firms introducing innovations new to the market ... (among these SMEs)	538 (299) Target: 50 % of participating SMEs introducing innovations new to the company or the market (project period plus three years) [263]
Number of participating firms introducing innovations new to the company ... (among these SMEs)	471 (251)

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

262 Based on survey of beneficiaries.
263 The remaining 5% of the projects are not classified.

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 % have 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 in recognition of its efforts to bring frontier research closer to the market[264].

LEIT ICT projects aim to translate R&I into commercially viable undertakings, thereby helping to bridge the gap between research and the market. Ongoing projects include demonstrating/piloting activities relating primarily 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[265], the majority of which are significantly improved products or new products which will be exploited either commercially (170 innovations) or internally by the organisations (61). For some (53), there are no plans for exploitation yet.

According to the **LEIT-NMBP** assessment, 75 % of the projects aim to develop a new product; 60 % a new process; 24 % a new service[266], 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 also include 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 on 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 European regions. 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 kilotonne 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, to protect EU borders. In so doing, it will prove its capability through live field trials under real conditions at different border control points.

264 http://www.eban.org/eban-winter-university-2015-in-copenhagen-highlights
265 Data up to July 2016.
266 Indicating that these will play a role in the current trend in European industry to introduce services.

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 the potentially ground-breaking impact of longer-term projects to be seized**.

Innovation actions belong to the key new actions introduced in Horizon 2020 to help bring 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 at the projects based on the proposal texts for 227 innovation actions, a study[267] identified three categories of projects:

- 'Pioneering' projects: scoring high on technological novelty, market scope and innovation readiness, but low on ecosystem embeddedness (64 out of 227 projects). They seem to focus on breakthrough technological results that may create markets. Pioneering projects involve relatively more private companies, especially 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 'innovative solutions in the ecosystem. Diffusing projects involve fewer 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, an 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, the majority of respondents consider their innovation project radical (60 %). However, the SME Instrument focuses in particular on product innovations[268], product performance innovations, and business model innovation. **Service innovations, network innovations, and customer engagement innovations receive less support**. The 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 %).

267 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 selected which 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.

268 Not normalised for a potential over-representation of successful applicants, which creates relatively high percentages.

THE OPEN DISRUPTIVE INNOVATION SCHEME UNDER THE SME INSTRUMENT [296]

The Open Disruptive Innovation (ODI) scheme is the most popular one 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. Applicants' most popular innovation fields 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 helped to develop business market strategy which supported the expansion their innovative product. Turnover has already increased slightly and the participants are expecting a gradual increase in the coming 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 puts forward an innovative device and mobile application designed to detect product freshness and the risk of food poisoning, became popular in Europe and in the US.

Project participants indicated that the ODI scheme helped their disruptive innovation to be developed further and expanded. In particular, phase I was considered as essential. It supported SMEs in gaining more knowledge and experience in entering new markets and further helped to build a contact network for new potential clients. Project participants indicated that throughout phase I they all established good networks in Europe. Overall, the scheme is highly selective with a funding rate of 5.3 % of 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 project end. Only a small number of projects received grants for phase II after the implementation of phase I.

Beyond the innovation actions in the cPPPs, the LEIT-NMBP portfolio also has a fair share of projects that are new to the world or at least to the EU (41 %), according to the coordinators. The remaining projects (59 %) are somewhat less novel, mainly a combination of existing technologies and their adaptation to another application area or sector, or to a company's specific production processes (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 on topics, or is inherent in the technology (e.g. nano-medicine, biotechnology). **The ambition towards 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 those led by a higher education institution or a research institute.**

In 2016, a Commission consultation (Call for Ideas[270]) 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**. They also think 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 yet to fully capture the potential of young, fast-growing firms.

269 Source: CARSA study.

270 https://ec.europa.eu/research/eic/pdf//eic_call_for_ideas-overview.pdf#view=fit&pagemode=none

INVOLVEMENT OF LEADING COMPANIES IN HORIZON 2020

Comparing various lists of innovative companies with Horizon 2020 participants, many of the top 'established' innovative companies take part, but – despite many positive examples, e.g. in the health sector[271] – **almost none of the young and fast-growing innovative companies take part in Horizon 2020**. Bigger companies and established innovators included in the European Patent Organisation's top 50 European Patents Applicants, the R&D Scoreboards, and Thomson Reuters top global innovators rankings are larger beneficiaries of Horizon 2020 funds than younger innovators from Wired Europe's hottest start-ups, Deloitte's fastest-growing European tech companies, Forbes' most innovative companies, and CB Insights' Unicorns list. Within the first rankings, only two have benefited from Horizon 2020 funding thus far. In addition, CB Insight's list of unicorns or young fast-growing companies reaching a capitalisation of US$1 billion indicates that 18 out of the 176 are EU-based, although no company in this list is currently benefiting from Horizon 2020. Along similar lines, only 12 % of the companies from MIT smartest companies and 3 % from 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 the potential to improve participants' competitive progress. The expected improvement mainly relates to access to new markets and the competitive position of partners internationally.** While it is too early to collect information on the growth of participating companies, early evidence from 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 achieve faster growth paths than in control groups and the scale-up of their activities is more likely and/or more significant**. Phase 2 beneficiaries which went through phase 1 report higher profitability, while phase 2 beneficiaries report stronger market presence, even at project implementation stage. The SME Instrument is used intensively by start-ups, especially phase 1 strand. The characteristics of phase 2, in terms of, for example, time-to-grant and cash flow, hinder the greater participation by 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 in 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[272] found evidence of the improved research capabilities and excellence of the FP7 research teams. According to the counter-factual analysis of FP7 survey data, the beneficiary teams grew by 24.4 % versus 12.6 % in the control group. **The estimated impact of EU FPs on the growth of the research teams is thus positive and amounts to 11.8 %.** Based on the counter-factual analysis of R&D budget data, it was further estimated that the beneficiary teams have 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 budget leverage created as the result of participating in EU FPs.**

271 In societal challenge 1 (SC1 - health), Horizon 2020 has funded two of the 11 top spin-off European healthcare companies which later became unicorns: Galapagos and Immunovia.

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

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.** To date, here is also no evidence available on approaches enabling identification of the dual-use potential of project results with a view to diversifying their market potential.

A study by the EIB on Access to Finance for KETs companies[273] shows that many KETs companies, especially small and middle-sized ones, struggle or fail to obtain adequate debt financing, thereby hampering their uptake of new technologies. Despite favourable market conditions, the banking sector does not meet the specific needs of many KETs companies because of a general aversion to risk, as well as a lack of knowledge concerning KETs sectors.

Of the public consultation respondents, 53 % think that Horizon 2020 is fully or to a large extent helping to foster European industrial leadership. Only 3.6 % feel this is not the case at all. The most positive respondents are businesses. If the programme's contribution 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 those 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) was implemented as a full-scale pilot in 2015 and 2016. It addresses industry-driven consortia seeking fast 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 of (re)shaping 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 at least doubled**[274]. Key aspects of the evaluation are summarised in the table below.

273 Available at: http://www.eib.org/attachments/documents/innovfin_access_to_finance_conditions_kets_en.pdf

274 '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.

FIGURE 74: Key findings from the Fast Track to Innovation pilot evaluation

	KEY FINDINGS OF THE EVALUATION OF THE FTI PILOT
Contribution to innovation	The FTI is highly relevant to Horizon 2020's broad policy goals 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 funded project coordinators 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 project coordinators are developing product innovations; process (29 %), service (21 %) and organisational (4 %) innovations are also supported. 89 % of project coordinators are convinced that successful completion of their projects will lead to global 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	In 2015, 75 % of all call beneficiaries were 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 for the 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 goes to companies numbering more than 1000 FTE – i.e. larger companies. Nevertheless, as part of the stakeholder consultation feeding into the assessment, some parties called for reconsideration of the intervention rate of 70 % – uniform across Horizon 2020 – for this type of entities, referring to the risk of dead-weight, 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 an understanding of the main areas of funded firms' commercial activity; 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 in FP7; this can be explained by the fact that the FTI – unlike the SME Instrument, for instance – targets consortia, which by definition requires connections and operational experience for their construction and administration to be successful.

KEY FINDINGS OF THE EVALUATION OF THE FTI PILOT	
Operational effectiveness and financing	Certain administrative requirements (in particular the need to comply with most of the standard features and templates for IAs) 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 at 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 a concern that projects are selected which have relatively mature innovation development and/or which lack adequate preparation and planning for the commercialisation process, pointing to a potential lack of commercial investment expertise at the evaluator level. To ensure the selection of more appropriate projects, clearer guidance on the role of TRL classification is recommended, together with more emphasis on business plan and market readiness during the appraisal process. In addition, there should be a review of the competencies of experts selected for appraisal, possibly linked to 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 %) were 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 well change as projects – which at best had been launched six months before the survey – progress along the innovation cycle. Follow-up interviews suggest that leveraging further investment is difficult. Most often, investors wait for 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 PROGRESS HAS BEEN 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 R&I efforts needed to achieve the Union's policy goals.

EXPECTATIONS FROM HORIZON 2020 FOR ACHIEVING SOCIETAL IMPACT

Whereas FP7 focused on specific domains, Horizon 2020 puts **more emphasis on societal impact** and aims to contribute through R&I to tackling the major societal challenges facing Europe and the world. 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 to tackle 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 of the FP7 Science in Society programme**, a dedicated programme part on 'science with and for society' is 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

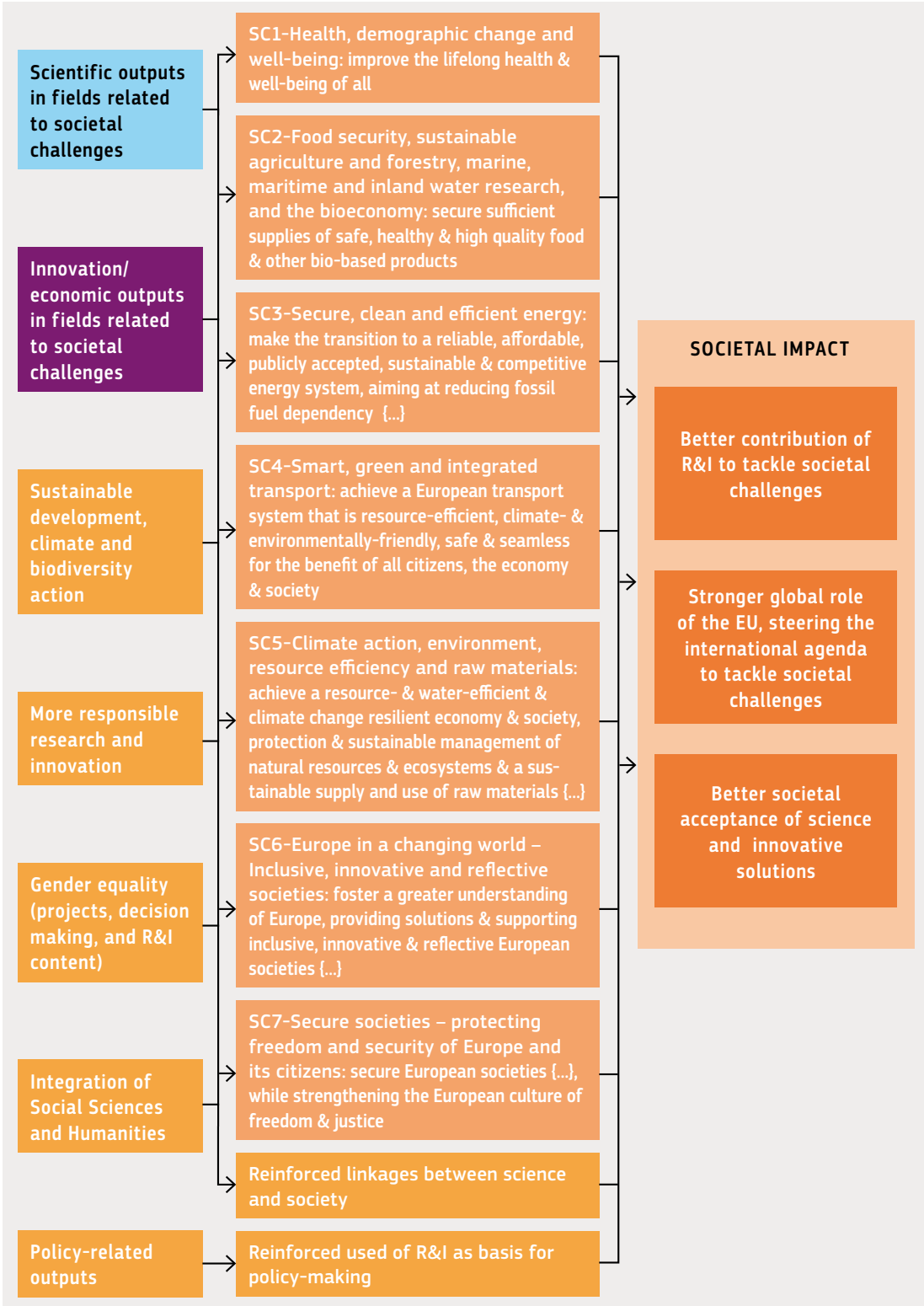
with social awareness and responsibility. In parallel, gender equality, responsible R&I, and social sciences and humanities have become cross-cutting issues promoted throughout the programme.

Figure 75 provides an overview of the approach used for analysing progress towards achieving societal impact. Horizon 2020's overall progress towards societal impacts relies, on the one hand, on the scientific and innovation/economic outputs/results/impacts (discussed above) in fields related to societal challenges and on more horizontal progress on cross-cutting issues supported across the programme. For example, these include sustainable development, climate and biodiversity action, more responsible R&I, gender equality, integration of social sciences and humanities (SSH) in R&I projects, and generating outputs for policy.

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.
- Thus far, the portfolio of Horizon 2020 projects selected under the societal challenges pillar and their progress are in line with the objectives set.
- Horizon 2020 projects already produce numerous results such as publications, patents, prototypes, products, processes and methods in societal relevance domains.
- 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 resolving societal challenges than in achieving 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 being 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 R&I in Horizon 2020, even if it is very uneven across the programme.

FIGURE 75: Approach to analysing progress towards societal impact



Source: European Commission

8.3.1. TACKLING SOCIETAL CHALLENGES

Horizon 2020 is supporting seven societal challenges (SC), as shown in Figure 74. To date, the societal challenges pillar has received 36.3 % of Horizon 2020 funding (EUR 7.4 billion), with the largest share going to the energy challenge (SC3 – 8.6 %), 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, for example, reducing CO_2 emissions, and improving citizens' health or security. No structured information has been collected on these so far, partly because of the difficulties in establishing direct links between individual project outcomes and long-term impacts, notably given the time needed for the impact to be observable and the previously discussed problems of attribution. However, further efforts should be made to identify whether projects under the societal challenges pillar are on track to deliver outputs/results/impacts of benefits for society beyond the more classical R&I indicators.

FIGURE 76 KPIs for the Horizon 2020 Societal Challenges pillar

	PUBLICATIONS IN PEER-REVIEWED JOURNALS	PATENT APPLICATIONS AND PATENTS AWARDED	NUMBER OF PROTOTYPES AND TESTING ACTIVITIES	NEW PRODUCTS, PROCESSES, AND METHODS LAUNCHED ON THE MARKET
Health, demographic change and wellbeing (SC1)	280	18 patent applications & 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 applications & 1 patent awarded	9	1
Secure, clean and efficient energy (SC3)	132	31 patent applications & 4 patents awarded	370	41
Smart, green and integrated transport (SC4)	62	11 patent applications & 4 patents awarded	30	13
Climate action, environment, resource efficiency and raw materials (SC5)	115	8 patent applications & 3 patents awarded	61	24
Europe in a changing world - inclusive, innovative and reflective societies (SC6)	21	0 patent applications & 0 patents awarded	1	2
Secure societies - protecting freedom and security of Europe and its citizens (SC7)	27	3 patent applications & 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 2941 projects selected under the societal challenges pillar have already generated **809 peer-reviewed publications, mainly from the health, food/bioeconomy, energy and environment domains.** Of the **76 patent applications and 23 patents already awarded to Horizon 2020 projects under this pillar**, the majority come from energy projects, followed by health and transport. In addition, more than half of **the 600 prototypes and testing activities already developed under Horizon 2020** come from energy projects, which have also made the strongest contribution to the **launch of 106 new products, processes and methods on the market**.

According to a survey of Horizon 2020 project coordinators, all projects supported under the societal challenges are expected to contribute to their specific challenges in the next 10 years (see Figure 76 below). **Projects under certain societal challenges (especially SC1 'Health') are challenge-specific, whereas those 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 indicate a 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 contributions to societal challenges expected from excellent science and industrial leadership projects is fairly evenly spread although some strong features are emerging:

- 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 an impact particularly on health and food, or bioeconomy issues (SC1 and SC2);
- LEIT-NMPB projects are expected to have particularly impacts on health and the environment/climate (SC1 and SC5). The PPPs under LEIT-NMPB are expected to have particularly impacts on energy and environment/climate (SC3 and SC5, related in particular 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, and the circular economy);
- LEIT-ICT projects are expected to have particular 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 notable impacts on transport (SC4) and security (SC7).

FIGURE 77: Do you expect your project to have a wider impact on any of these societal challenges in the next 10 years? 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=77)	52.0 %	21.5 %	32.2 %	34.5 %	30.0 %	55.8 %	38.5 %
LEIT-Space (n=6)	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 wellbeing (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, 2017

Figure 78 also shows more specific areas where impact is expected within the next 10 years in 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 was outlined in the survey questionnaire.

FIGURE 78: 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 AN 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

HORIZON 2020 SOCIETAL CHALLENGE	SPECIFIC CHALLENGES WITHIN THE SOCIETAL CHALLENGES	SHARE OF PROJECTS HAVING AN IMPACT ON THE SPECIFIC CHALLENGES
SC5: Climate action, environment, resource efficiency and raw materials	Reduction in greenhouse gas emissions	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, 2017

Respondents to the stakeholder consultation suggest that Horizon 2020 is helping less in addressing major societal challenges when compared to its other objectives, such as delivering on growth and jobs[275].

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).

275 A comparatively lower number of respondents agreed "fully" with the statements that were provided while more expressed their disagreement. Horizon 2020 scored higher when assessed on whether it is helping to foster 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 for all (SC1) (78 % agree to some extent, but 18 % also 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 with the majority noting that it needs to improve. Most of those commenting believe the current interpretation of programme impact is narrow and focused too much on the short term. Furthermore, a more 'sophisticated' approach should be adopted. Other stakeholders call for better monitoring of downstream impacts. A few NGOs in particular stressed the need for better impact measurements. 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 brief overview of progress is given 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 better health and quality of life for citizens, more sustainable health and care systems, and the opening up of new opportunities for jobs and growth in the sector. The only area where certain implementation difficulties have been 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 which can often be solved by extending the duration of a project. 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 %), '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 project abstracts, ICT projects under the excellent science pillar which relate to health issues indicate a 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), while 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 health-care systems. Health-care innovations and the cost-effectiveness of health systems and the development of related services play a prominent role. Among the ICT projects within societal challenges priority, the majority of keywords are also related to health aspects (patient and care, patient empowerment, health care and health monitoring), which also account for the highest number of projects. Under LEIT-NMBP, healthcare applications have been addressed in a set of calls and topics on biomaterials for health and nanomedicine. These activities have direct links to the personalised medicine activities 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.

IMMUNOVIA AB, A HORIZON 2020 HEALTH INNOVATION PROJECT ON THE EARLY DIAGNOSIS OF PANCREATIC CANCER

In 2014, Immunovia AB, a Swedish health company, received an SC1 SME Instrument Phase 2 grant for a project on the early diagnosis of pancreatic cancer. It has developed a method using a blood test to detect and diagnose pancreatic cancer earlier than competing methods, thereby increasing the chances of treating it. A world first in pancreatic cancer diagnostics, it could increase the overall five-year survival rate from 3-4 % to approximately 59 %. Thanks to EU-funding and the new capital injection, the company will now be able to commercialise it. In 2015, it had doubled its staff from 9 to 18 and developed sufficiently 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 1100 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 for entry in the market in US and EU."

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: EUR 4.2 million, EU contribution: EUR 4.2 million.

8.3.1.2. FOOD SECURITY, SUSTAINABLE AGRICULTURE AND FORESTRY, MARINE, MARITIME AND INLAND WATER RESEARCH, AND THE BIOECONOMY

From the thematic assessment of 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, and 29 % to empowering rural areas. In addition, the majority of SME phase I project proposals and reports mention several societal benefits which the innovation is expected to bring, such as improved welfare for consumers or producers (which generally involves reductions in costs, lower prices or higher product quality), improved food quality and food security, and greater resource efficiency. The expert group also analysed the impact on society the innovations explored in Phase 2 projects are expected to have if they are successfully commercialised. Most are expected to improve food quality (15 out of 26 projects) and food safety (14), followed by a reduction in air and soil pollution (12). Eleven projects envisage that their innovations will help increase the efficiency of water use society-wide. Improved energy efficiency is expected from eight innovation projects, with the same number tackling food waste along the value chain, while four expect to reduce food waste at source. Food security is expected to improve as a result of seven innovations receiving phase 2 support. Five projects stated their expected positive effect on preserving wild aquatic (4) and land (1) fauna, while the same number expected 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 four innovation projects, while three others expect to help improve work productivity.

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

COMPARE, A HORIZON 2020 FOOD SECURITY RESEARCH AND INNOVATION PROJECT ON THE DETECTION OF AND RESPONSE TO DISEASE OUTBREAKS

COMPARE is a large EU project designed 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 set up with the common vision to become: (a) the enabling analytical framework and globally linked data- and information-sharing platform system; and to provide for (b) 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. In spite of the quite high number of partners involved, the project is well organised and well managed. This is reflected in the rather numerous (49) published peer-review articles. In parallel, the project partners tend to establish a comprehensive database of protocols, information about reference genomes, etc.

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: EUR 20.85 million, EU contribution: EUR 20.82 million; 29 partners

8.3.1.3. SECURE, CLEAN AND EFFICIENT ENERGY

The current project portfolio represents only 25 % of the total available budget for Societal Challenge 3 'Secure, clean and efficient energy' (SC3). The portfolio covers a broad range of aspects within the area, is assessed in line with the area's scope and objectives specified in the legal base, and can be expected to contribute significantly 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 %), and 'Alternative fuels and mobile energy sources' (7.7 %). 'Robust decision-making and public engagement' and 'New knowledge and technologies' receive 2.4 % and 1.3 % of funding, respectively.

Energy-related keywords for ICT actions refer to the objectives of decreasing energy consumption in HPC, energy-efficient computing, energy harvesting and an 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).

STEELANOL, A HORIZON 2020 ENERGY RESEARCH AND INNOVATION PROJECT ON THE PRODUCTION OF BIOETHANOL FROM STEEL-MAKING PROCESS EMISSIONS

The project demonstrates the production of bioethanol from emissions from 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 tonnes/ethanol per year will be built in Belgium – the first of its kind in Europe and the largest facility built to date using this technology globally. The project consortium comprises five partners from four countries. This high-risk/high-impact project is expected to contribute to achieving the targets of the Paris Agreement and to advancing the circular economy.

Project title: STEELANOL[276] *'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: EUR 14.6 million, EU contribution: EUR 10.2 million*

8.3.1.4. SMART, GREEN AND INTEGRATED TRANSPORT

According to the thematic assessment of Societal Challenge 4 'Smart, green and integrated transport' (SC4), the programme is on track to reach its specific objectives. Analysis of the first two SC4 WPs (without the SME Instrument and JU), covering the period 2014-2017, shows that all main activity areas are being addressed. An assessment of the funded project portfolio shows that funded R&I activities are progressing towards providing the required impacts. The 'Resource efficient transport that respects the environment' activity area appears to have been more extensively covered to date (55.9 % of funds from the first two WP) – in line with the specific objective of a sustainable transport system. Significant parts of the specific programme content are also addressed through other implementation instruments beyond the WP calls, notably the JUs. Therefore, some topics, which appear to be covered in a rather limited way in the WPs, are addressed in a significant way through these instruments. Compared to FP7, Horizon 2020 project coordinators have higher expectations regarding their projects' ability to address long-term goals in transport. Over 80 % of the Horizon 2020 SC4 project coordinators surveyed estimated that their project results, if implemented, would contribute to the competitiveness of the EU transport industry, while just under 80 % expect to contribute to decarbonising and 'greening' the transport system, as well as increasing its efficiency.

Transport applications have also been addressed under LEIT-NMBP through contributions to the Electric Green Vehicles cPPP (EGVI), covering lightweight materials and next-generation batteries.

PROSPECT, A HORIZON 2020 TRANSPORT RESEARCH AND INNOVATION PROJECT ON CASUALTY REDUCTION

Although road safety has improved in recent years, accidents are still 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, representing the largest shares of road fatalities, PROSPECT aims to significantly improve 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 WP.

Project title: PROSPECT[277] *: 'PROactive Safety for PEdestrians and CyclisTs'; Research and Innovation Action; May 2015-October 2018; Total cost: EUR 6.9 million, EC contribution: EUR 6.9 million*

276 http://www.steelanol.eu/en

277 http://cordis.europa.eu/project/rcn/193275_en.html

8.3.1.5. CLIMATE ACTION, ENVIRONMENT, RESOURCE EFFICIENCY AND RAW MATERIALS

Since all the ongoing projects under Societal Challenge 5 'Climate action, environment, resource efficiency and raw materials' (SC5) are in their initial phases, there are few available data on outputs. Consequently, it is still too early to assess the actual effectiveness of the SC5 WPs. However, it is evident that SC5 has made a difference. So far, it has changed traditional R&I approaches, creating 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 largest share of the funding allocated to date has gone 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 the sustainable supply of non-energy and non-agricultural raw materials' (20.9 %), 'Fighting and adapting to climate change' (19.9 %), and 'Developing comprehensive and sustained global environmental observation and information systems' (10.9 %). Cultural heritage received 2 % of the funding (three projects).

Under LEIT-NMBP, climate action, resource efficiency and the circular economy are addressed in the cPPPs on energy-efficient buildings (EeB), on sustainable process industries (SPIRE) and on Factories of the Future (FoF). This involves decarbonisation through energy efficiency and, in the case of SPIRE, also concerns direct reductions of greenhouse gas emissions in process industries, the reuse 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 focusing on EGNSS and Copernicus, it is considered that earth observation addresses the environmental challenge.

The results of tracking **Horizon 2020 expenditure for sustainable development and climate change** show that for the first years of Horizon 2020 activity, the sums spent have fallen behind the expected expenditure for these objectives as of 1 January 2017. For climate action, expenditure was 27 % compared to a target of 35 % applicable to the whole period of Horizon 2020, and for sustainable development it was 53.3 % versus a target of 60 %. However, compared to FP7, the programme represents a considerable increase in research in those areas. 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 have identified that the main difficulty in reaching the expected investments are 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 requires further optimisation and fine-tuning. In particular, 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.

POWERSTEP, A HORIZON 2020 RESOURCE-EFFICIENCY R&I PROJECT ON CONVERTING SEWAGE-TREATMENT PLANTS INTO POWER-PRODUCTION FACILITIES

The project aims to convert sewage-treatment plants (STEPs) into power-production facilities (POWER). To achieve this, the partners will design and demonstrate energy-positive waste-water treatment plants with the available technologies in six full-scale case studies located in four European countries. The estimated benefits are energy savings: EUR 1.7 billion per year; CO_2 - equivalent emission savings: 5.9 million tonnes; and global market value: EUR 30 billion per year.

Project title: POWERSTEP 'Full scale demonstration of energy positive sewage treatment plant concepts towards market penetration'; Innovation Action; Total cost: EUR 5.2 million, EC contribution: EUR 4 million; 12 partners

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 at an early stage. A sample comprising 56 Horizon 2020 SC6 projects funded under the WP 2014-2015 was analysed for the SC6 thematic assessment. They were assessed on their expected response to the societal challenge and there have already been first publications in highly ranked scientific journals. Around 50 % of the projects have already developed or are expected to develop datasets/databases. Others will produce simulation tools and other technological devices aimed at fostering access to information and providing evidence for better policy decision-making: 91.3 % of the projects are aiming to make political recommendations based on the scientific evidence gathered, and 65.2 % are work to make an impact on the formulation of new policies. This has fostered a culture of multi-disciplinary collaboration and 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 related to society and inclusion, especially under LEIT-ICT where the main keywords mentioned are the participation of citizens and communities, usability, trust, networking, empowering and co-design. Keywords appearing in some ICT projects under excellent science relate to citizen participation, citizen engagement and co-design.

QUINNE, A HORIZON 2020 INCLUSIVE SOCIETIES RESEARCH AND INNOVATION PROJECT ON THE INTERACTION BETWEEN INNOVATION AND EMPLOYMENT

The QUINNE project also addresses the topic of EURO-2-2014: The European Growth Agenda. The project investigates how job quality and innovation mutually impact each other at the organisation 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[278].

Project title: QUINNE - 'Quality of jobs and Innovation generated Employment outcomes'; Research and Innovation Action; April 2015-March 2018; Total cost: EUR 2.5 million, EU contribution: EUR 2.5 million

278 QUINNE website: http://bryder.nu

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 the project coordinators who 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 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; it would appear that some project outputs are already being used by end-users.

To date, the largest share of funding has been allocated 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 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 4 % and 3.8 % of funding, respectively.

Many ICT projects are also related to security with the main keywords including privacy, safety, cyber-security, resilience and cloud security.

DARWIN, A HORIZON 2020 SECURITY RESEARCH AND INNOVATION PROJECT ON CRISIS RESPONSE

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 just one year, DARWIN has achieved promising results, including: i) definition of the catalogue of resilience concepts and requirements for developing the ERMG; ii) launch of the Community of Resilience and Crisis Practitioners; and iii) presenting the initial evaluation plan for the pilots. The guidelines will be user-friendly and presented in formats for easy use and maintenance. Furthermore, the project is exploring innovative tools, such as serious gaming and training packages, to facilitate adoption of the ERMG. DARWIN's target beneficiaries are infrastructure operators: service providers and related stakeholders who are responsible for critical infrastructures that might be affected by a crisis, as well as the public and media.

Project title: DARWIN[279]: 'Expecting the unexpected and know how to respond'; Research and Innovation Action; 1 June 2015-31 May 2018; Total cost: EUR 5 million, EU contribution: EUR 5 million

279 http://www.h2020darwin.eu/

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) is implementing a set of activities to build effective cooperation between science and society[280]. A review of the projects selected so far indicates that **progress is in line with expectations**, although data on the SWAFS KPI ('number of institutional changes') will only become available when projects end[281].

However, the SWAFS thematic assessment highlights 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, in particular in actually 'doing R&I' (for instance, in citizen science activities). Also, while institutional change is clearly defined along gender equality lines (as an ERA priority) it should be further operationalised for the other lines, and the focus should be on the 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[282] and 36.7 % in evaluation panels.** In addition, in December 2016, 6022 experts, 3904 women and 2118 men declared in the EC expert database that they have a gender expertise.

Concerning the workforce, **women represent 31 % of project coordinators**, including 24.5 % of ERC Principal Investigators, 42.2 % of MSCA Fellows and 26.9 % of scientific coordinators in other Horizon 2020 activities. These figures are higher compared to FP7 where, overall, women represented 28.5 % of project coordinators, 20 % of ERC Principal Investigators, 36.5 % of MSCA Fellows and 20 % of contacts for scientific aspects in other FP7 activities.

As regards the integration of gender into R&I content, gender-flagged topics increased from 99 among 610 topics in WP 2014-2015 to 108 of 568 topics in WP 2016-2017[283]. The wording of topics is often generic. At the level of projects, 32.4 % of them[284] were identified by projects officers[285] as having a gender dimension. However, it appeared that **this indicator is not reliable yet as it is not sufficiently understood what the gender dimension comprises.** The qualitative analysis of a subset of 111 projects from gender-flagged topics showed the 53 % included the gender dimension either well or in part. The notion does not seem to be well understood and is often confused

280 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; pro-mote 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.

281 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.

282 in FP7 33% of the members of the advisory groups were women.

283 At the level of the adoption of WPs – not taking into account the possible amendments.

284 The indicator does not include MSCA and ERC.

285 Who checked at the level of the Description of Activities annexed to the grant agreement when preparing grant agreements.

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), implying 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[286]. SC6 and its calls and topics attract many of the SSH disciplines. In the 2014-15 WP, 37 % of the topics have been identified as relevant for SSH researchers, and 41 % in the WP 2016-2017. **The quality of SSH integration is highly uneven across projects. However, 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 under-represented, 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 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 five to six Member States.

> *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, until now there have been no strict consequences if these topics are not carefully attended, which means a lack of liability and a lack of sustainability. Integrating the gender dimension in science and research means improved excel-lence.*
>
> Belgium, European Platform of Women Scientists

Of the respondents to the stakeholder consultation, 70.1 % agreed fully or to a large extent that Horizon 2020 is helping to support science with and for society, 21.4 % agreed to some extent, and 3.3 % not at all. The most positive respondents are businesses and research organisations, whereas the least positive are NGOs and public authorities.

286 European Commission, SSH monitoring report 2014 and 2015

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) as well as via 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 policymaking[287]. 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 to foster excellence through internal quality control and external peer-review, evaluation and benchmarking, whilst 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, as far as 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 JRC's research results have provided support to policymaking under Commission priorities; this included areas of high political activity, such as the Energy Union, sensitive issues like the regulatory framework for emissions from road vehicles, areas where the EU has taken a global leadership (such as negotiations on climate change), or pressing issues like the Economic and Monetary Union. JRC has also started to focus increasingly on pressing issues such as security and migration, and on supporting regional economic development. DG REGIO established the S3 Platform[288] jointly with the JRC to support 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 of this platform.

In 2013, the Board of Governors commended the JRC's internal review processes in a special report[289]. During the first years of Horizon 2020, a total of 350 occurrences of tangible specific impacts on European policies have been 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[290]. **More than 16 % of the JRC's peer-reviewed publications are among the world's highly-cited publications[291], confirming that JRC scientific publications have an impact in the international scientific community[292].**

287 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).

288 http://s3platform.jrc.ec.europa.eu/

289 Impact analysis of JRC activities - Special report for the 100th meeting of the Board of Governors, (2013).

290 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.

291 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.

292 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.

Science for policy is also generated through the Projects for Policy (P4P) initiative, which aims to identify portfolios of projects linked to different thematic areas in both FP7 and Horizon 2020 in order to develop recommendations arising from the results of funded projects. For instance, a portfolio analysis of 135 projects on efficient and sustainable batteries has shown an 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 improve 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 introduce new knowledge on understanding 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 health care have been delivered in terms of clinical guidelines for the diagnosis and treatment of rare diseases. Projects also provide tools for the 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. In this way, they strengthen the evidence base for future policy decisions regarding the regulatory pathway and access to new interventions.

Of the public consultation respondents, 87 % (3018) agreed, at least to some extent, that Horizon 2020 helps to develop and implement EU policies, although a comparatively low number of respondents (18 %) agreed "fully" with this statement, which is far fewer than those who did so for the programme's contribution 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 fostering the EU's role as a stronger global actor (92 %).**

EXAMPLES OF INITIATIVES OF SCIENCE FOR POLICY ACROSS HORIZON 2020

The **ERC** has supported some of the world's leading economists, including the Nobel Prizewinners Jean Tirole, Christopher Pissarides, James Heckman, Thomas Piketty and Hélène Rey.

The **MSCA** have launched a pilot society and enterprise 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 and 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 bio-monitoring in Europe and will thereby provide better evidence of the actual exposure of citizens to chemicals and the possible health effects to support policymaking.

SC3 has been supporting projects which influence policymaking, notably related to energy issues, at local, national and EU level. For example, the project AURES (CSA) aims to support policymakers 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 policymakers and market participants to make informed decisions when dealing with renewable support policies.

The **SC4** project Lowbrasys[293] is tackling for the first time the issue of particle emissions from brake pads and discs, starting from understanding their generation and effects to methods for their measurement and reduction. Thus, it is supporting the work of the Commission DGs involved in road emissions regulation and providing input to the United Nations Particle Measurement Programme Working Group by assessing the situation and developing legislation.

Under **SC6**, all the reviewed projects consider the relevance of their outcomes as providing 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 ongoing projects have already posted policy briefs in their web pages. Collaborations with policymakers at both national and EU level are described in most of the approved projects. For example, the Action Plan on the integration of Third Country nationals[294] takes into account recommendations from the migration policy review of projects under FP7 and SC6.

293 http://www.lowbrasys.eu/
294 COM(2016) 377 final

8.4. WHAT IS THE OVERALL PROGRESS OF HORIZON 2020 TOWARDS ITS GENERAL OBJECTIVE?

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 Juncker Commission priorities.
- 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 is contributing to achieving a Digital Single Market.
- Horizon 2020 is contributing to improved resource efficiency.
- Horizon 2020 is reinforcing the European Research Area.

By pursuing its general objective of building a society and an economy based on knowledge and innovation – and 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 to achieving the Juncker Commission priorities.

As highlighted above, 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 the KPIs set to measure progress against the general objective (the target of 3 % of GDP invested in R&D, 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[295]. Macro-econometric simulations were carried out using part real data on the actual allocation of Horizon 2020 funds during the first years and part 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 not have been implemented. The impact follows three main phases. In the first phase (maturation) up to 2023, there are only a few innovations and the increase in GDP is mainly the result of the demand created by investments in R&D via Horizon 2020. The recruitment of research personnel increases real

295 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 kept in mind that the benefits arising from Horizon 2020 are numerous and go far beyond a strict quantification in monetary terms.

STRENGTHS AND LIMITATIONS OF THE NEMESIS MODEL

NEMESIS is a macroeconometric 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 macroeconomic models for R&D and innovation policies (QUEST, RHOMOLO, GEM-E3). Process and product innovations are generated in each sector, 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 from 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 NEMESIS' strengths justify its relevance for measuring the impact of R&I policies, the model's specificities and approach also imply a number of limitations to be taken into account when interpreting the model's results. First, it relies on the empirical observation of relationships and allows for flexibility in behavioural functions, which may generate inconsistencies among the most recent developments in macroeconomic 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 that with investments in the educational system.

wages as well as final consumption. The inflationary pressures harm competitiveness while increased demand raises imports. After 2020, the reduced EU contribution pushes down the GDP gains. During the second phase (innovation) up to 2030, the arrival of process and product innovations increases internal and external demand. Gradually, external demand becomes 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 reference scenario GDP in 2030. During the third phase (maturity and obsolescence), the gradual obsolescence of new knowledge progressively cancels GDP gains.

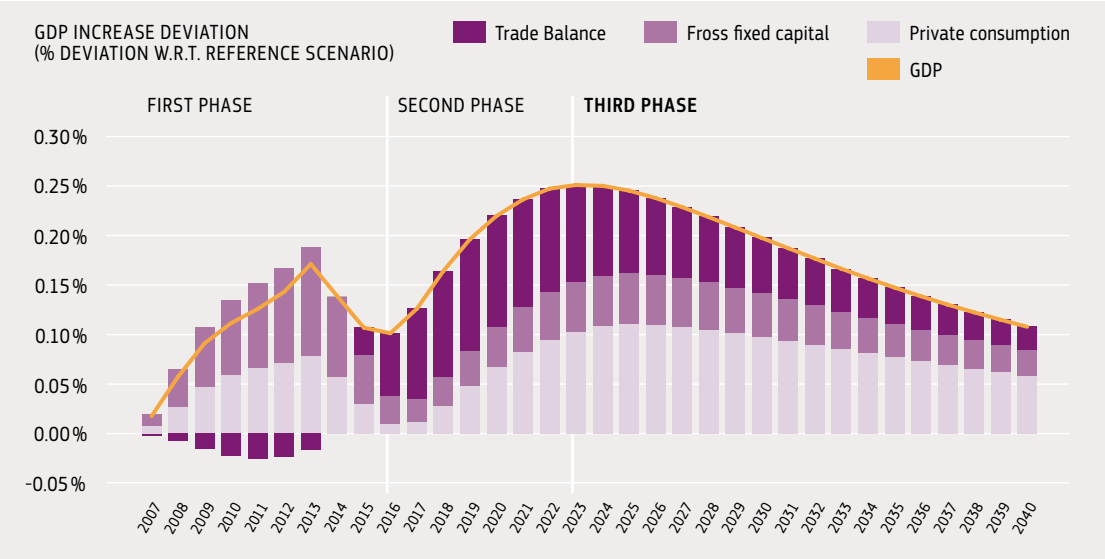
On average, the GDP gain is estimated to total between EUR 24 billion and EUR 35 billion per year (in 2014 prices) during 2014-2030. Over the same period of 17 years, the total GDP gain is between EUR 400 billion and EUR 600 billion: each EUR of Horizon 2020 investment brings a GDP increase of between 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 addedvalues (between 15 and 21 %[297]) and is better in terms of attracting additional funding (direct leverage of up to EUR 0.40 for each EUR invested)[298] compared to national programmes. These ranges are, nonetheless, based on sensitivity analysis considering both 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.

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.

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

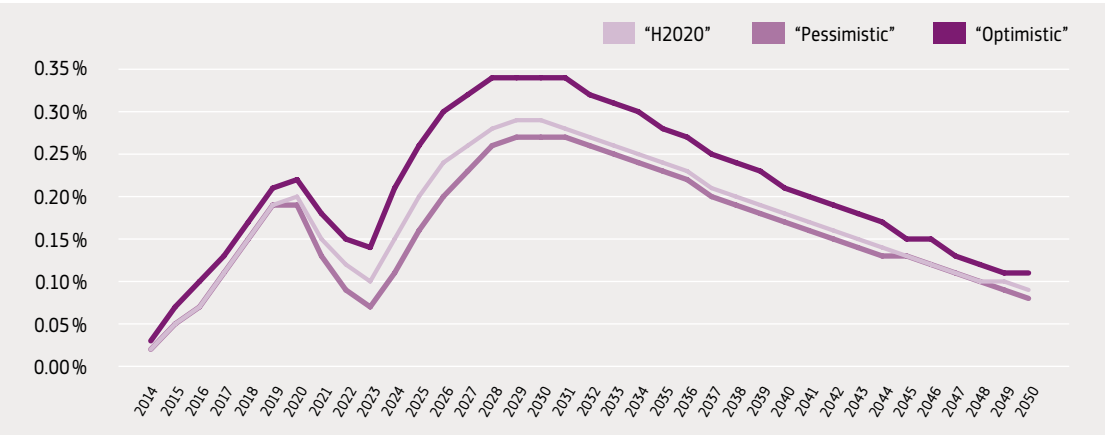
298 Calculated on estimations of total costs of Horizon 2020 projects, based on real data from Corda combined with a methodology for the estimation of real indirect costs.

FIGURE 79: The economic impact of Horizon 2020 funding for research on EU-28 GDP (in % deviation from reference scenario)



Source: PPMI based on NEMESIS model results

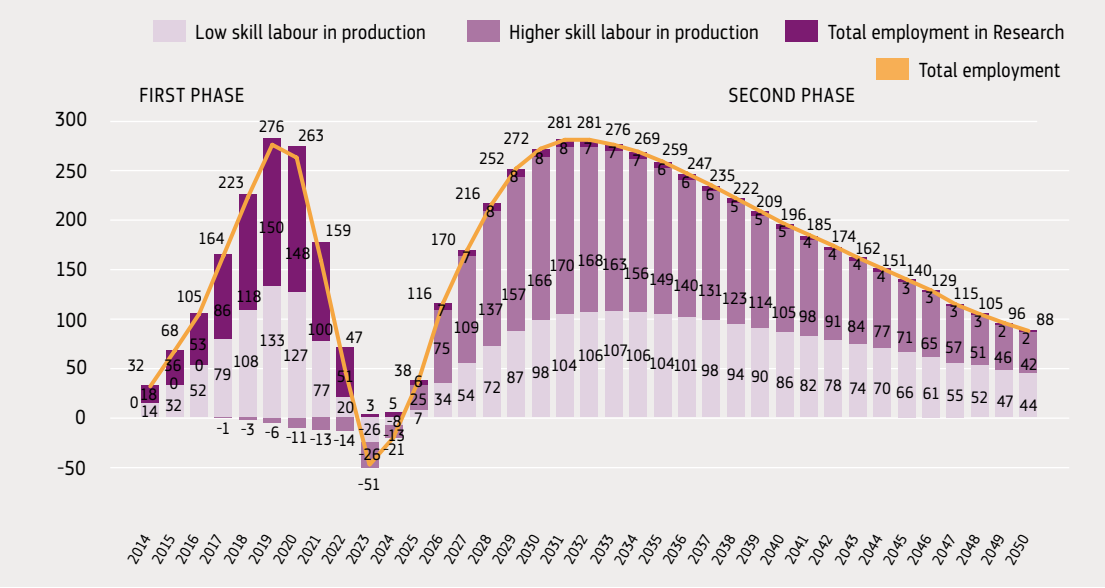
FIGURE 80: Sensitivity analysis of EU GDP gains from Horizon 2020 (in % deviation from reference scenario)



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 significantly increases 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 are in research sector). Once the Horizon 2020 funding starts to decline – i.e. beyond 2020 – employment in research falls close to zero. Innovations are not yet sufficiently numerous to vigorously push up the demand for goods and services, while the inflationary pressures in the first period continue to lower exports, resulting in a fall in total employment even below the reference scenario (-51 000 in 2023). In the second phase, innovation enters the market and boosts employment creation. In 2030, employment would reach 272 000 jobs more than in the reference

FIGURE 81: Impact of Horizon 2020 on total employment in thousands (difference from reference scenario)



Source: PPMI based on NEMESIS model results

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.**

There are many additional findings in the study: **in 2030, the internal rate of return[299] of the Horizon 2020 contribution would amount to between 26 % and 37 %; the investments in research stimulated by Horizon 2020 would increase labour productivity by between 0.16 and 0.20 %; Horizon 2020's 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 energy-related CO_2 emissions would be reduced by 0.2 %.** Under similar conditions, estimated GDP gains and estimated job creation in 2030 are, respectively, 34 % lower and 35 % lower compared to those predicted in the *ex-ante* impact assessment[300]. These discrepancies seem mainly related to the size of the budget input in the NEMESIS model[301] and to the assumptions made for the direct crowding-in[302].

299 The internal rate of return was calculated as the actualisation rate that equates the actualised sum of GDP gains to the actualised sum of the Horizon 2020 contribution. It increases slightly over time as annual GDP gains stay positive in most countries up to 2050 while the 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).

300 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 annually by EUR 450 million after 2020.

301 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 EUR 246 billion for the ex-ante Impact Assessment to EUR 217 billion for the Interim Evaluation – a difference of 12 % in budget size.

302 In the *ex-ante* Impact Assessment, the crowding-in effect was assumed to equal on average 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 was set at EUR 0.24.

FIGURE 82: Estimated revenue generated from the main innovations of FP-funded research teams

	REVENUE GENERATED FROM THE MAIN INNOVATION IN 2015 (EUR)			EXPECTED REVENUE DURING THE NEXT 3 YEARS (EUR)
	SHARE OF PROJECTS WHOSE MAIN INNOVATION HAS THIS REVENUE	TOTAL REVENUE GENERATED (EUR)	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

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 is 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.

Almost all the stakeholder consultation respondents agreed (at least to some extent) that Horizon 2020 is contributing to supporting jobs, growth and investments (94.5 %).

Among the stakeholder consultation respondents, 62 % 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. 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 come from umbrella organisations representing research organisations and NGOs. **74 % agree (at least to some extent) that Horizon 2020 is contributing to achieving a more in-depth and fairer internal market with a strengthened industrial base**, **72 % to promoting an Energy Union with a forward-looking climate policy** (25.3 % do not share this vision, which is the priority with the highest share of complete disagreement), and **66 % to helping to create a Digital Single Market** (29.4 % of respondents do not 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 a lack of indicators to track progress across all objectives, Horizon 2020 is on track to achieve its specific objectives – strengthening the science base, tackling insufficient technological leadership and innovation capability in the private sector, and addressing the insufficient contribution

of R&I to tackling societal challenges. Thereby, it is contributing to achieving its **general objective** – building a society and economy based on knowledge and innovation across the Union while playing a role in reinforcing the ERA and implementation of the Europe 2020 Strategy.

It is already strengthening 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, interdisciplinary, intra- and extra-European R&I networks. So far, 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 the KPIs 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 long term, which is projected to peak towards the end of the next decade, when new product and process innovations enter the market.

More specifically, with its focus on excellence, Horizon 2020 is on track towards achieving **scientific impact** by reinforcing R&I capacities, integrating R&I efforts, and its contribution to the achievement and reinforcement of the ERA. 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 increasing the knowledge base with shared distribution and access to data, materials and tools 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), although 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 is fostering 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 R&I 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, services, although these are becoming increasingly linked to manufacturing. Single-beneficiary projects have been quicker than collaborative projects to apply for IPR. However, a number of potential barriers 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: technology, regulation, standards, access to finance and the 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 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 focused on specific domains, Horizon 2020 puts more emphasis on **societal impact** and aims to contribute through R&I 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 relevant to society. The portfolio of projects selected and their progress are in line with the objectives set. Notably, most Horizon 2020 projects are expected to generate cross-cutting impacts, including from the excellent science and industrial leadership pillars, generating key discoveries and technologies. In terms of achieving the objectives set, stakeholders believe Horizon 2020 is helping relatively less well 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 is falling behind the expenditure target, mainly due to the bottom-up (hence unpredictable) parts of Horizon 2020 and methodological problems, which are being addressed. However, 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 there are some concerns about data quality. 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 KPI (number of institutional changes), and the under-representation of some parts of society (particularly private companies and other types of organisations) in the actions funded.

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 identifying 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 in the number of programme pillars and funding schemes is expected to facilitate the gearing of all programme components towards achieving the objectives.

KEY FINDINGS ON THE INTERNAL AND EXTERNAL COHERENCE OF HORIZON 2020

- The integration of R&I, the three-pillar structure, the challenge-based approach, and the use of focus areas are contributing to the internal coherence of Horizon 2020 compared to FP7.
- Outside the 'excellent science' pillar, Horizon 2020 is increasingly focused on R&I at higher TRLs. It should be ensured that this does not come at the expense of lower TRL collaborative research, which is regarded as a key source of future breakthrough innovations in line with societal needs.
- The large number of European R&I funding instruments is difficult for potential applicants 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.
- 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 also 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 out that **the integration of R&I into a single programme, the structuring around three pillars and a set of challenges rather than thematic domains have improved the programme's overall coherence compared to FP7**.

Figure 83 provides a quick overview of the different approaches pursued under each pillar and the main target groups.

The internal coherence at programming level is also regarded as being 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[306]. Focus areas were introduced whereby 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 greater impacts through stronger integration across different Horizon 2020 parts. And in particular, between the societal challenges and Leading Enabling and Industrial Technologies (LEITs) to add coherence to the programme and avoid silos. These interdisciplinary solutions are expected to cut across multiple specific objectives, ensuring both coherence and increased cost-efficiency. So far, 21 focus areas have been identified (12 in the 2014-2015 WP and 9 in 2016-2017 WP). The choice of focus areas was made according to the EU's key priorities and setting these against the R&I activities which could meet these needs.

FIGURE 83: 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[303]	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[304]	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[305]	Top-down (priority-based) Collaborative projects (+SME Instrument)	Scientific community, businesses & society

Source: European Commission

303 Based on Horizon 2020 Specific Programme.
304 Recital 9, Horizon 2020 Specific Programme.
305 Annex I, Part III, Societal Challenges, Horizon 2020 Regulation.

306 For example, the survey among project coordinators in SC4 found strong evidence (85 % agreement overall) of projects simultaneously tackling several challenges and giving rise to new competitive businesses and industries (e.g. contribution to lower CO2 emissions, improved marine environment, while creating greater competitiveness in the European paint industry). See more in-depth analysis in Section 8.3.1.

FIGURE 84: Contribution of Horizon 2020 programme parts to focus areas in WP 2014-2015 and 2016-2017

WORK PROGRAMME 2014-2015		WORK PROGRAMME 2016-2017
Sustainable food security: EUR 251.5 million Contributors: SC2: EUR 251.5 million	→	**Sustainable food security – Resilient and resource-efficient value chains: EUR 431.5 million** Contributors: SC1: EUR 1092.8 million and SC2: EUR 5.0 million
Energy Efficiency: EUR 198.2 million Contributors: SC3: EUR 193.2 million and SC5: EUR 5.0 million	→	**Energy Efficiency: EUR 194 million** Contributors: SC3: EUR 194 million
Digital security: EUR 97.3 million Contributors: SC7: EUR 97.3 million	→	**Digital security: EUR 118.0 million** Contributors: SC7: EUR 65.0 million, LEIT-ICT: EUR 42.0 million and SC1: EUR 11.0 million
Blue growth: unlocking the potential of seas and oceans: EUR 144.0 million Contributors: SC2: EUR 84.0 million, SC3: 3.0 million, SC4: EUR 19.0 million and SC5: EUR 38 million.	→	**Blue growth: unlocking the potential of seas and oceans: EUR 129.0 million** Contributors: SC2: EUR 68.0 million, SC3: 2.0 million, SC4: EUR 17.0 million SC5: EUR 40.0 million and LEIT-NMBP: EUR 2.0 million
Competitive low-carbon energy: EUR 742.9 million Contributors: SC3: EUR 742.9 million.	→	**Competitive low-carbon energy: EUR 723.3 million** Contributors: SC3: EUR 717.3 million and SC5: EUR 6.0 million
Smart cities and communities: EUR 199.5 million Contributors: SC3: EUR 159.5 million and SC4: EUR 40.0 million		**NEW: Internet of Things: EUR 139.0 million** Contributors: LEIT-ICT: EUR 114.0 million, SC2: EUR 15.0 million and SC1: EUR 10.0 million.
Mobility for growth: EUR 558.5 million Contributors: SC4: EUR 558.5 million		**NEW: Smart and Sustainable Cities: EUR 231.5 million** Contributors: SC3: EUR 231LEIT-ICT: EUR 114.0 million, SC2: EUR 15.0 million and SC1: EUR 10.0 million.
Waste: a resource to recycle, reuse and recover raw materials : EUR 131.0 million Contributors: SC5: EUR 103.0 million, LEIT-NMBP: EUR 5 million and SC2: EUR 23.0 million		**NEW: Industry 2020 in the Circular Economy: EUR 669.5 million** Contributors: LEIT-NMBP: EUR 396.0 million, SC2: EUR 3.0 million, SC5: EUR 154.5 million and LEIT-ICT: EUR 116.0 million
Overcoming the crisis: new ideas, strategies and governance structures for Europe: EUR 163.0 million Contributors: SC5: EUR 160.0 million and SC2: EUR 3.0 million		**NEW: Automated Road Transport – The New Frontier** Contributors: SC4: EUR114.0 million
Disaster-resilience: safeguarding and securing society, including adapting to climate change : EUR 170.1 million Contributors: SC7: EUR 124.1 million and SC5: EUR 46.0 million		
Personalising health and care: EUR 1097.8 million Contributors: SC1: EUR 1092.8 million and SC2: EUR 5.0 million		
TOTAL: EUR 3 806.8million		**TOTAL: EUR 2 749.8 million**

Source: European Commission, DG RTD, based on Horizon 2020 Work Programmes

STAKEHOLDER POSITION PAPERS

THE CURRENT PILLAR STRUCTURE IMPROVES THE PROGRAMME'S CLARITY 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, seeing it as a pragmatic and easy way to clarify the goals of different programme priorities.
However, others pointed out that the coherence and linkages between activities and projects under the three pillars should be strengthened. In particular, they mentioned the need for better links between the excellent research supported under pillar 1 and topics in pillars 2 and 3. To enhance such linkages, one academia representative, for instance, suggested extending 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 in particular hampers the FET projects (more fundamental research) from being 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 the WP should ensure and enable cross-pillar innovation by, for example, giving 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 to the overall complexity of the EU R&I support landscape. With reference to Horizon 2020, the three pillars alone comprise 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), and 10 Contractual Public Private Partnerships (cPPPs). Outside Horizon 2020 but providing inputs to its strategic programming, there are also five European Innovation Partnerships (EIP)[307] and 42 European Technology Platforms (ETPs)[308]. In addition, the COSME programme is supporting SMEs, the COST actions support international research actions, and EU programmes such as LIFE+ and European Structural and Investment 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 the EU level. Stakeholder consultation respondents also suggest that the funding architecture is too complex and may hinder organisations trying to identify the calls and instruments that best fit their needs, and increase the risk of duplication.

To ensure coherence between the different specific objectives and programme parts and to mitigate the risk of overlaps, different internal coordination mechanisms were put in place across Horizon 2020 at the programming and implementation level. These include: regular meetings of services interested in a given area; inter-service groups and consultations on the WPs; *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.

307 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.
308 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.

EXAMPLES OF COHERENCE BETWEEN HORIZON 2020 PROGRAMME PARTS

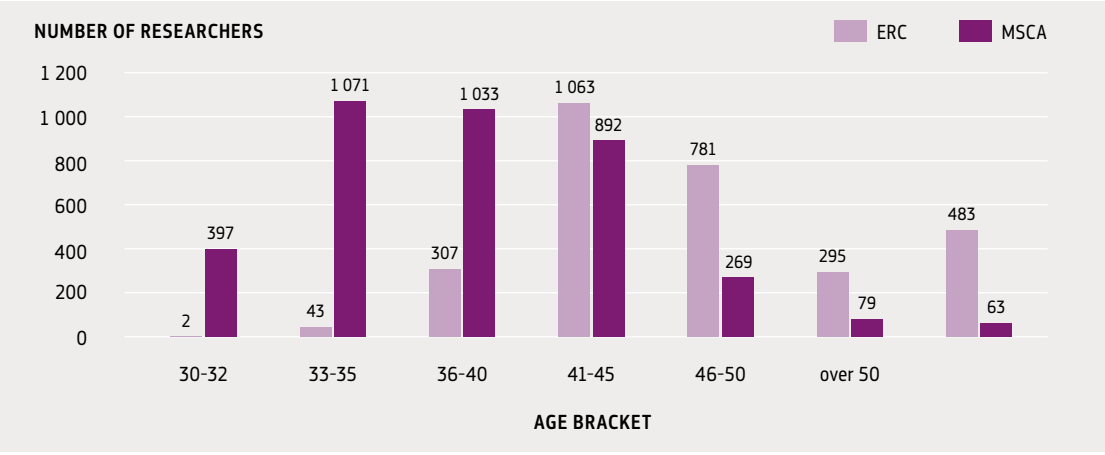
In SEWP, since the funding does not cover the cost of R&I, a survey among beneficiaries showed that 88 % of them have already received funding from other Horizon 2020 programme parts, such as **ERC, MSCA and Research Infrastructures,** to cover their R&I activities as such.

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 welcome 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 way 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 bridging Horizon 2020 support with 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.[309].

FIGURE 85: Number of researchers supported under ERC and MSCA by age

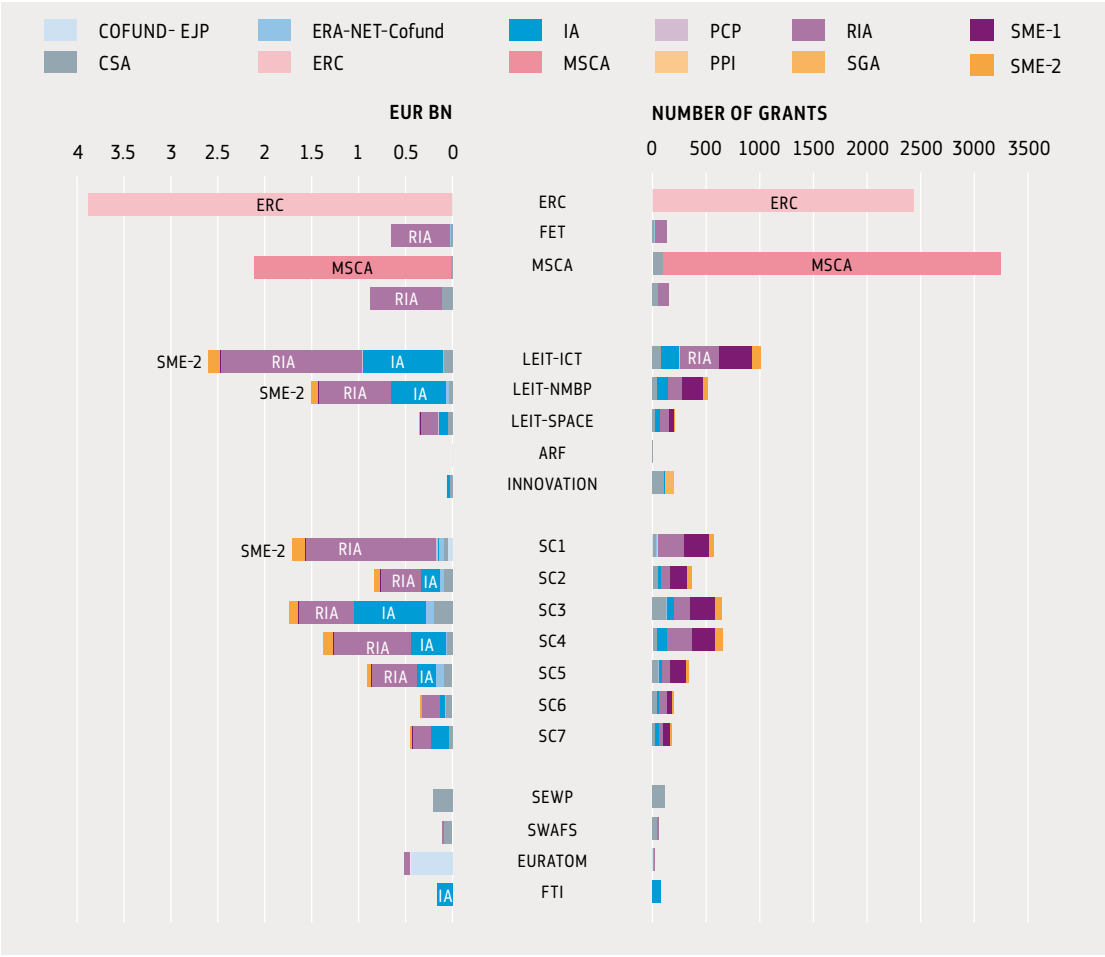


Source: European Commission, DG RTD, based on Corda data

309 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 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

Horizon 2020 projects are implemented via different actions (policy-mix) that are specified in the WPs, according to the objectives pursued (see Section 5.1 for an overview). As regards the types of actions, **approximately 75 % of the funding goes to instruments facilitating collaborative R&I**[310], bringing organisations across countries together. This is slightly higher than under FP7 (72 % (Cooperation + Capacities)). It 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 SMEs' R&I projects (SME Instrument).

FIGURE 86: 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)

310 Research and Innovation Actions, Innovation Actions, MSCA Innovative Training Networks (ITN) and RISE, and Coordination and Support Actions.

STAKEHOLDER POSITION PAPERS THE PROGRAMME MUST 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 about the Framework Programme's complexity. They believe 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.

The majority of public authorities that commented on the instruments noted that collaborative projects and grants were preferred over other types of projects and loans. Some of them have a positive view specifically related to those instruments bringing together states and regions, such as the P2Ps, cofound schemes and ERANETs, others, the SME Instrument, INNOSUP and MSCA. Some stakeholders from academia and research organisations also gave 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 JTIs, JUs and the cPPPs. They noted that Horizon 2020 provides a ring-fenced budget for PPPs, JTIs and other industry initiatives which is beneficial particularly for those industries represented by, or are member of, such initiatives. In addition, a few SME and business representatives commented on and welcomed the inclusion of innovation activities in Horizon 2020. Finally, a small number of stakeholders discussed the Seal of Excellence (SoE) instrument, some praising it while others pointed to the need to review its effectiveness.

As regards the **current balance of support provided for more science-driven or innovation-driven projects,** to date, 22 % of the Horizon 2020 budget goes to the industrial leadership pillar, 36 % to societal challenges (which is both R&I driven depending on the projects) and 37 % to excellent science (which also includes proof-of-concept projects). Further, 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 focused specifically on innovation which means such a comparison is not straightforward. However, the Entrepreneurship and Innovation Programme (EIP) had a budget of EUR 2,166 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 under Horizon 2020 alone, after three years of implementation. This does not include the financial instruments gaining in importance under Horizon 2020 compared to the Risk Sharing Finance Facility in FP7.

Due to the lack of centralised monitoring data, an overall picture of the current balance between Horizon 2020 grants and financial-instrument-type support (e.g. loans, equity, guarantees) is difficult to define. 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[311].

Overall, grants, loans and equity investments are complementary forms of finance for firms and other entities undertaking innovation[312]. As regards the costs of financing subsequent innovation phases

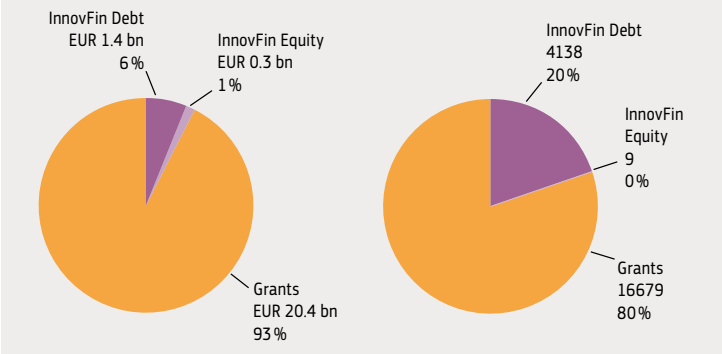
311 A discussion on stakeholders' preferred types of support is provided under section 6.3.2 'Programme attractiveness and take-up'.

312 A firm's investment in innovation typically covers R&D, capital equipment, design and marketing, and training. In most sectors, the most important item of expenditure is R&D, which accounts for over half the spend on innovation. R&D investments have three key characteristics that make them different from other investments: most R&D expenditure goes towards paying researchers; returns on R&D investment are highly uncertain; and the capital created from such investment is largely intangible. According to 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 innovation process: R&D. Typically, no lender or equity investor can tolerate the risk or offer loans or investments on reasonable terms.

from loans or equity, although there is no formula for calculating the appropriate debt/equity mix over the 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 companies 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 87: 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 regard to the EU contribution and as of 30/06/2016 with regard to operations, SC1- Health and SC3- Energy thematic assessments and Corda, cut-off date by 1/1/2017

As regards financial instruments, feedback from the survey of financial intermediaries carried out in the framework of the interim evaluation of Horizon 2020 financial instruments suggests 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 one replied said that they do not complement each other at all, while 45.8 % of those surveyed had no opinion. It should be noted that the survey is still under way.

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 life cycle. The four debt-based guarantee and loan instruments appear to be internally consistent and coherent, since investment size/instrument have all been distinctly defined to avoid overlaps. In this respect, bringing in the EIB loan scheme for large R&I projects has helped. Through the SMEG and Midcap Guarantee schemes there is a funding continuum of between EUR 25 000 and EUR 50 million, respectively, which covers a large range of guarantee needs of 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 life cycle 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. For debt instruments at least, 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)[313], and describes a situation in which EU FI programmes (ideally mirrored more widely in the financial system) 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.

313 The concept of Europe's 'funding escalator' was mentioned in the Action Plan on Building a Capital Markets Union, COM(2015)468 final.

FIGURE 88: Financial instruments schemes under Horizon 2020

INNOVFIN FINANCIAL INSTRUMENT SCHEMES	TYPE OF FINANCIAL INSTRUMENT	INVESTMENT SIZE PER BENEFICIARY	INVESTMENT DURATION
SME Guarantee	Guarantee	EUR 25 000 to EUR 7.5 m	1-10 years
MidCap Guarantee	Guarantee	EUR 7.5-50 m (firms with 500-3 000 employees)	Maturity from 2-10 years, with a fixed repayment schedule
MidCap Growth Finance'	Loans	EUR 7.5 m to EUR 25 m	Up to 10 years
Large projects	Loans	EUR 25 m to 300 m	Up to 10 years

Source: European Commission

Under InnovFin Debt, banks and other lenders are incentivised to provide loans on reasonable terms to SMEs through 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 2020 '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 via cornerstone investments by the EIF under the InnovFin Equity scheme.

The two pie charts below show the TRLs[314] 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.

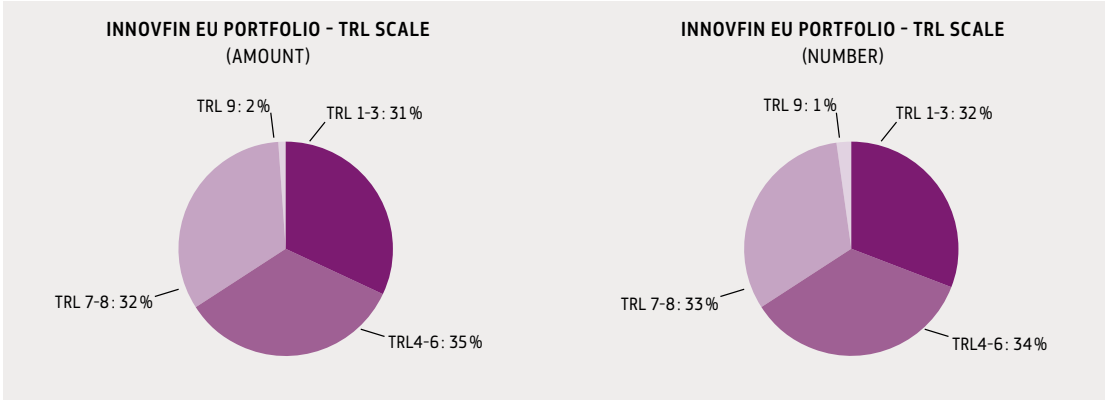
An analysis of the TRL supported across thematic areas shows that whereas the excellent science pillar focuses on more fundamental research and, with the exception of e-Infrastructures, does not move beyond the stage of an experimental proof of concept, the rest of the programme is rather concentrated on higher TRLs, the majority of which target product demonstration in both the industrial leadership and societal challenges pillars. This is notably a result of Horizon 2020 being a combination of R&I – 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 a key source of future breakthrough innovations, albeit longer-term, in line with societal needs.** The European Economic and Social Committee (EESC) in its opinion on the interim evaluation of Horizon 2020 also expresses 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 result that interaction between industry and academia has been reduced rather than strengthened[315].

314 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.

315 http://www.eesc.europa.eu/?i=portal.en.int-opinions.39284

FIGURE 89: Technology Readiness Levels of InnovFin EU portfolio (amount and number)



Source: Annual Operational Report, 2017

STAKEHOLDER POSITION PAPERS

ON THE BALANCE BETWEEN R&I AND TRLS: "THE IMPORTANCE OF BASIC, COLLABORATIVE AND FRONTIER RESEARCH SHOULD NOT DIMINISH"

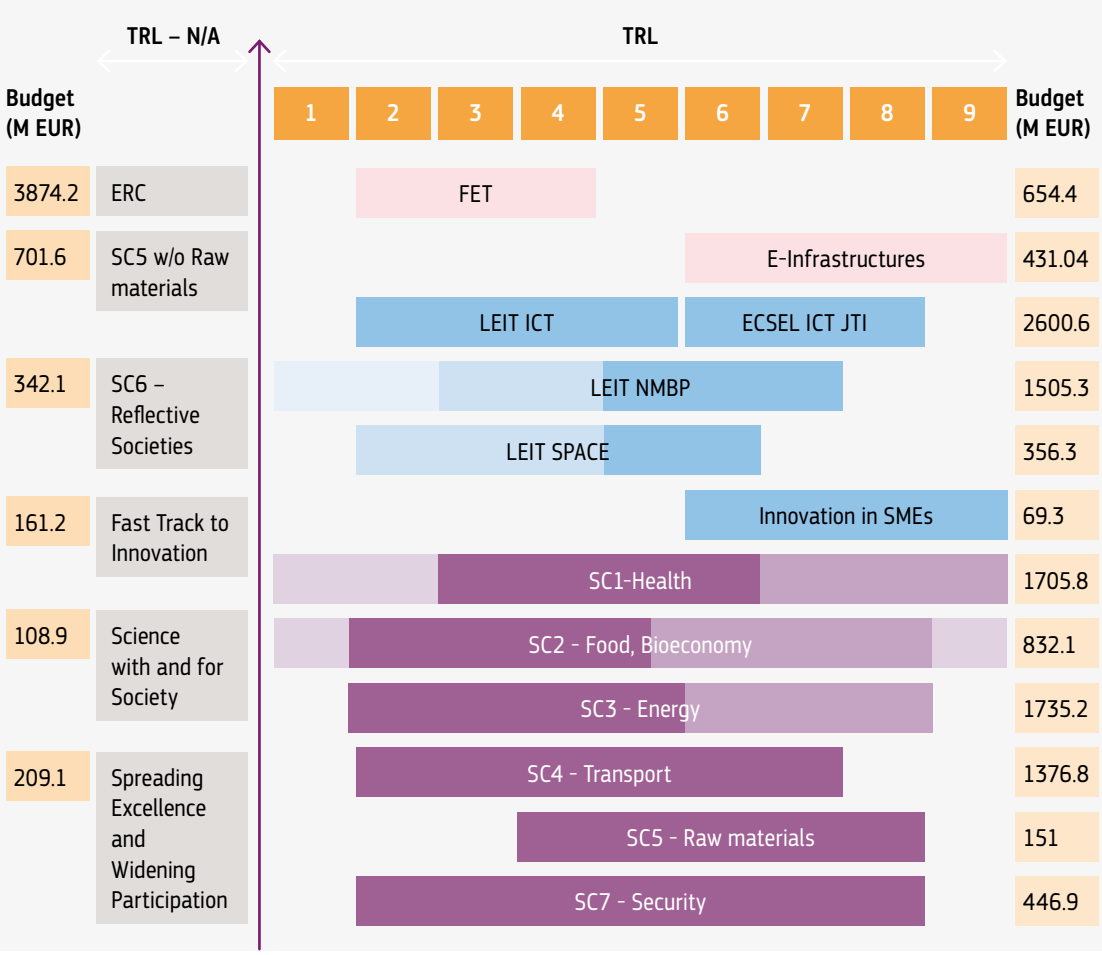
In their position papers, almost half of the stakeholders commented on the balance between research and innovation. The majority stated that the programme needs to ensure a better balance. By stakeholder group, the majority of those from academia, research organisations and public authorities pointed out 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 a ground-breaking technological foundation for innovation. Only business representatives are positive about the shift towards innovation that has taken place under Horizon 2020. Nevertheless, a few point to the current lack of TRL 3-5 projects.

Figure 90 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[316]. The information presented is partial and based on diverse methodologies, such as surveys, among project coordinators, project mapping by expert groups, external studies, estimates by policy and project officers, as well as internal project reviews[317]. Within each programme part the focus can be 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 are not comparable or sufficiently granular (e.g. TRL-level at the start or at end of the project). This is an area where further monitoring is needed.

316 See Annex 2 2 for the assessments of each Horizon 2020 programme part.

317 A detailed overview of the approach adopted for this analysis for each programme part is presented in Annex 1.

FIGURE 90: Overview of TRL supported across different Horizon 2020 programme parts based on non-comparable assessment methodologies



Source: European Commission, based on assessments of 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?

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[318].

9.2.1. OVERVIEW

Compared to FP7, Horizon 2020 attaches greater importance to coherence with other EU instruments, as illustrated by the legal base[319]. 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 discovery, research, development and innovation process and ensure better exploitation of projects/programmes results.

However, it is difficult to assess to what extent the political willingness to increase external coherence has been translated in practical implementation. The thematic assessments show that the practical implementation of this approach seems to differ across specific Horizon 2020 objectives.

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[320], projects that foresee taking 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 an 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 5 % in 2014 (corresponding to 2 out of 41 projects funded) to almost 32 % in 2015 (corresponding to 13 out of 41 projects 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 given in the box below. An internal survey among Commission services on the external coherence between EU instruments revealed that **most Horizon 2020 complementarities/ synergies with other EU policies or initiatives are perceived to be with the ESIF as well as with the EU's industry competitiveness and SMEs policy**. However, **in many cases, coherence with other EU initiatives is limited only to the programming level, which is not followed by concrete actions.** Indeed, the programmes might have different scales, scope or follow different implementation structures, intervention logics or time frames, even if they focus 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 coverage of other EU interventions, most of the stakeholder consultation respondents felt they were unable to assess this level of coherence because of

318 Article 20 of the Horizon 2020 Regulation.

319 In the case of ESIF, both programmes include legal provisions to maximise synergies.

320 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.

their lack of familiarity with other initiatives. When they were able to, they indicated that the synergy with other EU programmes remains very limited. More than 27 % of the stakeholder consultation respondents stated that Horizon 2020 and Erasmus+ complement each other; 15.6 % of respondents said the same about ESIF, and 12 % judged they work in synergy.

EXAMPLE OF EXTERNAL COHERENCE OF HORIZON 2020 WITH EU INITIATIVES

In case of **Research Infrastructures,** 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.

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 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. However, this coherence is not necessarily based on active coordination and exchanges, which can be further enhanced through more exchanges between the 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 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 EFSI is a new financing scheme rather than a new financial instrument.

The table shows there are clear differences between InnovFin and other EU funding instruments (especially the CEF[321]), although there are some possible areas of 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.

321 https://ec.europa.eu/inea/en/connecting-europe-facility

FIGURE 91: 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 EUR 2.5 billion of which 60 % (~ EUR 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 SMEs < EUR 150 000. Risk capital predominantly into SMEs at the growth and expansion stage > EUR 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 EUR 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.

FINANCIAL INSTRUMENTS SCHEMES (TITLE, DESCRIPTION)	BUDGET	TYPE OF INSTRUMENTS/ BUDGET	ELIGIBILITY CRITERIA	EXTENT OF DIFFERENTIATION WITH INNOVFIN
The Connecting Europe Facility (CEF) **Supports targeted infrastructure investment at EU level. Supports the development of interconnected trans-European networks in the fields of transport, energy and digital services.**	CEF programme budget – EUR 30.4 billion in total (EUR 22.4 billion for transport, EUR 4.7 billion for energy, and EUR 0.3 billion for telecom).	CEF – Grants, contributions to innovative financial instruments, developed together with entrusted financial institutions such as the EIB, 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 7.5 m and 75 m	CEF – transnational requirement. InnovFin Energy Demo: Only projects of TRL 7-8 are eligible under facility Only projects/ companies located in an EU Member State or H2020 Associated Countries eligible.	> 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 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 does not 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

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 as part of the process for developing the detailed programming architecture. This has meant that the two programmes, which risked duplication, 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 targeting overlap in the SME segment;
- 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 the emergence of a reasonably clear delineation, 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 greater emphasis on SMEs having to be innovative, the definition of innovative is quite broad; 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 is causing 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 be negative in practice since in some Member States financial intermediaries have only applied to COSME (or only 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 (EU-28 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 InnovFin thematic assessment it appears that it does not explicitly target start-ups. 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 EUR 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[322], although the micro-loans made are not backed by a guarantee.

There is good 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 out that concerning the INNOSUP call under Innovation in SMEs, there is room for 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[323]. The EIB's evaluation finds that there are 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 lay in the fact that the 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

322 http://www.bpifrance.fr/Toutes-nos-solutions/Prets/Prets-sans-garantie/Pret-d-amorcage

323Ad-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 the EU-13 received 9 % of EFSI support. Reasons mentioned for the lower support in the EU-13 include the competition from ESIF, less capacity to develop large pro-jects, less experience with PPPs, a less-developed venture capital market, and the small size of the projects.

under CEF and Horizon 2020 or financial instruments and grants under ESFI.

The ad-hoc audit recommends to further structure and enable complementarity 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 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 under way to refocus some InnovFin instruments partly because since the set-up of the 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 the EFSI has arguably slowed down the deployment of InnovFin. In 2016, the EIB signed only EUR l.5 billion of InnovFin transactions, reaching just 56 % of the annual objective, while it 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 of 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. To date, the budgetary contribution from the EU 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 EUR 8.1 billion target for the period was achieved, representing a cumulative shortfall of EUR 2.2 billion. InnovFin was expected to make up for this shortfall in the period 2018-2020 following the deployment of the EFSI, as originally conceived. However, in the context of discussions on the extension of the EFSI to 2020 ('EFSI 2.0'), this assumption is no longer valid.

Given the above, the EIB and the Commission's DG RTD have concluded that the current approach is no longer sustainable and that **changes are necessary to refocus InnovFin's deployment in the post-EFSI context**. The aim is to improve cooperation with the EFSI through better complementarity and to combine InnovFin and EFSI financing where needed, building on the success achieved under the EFSI's SME window (implemented with the European Investment Fund (EIF)) for both equity and debt joint InnovFin/ EFSI products.

Work is under way 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 in marketing terms, more closely target 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' and 'InnovFin Infectious Diseases' – and open up possibilities for crafting riskfinance 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 debt financing under the EFSI Infrastructure and Innovation Window (IIW); InnovFin MidCap Guarantee has an equivalent product offering as the EFSI's Risk Sharing; and equity-type operations under InnovFin Midcap Growth Finance have already been fully transferred under the EFSI with the European Growth Finance Facility.

Two new facilities are envisaged with minimal overlap with the 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 reported 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 the EIF, has been remodelled to improve its relevance to a wider range of constituencies.

9.2.3. SYNERGIES WITH THE EUROPEAN STRUCTURAL AND INVESTMENT FUNDS

Horizon 2020 shall also contribute to the closing of the R&I divide within the Union by promoting synergies with ESIF. Where possible cumulative funding may be used[324].

Synergies between Horizon 2020 and the ESIF aim to maximise 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, thereby ensuring the funds have a greater impact for a knowledge-based economic transformation.

The Commission has taken specific measures to facilitate the coherence between Horizon 2020 and the ESIF by publishing guidance for policy-makers and implementing bodies and a specific brochure for interested parties with examples of synergies[325]. Even though for the first time it is possible to combine Horizon 2020 and ESIF support in a single project in this programming period, and a strong focus and political importance are being put on synergies, Horizon 2020 is implemented under central management by the Commission whereas the ESIF is under shared management, with the joint responsibility of Member State authorities and the Commission. This leads to differences in implementation rules and procedures as actors' commitment as well as the application and project execution requirements differ.

Under the ESIF, the selection of a specific type of R&I intervention can vary among regions (research infrastructure, industry academia cooperation, etc.) and Member States, according to the strategic choices made in each territorial context. The 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 to Horizon 2020's specific objectives (LEIT NMPB, SC1, SC3 and SWAFS) in terms of TRL covered. However, an overlap between the two programme is considered not possible due to the different **geographical coverage** of the two instruments, i.e. the ESIF funds **national or regional initiatives** while Horizon 2020 is based on transnational partnerships and networking and hence helps strengthen scientific collaboration at the EU and international scale.

According to an external study[326], the development of synergies between both programmes is still at the early stage and 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.** Enhancement of the coherence between Horizon 2020 and ESIF

[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

324 Article 21 of the Horizon 2020 Regulation.

325 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

326 'Synergies between Framework Programmes for Research and Innovation and the European Structural and Investment Funds' (forthcoming).

is rather incidental, as confirmed by the thematic assessments. During the project phase, there are notable discrepancies that hinder the combined use of funding means. These include different funding rates and eligibility rules, which are not always coherent with each other. Furthermore, the difference in state aid rules under the ESIF and Horizon 2020 leads to legal uncertainty for potential beneficiaries.

In recent 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 the 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 the EU-13 Member States and their regions in this respect[327].

In order to build upon the evaluations of high-quality proposals under Horizon 2020's 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 were successful in the Horizon 2020 evaluation process. The regional and national authorities decide whether to fund the SoE proposals (with national or ESIF resources) on the basis of eligibility and the way in which they help to achieve the objectives of their regional or national Smart Specialisation Strategies. This is expected to result in an operation with 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 have 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 project proposals awarded with an SoE[328]. However, it has been recognised that **the SoE initiative has yet to tap into its full potential, which would be possible with an alignment of the rules, for example in the case of state aid rules**[329]. 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 its limited influence so far, there are signs that this may change in the near future. SoE holders demonstrate strong confidence that the SoE makes and will continue to make a difference in funding decisions, be it implicitly or explicitly.

The box below provides examples of the coherence of Horizon 2020 programme parts with the ESIF.

327 Stairway to excellence (S2E) is a European Parliament Pilot Project carried out by DG JRC and DG REGIO. It assists EU-13 Member States and their regions in closing the innovation gap, in order to promote excellence and stimulate the early and effective implementation of national and regional Smart Specialisation Strategies: http://s3platform.jrc.ec.europa.eu/stairway-to-excellence

328 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 (eight southern regions, plus Lombardy, Piedmont, Friuli-Venezia Giulia), France (Île-de-France), Sweden, Norway, Czech Republic (Brno), Cyprus, Slovenia, Hungary and Finland. Moreover, it is expected that more seal schemes will soon be launched in other EU counties and/regions. In the case of MSCA, Cyprus and the Czech Republic have already introduced funding schemes using the ESIF to support recipients of the SoE, while Croatia, Greece, Lithuania, Poland, Slovenia, and Sweden have initiatives in the pipeline..

329 For further information about the state aid implications of the SoE, 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 support to SME Instrument project proposals with a Horizon 2020 'Seal of Excellence', SWD(2017) 11 final.

EXAMPLES OF COHERENCE OF HORIZON 2020 PROGRAMME PARTS WITH THE 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[330] showed that most regions have participated as much as might be expected 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 80s and 90s to diversify incentives to innovation, appears to have paid off.

The **SC5** Work Programmes 2014-15 and 2016-17 emphasise 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 for accessing this complementary ESIF financing further to the Horizon 2020 funding are explained in the WP. Until the end of 2016, 29 out of a sample of 75 proposals mentioned synergies. Among these 75 proposals, 19 have been granted, of which 15 refer to complementarity with the ESIF. Interestingly, proposals arguing their potential synergies have a higher success rate. However, there is no strong commitment to deliver on synergies as a project outcome and the actual complementarity between Horizon 2020 and the ESIF may not be reflected in the annual ESIF reporting.

In case of **SEWP**, the programme design 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 Cohesion Policy's overall objectives, notably to help less-developed European countries and regions to catch up and thus 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).

330 Study 'Mapping the regional embeddedness of the NMP programme', INNOVA et al., 2016. Since no significant differences were detected between NMBP areas, these results are also considered relevant 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 (P2P), with international, national and regional programmes that support R&I. In that context, Horizon 2020 should encourage the optimal use of resources and avoid unnecessary duplication[331].

9.3.1. OVERVIEW

At the international level, the establishment of Sustainable Development Goals (SDGs), the successor to 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.** R&I policy and related implementation measures are seen as engines of a transformative agenda built around universally applicable SDGs[332]. Examples of coherence between Horizon 2020 and international initiatives can be found in LEIT-Space and the European Space Agency (ESA)[333], or in the case of SC5's strong alignment at international level, e.g. through the Belmont Forum, GEO, IPCC and 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 is further strengthening 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 help Member States to implement effective reforms, in line with the priorities of the ERA.

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 considered crucial by Member States. 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 Member State involvement in its activities is of special interest and often underlined by these States.

Horizon 2020 aims to improve the coherence with national programmes by supporting P2Ps, including JPIs, the ERA-NET Cofund instrument and Art.185 initiatives[334]. Member State efforts towards coordination in the field of P2Ps are core components of the ERA Roadmap and national ERA 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 aim of networking 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

331 See recital 39 of the Horizon 2020 Regulation.

332 Report 'Follow-up to Rio+20, notably the Sustainable Development Goals (SDGs)' by an independent expert group: https://ec.europa.eu/programmes/horizon2020/en/news/role-science-technology-and-innovation-policies-foster-implementation-sustainable-development

333 The Delegation Agreement for Galileo R&D has represented a major achievement in this regard.

334 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.

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. Of the projects financed by the EIB's InnovFin Large Projects scheme, at least 40 % are KETs-related.

Societal Challenge 1 has set encouraging precedents of associating EU regional partners with the definition and implementation of roadmaps and strategic agendas. However, expanding this would require some additional work.

Several actions within **Societal Challenge 2** have supported links with the national or regional plans and Smart Specialisation Strategies using the ESIF, for instance those targeting the development of new bio-based industries. The ERA-NET co-fund actions included in the calls are potentially highly effective strategic investments in ERA, with a structuring effect and ensuring coherence between the EU and national research programmes in the bioeconomy.

In **Societal Challenge 3,** 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.

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 5500 projects with a cumulative budget of about EUR 5 000 million from national sources have been implemented through P2Ps.

9.3.2. ERA-NET COFUND UNDER HORIZON 2020

ERA-NET Cofund is a policy instrument across all Horizon 2020 priorities to catalyse joint calls and other joint activities in national R&D programmes through additional Horizon 2020 top-up funding. Member State and Associated State joint activities contribute to increasing the quality of national research, raising the level of national funding and avoiding 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 WPs, significant coherence between national and EU programming can be ensured via the responsible Programme Committees.

The Horizon 2020 WP 2014-2015 included calls for proposals for ERA-NET Cofund actions, resulting in 27 proposals selected for funding by the European Commission. The direct leverage effect of these 27 actions is 2.31, i.e. for each euro invested by the EU, the participating states invest an additional EUR 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 WPs. Funding for these from Horizon 2020 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 in the national funding for both the co-funded 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 92: Calls for ERA-NET Cofund actions published in the WPs 2014-2017

	2014		2015		2016		2017	
	EUR MILLION	NUMBER	EUR MILLION	NUMBER	EUR MILLION	NUMBER	EUR MILLION	NUMBER
Excellent Science					18.0	2	5	1
Future and Emerging Technologies								
Industrial leadership								
ICT			6	1				
Nano, Materials, Biotech and Manufacturing			12.5	1	30	3		
Societal Challenges								
Health, demographic change and wellbeing	27.4	4	15	3			5	1
Food security, agriculture, marine, bioeconomy	5	1	15	3	35	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	1		
Climate action, environment, resource efficiency and raw materials	18.2	2	51	3	13	3	30	3
Europe in a changing world - Inclusive, innovative and reflective societies	5	1	5	1	5	1	5	1
Science with and for Society					5	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[335] highlights that the main added value is the lasting collaboration between and learning among funding agencies, as well as capacity building. ERA-NET Cofund actions are **perceived less 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. However, the lack of clear understanding of the financial aspects of the ERA-NET Cofund instrument was highlighted as an area for improvement. While the relevance of the ERA-NET Cofund instrument has been confirmed, **coherence among ERA-NETs as well as 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 a widening participation from lower-performing countries and is also gradually increasing the participation of third countries.

335 https://bookshop.europa.eu/en/analysis-of-era-net-cofund-actions-under-horizon-2020-pbKI0116995/

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[336].

Article 185 initiatives are jointly implemented Member State programmes[337]. They include Associated Countries and, in some cases, extend the collaboration to third countries. They are implemented on the basis of annual work plans for research activities that receive EU funds from Horizon 2020[338], which currently implements four Article 185 initiatives[339]. The following table summarises the financial contribution of the EU and participating states to the four Article 185 initiatives.

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 socio-economic 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 the end of 2017.

FIGURE 93: Financial contribution of the Union and the participating states to 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) **EDCTP (FP6)**	683 **200**	683 **200**
European Metrology Research Programme (EMPIR) **EMRP, FP7**	300 **200**	300 **200**
Eurostars2 (for SMEs) **Eurostars1 (FP7)**	287 100	861 300
Active and Assisted Living R&D Programme (AAL2) **AAL (FP7)**	175 **150**	175 **200**

Source: European Commission, (in bold: contributions for the predecessor programmes FP6/FP7)

336 See Article 26 (b) of the Horizon 2020 Regulation.

337 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.

338 The origin of the name stems from the legal basis, Art.185 of the Treaty on the Functioning of the European Union.

339 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.

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 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 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 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.

The joint programming evaluation[340] highlights in particular that the societal challenges of the JPIs were selected by Member States but **the overall level of ambition does not meet initial expectations**. So far, the level of co-investment 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; and inter-ministerial structures to support the joint programming process is rather mixed. Some demonstrate a high level of commitment but too many have not really made any progress; financial support through CSA and the ERA-NET instruments has been vital to developing 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 insufficient resources are invested in ensuring the overall socio-economic impact of JPIs.

FIGURE 94: Support from the Framework Programme for the JPIs via CSAs, 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

340 http://bookshop.europa.eu/en/evaluation-of-joint-programming-to-address-grand-societal-challenges-pbKI0416204/?CatalogCategoryID=7QwKABstDHwAAAEjK5EY4e5L

9.4. KEY CONCLUSIONS ON THE COHERENCE OF HORIZON 2020

The integration of R&I into a single programme, the three-pillar structure of Horizon 2020 and its focus on finding solutions to challenges (notably through the use of focus areas) rather than being domain-oriented has 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 TRLs in order to maintain a link between industry and academia and to create ground-breaking technological foundation for innovations. An analysis of the TRLs 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 pillars. Multiple types of stakeholders regret that societal challenges and LEIT do not invest more in lower TRL collaborative research, which is regarded as a key source of future breakthrough innovations, albeit longer-term, in line with societal needs.

The different types of action of Horizon 2020 appear coherent to address the programme's various objectives, but the large number of instruments at EU level and complex funding rules are difficult for potential applicants to understand and may lead to overlaps.

In terms of **external coherence,** there is a clear strategic willingness to ensure Horizon 2020 complementarity and synergies with other EU programmes, in particular the ESIF and the EFSI. Compared to FP7, efforts have already been made to increase the synergies between Horizon 2020 and other programmes, notably the ESIF. However, there is a lack of strong evidence on how far this has materialised in practice. Given the different rules and implementation structures, promoting synergies at project level (in term of combining different financing sources for the same project) still seems difficult. Furthermore, the difference in state aid rules leads to legal uncertainty for potential beneficiaries.

Member State support for P2P has increased significantly in recent years. Although generating lasting collaborations between entities and improved capacities, the P2P are not seen as influencing the alignment of national strategies and policies. The Member State-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 in addition 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 re-nationalisation of R&I policies, the programme is expected to enable the orientation of European R&I programmes to commonly agreed objectives, as well as fostering 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.

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, transnational, multidisciplinary networks, pooling 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 participants' competitive advantage, 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 to be 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[341].

The design of earlier FPs had taken up considerations such as scale, complementarity of efforts, transnational interaction, standardisation, implementation of EU policy, achievement of societal objectives, and structuring effects on the European R&I ecosystem. FP7 introduced the concept of EAV derived from EU-wide competition for excellence (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'[342].

341 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

342 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.

FIGURE 95: The evolving character of EAV 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 State 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 coordinating 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

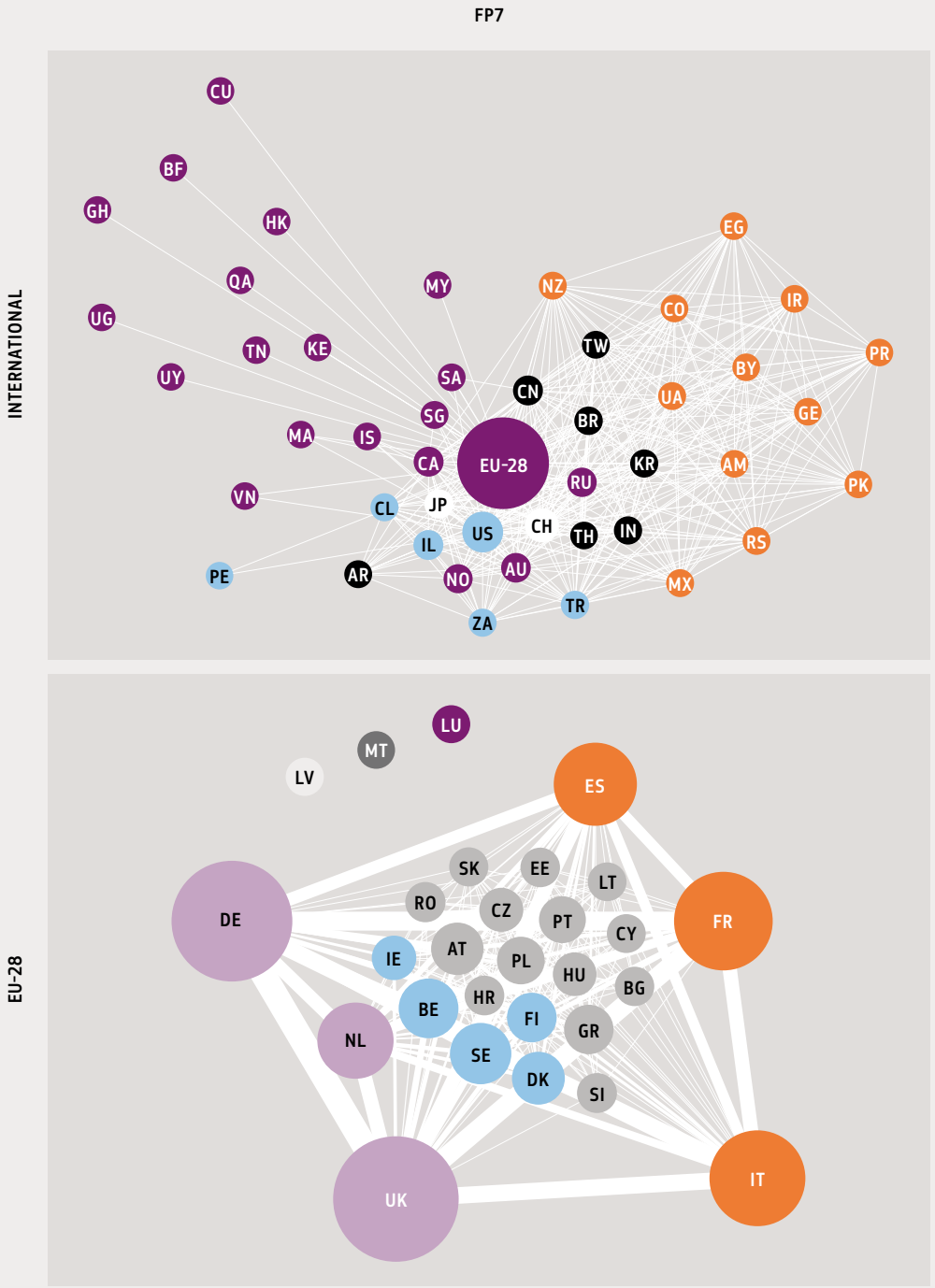
Source: Technopolis, Science Metrix, Understanding the Long Term Impact of the Framework Programme, 2012

Much of EU support to R&I is unique compared to 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[343]. Furthermore, the full value and impact of opportunities is often revealed after many years, illustrated by the number of Nobel Prizewinners 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 transnational collaborations of systemic importance. This collaboration brings the R&I effort closer to the critical mass required to tackle challenges on a societal scale. This is most evident in challenges of such scale and complexity that no single Member State can provide the necessary resources to tackle them. Several examples of such 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) the resolution of which is increasingly dependent on establishing a common scientific base leading to harmonised laws and standards that can support innovation.

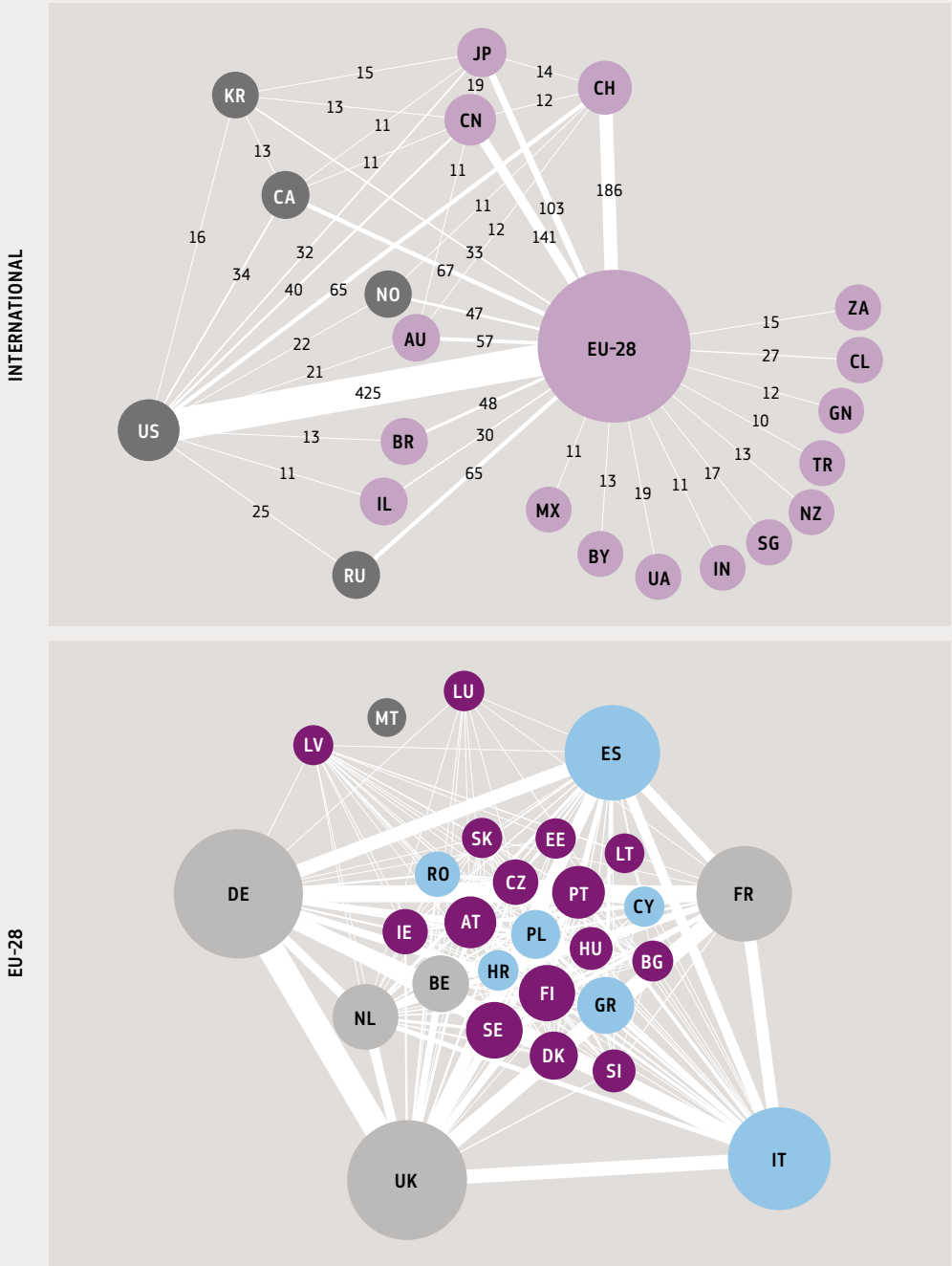
343 http://www.oecd.org/sti/Science-brief-scoreboard.pdf "Outflows tend to be associated with higher-rated publications than their staying or returning counterparts. Assuming one could raise the performance of 'stayers' to the level of their internationally mobile researchers [...] this would help countries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

FIGURE 96: 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. For printing reasons, connections between countries with less than 5 co-publications are displayed with the same edge thickness. Country codes outside the EU-28 are based on ISO codes.

HORIZON 2020



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. For printing reasons, connections between countries with less than 5 co-publications are displayed with the same edge thickness. Country codes outside the EU-28 are based on ISO codes.

EUROPEAN ADDED VALUE CASE STUDY – THE FIGHT AGAINST ANTIMICROBIAL RESISTANCE

Antimicrobial resistance (AMR) is the ability of micro-organisms 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 speeding up the evolution of resistant strains of microbes and transforming AMR into a worldwide public health threat. A subset of multi-drug-resistant bacteria in Europe are responsible for about 25 000 human deaths annually[344].

In addition to the avoidable deaths, this also translates into extra health-care 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[345].

In order to tackle AMR, 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 AMR[346]. Through its research Framework Programmes (e.g. FP7, Horizon 2020) it contributed to several of these areas by funding research activities in fields related to AMR.
Research projects directly or indirectly related to AMR 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.
To promote the adequate use of antimicrobial drugs, in 2015, the Commission launched 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 a bacterial infection in less than ten minutes and identify if a patient can be treated safely without antibiotics.
To foster the engagement of industry in antibiotic research, several AMR-related projects were launched under the Innovative Medicines Initiative. This initiative was launched in 2008 and is currently one of the largest PPPs between the EU and the European Federation of Pharmaceutical Industries and Associations. Overall, the EU has contributed more than EUR 1 billion towards combating AMR over the years.

A direct outcome of the R&I transnational networks built as a result of participating in the FPs is the transnational co-publication of research articles. A study carried out by Elsevier[347] 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 illustrate the intra-European and international co-publications networks under FP7 and Horizon 2020.

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, while those with smaller R&I domestic ecosystems often collaborate 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

344 EMEA and ECDC Joint Technical Report. The bacterial challenge: time to react. 2009.
345 Tackling drug-resistant infections globally: final report and recommendations. The review of antimicrobial resistance chaired by Jim O'Neill. (2016).
346 Communication from the Commission to the European Parliament and the Council - Action plan against the rising threats from Antimicrobial Resistance. COM (2011) 748 final.
347 Elsevier, Study of FP7 and Horizon 2020 publications (forthcoming), see details in Annex Part 2.

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[348] is that **EU FPs fund distinctive projects which are unlike the projects funded at national or regional level**. More than four out of five Horizon 2020 projects (83 %) would not have gone ahead without Horizon 2020 funding, particularly in research infrastructures (100 %), space (95 %) and FET (95 %). On average, only around 14 % of Horizon 2020 projects would have continued without EU funding, although the actual size of this potential crowding-out is likely to be even lower[349]. 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 in the EU FPs which results from the distinctive characteristics of EU-funded research projects**.

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 supported 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 **four in five 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, in most cases the national projects were 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 example of where the research performed benefitted significantly from the collection and analysis of cross-country patient cohort data coupled with a large volume of omics, clinical, lifestyle and imaging information. The multi-centre and interdisciplinary approach practised in EU-funded research projects strongly contributed to developing personalised medicine.

Following the counter-factual analysis, the PPMI study established that, on average, the EU FPs teams had 13.3 collaborations as against six in the control group. The beneficiary teams also built almost twice as many collaborations with partners from outside the EU (on average, 3.6 partners from third countries versus 2.1 partners in the control group). Overall, these data point to the EU FPs' substantial structuring effect and provide a quantification for the additional collaborations developed both across the EU and outside of it. Consistent results were found among Horizon 2020 beneficiaries.

348 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 have been drawn from this study which performed a counter-factual analysis (based on a regression discontinuity with propensity matching) of FP7 top-scoring applicants who were just above (intervention group) or below (control group) the funding threshold. This is corroborated with a survey of Horizon 2020 beneficiaries (for which it has not been possible yet to carry out the same design analysis) and in-depth case studies of EAV.

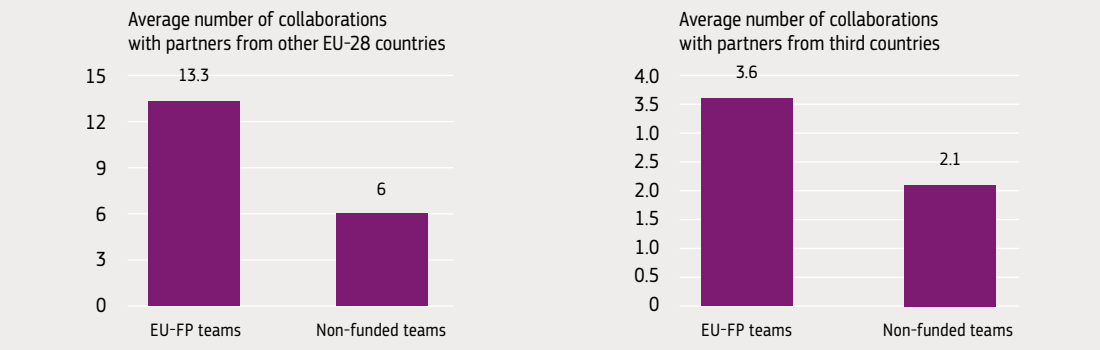
349 Idea Consult (2009), Assessing the behavioural additionality of the Sixth Framework Programme, European Commission, Brussels; or PPMI (2013), Interim evaluation of FP7 Marie Curie Actions, European Commission, Brussels.

FIGURE 97: Continuity of Horizon 2020 projects had they not received EU funding

	THE PROJECT WOULD HAVE GONE AHEAD WITH NO 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			
NMBP	12.9 %	35.8 %	51.3 %
Subtotal within NMBP: 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 %
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 %**

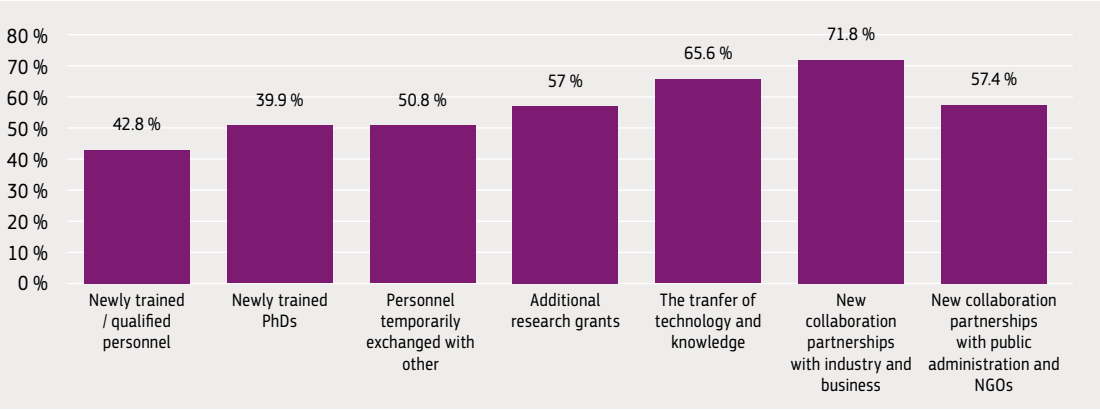
Source: PPMI, 'Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)', forthcoming

FIGURE 98: Number of partners from other EU-28 and third countries with which the teams analysed collaborated in 2015



Source: PPMI, 'Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)', forthcoming

FIGURE 99: Share of project and consortium partners for whom research capacity outputs would have fallen 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 underlying trend is that there would be a significant decline 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[350]. However, the publications produced in FP7 projects were published in higher-impact journals (average SJR[351] 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 both access and exposure to higher scientific impact.

350 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 on large-scale international research programmes, notably for the NIH (National Institutes of Health in the USA): Brian A. Jacob, Lars Lefgren, Corrigendum to 'The im-pact of NIH postdoctoral training grants on scientific productivity' [Res. Policy 40 (2011) 864–874], Research Policy, Volume 41, Issue 2, March 2012, page 497.

351 SCImago Journal Rank (SJR indicator) is a measure of the 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 from which such citations come.

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 replied that transfer of technology and knowledge as an output of their project would have fallen if their projects had been funded by national/regional programmes.

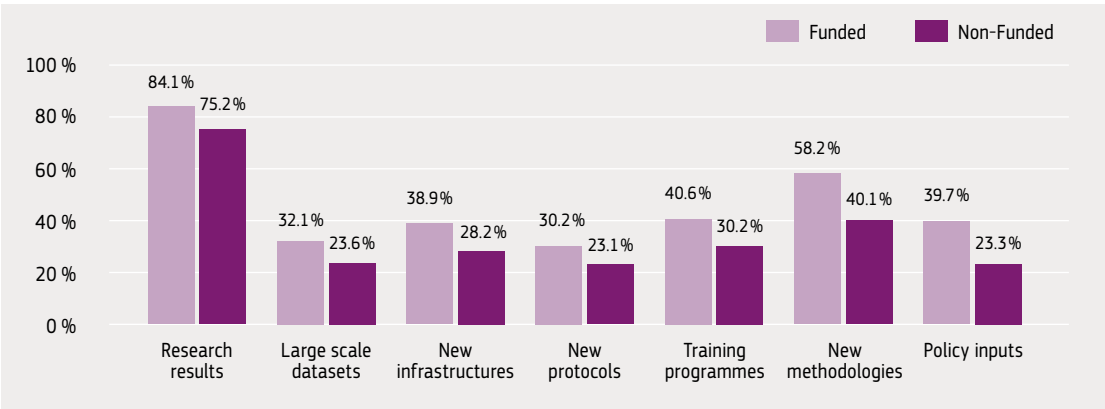
The analysis showed that distinctive research activities and better results subsequently lead to pan-European/societal challenges being better addressed. Around three in four Horizon 2020 project coordinators thought that the capacity to address EU citizens' needs (74 %) and to tackle global challenges (73 %) would have declined if the project had been funded with national or regional funds rather than 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 the sufficient scale of the research activities was a key factor in addressing pan-European challenges.

The study also found that the EU FPs helped achieve results faster in almost half of the projects (45 %). In some EAV areas analysed, such as food waste, Horizon 2020 and FP7 enabled the research results to reach the market three to five years or more faster than national projects. This suggests that the reduction in time 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 an improvement in this area) and access to new markets (71 %). Revenue would have fallen 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 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, particularly large-scale demonstration initiatives, prototypes/testing activities, new/improved commercial products, business models and IPR.

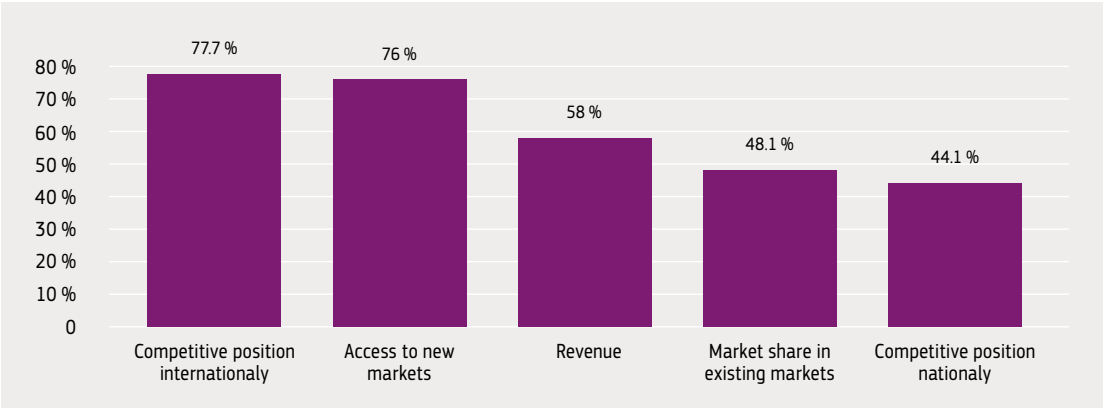
Lastly, **improvements in the quality of R&I through exposure to EU-wide competition** is another important element of EU added value. This is evidenced in the individual thematic assessments (Annex 2), notably in those where mono-beneficiaries are possible, like the SME Instrument and the ERC. The

FIGURE 100: 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

FIGURE 101: Share of the project and consortium partners for whom their commercial advantage would have decreased had they received national/regional rather than Horizon 2020 funding



Source: PPMI, 'Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)', forthcoming

EU added value of the ERC resulting 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 which is comparable to Nobel prizes or Fields medals. An in-depth evaluation study of the SME Instrument carried out by Technopolis positively assessed its EU added value. It is unique compared to similar support schemes at national/regional level (which only focus on certain priority domains, do not have rolling submissions, have significantly smaller project volumes, and require project collaboration with other SMEs or universities). Moreover, EU added value at individual project level is assessed in the evaluation process.

The European added value of R&I is complex, with different views on it from stakeholders, EU institutions and EU Member States. For example, the EESC "believes that cross-border cooperation between academia, industry, SMEs and research organisations is the main added value of Horizon 2020. The EESC believes that this cross-border collaboration and networking is more important than the absolute amount of funding"[352]. Similarly, the report by the High Level Group chaired by M. Monti[353] found R&I 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 % (2176) of the respondents rate the added value of Horizon 2020 higher when compared to national and/or regional programmes for R&I (see below). Research organisations and business respondents are the group in which the highest percentage of respondents agree that the programme is of higher value (66 % and 65 %, respectively), while public authorities are the group with the lowest percentage (56 %).

352 EESC information report INT/807.

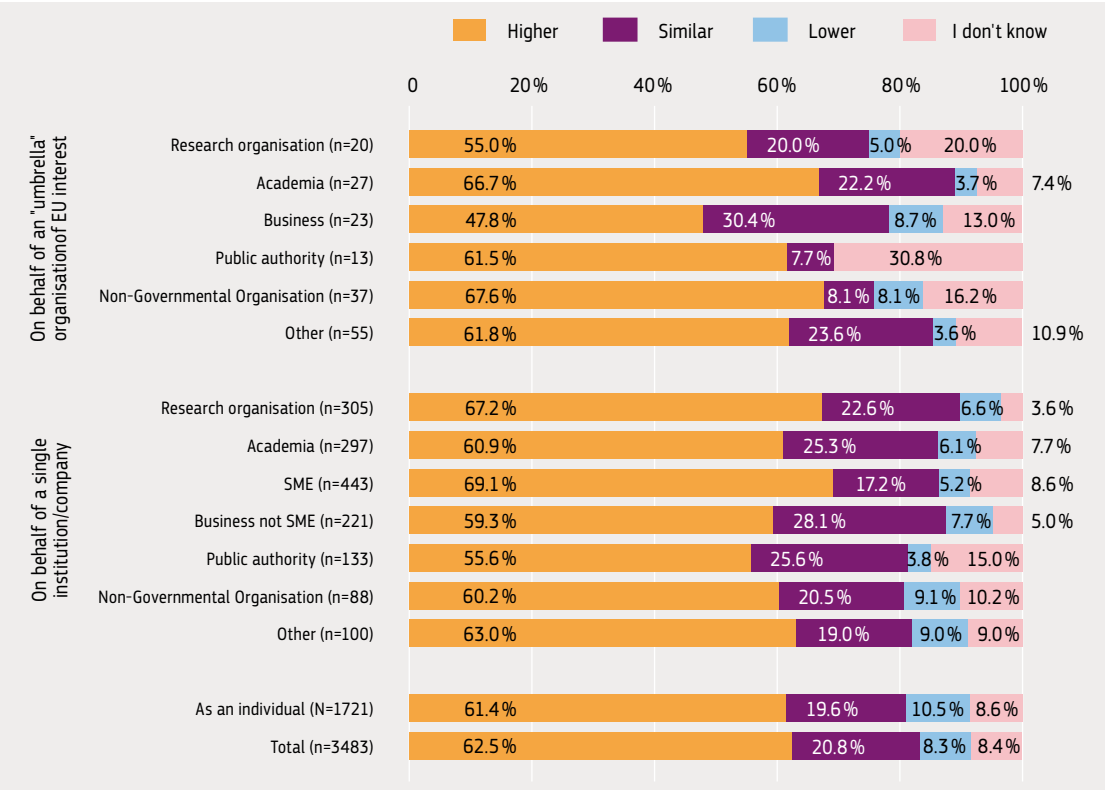
353 High Level Group Own Resources report, http://ec.europa.eu/budget/mff/hlgor/library/reports-communication/hlgor-report_20170104.pdf

Furthermore, of the 835 respondents who did not participate in Horizon 2020, a rather low number prefer to participate 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 either participating or expecting to participate.

In terms of effectiveness, the respondents strongly agree with statements suggesting that Horizon 2020 has strengthened the quality and visibility of research in the EU. For 1908 respondents, it contributes to improving international visibility, while 1357 are confident that it improves excellence in R&I. In their open comments, respondents also outline the visibility and reputation they gain from being selected. Horizon 2020 is qualified as a "prestigious" programme that sets high standards for R&I in Europe and could lead to career development or help organisations attract top researchers.

> *I see in Horizon 2020 an added value in potentially increasing the relevance of social sciences. The effort to embed 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

FIGURE 102: How do you rate the overall added value of Horizon 2020 compared to national and/or regional-level R&I 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 efficiency, for 1076 (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. Among the respondents, 1574 emphasise that it finances projects which could not otherwise be supported at national or regional level. For 788 respondents, European funding is all the more important since the reimbursement of costs is higher than for national/regional programmes. In open responses, some respondents also outline that 100 % cost funding for SMEs is a main incentive to participate (although it should be noted that a few comments are against full reimbursement).

In terms of synergy, Horizon 2020 is said to have contributed to strengthening interdisciplinary cooperation (by 1147 respondents, 33 %) as well as cooperation between academia and the private sector (873 respondents, 25 %). Additional comments provided 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 R&I system, one that links 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 in particular), thus encouraging the confrontation of different points of views, stimulating ideas and fostering creativity and the emergence of disruptive ideas.

To provide a further analysis of the programme's added value and additionality, stakeholder consultation's respondents were asked what the impact would be if EU support to R&I (Horizon 2020 and its possible successor) were to be discontinued. Very few respondents think that discontinuation of the Framework Programme would only have a limited impact on their organisation, most of whom are NGOs and public authorities (a few businesses, very few academics). Overall, **discontinuation of the programme would be judged as "catastrophic", "devastating", "a nightmare" or a significant "drawback"**.

> *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

Potential negative impacts are numerous and vary based on the organisation's dependence on Horizon 2020 funding. The impacts are worst for businesses whose activities are very much dependent on EU funding – programme discontinuation would result in a reduction in scope or even an end to R&I activities, slower product development and fewer business activities).

For academia and research organisations it would mean: less funding for fundamental, interdisciplinary, risky and disruptive research; less drive to cooperate; fewer 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 disappearance of existing networks 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 R&I actions would simply not take place or would be far less ambitious, the discontinuation of Horizon 2020 will be a drawback for R&I in the EU. It would affect Europeans' ability to carry out leading research and to address global challenges, thereby resulting in a decline in competitiveness, a loss of social, environmental, economic and EU policy impacts and less international visibility for the EU on the international R&I 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 transnational, multi-disciplinary networks, pooling resources and creating critical mass to tackle global challenges. Thus, it enhances the EU's attractiveness as a place to carry out research. Stakeholders consider that Horizon 2020 has higher added value than other programmes.

The programme's **additionality** (i.e. neither displacing nor 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. The 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[354] was published in 2016 – approximately two years after the end of the programme and after the start of Horizon 2020. The figure below presents updated data on the state of play in 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 cited more often than Member State 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 average for the world, the USA and Japan. Further findings on FP7 publications include:

- A higher impact (field-weighted citation impact)[360] 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 includes 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 %), USA (3.2 %) and world averages (1.7 %)[361].

FIGURE 103: State of play on outputs from FP7 projects

KEY INDICATORS	FP7 OUTPUT
Signed grants in FP7	25 289
Finalised projects[355]	15 612
Publications[356]	207 501
Open access publication (Share of open access publications)[357]	64.7 %
Patent applications[358]	2 669
Commercial use of R&D results[359]	10 260

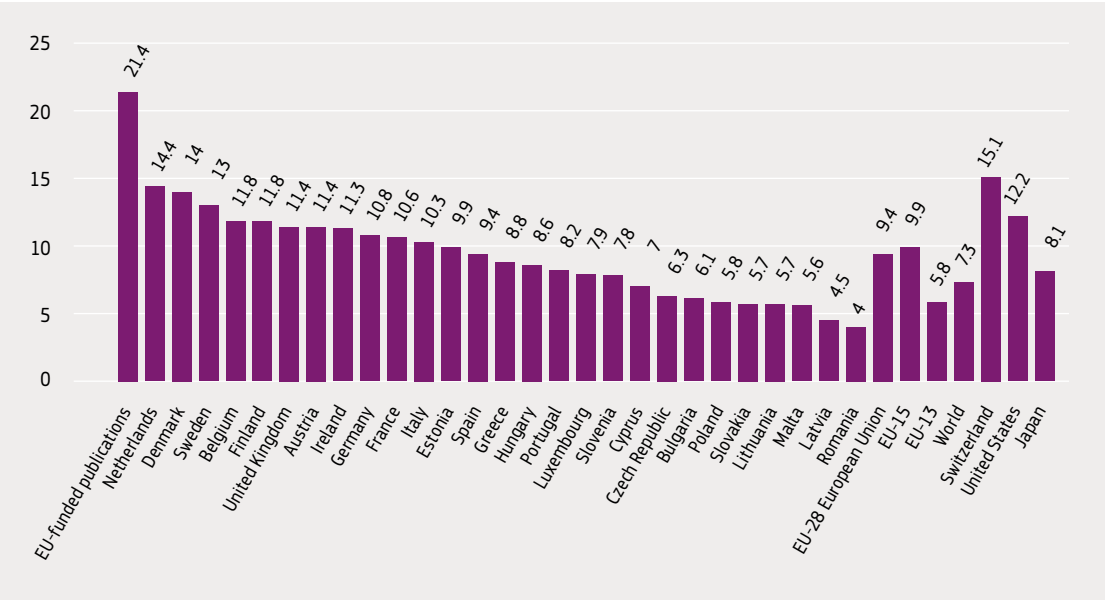
Source: Corda, 21/12/2016

354 https://ec.europa.eu/research/evaluations/index_en.cfm
355 13341 from Sesam-Respir extraction date 22/2/2017, 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 1254 from DG CONNECT.

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 40 000 to 94 000 researchers due to the implementation of FP7. Similarly, FP7 had

360 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.
361 To see all details please see Horizon 2020 Annual Monitoring Report 2015, pp 66-68

FIGURE 104: Citations per FP7 publication, average (2007-2016)



Source: SciVal based on Corda-Sesam-Respir data, 9/8/2016

a positive effect on the R&D budget of high-quality European research units. FP7 beneficiaries' R&D budget tended to grow around 24.6 p.p. more than similar non-funded units (i.e. a high leverage effect). An estimated EUR 8 to 17.5 billion of R&D funding was attracted to European high-quality research units thanks to FP7. Framework Programme funding also helped to attract more private R&D funding in EU-13 research organisations.

FP7 funding increased research collaborations in funded organisations with research teams in other EU countries by 120 %. FPs also increased collaborations among beneficiaries with non-EU-based research units by of 60 % (at least 100 000 collaborations).

At least 7 000 to 15 500 European researchers would have moved from one EU country to another as a direct consequence of FP7.

11.2. LONGER-TERM IMPACT OF PREVIOUS FRAMEWORK PROGRAMMES

As for Horizon 2020, the longer-term impact of FP7[362] 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 (see figure below):

- The first phase (maturation) from 2007 to 2016, where GDP gains (compared with the reference scenario) are mainly due to R&D investment flows and the private consumption favoured by FP7 investment, whereas the external balance, penalised by the inflationary pressure and by the rise in internal demand, is contributing negatively to EU GDP.
- During the 'Innovation' phase (i.e. 2017-2023), the GDP gains result from the acceleration in 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), under the progressive obsolescence of the new innovations, GDP gains decline 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 billion: each EUR of FP7 direct budget (EUR 42.6 billion in 2014 prices) brought an estimated increase in GDP of about EUR 9[363].

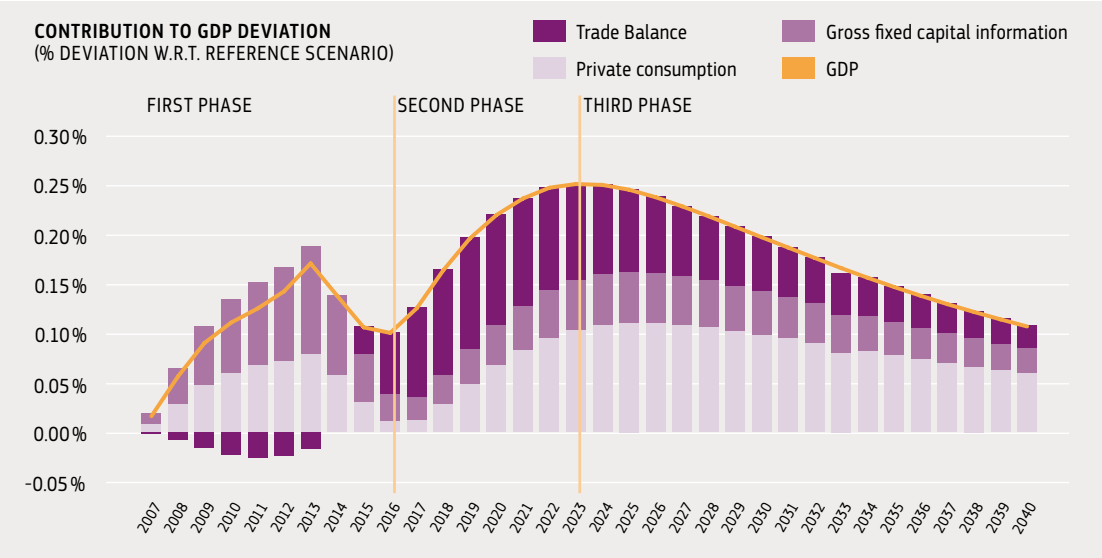
In terms of employment, as in the Horizon 2020 simulations, two phases can be distinguished:

- 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 employment in R&D activities (up to 121 000). With the decline in FP7 funds after 2013, total employment started to fall due to the inflationary pressures of the first period.
- In the following phase, total employment gains increase again as a result of new innovations entering the market. Job creation peaks in 2025 (with 249 000 more jobs compared to the reference scenario) then declines progressively. On average, during the period 2007-2023, the EU contribution through FP7 has increased the level of employment by 123 000 units, including 42 000 in research.

362 The analysis (PPMI, 'Assessment of the Union Added Value and the Economic Impact of the EU Framework Programmes (FP7, Horizon 2020)', forthcoming) also quantified 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 FP 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.

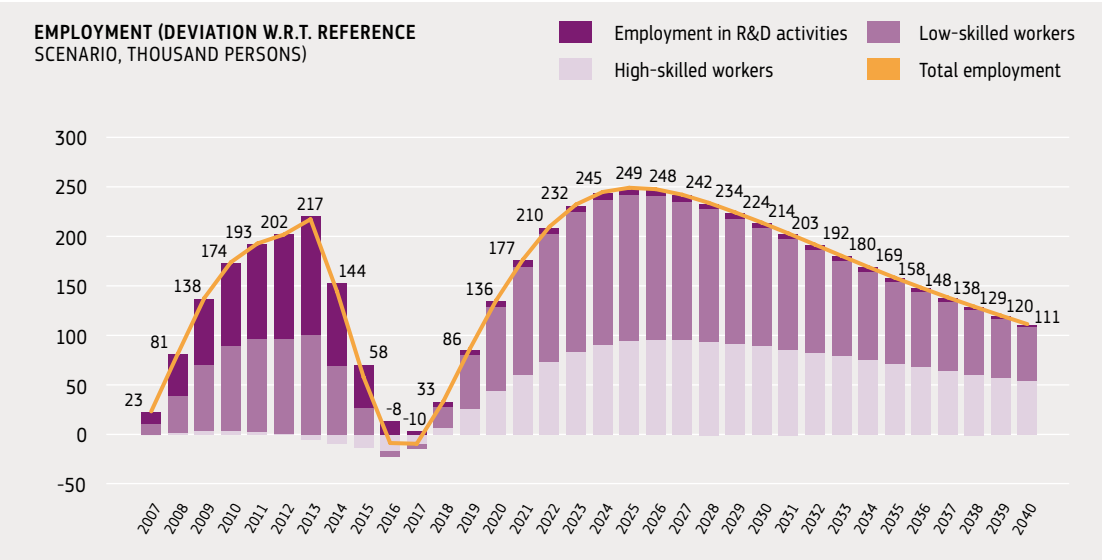
363 These estimates are based on a crowding-in factor of 0.64 (each EUR of Commission contribution leading to an additional R&D expenditure of EUR 0.64 from other public and private actors) as observed in the real data extracted from Corda (January 2017).

FIGURE 105: The impact of FP7 funding on EU GDP (in % deviation from reference scenario)



Source: NEMESIS model

FIGURE 106: Impact of 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 WP 2018-2020, to provide input to the report from the High Level Expert Group on maximising the impact of EU R&I programmes and to inform the design of future Framework Programmes. This section summarises 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 under way 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 R&I.
- R&I 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 clear pre-defined intervention logic.
- Most monitoring indicators focus on input and output and not on results and (societal) impacts.
- There are monitoring gaps, including lack of data beyond a project's lifetime.

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 by flagging up cross-cutting issues and understanding certain notions, e.g. with the notion of 'gender dimension in research content'.
- Track longer-term impacts beyond a project's lifetime.

Longer term

- Develop a clear intervention logic at the beginning of a new Framework Programme, starting with the expected impacts (longer term) and linking 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 lifetime.

12.2. RELEVANCE

KEY FINDINGS

- The original Horizon 2020 rationale for intervention and objectives also remains valid in light of the Juncker priorities and implementation of the SDGs.
- Horizon 2020 has proven fairly flexible in responding to new emerging needs.
- Horizon 2020 is broadly in line with stakeholders' needs and is attractive for newcomers.
- The strategic programming process has 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 two-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 room overall 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 projects' results and their scientific, technological, economic and societal impacts for 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 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 with 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 has lowered the administrative burden for participants and led to large reductions 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 has not led to a significant change in funding rates compared to FP7.
- Horizon 2020 suffers from underfunding which is 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 although some aspects such as the feedback to applicants could be improved.
- Despite the low success rates, and cost of proposal writing, the costs for stakeholders seem to be proportionate given the (expected) benefits of participation, which go beyond the financial contribution received.
- The balance in project size has not changed significantly compared to FP7 and does not seem to be having 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, although it is also rather concentrated.
- Horizon 2020 is open to the world and has a broad international outreach; however, funding participants from third countries has declined 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 given 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 Framework Programme implementation.
- 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 which 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 – founded on its early progress towards achieving scientific, economic and societal impact.
- Horizon 2020 is projected to produce large-scale economic impacts.
- Horizon 2020 is making an important contribution to the Commission's policy on 'Budget for Results'[364] 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.
- Although Horizon 2020 is attracting the best universities, research organisations, researchers and many of the top 'established' innovative companies, it has not been able to reach out to young and fast-growing innovative companies worldwide.
- Horizon 2020 builds cross-sectoral, interdisciplinary, intra- and extra-European R&I networks.
- Horizon 2020 projects already produce numerous outputs, such as publications, patents, prototypes, new or improved products, processes and methods, including in domains of societal relevance with the potential to generate scientific breakthroughs.
- Technology, regulation, standards, 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 excellence and widening participation, with noticeable performance differences and heterogeneity among the EU-13 countries and across Horizon 2020 programme parts.
- Progress is being made with respect to promoting gender equality under Horizon 2020, although concerns over data quality remain.
- The expenditure targets for sustainable development and climate change have not been achieved yet.
- Results are encouraging in terms of the integration of social sciences and humanities (SSH) in Horizon 2020, even if they are highly uneven across the programme.

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 the EU level in order to stimulate market-creating disruptive innovation.
- Further strengthen feedback from R&I projects to policymaking.
- Ensure gender balance in terms of representation in 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 WPs (contributions from certain SSH disciplines are relatively well represented, while others are hardly present at all).
- Continue progressing with making scientific publications and the data they generate openly accessible to the wider scientific community and the public.

Longer term

- Give better support to 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 better policy coordination at EU, national and regional level, and 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 firms.
- Engage future users in the agenda-setting and development of market-creating innovations.
- Focus investments in areas of strategic interest for the EU which are relevant to society, and where multiple impacts are expected, for example through focus areas.
- Better address the potential barriers to innovation (regulations, standards, access to finance,

364 http://ec.europa.eu/budget/budget4results/index_en.cfm

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 project 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 R&I at higher technology readiness levels (TRL). It must be ensured that this does not come at the expense of lower TRL collaborative research, which is regarded as a 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 various funding and other regulations 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, although capacity-building benefits do not seem to really influence the alignment of national strategies and policies.

AREAS FOR IMPROVEMENT

Short term

- 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.

Longer term

- 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 WP fragmentation must be reduced in order to maximise the impact of the activities supported.
- 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 competitions; creating international, transnational and multidisciplinary networks; pooling resources; creating a significant leverage effect and building critical mass to tackle global challenges.
- Horizon 2020 is enhancing the EU's attractiveness as a place to carry out R&I.
- Horizon 2020 is seen as improving participants' competitive advantage, 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 to be very large.

AREAS FOR IMPROVEMENT

Longer term

- Consider an impact-focused 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 the national or regional level.

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The Framework Programmes are the EU's main instruments for the funding of research and innovation 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 77 billion. It was designed to drive economic growth and create jobs by coupling research and innovation with an emphasis on excellent science, industrial leadership and tackling societal challenges.

After three years of implementation this book presents the results of the interim evaluation of Horizon 2020, in line with Article 32 of the Horizon 2020 Regulation and the Commission's Better Regulation Guidelines. It looks at whether Horizon 2020 is on track to achieve its objectives and provides lessons learnt for the next Horizon 2020 Work Programme and the preparations of future Framework Programmes.

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