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EVALUATION

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REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Ex-post evaluation of Horizon 2020, the EU Framework Programme for Research and Innovation

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Abbreviations

AAL	Active Assisted Living
CCI	Cross-cutting issue
CEF	Connecting Europe Facility
CIP	Competitiveness and Innovation Programme
COSME	EU programme to improve competitiveness of enterprises (2014-2020)
CS	Case study
DG	Directorate-General
ECA	European Court of Auditors
EESC	European Economic and Social Committee
EF	European fellowships
EFSI	European Fund for Strategic Investments
EIC	European Innovation Council
EIT	European Institute of Innovation and Technology
EJP	European Joint Programming
EMPIR	European Metrology Programme for Innovation and Research
ERA	European Research Area
ERC	European Research Council
ERICs	European research infrastructure consortia
ESIF	European Structural and Investment Funds
ERDF	European Regional Development Fund
ESS	European Spallation Source
EU	European Union
FET	Future and Emerging Technologies
FP	Framework programme
FTE	Full-time equivalent
GACD	Global Alliance for Chronic Diseases
GDP	Gross domestic product
GloPID-R	Global Research Collaboration for Infectious Diseases
IA	Innovation actions

IF	Individual fellowships
IOI	EU innovation output indicator
IPR	Intellectual property rights
IRDiRC	International Rare Disease Research Consortium
ITN	Innovative training networks
JPIAMR	Joint Programming Initiative on Anti-Microbial Resistance
JRC	Joint Research Centre
JU	Joint undertaking
KIC	Knowledge and Innovation Communities
KPI	Key performance indicator
LEIT	Leadership in Enabling and Industrial Technologies
MORE	Mobility of Researchers in Europe
MSCA	Marie Skłodowska-Curie actions
NMBP	Nanotechnologies, advanced materials, biotechnology and advanced manufacturing and processing
PRIMA	Partnership for Research & Innovation in the Mediterranean Area
PRC	Private for-profit entities (excluding higher or secondary education bodies)
RIA	Research and innovation actions
R&I	Research and innovation
RI	Research infrastructure
RISE	Research, innovation and science expert group
SC	Societal Challenges
SDG	Sustainable Development Goals
SME	Small and medium-sized enterprises
SoE	Seal of excellence
SwafS	Science with and for society
SWD	Staff working document
SEWP	Spreading excellence and widening participation
TFEU	Treaty on the Functioning of the European Union
TRL	Technology readiness levels

VC	Venture capital
UN	United Nations
WHO	World Health Organization

Glossary

Term	*Meaning or definition*
Administrative data	Data collected by government entities and agencies in the course of their regular activity for administrative purposes, such as to keep track of project payments.
Applicant	Legal entity submitting an application for a call for proposals.
Application	The involvement of a legal entity in a proposal. A single applicant can make several applications in different proposals. A single proposal can include several organisations and, therefore, several applications.
Associated countries	Association to Horizon 2020 is governed by Article 7 of the Horizon 2020 Regulation. Entities from associated countries can participate under the same conditions as those from EU countries. A country becomes associated to Horizon 2020 through an international agreement. Associated countries and territories in Horizon 2020 were: Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia, Turkey, Iceland, Norway, Switzerland, Armenia, Georgia, Israel, Moldova, Tunisia, Ukraine, and the Faroe Islands.
Background and foreground IPR	Background patents, i.e. patent (or other IPR) applications that are inputs of research rather than outputs, i.e. for which no causal link can be established with the support received by the programme (e.g. IPR applications reported by participants but filed before the start of the Horizon 2020 project. Foreground patents (or other IPR) are those filed after the start of the project that are genuine outputs of project research.
Causality	The sufficient link from one factor or event, the cause, to another factor or event, the effect.
Citation Distribution Index (CDI)	The citation distribution index is the sum of the weighted share of each decile of a distribution of publications, ranked by citation count (i.e., the 1st decile includes the 10% least-cited publications, the 10th decile includes the 10% most cited publications). This indicator is also normalised by year and by subfield of science. The CDI is normalised to 0 (i.e., the world average). A score above 0 indicates a level of performance above average, while a score below 0 indicates the opposite.
Close-to-market actions	Type of action under the Horizon 2020 Programme. They funded activities intended to produce plans, arrangements or designs for new, altered or improved products, processes or services, including: prototyping, testing, demonstrations, pilots, large-scale product validation and market replication.
Contractual public-private partnership (cPPP)	Structured public-private partnerships that have direct input into the preparation of work programmes in areas of major industrial significance. They develop roadmaps for research and innovation activities. There are currently eight partnerships: Factories of the Future, Energy-efficient Buildings, Green Vehicles, Future Internet, Sustainable Process Industry, Robotics, Photonics and High Performance Computing.
Control group	A group that is suitable for comparison with the group of units that were subject to a given policy. For more information, see Annex 2.

Coordination and support action (CSA)	An action 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 infrastructures. This may also include complementary networking and coordination activities between programmes in different countries.
CORDA (and eCORDA)	CORDA stands for Common Research Datawarehouse. It is the internal repository of Research & Innovation data gathered from EU research and innovation framework programmes. eCORDA stands for External COmmon Research Datawarehouse. It contains data on projects and proposals.
Correlation	Association between two variables. The establishment of a reasonable correlation between variables does not imply the establishment of a causal effect.
Counterfactual impact evaluation (CIE)	Refers to statistical procedures to assess the effect of a policy measure and gauge the degree to which it attained its intended consequences. For more information, see Annex 2.
Cross-cutting issues	In Horizon 2020: 1. The development and application of key enabling and industrial technologies as well as future and emerging technologies 2. Areas relating to bridging the gap between discovery and market application 3. Interdisciplinary and cross-sectoral research and innovation 4. Social and economic sciences and humanities (used interchangeably with social sciences and humanities, SSH) 5. Climate change and sustainable development 6. Fostering the functioning and achievement of the ERA and of the flagship initiative 'Innovation Union' 7. Framework conditions in support of the flagship initiative 'Innovation Union' 8. Contributing to all relevant Europe 2020 flagship initiatives 9. Widening participation across the EU in research and innovation and helping to close the research and innovation divide in Europe 10. International networks for excellent researchers and innovators such as European Cooperation in Science and Technology (COST) 11. Cooperation with third countries 12. Responsible research and innovation, including gender 13. SME involvement in research and innovation and broader private sector participation 14. Enhancing the attractiveness of the research profession 15. Facilitating transnational and cross-sector mobility of researchers.
Differences in Differences (DiD)	A counterfactual impact evaluation (CIE) method. For more information, see Annex 2.
Direct leverage	Difference between a project's total costs and the EU contribution given to the project.
Direct leverage factor	Ratio of the direct leverage and the EU contribution. It is related to the 'Funding rate' (see the definition below) via the following formula: $Direct\ leverage\ factor = \frac{1}{Funding\ rate} - 1$
Dissemination action	The public disclosure of the results by any appropriate means (other than resulting from protecting or exploiting the results), including by scientific publications in any medium.
European innovation partnerships (EIPs)	Public-private partnerships that bring together actors at EU, national and regional level to: boost research and development; coordinate investment in demonstration and pilots; anticipate and fast-track any necessary regulations or standards; and increase demand,

	in particular through better coordinated public procurement to ensure that any breakthroughs are quickly brought to market.
European Research Council (ERC)	The European Research Council is a European funding organisation for excellent frontier research which offers different grant schemes: starting grants, consolidator grants, advanced grants, synergy grants and proof of concept. The ERC is led by an independent governing body, the Scientific Council.
European technology platforms (ETPs)	Public-private partnerships in the form of industry-led stakeholder forums to develop research and innovation agendas and roadmaps for action at EU and national level (private and public funding), mobilise stakeholders to deliver on agreed priorities and share information across the EU.
Eurostars-2	The Eurostars-2 joint programme under Horizon 2020 supported SMEs that carried out R&D. It brought together 33 participating countries, 4 partner countries and the EU. The programme was based on Article 185 of the TFEU and was implemented by the EUREKA Secretariat (ESE), participating countries and the EU.
Excellent proposals	Eligible proposals assessed with a score above the quality threshold (proposals evaluated positively).
Exploitation action	The use of results in further research activities other than those covered by the action concerned, or in developing, creating and marketing a product or process, or in creating and providing a service, or in standardisation activities.
FET flagships	Large-scale European public-private partnerships that are science-driven at the start but gradually increase industrial participation over their 10-year duration. There are currently two flagships: Graphene and the Human Brain Project.
Financial instruments	Equity or quasi-equity investments, loans, guarantees and other risk-sharing instruments. Horizon 2020's financial instruments operated in conjunction with those of COSME. Strong synergies were to be ensured with the European Fund for Strategic Investments (EFSI) to create the maximum possible impact. This was the main form of funding for activities close to market under Horizon 2020.
Fast track to innovation (FTI) actions	A type of action under Horizon 2020 that funded any kind of project on close-to-market innovation activities.
Focus areas	Five focus areas were defined in Horizon 2020 to stimulate the development of knowledge and technologies deemed crucial to tackling societal challenges: • boosting the effectiveness of the Security Union (predominantly funding projects on vulnerabilities and threats related to European cybersecurity, migration and (financial) technologies); • connecting economic and environmental gains - the circular economy (predominantly funding projects on technological innovations in industrial processes and the reuse of resources to reduce waste and CO_2 emissions); • digitising and transforming European industry and services (predominantly funding projects concerned with automation, artificial intelligence and machine learning, as well as Earth observation); • building a low carbon, climate-resilient future (predominantly funding projects on energy production and consumption, emphasising the economic and environmental aspects of electricity storage, distribution and use). • promoting sustainable blue growth in the marine and maritime sectors through a responsible management of marine resources for a healthy, productive, safe, secure

	and resilient seas that are at the core of thriving eco-systems, climate regulation, global food security, human health, livelihoods and economies.[1]
Funding rate	Ratio of the EU contribution to a project and project's total costs.
Future and emerging technologies (FET) actions	Type of action under Horizon 2020, funding projects on future and emerging technologies (such as biotechnology, global system science, green technology, medical and neuro-technology, nanotechnology, quantum technology, robotics, and new materials).
High quality proposal	A proposal that scores above the quality threshold.
IKAA	In-kind contributions to additional activities. Under Horizon 2020, private members of some JUs (CS, FCH, BBI, S2R) had also to provide a minimum amount of in-kind contributions in respect of costs incurred for 'additional activities' outside the JU's work programme and budget, but falling within the scope of the JU's general objectives.
IKOP	In-kind contribution to operational activities. As provided for in the Joint Undertakings' founding regulations, all private members must contribute a minimum amount to the costs of the JUs' research and innovation projects. Under Horizon 2020, IKOP represented the total costs incurred by private members in implementing the JU's research and innovation actions, less the contribution of the other members of the JU (EU co-financing, contribution of participating states or intergovernmental organisations), as well as any other EU contribution to those costs.
Innovation action	An action primarily consisting of activities directly aimed at producing plans and arrangements or designs for new, altered or improved products, processes or services.
Interservice groups	Commission mechanism to ensure internal consistency of policy interventions.
Intervention logic	A (narrative) description and usually a diagram summarising how the intervention was expected to work. It describes the expected logic of the intervention or chain of events that should lead to the intended change
Joint programming initiatives (JPIs)	Public-public partnerships with EU Member State authorities to increase joint programming of national research programmes in a specific area, by developing a shared vision for the area, defining a Strategic Research Agenda (SRA) and SMART objectives (specific, measurable, achievable, relevant and time-bound) and preparing their implementation.
Joint undertakings (JUs)	Public-private partnerships with industry and stakeholders for the joint funding and implementation of strategic research and innovation agendas (via a joint undertaking under Article 187 of the EU Treaty, co-owned by the EU). There are currently six initiatives: the Innovative Medicines Initiative (IMI), Electronic Components and Systems for European Leadership (ECSEL), Fuel Cells and Hydrogen (FCH), Clean Sky, Bio-based Industries (BBI)and Shift2Rail (S2R). In addition, there are two JUs that are not JTIs: Single European Sky ATM Research (SESAR) and Fusion for Energy (F4E).
Knowledge and Innovation Communities (EIT KICs)	Partnerships between stakeholders in the innovation process (higher education institutions, research organisations, companies, etc.). They take the form of a strategic network, co-funded by the European Institute of Innovation and Technology (EIT). The network can have various legal forms and carries out multi-annual strategic planning

[1] European Commission, Blue Economy Report, 2021, pp. 109-110,

	(mid- to long-term), to develop innovative products and services, start or support new companies and train entrepreneurs. The EIT KICs under Horizon 2020 were: EIT Climate-KIC, EIT Digital, EIT InnoEnergy, EIT Health, EIT Raw Materials, EIT Food, EIT Manufacturing and EIT Urban Mobility. The EIT Culture and Creativity has been created under Horizon Europe.
National contact points	Network funded by the framework programme tasked with providing guidance, practical information and assistance on all aspects of participation in Horizon 2020.
Newcomer	A Horizon 2020 participant who was not involved in an FP7 Project (not an FP7 participant).
Oversubscription	Share of eligible proposals evaluated as above quality threshold that were not retained due to budget constraints, out of all eligible proposals evaluated by experts with a score above the quality threshold.
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.
Policy mix	The set of activities, instruments and types of actions used to implement Horizon 2020.
Prizes	Financial contribution (lump-sum) given as the prize in a contest. Prizes are a 'test-validate-scale' open innovation approach that brings together players who are new to an industry 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 a set target, solving the challenge defined.
Programme co-fund action	An action funded through a grant. The main purpose is to supplement individual calls or programmes funded by entities, other than EU funding bodies, that manage research and innovation programmes. A programme co-fund action may also include complementary networking and coordination activities between programmes in different countries.
Public-private partnership (PPP)	These support the development and implementation of research and innovation 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 Art. 187 of the TFEU and organise their own research agenda.
PPPs also provided via the Art. 185 initiatives	Article 185 of the TFEU allows the integration of national efforts into a programme undertaken jointly by several Member States, with the participation of the EU, including participation in the structures created for the execution of the joint programme.
Regression discontinuity design (RDD)	A counterfactual impact evaluation (CIE) method. For more information, see Annex 2.
Reimbursement rate	See funding rate.
Research and innovation action (RIA)	An action primarily consisting of activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution. It may include basic and applied research, technology development and integration, or testing and validation on a small-scale prototype in a laboratory or simulated environment.

SME instrument	The SME instrument targeted all types of innovative SMEs that showed a strong ambition to develop, grow and internationalise. It provided support at different stages of the entire 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. • Phase 2: Innovation projects that demonstrate high potential in terms of company competitiveness and growth underpinned by a strategic business plan. • Phase 3: Support to commercialisation.
Social Sciences and Humanities (SSH)	SSH encompass various disciplines such as social sciences, education, business, law, and humanities and the arts, including economics, sociology, demography, anthropology, psychology, geography, human rights, journalism, library and museum science, religion and theology, foreign languages and cultures, history, philosophy, fine arts, performing arts, graphic and audio-visual arts design.
Societal Challenges	Priorities identified in the Europe 2020 strategy aiming at stimulating research and innovation to achieve the EU's policy goals: 1. Health, demographic change and wellbeing 2. Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy 3. Secure, clean and efficient energy 4. Smart, green and integrated transport 5. Climate action, environment, resource efficiency and raw materials 6. Europe in a changing world: inclusive, innovative and reflective societies 7. Secure societies: protecting freedom and security of Europe and its citizens.
Success rate	The percentage of proposals that are retained for funding out of the total number of eligible proposals expressed as a percentage (Funded proposals/Eligible proposals*100).
Synergy	Synergy occurs when the sum of the (expected) results of programmes or initiatives, as a whole, is greater than the sum of the parts. Upstream synergies are defined in this document as occurring when another programme paves the way to apply to Horizon 2020. Downstream synergies, on the contrary, occur when other programmes take up the outputs of Horizon 2020 towards the market.
Technology Readiness Levels (TRL)	Technology Readiness Levels indicate the maturity level of particular technologies through 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 the lab; TRL 5 – technology validated in a suitable environment; TRL 6 – technology demonstrated in a suitable environment; TRL 7 – system prototype demonstration in an operational environment; TRL 8 – system complete and qualified; TRL 9 – actual system proven in an operational environment.
Widening countries	Countries identified as 'low-performing' in research and innovation, and thus eligible to apply for actions dedicated to spreading excellence and widening participation. In Horizon 2020, these were Bulgaria, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovakia and Slovenia (EU Member States) and Albania, Armenia, Bosnia and Herzegovina, Faroe Islands, Georgia, Moldova, Montenegro, North Macedonia, Serbia, Tunisia, Turkey and Ukraine (associated countries).

1. INTRODUCTION: PURPOSE AND SCOPE OF THE EVALUATION

Horizon 2020 is the eighth EU framework programme for research and innovation, set up by Regulation 1291/2013.[2] Following the adoption of the regulation on the European Fund for Strategic Investments[3], the total budget of Horizon 2020 was set at EUR 75 623 million in current prices. This *ex post* evaluation of the programme was required to be carried out by 31 December 2023.[4]

The scope of this evaluation is Horizon 2020, including the activities of the European Institute of Innovation and Technology[5] and the direct, non-nuclear, research activities of the Joint Research Centre.[6] It covers activities carried out or begun between 2014 and 2020 in the EU constituted of 28 Member States for the period of 2014-2020 (including the UK[7]) but also in a set of non-EU countries participating to the programme, including those associated to Horizon 2020.[8] An interim evaluation of Horizon 2020 was published in 2017.[9]

The evaluation covers the whole programme Horizon 2020. It addresses in more detail programme parts when they are particularly relevant for reaching one of the programme objectives, for instance the Marie Skłodowska-Curie Actions (programme part), for providing training, career development and transnational mobility of researchers (programme's specific objective) or InnovFin (programme part) for enhancing access to risk finance in the EU (programme's specific objective).

Exceptions are seven public-private partnerships[10] (implemented through Joint Undertakings established under Article 187 of the Treaty on the Functioning of the European Union (TFEU)) funded under Horizon 2020 which have legal successors in Horizon Europe. Whereas this evaluation explains how Joint Undertakings contributed to Horizon 2020 and the additional funds they leveraged, they will be fully evaluated as part of the interim evaluation of Horizon Europe according to regulation 2021/2085, which repeals and replaces previous relevant individual regulations of Joint Undertakings[11]. This evaluation also refers to the contribution of three public-public partnerships established under Article 185 of TFEU and already evaluated in 2022[12]: the Partnership for Research & Innovation in the Mediterranean Area (PRIMA), Active and Assisted Living Research and Eurostars 2.

Data from the seventh framework programme (FP7), that preceded Horizon 2020, are used to

[2] Complemented by Regulation 1290/2013 laying down the rules for participation and dissemination in Horizon 2020 and by Council Decision 2013/743 establishing the specific programme implementing Horizon 2020.
[3] In line with Regulation (EU) 2015/1017 on the European Fund for Strategic Investments, the European Investment Advisory Hub and the European Investment Project Portal, amending the Horizon 2020 regulation (EU) NO 191/2013, and Regulation (EU) NO 1316/2013.
[4] Article 32.4 of Regulation (EU) No 1291/2013 establishing Horizon 2020 - the framework programme for research and innovation (2014-2020).
[5] The European Institute of Innovation and Technology (EIT) has a separate legal base and is funded by Horizon 2020. It was allocated EUR 2 711 million in current prices, representing 3.18% of Horizon 2020 total budget.
[6] Nuclear research actions by the JRC are evaluated in the evaluation of the Euratom programme. Non-nuclear direct actions of the JRC were allocated EUR 1 855 million (2.45% of Horizon 2020).
[7] The UK's withdrawal from the EU took effect on 31 January 2020 but the Withdrawal Agreement allowed the UK to continue to participate in EU programmes, including Horizon 2020, until the end of the transition period.
[8] Associated countries: Albania, Armenia, Bosnia and Herzegovina, Faroe Islands, Georgia, Iceland, Israel, Moldova, Montenegro, North Macedonia, Norway, Serbia, Switzerland, Tunisia, Turkey, Ukraine. Other: the United Kingdom.https://research-and-innovation.ec.europa.eu/statistics/framework-programme-facts-and-figures/horizon-2020-country-profiles_en
[9] Interim Evaluation of Horizon 2020 (2017), https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/interim-evaluation-horizon-2020-key-documents_en
[10] Bio-based Europe, Clean Aviation, Clean Hydrogen, Europe's Rail, The Innovative Health Initiative, The Key Digital Technologies, Single European Sky ATM Research.
[11] Article 174.13 of Council Regulation (EU) 2021/2085 establishing the Joint Undertakings under Horizon Europe.
[12] PRIMA COM(2023) 285, Final evaluation of the Active and Assisted Living Research and Development Programme SWD/2022/404 final), and Eurostars-2 (2023, https://data.europa.eu/doi/10.2777/333838).

assess the long-term impact of the programme, in accordance with the relevant Council conclusions.[13]

All five compulsory evaluation criteria (i.e. effectiveness, efficiency, relevance, coherence, and the European added value of Horizon 2020) are assessed in this evaluation. This evaluation is informed by a set of 12 external studies[14], Commission monitoring reports, studies and reports issued by other European institutions (the European Court of Auditors, the European Economic and Social Committee, the European Parliament). The evaluation methods used include: (i) a review of documentation and analytical data; (ii) text analysis; (iii) more than 1,000 interviews with beneficiaries, national authorities and implementing bodies; (iv) a survey of successful and unsuccessful applicants[15]; (v) counterfactual analysis; (vi) a stakeholder consultation which ran from 1 December 2022 to 23 February 2023 gathering 1 818 replies. This mix of qualitative and quantitative methods provided a comprehensive evidence base.

Limitations in the analysis are due to the sizable share of projects that were still ongoing at the time of preparing this final evaluation: only 21 030 (59%) of the 35 426 projects signed had finished (59%), while 14 396 projects (41%) are still ongoing, in all programme parts and in all three pillars[16]. In addition, it is widely acknowledged in economics research[17] that evaluating R&I activities is challenging because of the nature of knowledge generation and its diffusion process. It takes time for R&I activities to produce results, outcomes, and impacts because of the importance of trial and errors, with an inherent need for risk taking and failures. The question of attribution of the effects observed is another challenge as scientific progress builds on knowledge that cumulates over decades and spreads unexpectedly in multiple domains and applications.

Programme indicators[18] used in this evaluation are referred to in section 4 and in the evaluation matrix, in Annex 3. It should be noted that the performance on all programme indicators is expected to still increase as projects continue delivering upon their completion.

Indicators and their monitoring system suffer from inherent shortcomings. Thorough checks were conducted in order to ensure that data is robust. Nevertheless, the evaluation wants to recognize four challenges in this field. First, as already noted in the interim evaluation, Horizon 2020 indicators refer only to parts of the programme's intervention logic. Second, indicators could have been better designed, as they were not accompanied systematically by baselines values (i.e. values before the programme) or by target values (i.e. expected values at the end of the programme). Third, monitoring data recorded in the Commission's IT systems can minimise but not completely exclude cases of multiple counting, e.g. the same publications/patents reported in one year are reported again in other years. Fourth, information on patents is provided voluntarily by beneficiaries with possible cases of erroneous reporting and under-reporting. In addition, Intellectual Property Rights (IPR) from Horizon 2020 and FP7 may include "background patents", i.e. patent (or other IPR) applications filed before the start of the Horizon 2020 project, for which no causal link can be established with the support received by the programme.

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[13] Council conclusions on the seventh framework programme (FP7) ex post evaluation of 27 May 2016 (https://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/119692.pdf,) and the Council conclusions on Horizon 2020 interim evaluation of 1 December 2017 (https://www.consilium.europa.eu/media/31888/st15320en17.pdf) invited the Commission to assess the long-term impact of the programme, in the *ex post* evaluation of Horizon 2020.

[14] Available at Horizon 2020 indicators - Publications Office of the EU (europa.eu) and also listed in the evaluation matrix (Annex 3).

[15] 5 417 complete and 449 partial responses were received, covering Pillar 1, horizontal SWEPs and SwafS.

[16] European Commission, R&I dashboard, figures as of 31/12/2022.

[17] Cunningham, J. A., Harney, B., & Fitzgerald, C. (2020). University research commercialisation: Contextual factors. In Effective Technology Transfer Offices (pp. 15-31). Springer, Cham. Science, Research & Innovation performance of the EU, 2022 (SRIP), Chapter 15, - Science and technology gestation lags.

[18] Horizon 2020 indicators: assessing the results and impact of Horizon, Publications Office, 2015, https://data.europa.eu/doi/10.2777/71098

Data used in this evaluation is publicly available in the Horizon dashboard database, but a direct one-to-one comparation between the figures presented here and the dashboards is not possible due to different reference dates and, for some indicators, different approaches to data cleaning and removal of duplicates.

Section 3 provides data on the implementation of the programme since its launch until 1 January 2023. Section 4 provides an evaluation of the programme based on triangulation of evidence that predates 1 January 2023[19] (e.g. most external studies were carried out in 2022, based on programme data that was extracted at the end of 2021).

2. WHAT WERE THE EXPECTED OUTCOMES OF HORIZON 2020?

2.1 Horizon 2020 and its objectives

The impact assessment[20] of Horizon 2020 identified several **weaknesses** in the European science and innovation system, which were factors in low productivity, declining competitiveness and inadequate responses to societal challenges.

While Europe has a historically strong science base, it often lags behind the United States when it comes to highly cited science or top-ranking universities, with increasing competition as well from other countries. An **increase in spending on frontier research**, associated infrastructure and training and education was identified as necessary to strengthen Europe's scientific and technological performance, and to provide the basis for the EU's competitiveness in the future.

The EU had not yet managed to translate its early lead in many green and 'quality of life' technologies (in health or security, etc.) into an innovative and competitive lead, experiencing **insufficient technological leadership and a lack of innovation capacity in companies**.

In addition, a lack of coordination of research to tackle the challenges faced by society led to missed opportunities to generate scale and synergies. Coordination between Member States for R&I was deemed insufficient. On average, in the EU, only some 10% of public budget for R&D is allocated at European level through the FP for R&I, enabling coordination and collaboration across countries.[21]

The **complexity of administrative procedures to apply for funding and take part in the framework programme** were identified as the **biggest obstacle to implementation.**[22]

In line with the needs described above, Horizon 2020 was designed with the **general objective** to '*contribute* to *building a society and an economy based on knowledge and innovation by leveraging additional R&I funding, and contribute to attaining R&I targets, including the target of 3% of GDP for R&D by 2020. It shall 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)'.*

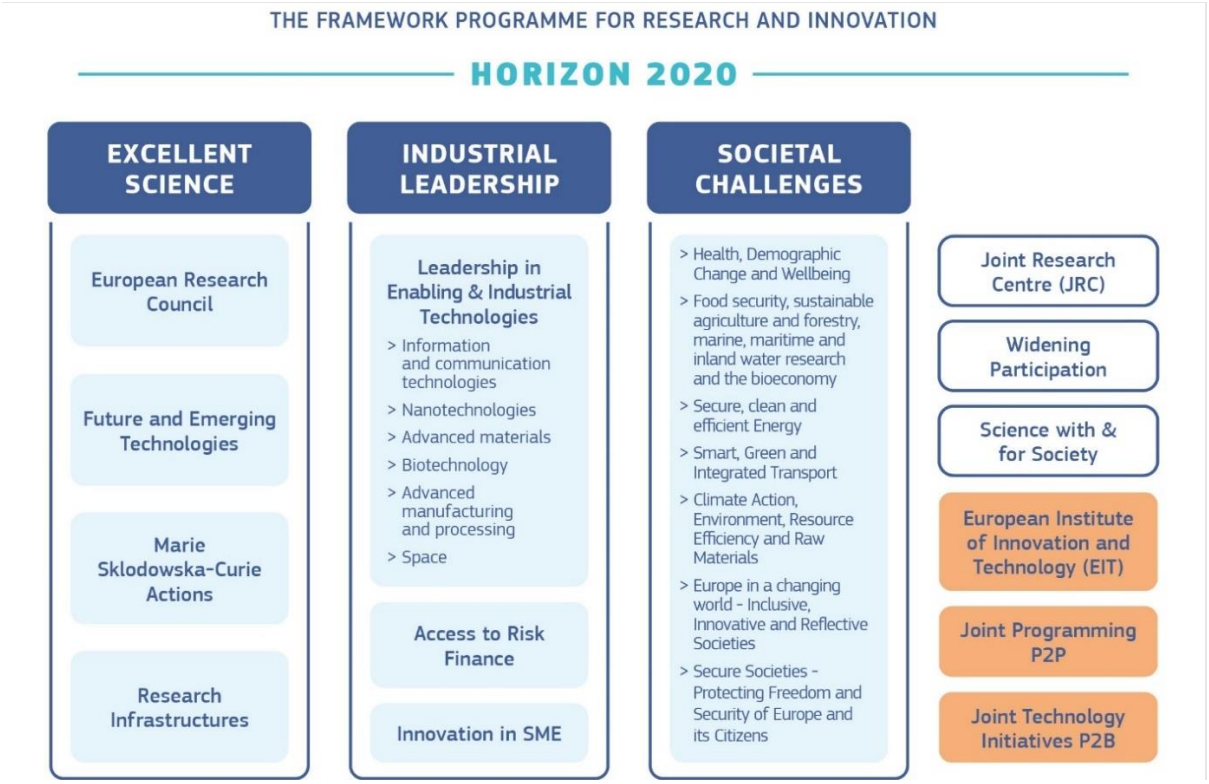
[19] Figures on Key Performance Indicators extracted by the Commission's internal monitoring system are updated, unless otherwise specified, on 21 April 2023.
[20] SEC(2011) 1427, volume 1, p. 6, https://research-and-innovation.ec.europa.eu/document/e9965187-3737-488f-a051-9cd8f5c6e867_en.
[21] DG RTD calculations using GBARD and EU Spending and revenue (europa.eu), as of August 2023.
[22] SEC (2011) 1428, volume 2, p. 14.

The programme's **specific objectives** were to:

1. **Strengthen Europe's scientific base (32% of the total budget)**, through:
    a. the European Research Council (ERC) providing attractive and flexible funding to enable EU competition for frontier research. (17% of the total budget);
    b. fostering collaboration on radically new ideas to accelerate the development of Future and Emerging Technologies; (4% of the total budget);
    c. Marie Skłodowska-Curie actions, providing training, career development and transnational mobility of researchers; (8% of the total budget);
    d. Support for excellent European research infrastructures. (3% of the total budget).
2. **Boost Europe's industrial leadership and competitiveness (22% of the total budget)** thanks to:
    a. Leadership in enabling and industrial technologies, i.e. support for research, development and demonstration of key technologies; (17.5% of the total budget);
    b. Access to risk finance, i.e. provision of debt and equity finance for R&I driven companies; (3.5% of the total budget);
    c. Innovation in SMEs, support for all forms of innovation in SMEs. (1% of the total budget).
3. **Increase R&I's contribution to tackling Societal Challenges (SC) (39% of the total budget)**, through basic research, applied research, knowledge transfer and innovation. The focus should be on the EU's policy priorities, without predetermining the precise choice of technologies or solutions that should be developed in:
    a. Health, demographic change and well-being (Societal Challenge (SC)1) (10% of the total budget);
    b. Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bio economy (SC2) (5% of the total budget);
    c. Secure, clean and efficient energy (SC3) (8% of the total budget);
    d. Smart, green and integrated transport (SC4) (8% of the total budget);
    e. Climate action, environment, resource efficiency and raw materials (SC5) (4% of the total budget);
    f. Inclusive, innovative and reflective societies (SC6) (2% of the total budget);
    g. Secure societies (SC7) (2% of the total budget).
4. **Spread excellence and widen participation (1% of the total budget)** via actions aimed at distributing the benefits of an innovation-led economy across the EU, in accordance with the principle of excellence.
5. **Increase the role of science in society (1% of the total budget),** to build effective cooperation between science and society.
6. **Optimise the delivery of the programme.**[23]

[23] Source: Horizon 2020 implementation data. Percentages include funding provided to EIT (3% of budget) and JRC direct actions (2%).

Figure 1: Horizon 2020's structure



Source: European Commission, 2023.

A set of **cross-cutting issues** were also promoted across the programme, in particular gender equality, social sciences and humanities, international cooperation, responsible research and innovation, widening participation, sustainable development, biodiversity and climate action, the digital agenda, SMEs and broader private sector participation.

From an **implementation perspective**, the programme's objective was focused on simplifying and reducing the administrative burden during the phases of preparing a proposal and implementing a project, with targets for the time to award a grant and the time to pay.[24] To boost innovation, a target was set in Leadership in Enabling and Industrial Technologies (LEIT) and Societal Challenges to allocate at least 20% of the budget to SMEs.[25]

The JRC (with 2% of Horizon 2020's total budget) and the EIT (3% of the total budget) were expected to contribute to both the general objective and the specific objectives by (1) providing customer-driven scientific and technical support for EU policies, and (2) integrating the knowledge triangle of higher education, research and innovation. The indicators for assessing the performance of the EIT[26] stem from the activities of universities, businesses and research organisations integrated in the EIT Knowledge and Innovation Communities and collaboration inside the knowledge triangle leading to the development of innovative products, services and processes.

As a result of the annual budget procedures from 2014 to 2020, the programme finally received a voted budget of EUR 75 623.6 million (in current prices[27]). A total of 78% of the budget was

[24] Horizon 2020 rules for participation.
[25] Horizon 2020 Regulation recital (35), article 22(3) and Annex II 'Breakdown of the budget'.
[26] Full list of EIT Key Performance Indicators: https://eit.europa.eu/sites/default/files/2022-08_20220316-gb71-08_eit_kpis.pdf
[27] MFF 2014-2020 – Horizon 2020 – Budget implementation, https://commission.europa.eu/strategy-and-policy/eu-budget/performance-and-reporting/programme-performance-overview/horizon-europe-performance_en#mff-2014-2020--horizon-2020. This amount is the final budget, including transfers and adjustments following the annual budget adoption, while the amount on p.1 is the amount of the legal base, after amendment by the EFSI Regulation.

granted to transnational collaborative projects (through research and innovation actions and innovation actions) while support to individual researchers and companies was provided through the ERC grants, some Future and Emerging Technologies (FET) schemes, the Marie Skłodowska-Curie Actions (MSCA) and under the SME instrument. Other types of actions included the procurement of innovative solutions, public-public partnerships (including ERA-NET Co-funds and Article 185 actions), public-private partnerships (including Article 187 partnerships, Joint Technology Initiatives and contractual public-private partnerships), inducement prizes and financial instruments. Coordination and Support Actions (CSA) and procurements were used for studies, expert groups, conferences, and to disseminate and exploit results. A special form of collaborative project was also piloted, the Fast Track to Innovation, which focused on industrial actors. The Commission also undertook direct R&I actions through its Joint Research Centre.

Funding was mostly allocated through biennial work programmes. In evaluating project proposals excellence was the main criterion, next to the quality and efficiency of implementation and the expected impact.

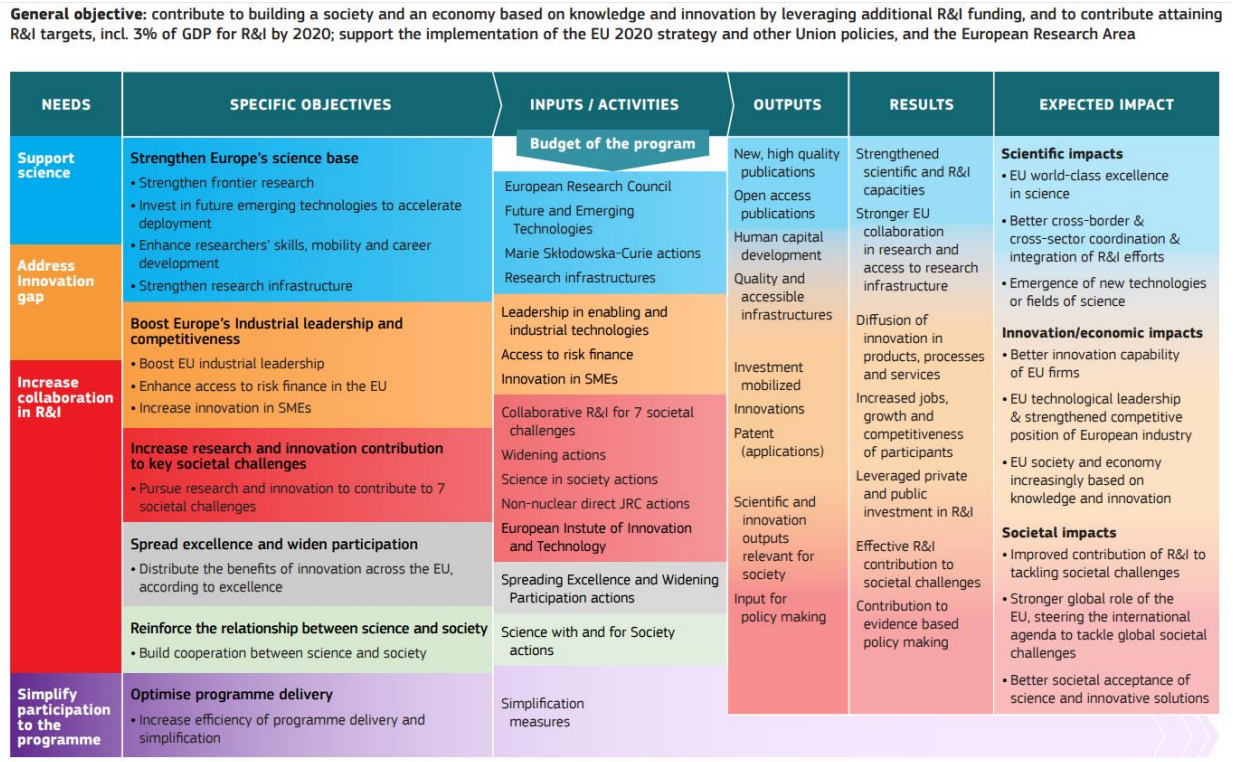
Horizon 2020 brought considerable change compared to FP7 by including all support for innovation in one programme, which had previously been financed by separate EU programmes: the innovation-related part of the Competitiveness and Innovation Programme, and the EIT.

Horizon 2020 attempted to simplify access for participants, with a single web portal for all information and projects, less paperwork when applying, and more focused controls and audits.

Several changes were made during the last two years of the programme, following the interim evaluation. These included a pilot of lump sum funding and two-stage application procedures, the launch of a pilot for the European Innovation Council, flagship initiatives for international cooperation, and cross-cutting calls for proposals on specific policy priorities, such as the 2020 call for proposals to support the European Green Deal through R&I.

Horizon 2020 **was expected to deliver** scientific, technological and innovation outputs that would translate into scientific, economic and societal impacts related to the specific objectives of the programme. The main impacts expected of Horizon 2020 are illustrated in Figure 2 (on the programme's intervention logic). It shows that all parts of the programme can bring scientific, economic and/or societal value.

Figure 2: Horizon 2020 intervention logic



Source: European Commission, 2023.

Progress towards the objectives was monitored according to **23 key performance indicators** (KPIs) that were either set out in the legal base[28] or subsequently developed by the Commission[29]. The Horizon 2020 indicators represented a step forward in the monitoring process because this was the first time that KPIs were introduced, although they did not cover the entire programme and contained a number of shortcomings (presented in Annex 2).

The performance indicators for assessing progress against the general objective were[30]:

- the **research and development target (3% of GDP)** of the Europe 2020 strategy;
- the **innovation output indicator** in the Europe 2020 strategy[31]; and
- the **proportion of researchers in the active population**.

Some indicators were accompanied by baseline values and specific **targets** for the end of Horizon 2020. All indicators are presented in the evaluation matrix in Annex 3.

The Horizon 2020 programme set additional quantitative targets for:

- Sustainable development related investment: at least at 60% of overall investment;
- Renewable energy, end user energy efficiency, smart grids and energy storage activities: at least 85% of the overall Energy Societal Challenge funds;
- Funding to SME: at least 20% of in the LEIT programme and under Societal Challenges (of which 7% committed through the SME instrument);
- Climate change-related investment: at least 35% of overall investment.

[28] Annex II of Council Decision 2013/743.
[29] Horizon 2020 indicators (2015) https://ec.europa.eu/newsroom/horizon2020/items/25823/en.
[30] Article 32.5 of the Horizon 2020 Regulation states that the performance indicators for assessing progress against the general objective of Horizon 2020 and for the EIT are set out in Annex I.
[31] Communication from the European Commission to the EP, the Council, the European Economic and Social Committee and the Committee of the Regions, 'Measuring innovation output in Europe: towards a new indicator', COM(2013)0624 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0624:FIN:EN:PDF.

2.2 Points of comparison

The main point of comparison is the impact assessment carried out for Horizon 2020. Where the expected effects were quantitatively estimated or targets were set in the Horizon 2020 impact assessment or in the legal base, this evaluation compares the actual Horizon 2020 data to these expectations. This is the case for the analysis of macroeconomic impacts and KPIs on publications, patent applications, mobility of researchers, risk finance, and for targets on simplification, SME participation and climate-related spending, high quality publications by FET, female representation in advisory panels, efficiency metrics (time to contract, time to pay, error rate, etc), leverage factors per selected JU).

In the absence of targets, this evaluation compares the current Horizon 2020 performance to data from the end of FP7. This is the case for the number of publications, patents funded with a contribution from Horizon 2020, female representation in advisory panels, participation from entities located in widening countries, contribution to Sustainable Development Goals, JRC concrete contributions to policies and international cooperation.

Where this approach is not possible, or where additional insights could be gained, this evaluation compares the actual results of Horizon 2020 against those of other relevant EU or international benchmarks. This is the case for the quality and influence of scientific publications, JRC's publications, share of publications freely and publicly available, number of public private academic co-publications.

If none of the above is possible, newly available data on Horizon 2020 are presented, without any baseline nor benchmark. This is the case for the number of patents and publications for some of the Societal Challenges and leverage factor at programme level.

3. HOW HAS THE SITUATION EVOLVED DURING THE EVALUATION PERIOD?

The overall completion rate of Horizon 2020 projects at the time of this final evaluation is 59%, while the remaining projects are still in progress and due to submit their final report. The cumulative implementation rates at the time of the evaluation were 99.99% for Horizon 2020 commitments and 87.84% for payments.

Implementation delays due to lockdowns linked with the Covid pandemic temporarily affected networking and project dissemination and exploitation opportunities. However, the completion rate of Horizon 2020 is higher than at the time of the final evaluation of the preceding programme, FP7 (50%). While unfinished projects inevitably generate a degree of uncertainty, comparison of results with the FP7 baseline is being done at a similar point in time. Long-term analysis of FP7 also shows that some effects are likely to increase as the final project reports are received and in the years that follow (see section 4.1.5. on long-term impacts).

Calls for proposals

During the lifetime of Horizon 2020, 1 076 calls for proposals, covering a total of 3 706 topics, were launched and evaluated. These calls attracted over **285 000 eligible proposals,** which **requested** EUR 478 billion in EU funding. A total of 1.8% of the proposals submitted were ineligible.[32]

[32] CORDA data extracted on 1 March 2023, including ineligible, inadmissible and duplicate proposals.

Although 46% of the eligible proposals were assessed as being of high quality[33] by external experts, funding could not be granted to all, resulting in an average success rate[34] of 11.9% and an oversubscription rate[35] of 74%.

The percentage of proposals above the quality threshold and the percentage of proposals funded (success rate) were highest under Spreading Excellence and Widening Participation (67.1% and 15.9%), followed by Excellent Science (55.2% and 13.7%), and lowest under Industrial Leadership (34.3% and 8.7%).

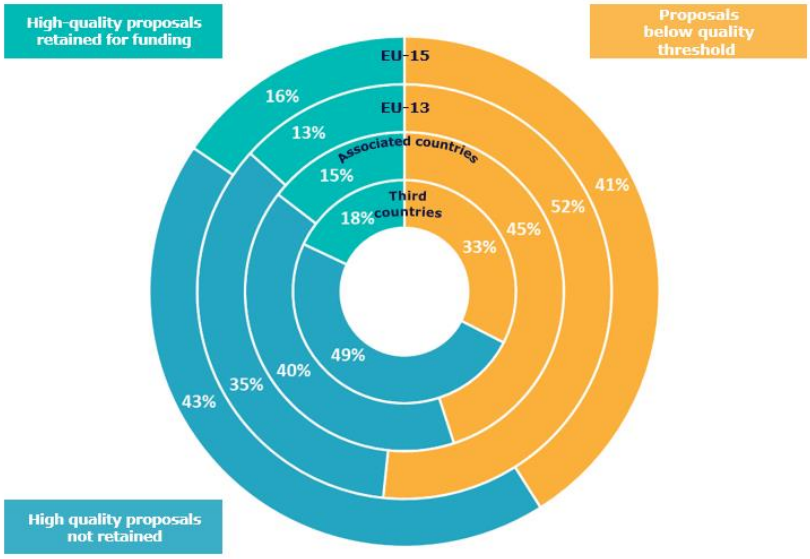
Applications to Horizon 2020

The eligible proposals included over **1 million applications**[36]. Most applications originated from private for-profit organisations (40%), followed by higher education institutions (36%) and research organisations (17%). SMEs accounted for 24% of applications. More details are provided in Annex 6, including detailed data tables on applications by country, organisation type and pillar, and success rates by country.

88% of the applications originate from EU-28 Member States, half of which originated from entities located in four countries: Spain, Italy, Germany and the United Kingdom. EU-13 countries represent 10% of the applications and - putting the number of applications in perspective with the scientific population of each country - the most active Member States were Cyprus, Greece, Slovenia and Estonia.

Figure 3 presents applications coming from EU-15 (Member States that joined the EU before 2004), EU-13 (Member States that joined in or after 2004), associated countries and third countries.

Figure 3: Applications by country group



Source: CORDA data – cut-off date: 1 January 2023

As regards third countries, Switzerland, Norway, Israel and Turkey accounted for 84% of the 83 377 applications submitted by entities located in countries associated to Horizon 2020. Entities

[33] Proposals are considered as being of high quality when the expert evaluators gave them a score above the quality threshold.
[34] The success rate is the percentage of proposals that are retained for funding out of the total number of eligible proposals.
[35] The proportion of eligible proposals evaluated as above the quality threshold and which were not retained due to budget constraints, out of all eligible proposals evaluated by experts to be above the quality threshold.
[36] Note: the same organisation applying N times in N different proposals is counted N times.

located in non-associated countries outside the EU represent 3.7% of all applications and 1.2% of the requested amount in retained proposals. The United States led with 10 336 applications, almost one third of all applications from non-associated countries, followed by China (2 970 applications) and Canada (2 282 applications).

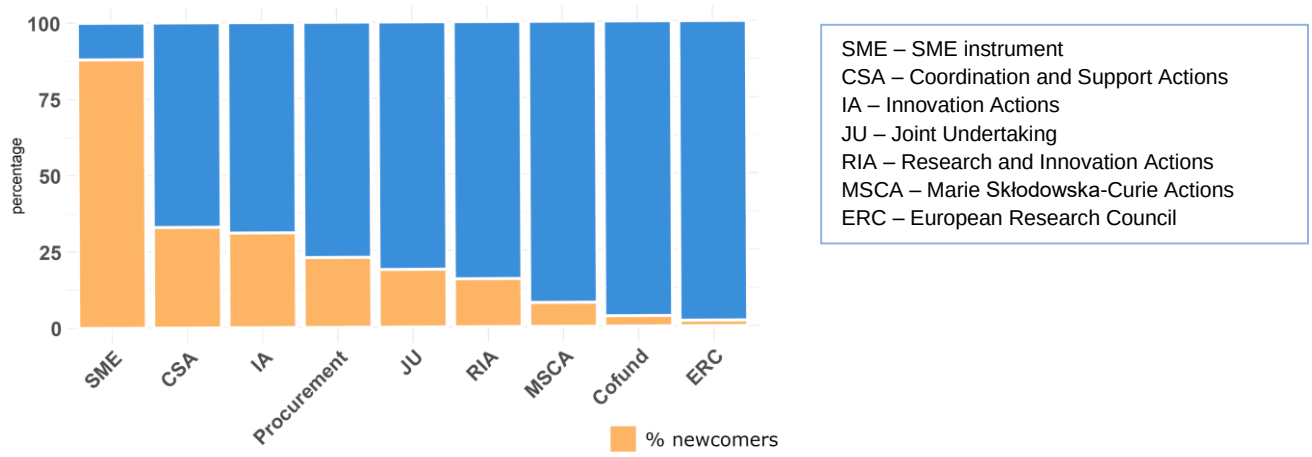
Funding allocation

EUR 68.3 billion were allocated through 35 426 signed grants, 31.6% of the funds being allocated to the top 100 beneficiaries.

Around 50% of Horizon 2020 funding was allocated to 341 organisations. Around 10% of funding went to the 50 best-performing universities in Europe, based on the Leiden ranking data.[37]

Around 19% of Horizon 2020 funding (approx. EUR 12.9 billion) went to newcomer organisations, i.e. organisations that had not participated in FP7. Across the programme, around 50% of the total funding to private companies went to newcomers: most newcomers are in fact SMEs. Newcomers are in general more common in types of actions with high industry participation; within Joint Undertakings, 19% of all funding went to newcomers.[38]

Figure 4: Share of EU funding to Horizon 2020 newcomers by type of action[39]



Source: CORDA data, 2 August 2022. Taken from European Commission, 'Newcomers in EU R&I programmes – Main trends in Horizon 2020, first evidence from Horizon Europe', monitoring & evaluation report, https://data.europa.eu/doi/10.2777/198795

The **average budgetary size** of the signed grants[40] was EUR 2.3 million but this varied substantially between the three pillars, from EUR 1.2 million under Excellent Science to EUR 3.7 million under Societal Challenges.

SMEs, with an application success rate of 12% (slightly higher than the programme average), accounted for 19.8% of all participations and received EUR 11.4 billion in funding.

[37] Ibid. https://www.leidenranking.com/

[38] European Commission, DG for Research and Innovation, "Newcomers in EU R&I programmes: main trends in Horizon 2020, first evidence from Horizon Europe", Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2777/911220.

[39] An overview of Horizon 2020 types of action is available in the Horizon 2020 online manual, section "What you need to know about Horizon 2020 calls": https://ec.europa.eu/research/participants/docs/h2020-funding-guide/grants/applying-for-funding/find-a-call/what-you-need-to-know_en.htm

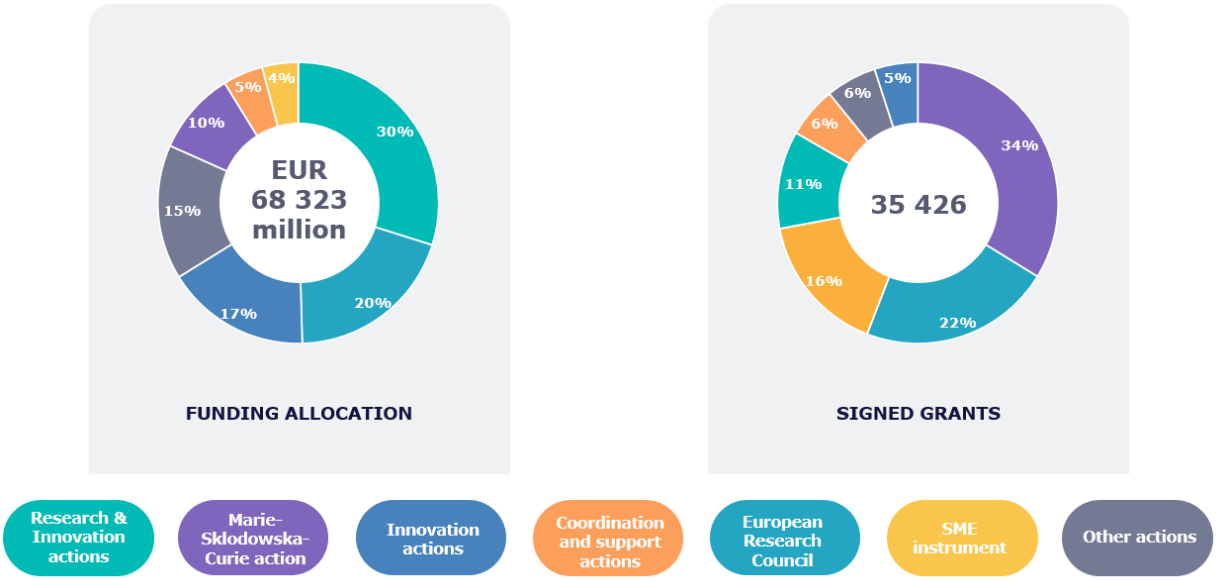
[40] FP7's average grant size was EUR 1.8 million, suggesting an increase under Horizon 2020 (under 18%), even when adjusted for inflation. Calculation of Horizon 2020's average grant size excludes very small grants of 50 000 EUR under SME instrument phase 1, to avoid distorting the overall figure. When included, the average drops to EUR 1.9 million.

The proportion of Horizon 2020 **budget spent on climate action**[41] reached **32%.**[42]

Type of Actions

Most funding was allocated through research and innovation actions (RIAs, 9.830% of the funding), followed by frontier research grants awarded by the ERC (19.7%), innovation actions (17%) and the MSCA (10%). The MSCA accounts for the highest number of signed grants (11 960) followed by the ERC (7 838), the SME instrument (5 734) and RIAs (3 978).

Figure 5: Funding allocation by type of action



Source: CORDA data – cut-off date: 1 January 2023

The new funding scheme for innovation, the **innovation actions (IAs),** aimed at producing plans and arrangements or designs for new, altered or improved products, processes or services, demonstrations, piloting and prototyping. Despite representing just 6% of all Horizon 2020 projects, IAs represented 17% of the total financial contribution (or EUR 11.4 billion). Except for the first year of the programme, the proportion of funding to IAs constantly increased, from 13% in 2015 to 21% in 2021[43]. IAs are characterised by high participation rates by private for-profit entities, which received over EUR 5 billion in total. In the Industrial Leadership pillar, 32% of all funding was for IAs and 25% in Societal Challenges (35%). The balance between demonstration activities and 'first-of-a-kind' innovation activities is heavily lopsided towards the former, by a ratio of almost ten to one (and even higher in the Industrial Leadership pillar).[44]

Beneficiaries

Different organisations received Horizon 2020 funding, 42% of which were SMEs and 69% were newcomers to EU research and innovation programmes.[45]

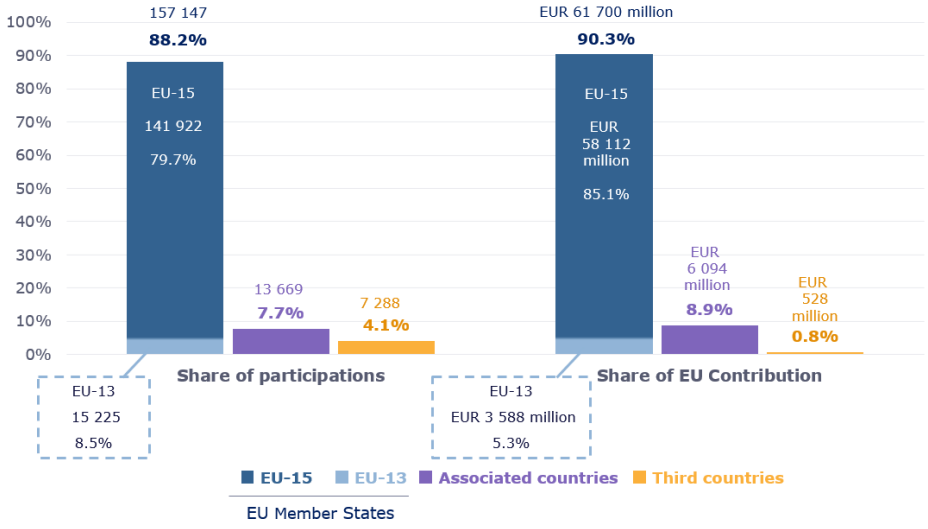
The majority of funding (78% or EUR 53.3 billion) went to **collaborative projects**, which brought together an average of 11 participants in 14 612 supported projects. Looking at the number of individual grants, 59% (20 814 grants) went to a **single beneficiary**, mostly for ERC, MSCA and SME instrument representing 22% of the funding (EUR 15 billion).

[41] This is calculated on the basis of the 'RIO markers' methodology developed by the OECD.
[42] Based on Programme Statement data. This is slightly higher than the 31.6% reported by the Study on the Relevance and Internal Coherence of Horizon 2020, which was based only on programme data that is available in eCorda.
[43] Source: CORDA data – cut-off date: 1 January 2023.
[44] Ibid, Annex 3, section 6.3, pp. 79-81.
[45] European Commission, DG for Research and Innovation, "Newcomers in EU R&I programmes: main trends in Horizon 2020, first evidence from Horizon Europe", op. cit., https://data.europa.eu/doi/10.2777/911220.

Higher education institutions come first in terms of the EU contribution received (39% or EUR 26.8 billion), followed by private for-profit entities (28% or EUR 19.3 billion) and research organisations (25% or EUR 17.1 billion).

Participation varied by country group, between EU Member States, associated countries and third countries as shown in Figure 6.

Figure 6: Participants and funds by country group in Horizon 2020



Source: CORDA data – cut-off date: 01/01/23

More than half of the Horizon 2020 funding allocated to **Member States** went to four countries: Germany (16%), the United Kingdom (13%), France (12%) and Spain (10%). However, when comparing the amounts received from Horizon 2020 to million EUR of gross domestic expenditure on R&D, smaller countries such as Estonia, Greece, Cyprus and Latvia performed better than bigger Member States. More details on this are available in Annex 6, including detailed data tables on Horizon 2020 investment by country, pillar and organisation type.

For **non-associated third countries**, the share of participations is around 4%. The relatively low figure for the share of EU funding that went to these participants can be explained by the fact that only low- and middle-income third countries are automatically eligible for funding, while high-income countries had to contribute with their own funds to Horizon 2020 projects.[46]

Participation of SMEs

The participation of private for-profit entities in Horizon 2020 was higher than in FP7. They accounted for 33.5% of all participations (against 30.3% in FP7), and 28.2% of all EU financial contributions to the programme, 3.3 percentage points more than in FP7.[47]

Horizon 2020 has so far awarded 22.2% of EU funding to SMEs in the LEIT programme and under Societal Challenges. The highest rate of SME participation was in Nanotechnologies, advanced materials, biotechnology and advanced manufacturing and processing (NMBP, 29%)[48], where a few sub-programmes had particularly high 1.5 participation: 42% of funding in nanotechnology topics and 36% in biotechnologies went to SMEs. This was much higher than the SME share in the New Production Technologies theme of FP7 (25.6%).[49] Lower shares of

[46] Compared to FP7, some sizeable countries (Brazil, Russia, India and China) were moved from the category of low- and middle-income countries to high-income countries, so they were no longer automatically eligible for funding.
[47] European Commission, R&I projects Dashboard, data frozen on 31/12/2022.
[48] Figures from the R&I Project Dashboard. The share of SMEs in NMBP diminishes to 25% if only SMEs flagged as "private for-profit" entities are considered - cf. Digital and Industrial Transition study, section 3.2.2, p. 28.
[49] FP7 figures are extracted from the R&I Project Dashboard.

EU funding were seen in SC1 (health, 17%), SC4 (transport, 17%) and SC6 (inclusive societies, 14%).

Around one third of funding to SMEs was provided through the SME instrument. This represents 7.1% of overall Horizon 2020 funding, which is above the 7% target set at the start of the programme (see Table 1).

Table 1: Cross-cutting key performance indicators (KPIs) on SME participation in Horizon 2020

Source: Cross-cutting issues study (2023), elaboration on CORDA data (2022).

Horizon 2020 was also successful in attracting new SME participants. Around half (50.3%) of all EU funding to private for-profit businesses went to newcomers, and two thirds of this amount to SMEs. In general, actions that attract more SMEs – the SME instrument, as well as innovation actions – have high rates of newcomer participation. Conversely, actions that target collaboration with the private sector, but not necessarily SMEs, had fewer new participants.[50]

[50] European Commission (2023), DG for Research and Innovation, "Newcomers in EU R&I programmes – Main trends in Horizon 2020, first evidence from Horizon Europe", op. cit., https://data.europa.eu/doi/10.2777/911220.

4. EVALUATION FINDINGS

4.1 To what extent was Horizon 2020 successful and why?

This section provides an evidence-based assessment of the successes and shortcomings of the Horizon 2020 programme in terms of its effectiveness, efficiency and coherence. It begins by examining how effectively Horizon 2020 achieved its scientific, societal and economic objectives, as well as the programme's parallel objectives of spreading excellence, widening participation and promoting science in society. This section then considers the cost of pursuing these objectives. Finally, it provides evidence of the degree to which the programme has operated in a coherent way, both internally between its different instruments, and externally with other relevant EU and national programmes.

4.1.1. Effectiveness: **Scientific impacts** – To what extent has Horizon 2020 strengthened Europe's scientific base?

The objective of Horizon 2020 was to reinforce and extend the excellence of the Union's science base and to consolidate the European Research Area (ERA) in order to make the Union's research and innovation system more competitive on a global scale. Throughout the course of Horizon 2020, excellence was assured by means of pan-European competition for funding and a stringent project proposal evaluation process[51]. All actions across all Horizon 2020 pillars are expected to contribute towards achieving scientific impact.

The Horizon 2020 Regulation[52] requires that progress on its over-arching general objective is assessed against a number of indicators, including the proportion of researchers in the active population in the EU. Eurostat data show that, in 2021, the number of full-time equivalent (FTE) researchers employed in the EU was 2 million[53], or 1% of the total active population[54]. This represents an increase[55] of over 570,000 researchers compared with 2012 (1.43 million, 0.7% of the labour force). This 33% increase in the number of researchers in the active EU population between 2012 and 2021 is not considered a direct consequence of Horizon 2020 funding as other external factors (e.g. tax and labour law changes in Member States) also play a role and this evaluation is unable to quantify the direct contribution of Horizon 2020 to this increase.

Horizon 2020 contributed to scientific impact through multiple streams that delivered quality research and contributed to scientific breakthroughs, while reinforcing human capital, research infrastructure[56], and encouraging participation from countries least performing in research and innovation as described in the sections that follow.

What messages emerged from the stakeholder consultation?

Overall, 80% (1 432) of respondents to the consultation agreed or strongly agreed that **Horizon 2020 encouraged excellent science**: this view was held by 82% (760) of respondents from academic and research organisations, 65% (20) from business associations, 84% (175) of EU citizens and 88% (53) of non-EU citizens. Among all other stakeholder groups (including, among others, companies, public authorities, trade unions, NGOs and environmental organisations, 77% (424) agreed or strongly agreed with this view. Similarly, EU citizens (775) and

[51] Study on the proposal evaluation system for the EU R&I framework programme: final report, Publications Office of the European Union (2022), https://data.europa.eu/doi/10.2777/16211
[52] Regulation (EU) No 1291/2013, Annex 1.
[53] Eurostat (RD_P_PERSOCC), Professional position: Researchers, FTE.
[54] Eurostat (RD_P_PERSLF), Professional position: Researchers, Percentage of population in labour force – numerator in FTE.
[55] Within the EU, the number of researchers increased in almost all Member States between 2011 and 2021. In the case of Poland and Sweden, the total number more than doubled, reaching 135 700 and 100 100, respectively, in 2021. In relative terms, Hungary (88%), Greece and Belgium (both 79%) recorded the highest growth rates. In absolute terms, Germany, followed by France, Italy, Spain and Poland are the EU countries with the highest number of researchers employed.
[56] European Commission, DG for Research and Innovation, Horizon 2020 indicators: assessing the results and impact of Horizon, Publications Office, 2015, https://data.europa.eu/doi/10.2777/71098

respondents from academic and research organisations (184) - both respectively 84% - either agreed or strongly agreed that **Horizon 2020 supported the development of the European Research Area**. 88% (52) of non-EU respondents indicated that Horizon 2020 supported the development of the European Research Area, showing that the views regarding the scientific impacts of Horizon 2020 are coherent.

According to 78% (711) of respondents from academic and research institutions, 75% (24) of business associations and 73% (226) of respondents from companies, Horizon 2020 fosters **scientific breakthroughs, higher risk research and research in emerging areas of science and technology.** This claim was supported by 76% of EU citizens (163) and an even greater share of non-EU citizens (86%; 59).

More respondents agreed or strongly agreed that Horizon 2020 **improved the skills of Europe's researchers and facilitated the emergence of new researchers** (85%; 1 500): 92% (54) of non-EU citizens, 88% (803) of respondents from academia, 82% of respondents from NGOs (61) and EU citizens (179) and 81% (26) of respondents from business associations supported this claim.

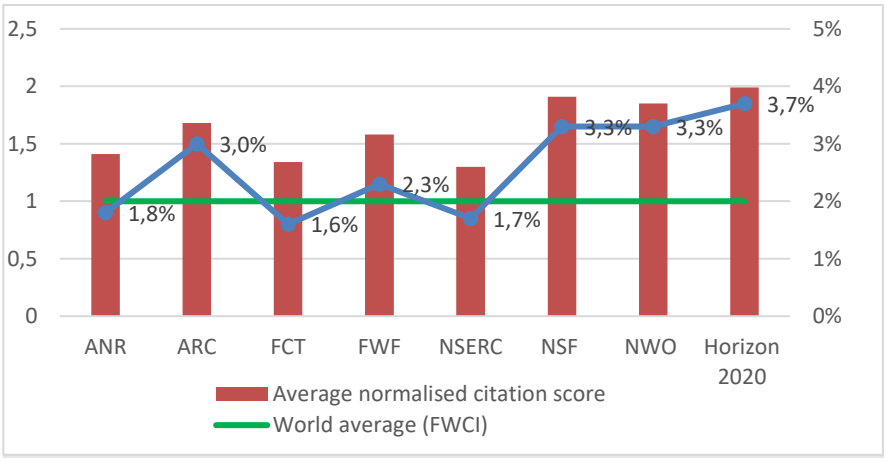
In terms of **facilitating cross-sector and cross-border mobility of researchers**, 88% (804) of respondents from academia, 76% (235) of respondents from companies as well as 71% (22) of business associations either agreed or strongly agreed that Horizon 2020 had a positive effect. Similarly, 73% (666) of respondents from academia, 67% (20) of respondents from business associations as well as 60% (90) of companies deemed that the programme is **making Europe more attractive for world class researchers from abroad.** This claim is also supported by 66% (52) of non-EU citizens, compared to 88% (164) of EU citizens responding.

Strengthening frontier research: Publications, quality of research and scientific advancements

Horizon 2020 has strengthened the EU's scientific position worldwide. Bibliometric analysis shows that Horizon 2020 had a significant positive impact, both in terms the overall number and the quality of publications produced, and of the standards of scientific excellence across the entire programme.[57] In the period 2014-2022, Horizon 2020 produced a total of 276 784 peer-reviewed publications.[58] Compared with the previous framework programme (FP7: 219 620 publications[59]), the total number of publications is higher and is still expected to rise when all projects have been completed. Horizon 2020 publications are cited at twice the world average rate for similar publications (with an FWCI of 2.03), while 3.9% of these publications are among the top 1% most cited publications worldwide.[60] Furthermore, evidence from benchmarking exercises[61] demonstrates that the citation scores for Horizon 2020 are higher than those of selected international funders,[62] both as a proportion of the top 1% most cited publications and in terms of its average normalised citation score. Activities funded under the Excellent Science pillar have the highest number of publications, mainly under the European Research Council (ERC) and Marie Skłodowska-Curie Actions (MSCA) (36% and 22% respectively).[63]

[57] Excellent Science evaluation study (2023), op. cit., p. 45. Also: Mahieu, B., Lotito, A., Viscido, S., et al., Evaluation study on for addressing Global Challenges and Industrial Competitiveness - Focus on activities for the Digital and Industrial Transition (2023), p. 77-78, https://data.europa.eu/doi/10.2777/99438.
[58] Commission monitoring system (CORDA), figures updated on 24/04/2023.
[59] European Commission, DG for Research and Innovation, Interim evaluation of Horizon 2020: Commission staff working document, Publications Office, 2017, p. 39, data reference date: 01/01/2017, https://data.europa.eu/doi/10.2777/220768
[60] Excellent Science evaluation study (2023), op. cit., table 14, p. 34.
[61] Excellent Science evaluation study (2023), op. cit., table 15, p. 34, with details in Annex 6.15 - case study: Impact of the FP in spreading excellence across the Union, p. 951, https://data.europa.eu/doi/10.2777/353383.
[62] Horizon 2020 was compared with: NWO (the Netherlands), the French National Research Agency (ANR), the Australian Research Council (ARC), the FCT (Portugal), the Austrian Science Fund (FWF), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the National Science Foundation (USA).
[63] Of the total number of publications validated by the Excellent Science study (2023), Annex 3, section 1.6, pp. 430-431, figure 3.1.2, https://data.europa.eu/doi/10.2777/353383.

Figure 7: Horizon 2020 key publication metric comparison with other funders



Source: Bibliometric analysis, Excellent Science Evaluation study, 2023. *NWO (the Netherlands), the French National Research Agency (ANR), the Australian Research Council (ARC), the FCT (Portugal), the Austrian Science Fund (FWF), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the National Science Foundation (USA).*

The ERC has provided attractive and flexible funding to encourage EU competition in frontier research. Not only did it exceed its Horizon 2020 target (see KPI 1 in Table 3), but it currently accounts for the highest number of peer-reviewed publications across Horizon 2020 (49 496 publications), receiving an average of 24.4 citations per publication.[64] ERC publications have also been cited at over twice the average worldwide rate for similar publications (an FWCI of 2.32).

The Future and Emerging Technologies (FET) programme has met its Horizon 2020 target for high-quality publications (see KPI 2, Table 3). The value is likely to increase further as project implementation is still ongoing. It has also achieved high citation impact, with, on average, 28.2 citations per publication.

The **Societal Challenges pillar** has made limited progress towards its Horizon 2020 target related to publications (KPI 14). Nevertheless, the Societal Challenge 1 (health, demographic change and well-being) and Societal Challenge 5 (climate action, environment, resource efficiency and raw materials), have achieved high citation rates, with 7.4% and 5.9% of their publications among the top 1% most cited publications, respectively. Moreover, those publications were cited close to three times the global average rate (with FWCIs of 2.86 and 2.61, respectively).

The scientific impact of JRC publications, as measured by bibliometric indicators[65], is on a par with leading universities and prestigious research organisations. During the course of Horizon 2020, JRC scientists published over 7 000 peer-reviewed scholarly publications, a third of which feature in the top 10% most highly cited publications in their field.[66] In addition, the JRC produced a wide range of policy-relevant outputs, such as standards, reference materials, technical systems and guidance on policy implementation (KPI 22 below).

[64] Numbers are expected to increase when all Horizon 2020 projects are finalised.
[65] Field-Weighted Citation Impact, Publications in Top 1% Journal Percentiles by SJR (%), Publications in Top 10% Journal Percentiles by SJR (%), Output in Top 1% Citation Percentiles (%), Output in Top 10% Citation Percentiles (%).
[66] Excellent Science evaluation study (2023), op. cit., p. 35.

Table 2: Horizon 2020 KPIs on scientific impact[67] – **KPIs, 1, 2, 14, 22, and 23**		
KPI 1: percentage of publications from ERC funded projects which are among the top 1 % highly cited[68]		
Baseline (FP7)	Target at the end of Horizon 2020	Achieved value
Data unavailable	1.8%	6.4%
KPIs 2, 14: Number of peer-reviewed publications/EUR 10 million		
Baseline (FP7)	Target at the end of Horizon 2020	Achieved value
FET: *Data unavailable*	FET: 25 publications/EUR 10 million	FET: 25.4 publications/EUR 10 million
Societal Challenges: *Data unavailable*	Societal Challenges: 20 publications/EUR 10 million	Societal Challenges: 7.0 publications/EUR 10 million
KPI 22: JRC – annual number of occurrences of tangible, specific impacts on European policies resulting from technical and scientific support provided by the JRC		
Baseline (FP7, in 2013)	Target (in 2020)	Achieved value (in 2020)
248	330	513
KPI 23: JRC – annual number of peer-reviewed publications in high impact journals		
Baseline (FP7, in 2013)	Target (in 2020)	Achieved value (in 2020)
460	500	548

Sources: KPI1 - European Research Council Executive Agency, Annual Activity Report 2022, p. 6, https://commission.europa.eu/system/files/2023-06/ERCEA_AAR_2022_en.pdf; KPIs 2 and 14 - Commission monitoring systems - CORDA, data on 24/04/2023; KPIs 22 and 23 - Joint Research Centre, *Ex post* evaluation of the activities of the Joint Research Centre under Horizon 2020 and Euratom 2014-2020: final report of the ex post evaluation panel, Publications Office of the European Union, 2022, p. 69, https://data.europa.eu/doi/10.2760/257315

Horizon 2020 support has enabled European and other supported researchers to **reach top-tier status in their field**. For Societal Challenges 2, 3, 4 and 5, Horizon 2020 funding boosted citation impact for 2014-2021 publications when measured against a baseline of comparable publications by the same authors.[69] Likewise, Horizon 2020 funding in this area enabled researchers to out-perform other, non-Horizon 2020-funded, publications.[70]

Horizon 2020's **open access principles and requirements** had a positive impact on the proportion of publications that were made freely and publicly available online, which rose from 65% in 2014 to 82% in 2022 and compares favourably with similar international programmes.[71] The number of open access datasets arising from Horizon 2020 projects also increased, from 64 open datasets in 2015 to 1 694 open datasets in 2020. However, despite Horizon 2020 producing a larger number of open access datasets, this data did not always meet the principles of findability, accessibility, interoperability and reusability (FAIR) and there were significant variations across disciplines and programme parts. Although over half of all respondents to a survey on the matter[72]

[67] Numbers are expected to increase when all Horizon 2020 projects are finalised.

[68] Number of the KPI follow the publication: European Commission, DG for Research and Innovation, Horizon 2020 indicators: assessing the results and impact of Horizon, Publications Office, 2015, https://data.europa.eu/doi/10.2777/71098

[69] The analysis was based on citation impact profiles including 5 indexes: Average of relative citations (ARC), Citation distribution index (CDI) and Shares of highly cited publications at 10%, 5% and 1% threshold). For all Societal Challenges 2, 3, 4 and 5 the citation impact profiles demonstrated a higher performance, along all indexes for Horizon 2020 funded research. Evaluation study on the European FPs for Research and Innovation for addressing Global Challenges and Industrial Competitiveness - Focus on activities for the Green Transition, Annex 5, section 3.3.4, pp. 111-113, https://data.europa.eu/doi/10.2777/744656.

[70] Based on the counterfactual analysis on the Citation Distribution Index considering Horizon 2020 supported publications and non-Horizon 2020 publications (parallel papers), conducted by evaluation study on the European FPs for Research and Innovation for addressing Global Challenges and Industrial Competitiveness - Focus on activities for the Digital and Industrial Transition, op. cit., p. 50. For DIT overall and its research areas as well as the three LEIT programmes, analyses show a higher Citation Distribution Index (CDIs) (19.8 against 7.0 for non-funded research) and higher score for highly cited publications (2.4 against 1.2 for non-FP funded research). The levels observed are similar to the ones in FP7. (Annex 5, section 2.4).

[71] Excellent Science evaluation study, op. cit., p. 37.

[72] MOAP survey: European Commission, DG for Research and Innovation, Monitoring the Open Access Policy of Horizon 2020: final report, Publications Office, 2021, https://data.europa.eu/doi/10.2777/268348

considered that their Horizon 2020-funded study was reproducible[73], complementary research[74] found that many open access datasets did not meet all the FAIR principles. For instance, only 35% of datasets were findable and only 29% were accessible and interoperable. In terms of reusability, only 61% of datasets included a text and data mining licence.

The total number of **public-private academic co-publications** produced under Horizon 2020 was 53 813[75]. Although no target was set for this indicator, either in the legal basis for Horizon 2020 or in subsequent programme statements, some desk research suggests that more **public-private co-publications were produced than under FP7 (see Table 4)**[76]. This rate was also higher than for equivalent non-framework programme publications in other EU countries and internationally. This suggests that Horizon 2020 successfully selected projects and researchers that were able to contribute to knowledge transfer between the business and academic sectors. Some partnerships, such as ECSEL, cPPP 5G, cPPP Photonics, cPPP SPIRE and EIT Raw Materials, also produced high proportions of public-private co-publications[77].

For the Societal Challenges, direct comparison with FP7 is more difficult. However, some performed especially well, notably SC7 and SC3. Public-private co-publications were also more common under Horizon 2020 projects than under non-framework programme projects.[78]

Table 3: Number of joint public-private publications, **KPI 8 and KPI 17**		
Baseline (FP7)	Target at the end of Horizon 2020	Achieved value
No baseline as new approach in Horizon 2020	*Unavailable*	LEIT (KPI 8): 10 907 Societal Challenges (KPI 17): 13 436

Source: Internal Commission monitoring systems (CORDA), data on 24/04/2023. Numbers are expected to increase when all Horizon 2020 projects are finalised.

Scientific breakthroughs and advancements

External evaluation showed that Horizon 2020 **contributed to scientific breakthroughs**[79] **and advancements** in emerging areas of science and technology, especially in the medical sciences, quantum mechanics, chemical engineering and composite materials. Specific examples include: capturing the first ever image of a black hole[80]; research into metal-halide perovskites[81] (with potential applications in solar cells, light-emitting diodes and other optoelectronic devices); strong coupling plasmonic[82] (with potential applications in quantum-mechanical and classical optical information processing and in fundamental studies of light-matter interaction) and quantum entanglement[83]

2022 Nobel Prize winners supported by Horizon 2020
Three ERC grantees won Nobel Prizes in 2022 (two were also former MSCA supervisors, as was the winner of the Nobel Prize in Chemistry):

- **Svante Pääbo**, Nobel Prize in Physiology or Medicine (former ERC grantee)
- **Alain Aspect** and **Anton Zeilinger**, Nobel Prize in Physics (former ERC grantees, MSCA supervisors and FET beneficiaries)
- **John F. Clauser**, Nobel Prize in Chemistry (former MSCA supervisor).

[73] European Commission, DG for Research and Innovation, Assessing the Reproducibility of Research Results in EU Framework Programmes for Research, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/186782
[74] European Commission, DG for Research and Innovation, Monitoring the Open Access Policy of Horizon 2020, Publications Office, 2021, https://data.europa.eu/doi/10.2777/268348.
[75] Commission monitoring system (CORDA), figure at 24/04/2023.
[76] European Commission, R&I Dashboard, "Key Performance Indicators (KPI)", data frozen on 31/12/2022.
[77] Digital and Industrial transition study (2023), op. cit., section 6.2.4., p. 57-58.
[78] Digital and Industrial transition study (2023), Annex V ("Bibliometrics"), pp. 464-469.
[79] Excellent Science evaluation study (2023), Annex 6.2, case study on the ERC Proof of Concept (PoC), p. 722.
[80] BlackHoleCam project: https://cordis.europa.eu/project/id/610058.
[81] For an overview: https://erc.europa.eu/projects-figures/stories/perovskites-promise-boost-solar-power-technology
[82] HYPER project: https://cordis.europa.eu/project/id/279881
[83] Example, the CAVITYQPD project: https://cordis.europa.eu/project/id/615755

(observation of the quantum properties of macroscopic objects and quantum cryptography). The programme also made advances in ancient DNA dating (including the discovery of the Denisovans[84], and evidence of Europe's first homo sapiens[85]), predicting new protein structures and interactions[86] (by applying powerful AI tools to structural biology and chemistry), immunotherapy (personalised cancer vaccines[87]), understanding climate change, as well as developing the Pfizer-BioNTech and Oxford-AstraZeneca vaccines against Covid-19.[88]

The contribution of Horizon 2020 to the **advancement of frontier research** has been recognised internationally through various rewards and prizes. Horizon 2020 has supported 33 Nobel Prize winners[89] prior to or after the award of their prize (up from 17 reported in the interim evaluation). In addition, between 2014 and 2020, six ERC grantees were awarded a Wolf Prize and one received a Fields Medal. Furthermore, a survey of beneficiaries suggests that they recognise Horizon 2020's role in helping to promote fundamental and novel research activities, owing to the degree of freedom and originality the programme offered them.[90] Beneficiaries felt that their participation boosted their credibility among their peers and helped to position them at the centre of international networks of R&I experts.[91] The survey findings also confirmed Horizon 2020's role in helping to generate high-quality research outputs and findings, obtain scientific awards and prizes and produce high-quality publications.[92]

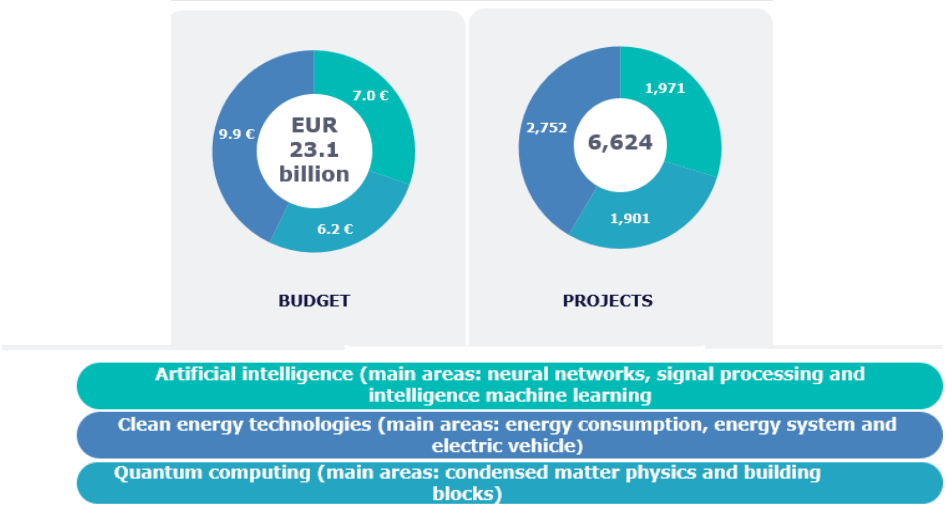
Investing in future emerging technologies to accelerate deployment

Bibliometric analysis provides additional evidence on the contribution of **Horizon 2020 to new and fast-growing research topics in science**.[93] Namely, 26% of all Horizon 2020 publications were linked to these topics, of which 1.5% were also among the top 1% of most highly cited publications worldwide. Pillar 1 performed similarly well, with 24% of publications linked to these hot topics and 1.6% of those among the top 1% most cited publications. Under Pillars 2 and 3, around one third of publications concerned new and fast-growing research fields, of which 2.2% and 1.3%, respectively, were among the top 1% most highly cited.

Horizon 2020 allocated significant resources to projects in the fields of **artificial intelligence, quantum computing and clean energy technologies** (see Figure 8). Biological sciences, gene expression and environmental engineering were the top three frontier research areas tackled by ERC grantees, followed by astronomy, theoretical physics, atmospheric sciences, and magnetic fields.[94]

[84] FINDER project: https://cordis.europa.eu/project/id/715069
[85] SUCCESS project: https://cordis.europa.eu/project/id/724046
[86] DeNovoImmunoDesign project: https://cordis.europa.eu/project/id/716058, and the ComplexAssembly project: https://cordis.europa.eu/project/id/724349
[87] SUMMIT project: https://cordis.europa.eu/project/id/789256
[88] For an overview: https://erc.europa.eu/news-events/magazine/tackling-covid-19-%E2%80%93-role-european-research
[89] Commission's internal records.
[90] European Commission, DG for Research and Innovation, Evaluation study on the external coherence and synergies of Horizon 2020 within the European research and innovation support system, hereafter "External Coherence study" (2023), case study 8: Coherence in support to agri-food value chains; case study 16: Fictional case on a fish farmer, https://data.europa.eu/doi/10.2777/90147.
[91] External coherence study (2023), case study 3: Complementary financing with Cohesion policy at project level, case study 8: Coherence in support to agri-food value chains.
[92] Excellent Science evaluation study (2023), op. cit., Survey of Horizon 2020 beneficiaries.
[93] Excellent Science evaluation study (2023), Annex 3.1, p. 456. A total of 132 Horizon 2020 publications were analysed. Future and emerging technologies are research activities thematically related to new and fast-growing research topics in science. 9 000 of such topics were identified and they include: gut microbiome, microplastics, random forest and artificial intelligence.
[94] Excellent Science evaluation study (2023), Annex 6.1, case study on the ERC impact on creating new or pushing existing frontiers of science, p. 699.

Figure 8: Horizon 2020 funding to new and emerging areas



Source: CORDA data – cut-off date: 04/04/22 from the Excellent Science study

The FET **flagships** in particular (see two examples in the box below) had a sizeable impact on knowledge creation. The majority of FET projects (83%) dealt with research ideas not previously present in the scientific community and thus deemed to be 'radically new'.[95] As a consequence, more than one third of the publications stemming from the FET programme are linked to future and emerging research and technology fields with 1.6% being amongst the top-1% most highly cited worldwide. With publications in high impact journals like Science or Nature,[96] FET results were cited in many different scientific fields.[97]

'Graphene Flagship' and the 'Human Brain Project'

The **Graphene Flagship** was a large collaborative research and innovation project launched in 2013 with the objective of creating and commercialising new technologies based on graphene and related materials. It was funded with EUR 500 million from the European Commission and €500 million from EU Member States and other sources.[98] Over the past nine years, the Graphene Flagship has brought graphene out of the lab, creating a productive European industrial ecosystem that develops new applications for graphene and layered materials, which, based on evaluation evidence would not have been possible without the FET flagship instrument. It also led to the establishment of many companies, start-ups and infrastructures. Evaluation evidence shows that this flagship has halved the time-to-market for new materials in commercial applications. Currently, the flagship includes over 100 companies working together with academic partners in fields ranging from aviation and electronics to energy, and biomedicine.

The **Human brain project (HBP)** began in 2013 and was one of the largest research projects in the world, with total costs of EUR 1.019 billion (EUR 500 million from the European Commission and the rest from national, public and private organisations)[99]. More than 500 scientists and engineers at over 140 universities, teaching hospitals and research centres across Europe came together to study the human brain. During its lifetime, the HBP drove outstanding advances in the field of brain research and in the development of brain-derived applications in medicine and technology, e.g. human brain simulation, medical imaging and insights into brain function. Evidence suggests that these scientific findings and the emergence of the surrounding ecosystem and infrastructure would not have been possible without the flagship instrument.

For both these projects, evaluation findings suggest that building an enduring network and establishing long-lasting partnerships across Europe were among their greatest achievements.

[95] Excellent Science evaluation study (2023), Annex 1, Section 3.2, p. 131.
[96] Excellent Science evaluation study (2023), Annex 1, Section 3.2, p. 143.
[97] 36% of the sample of FET projects analyses had an impact on more than 20 scientific fields.
[98] Excellent Science evaluation study (2023), Annex 6.6, p. 796.
[99] Ibid, Annex 6.7, p. 809.

Enhancing researchers' skills, mobility and career development

Horizon 2020 has **diversified and improved researchers' skills and knowledge**. The survey of beneficiaries showed that around 85% of those who were awarded MSCA individual fellowships considered the training provided and supervision to be 'very good' or 'good'. The survey also showed that 70% of respondents had received training on new or advanced scientific methods in their own research field.[100] Under ERC projects the skills most frequently developed were 'scientific methods and/or techniques, 'project and people management' and 'thinking'.[101] The 'Research infrastructures' and 'Science with and for society' (SwafS) programmes also contributed to skills development, as training was a frequent project component. Specifically, over 80% of the SwafS survey respondents said their projects had improved their research skills and knowledge and given them transferable skills (e.g. project management and teamwork).[102]

Horizon 2020, mainly via the MSCA, also supported the international and intersectoral mobility of researchers. The corresponding programme target (KPI 4) is expected to be met once all projects are completed.

Table 4: **KPI 4** on the number of researchers undertaking cross-sector and cross-country mobility, including PhD candidates

Baseline (FP7)	Target at the end of Horizon 2020	Achieved value[103]
50 000 researchers (2007-2013), of which 20% PhD-level	65 000 researchers (out of which 25 000 PhD candidates)	49 475 *unique* researchers (of which 25 676 PhDs)

Source: Baseline from: European Commission, DG for Research and Innovation, Horizon 2020 indicators: assessing the results and impact of Horizon, Publications Office, 2015, https://data.europa.eu/doi/10.2777/71098. Achieved values: CORDA data, updated on 19/01/2023 (provided by DG EAC). Numbers are expected to increase when all Horizon 2020 projects are finalised.

Horizon 2020 plays a strong role **worldwide as regards the international mobility of researchers**. According to survey results, around 89% of recipients of individual fellowships under the MSCA[104] said their project offered international mobility opportunities. This proportion was significantly lower (63%) for unsuccessful applicants who still implemented their project, indicating that the programme was successful in this regard. Almost 70% of the ERC principal investigators surveyed,[105] at the very least 'rather agreed' that ERC projects contributed to international mobility opportunities. Indeed, half of the programme's ERC team members were nationals of a country other than that of the host institution, while 40% of the scientific and technical staff moved country when they started working on the ERC grant.[106]

The Horizon 2020 programme also had a positive impact on **intersectoral mobility**. For example, the MSCA Research and Innovation Staff Exchange (RISE) and the Innovative Training Networks (ITN) actions contributed significantly to the mobility of fellows to the private sector (24.2% of RISE and 15.7% of ITN beneficiary fellows had a private for-profit organisation as their main host institution). Similarly, 36% of those awarded fellowships under RISE and 23% of ERC principal investigators said they had intersectoral mobility opportunities because of their project (compared with 26% and 17%, respectively, among the unsuccessful applicants to the same programmes).[107] Finally, MSCA fellows who engaged in intersectoral

[100] Excellent Science evaluation study (2023), Annex 1, p. 75.
[101] Excellent Science evaluation study (2023), Annex 1, p. 27.
[102] Excellent Science study (2023), op. cit., p. 48, Survey of Horizon 2020 beneficiary organisations.
[103] The figure is expected to increase, as 39% of COFUND, RISE and ITN projects were still ongoing at the reference date (19 January 2023).
[104] Excellent Science evaluation study (2023), op. cit., Survey of Horizon 2020 MSCA beneficiaries.
[105] Excellent Science evaluation study (2023), op. cit., Survey of Horizon 2020 ERC beneficiaries.
[106] Excellent Science evaluation study (2023), op. cit., p. 48.
[107] Excellent Science evaluation study (2023), Annex 6.15 – case study "Impact of the Framework Programme in spreading excellence across the Union", table 5 on p. 957.

mobility were more likely than other MSCA fellows to be employed after the end of the fellowship and found better and more diverse job opportunities outside of academia.[108]

MSCA further supported mobility flows between countries by enabling researchers to return to their home country, if they so wished. In particular, the Reintegration Panel of the European Fellowships (IF-EF) helped nationals or long-term residents of Member States or Associated Countries to return to their home country. In several countries where priority was given to widening participation,[109] (Romania, Lithuania, Bulgaria, Latvia, Slovakia, Cyprus, Croatia, Estonia, Poland and Hungary), over half of incoming MSCA researchers awarded individual fellowships were returning to their country of origin. Similarly, over 25% of experienced postdoctoral researchers used the MSCA COFUND to return to Member States where widening participation was prioritised. This proportion rose to 50% for the specific countries mentioned above. In the context of MSCA, 570 EU nationals benefited from the IF-EF scheme, or 7.2% of all IF-EF fellows. Of these, 335 fellows (58.8%) used the scheme to return to their home country.[110] Furthermore, the 'Widening Fellowship' pilot (renamed 'ERA fellowships' under Horizon Europe) significantly increased the inflow of researchers to countries designated as widening countries.

Participation in Horizon 2020 improved **researchers' career prospects**, particularly those of early career researchers, such as MSCA fellows, ERC Starting and Consolidator grantees, FET grantees and more junior members of teams supported by 'Spreading Excellence and Widening Participation' (SEWP) actions.[111] Almost 93% of ERC principal investigators rated their ERC project as having had, at least, a 'good' impact on their career prospects, with the impact being particularly evident for early stage researchers.[112] Most FET researchers said that FET projects had advanced their careers and enabled them to venture into previously unfamiliar areas and disciplines and to benefit from an interdisciplinary approach.[113] SEWP interviewees and survey respondents were generally convinced that the widening actions had had a positive impact on research careers across all career stages and that SEWP actions and enabled them to further develop their skills.[114] The main benefits cited were: study visits to institutions in countries where the research was more advanced; knowledge exchange with partners more advanced in the field; training activities and access to and more effective use of high-quality research infrastructure.

Strengthening Research Infrastructures

Horizon 2020 has enabled the EU to conceive, deliver and upgrade large-scale research infrastructures at a European and global level. The **Research Infrastructures** programme, in particular, played a role in promoting the development of pan-EU research infrastructures, providing support for collaboration, joint research and services, as well as access to such infrastructures. It also provided support for the development of the pan-EU research infrastructures included in the European roadmaps published by the **European Strategy Forum on Research Infrastructures (ESFRI)**. These roadmaps list the most important research infrastructures in Europe for the next 10-20 years, with the aim of stimulating the implementation or upgrading of these infrastructures. In 2021, 41 infrastructures listed by ESFRI had achieved a state of maturity. Interviews with stakeholders and beneficiaries[115] confirm that this was largely thanks to the contribution of INFRA calls. The INFRA programme is on track to achieve its Horizon 2020 target as project implementation is still ongoing. The three most-used research

[108] Excellent Science evaluation study (2023), Annex 1 - MSCA effectiveness, p. 61.
[109] Countries identified as "low R&I performing", and thus eligible to apply to dedicated spreading excellence and widening participation actions, are listed in the Horizon 2020 regulation and in the glossary, for ease of reference.
[110] Excellent Science evaluation study (2023), Annex 1 – MSCA effectiveness, p. 70.
[111] Excellent Science evaluation study (2023), op. cit., section 4.4.7, p. 48.
[112] Excellent Science evaluation study (2023), Survey of Horizon 2020 ERC beneficiaries, Annex 1, p. 23.
[113] Excellent Science evaluation study (2023), Annex 1, Section 3.2.2, p. 143.
[114] 71% of the SEWP beneficiaries indicated that their SEWP project increased the research skills, knowledge and competences of researchers, incl. an increase in researchers' transferable skills of (73%).
[115] Excellent Science evaluation study (2023), op. cit., p. 45.

infrastructures were SOLEIL in France, Diamond in the UK, and MAX IV in Sweden. However, support of Horizon 2020-funded work on infrastructures experienced regular difficulties in implementation, due to legal issues, see section 4.3.2. on synergies.

Table 5: **KPI 5** – number of researchers who have access to research (e-)infrastructures through Union support		
Baseline (FP7, 2013)	Target at the end of Horizon 2020	Achieved value
22 000 researchers (excluding e-infrastructures)	20 000 additional researchers	24 235 researchers. Share of researchers with access to e-infrastructures[116]: 35.6%

Source: Baseline from: European Commission, DG for Research and Innovation, Horizon 2020 indicators: assessing the results and impact of Horizon, Publications Office, 2015, https://data.europa.eu/doi/10.2777/71098. Achieved values: Commission monitoring system (CORDA), data on 24/04/2023. Numbers are expected to increase when all Horizon 2020 projects are finalised.

Spreading excellence and widening participation

Horizon 2020 aimed to spread excellence and build up R&I capacity across the EU. It earmarked EUR 935 million of funding under SEWPs to widen participation in lower R&I-performing countries.[117] Evaluations show that some progress was made in expanding participation and funding to institutions in these countries.[118] Overall, entities from 'widening countries' represented 12.3% of Horizon 2020 participations, a 1.3 percentage point increase from the FP7 baseline.[119] All 'widening countries', except Croatia and Hungary, increased their participation. In terms of the average number of applications received per 1 000 scientists and engineers as a proportion of the country's population, or the amount of EU funding received as a percentage of GDP, widening countries performed very well compared to other Member States, especially Cyprus, Estonia and Slovenia.[120]

What messages emerged from the stakeholder consultation?

In total, 74% (1 305) of respondents agreed or strongly agreed in the stakeholder consultation with the notion that **Horizon 2020 spread excellence and widened participation in R&I**. This view was held by 81% (677) of respondents from business associations, 75% (26) of respondents replying on behalf of companies and businesses, 74% (677) of respondents from academia and 73% (48) of respondents replying on behalf of NGOs. At the same time, 73% of non-EU citizens agreed or strongly agreed (43), compared to 68% of EU citizens (148).

Breaking down the responses of all respondents by countries, it becomes clear that 77% (138) of respondents from EU-13 countries, 74% (1 027) of EU-15 countries, 73% (99) of associated countries and 70% (41) of third countries agree or strongly agree with the notion that Horizon 2020 spread excellence and widened participation in R&I.

Comparatively, only 62% (1 097) of respondents believed that **Horizon 2020 helped building R&I capacity in EU countries lagging behind**: this view was primarily shared by non-EU citizens (70%; 41), environmental organisations (67%; 2), companies and businesses (64%; 199), academia / research organisations (62%; 566) followed by EU citizens (61%; 132). The views of business associations were less favourable, only having 55% (17) supporting the claim that the programme helped building R&I capacity in EU countries lagging behind, whereas 23% (199) of respondents replying on behalf of businesses indicated that the effect of Horizon 2020 in this endeavour was neutral. Nevertheless, other stakeholder groups held more favourable views, with less respondents deeming the effect neutral, e.g. 11% of academia (200), 10% of companies (31). Overall, only a small fraction of respondents indicated that it had no effect at all: 3% of businesses (8) and companies and 1.5% of academia (14).

Given its specific focus, participation from widening countries is much higher for SEWP actions than the rest of the programme.[121] There are important differences in the widening countries' participation patterns: around half of the Horizon 2020 SEWP funding went to four of the 15

[116] Defined as number of e-infrastructure users divided by maximum possible number.
[117] The full list of widening countries is provided in the glossary.
[118] Cross-cutting issues evaluation study, op. cit., Annex 10 - Case study "Widening Participation", p. 14.
[119] The total amount of EU financial contribution to widening countries (EUR millions) was 7.7% for Horizon 2020 – an increase of 1.7 percentage points from the baseline of FP7.
[120] ECA (2022), Special Report N.15, Figure 6, https://op.europa.eu/webpub/eca/special-reports/h2020-15-2022/en/.
[121] 51% of the participants in these actions come from widening countries. 32% of participants come from EU-13. Evaluation study on Excellent Science in the European FPs for Research and Innovation, p. 50.

countries (Portugal, Cyprus, Poland and Estonia).[122] Also, when the widening funding is normalised considering the population size, it can be observed that the countries benefiting the most from the widening measures are Cyprus, Estonia, Latvia, Slovakia, which also demonstrated higher participation in previous FPs.[123]

In a dedicated report on measures aiming to widen participation in Horizon 2020, the European Court of Auditors noted that, although the large-scale effects of the widening instruments will only be visible in the long term[124], change depends to a large degree on R&I investments and reforms at national level.[125] Similarly, the evaluation study on the cross-cutting issues of Horizon 2020 concluded that the degree to which widening measures were a causal factor in raising levels of participation across Horizon 2020 is difficult to gauge and that they are likely to have long-term rather than immediate impact.[126]

Nonetheless, initial results of the participation of widening countries over Horizon 2020 have been positive. The SEWP actions funded **researchers and research groups with high levels of excellence.** This is reflected by the good representation in SEWP actions of institutions listed in the Leiden Europe 250 ranking[127], both for participants from widening and non-widening countries. At the same time, the participating researchers and research groups from widening countries seemed to be able to **improve research production and quality thanks to the participation in SEWP**. Beneficiaries of twinning and teaming projects indicated that it is specifically the partnering with the advanced institutions (e.g. through trainings, workshops and staff exchanges with these partners) that contributed the most to the quality of the research.[128] The survey and interviews stressed that the widening projects helped the project partners to structure and institutionalise these collaborations. Specifically, 97% of respondents indicated that these projects strengthened existing collaborations with partner organisations, enabling researchers in the widening countries to access know-how, expertise, infrastructure and equipment that is often not available in their countries.[129]

As a result of participation in the programme, widening countries improved their research production and quality. While publications stemming from the SEWP actions account for 3.6% of all Horizon 2020 publications[130], for widening Member States almost one-third of their total number of publications generated in Horizon 2020 is produced within the widening actions.[131] Among publications stemming from the SEWP actions, highly cited ones increased from 6% in 2014 to 17% in 2020. Moreover, 28% of the highly cited Horizon 2020 publications produced by widening countries were linked to widening actions. This reflects the importance of this programme part for widening countries in terms of producing excellent science. This relative importance is particularly high for Cyprus, Estonia, and Latvia.

However, evaluation findings show that there are few new entrants in the SEWP programme, compared to the share of newcomers in Horizon 2020. This shows that **SEWP-funded researchers and research groups had often previously participated in the FP.**[132]

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[122] ECA (2022), Special Report No15, p. 23.
[123] ECA (2022), Special Report No15, pp. 24-25.
[124] ECA (2022), Special Report No15, p. 26.
[125] ECA (2022), Special Report No15, p. 26.
[126] Cross-cutting issues evaluation study, Case study "Widening participation", p. 11.
[127] The Leiden University rankings are based on bibliometric data. In this exercise, the "Scientific excellence" dimension of the rankings have been used over the time period of 2017-2020. The indicators are based on the share of highly cited publications in the university's publication count.
[128] Excellent Science evaluation study (2023), Annex 1, pp. 240-241.
[129] Excellent Science evaluation study (2023), Annex 1, p. 223.
[130] Excellent Science evaluation study (2023), Annex 3: bibliometric analysis.
[131] Ibid, case study: Impact of SEWP in improving quality (and coverage) of research in widening countries.
[132] 14% of unique participants according to the Excellent Science study (2023) p. 31 and Corda data. This analysis was based on organisation-level information (i.e. PIC numbers) and conceals the impacts at the level of research groups and individual researchers.

Table 6: **KPI 20** on SEWP: evolution of peer-reviewed publications in high-impact journals (ERA Chairs and Twinning activities)[133]		
Baseline (FP7)	Target at the end of Horizon 2020	Achieved value
Data unavailable	No target	Before EU funding: 1 263 After EU funding: 3 098

Source: Commission monitoring system (CORDA), data on 24/04/2023

4.1.2. Effectiveness: **'Societal impacts'** – To what extent has Horizon 2020 increased the R&I contribution to Societal Challenges?

This section reports on the effects of Horizon 2020 actions grouped under **'Societal impacts'** in the Intervention Logic (Figure 2). The term primarily refers to the **direct, non-market benefits**[134] of the programme, which increase the **welfare of society**, for instance by means of improvements in **health, security** and the **environment**. In general, these effects only become visible in the medium-longer term. This also covers a few **indirect, non-monetary benefits** such as positive impacts on **gender equality**. The section describes the **impact** Horizon 2020 had on national, European and international **policies** including via research actions by the JRC and addresses the programme's contribution to the Sustainable Development Goals (**SDGs**). Conclusions on the effectiveness of actions under this pillar are based both on KPI data and the qualitative evidence from case studies provided below.

Pursuing research and innovation to contribute to Societal Challenges

The programme allocated funding in seven broad areas, referred to as Societal Challenges.[135] Table 8 details the baseline, targets and results for the two key performance indicators relevant to all Societal Challenges (KPIs 14 and 15).

Table 7: KPIs 14, 15 – Number of publications and patents in the areas of different Societal Challenges		
KPI 14: Publications in peer-reviewed high impact journals, per EUR 10 million		
Baseline (FP7)	**Target at the end of Horizon 2020**	**Achieved value**
Data unavailable – new approach in Horizon 2020	20 (for all Societal Challenges)	7.0 publications per EUR 10 million of EU funding[136]
KPI 15: Patent applications and patent awarded, per EUR 10 million		
Baseline (FP7)	**Target at the end of Horizon 2020**	**Achieved value**
Data unavailable – new approach in Horizon 2020	2 patent applications and patents awarded per EUR 10 million funding	0.35 patent applications and 0.26 patents awarded per EUR 10 million[137]

Source: Commission monitoring systems (CORDA), data on 24/04/2023.

The evaluation has made apparent that the Horizon 2020 monitoring and evaluation framework is not adequate to comprehensively capture positive effects under Societal Impacts. The

[133] "Evolution (compared to a reference period prior to the signature of the grant agreement) of the publications in high impact journals in the given research field of the research organisation funded". Numbers are expected to increase when all Horizon 2020 projects are finalised.
[134] Better Regulation Toolbox, tool #57, section 5.
[135] The seven Societal Challenges are presented in figure 1 and recalled here, for ease of reference: SC1) Health, demographic change and wellbeing; SC2) Food security, sustainable agriculture, marine and maritime research and the bio-economy; SC3) Secure, clean and efficient energy; SC4) Smart, green and integrated transport; SC5) Climate action, environment, resource efficiency and raw materials; SC6) Europe in a changing world, inclusive innovative and reflective societies; SC7) Secure societies, protecting freedom and security of Europe and its citizens.
[136] Achieved values broken down per Societal Challenge: SC1: 13.5 publications; SC2: 8.7 publications; SC3: 3.8 publications; SC4: 1.7 publications; SC5: 10.6 publications; SC6: 4.7 publications; SC7: 1.9 publications.
[137] The achieved values, broken down per Societal Challenge, are as follows: SC1: 0.23 patent applications; SC2: 0.27; SC3: 0.47; SC4: 0.42; SC5: 0.32; SC6: none; SC7: 0.17. If only *foreground* patent applications (see Annex 2) are considered, the ratios to EUR 10 million is 0.20 (across the Societal challenges).

outcomes and even outputs of some projects such as of projects fostering cross-border co-operation or resulting in an influence on a specific policy agenda were incompletely recorded. Potential additional effects from projects cannot be excluded. Case study evidence nevertheless suggests that encouraging trends and clear effects could be observed in specific topic areas, as illustrated by the examples that follow. A more detailed account of societal impacts of Horizon 2020 projects is provided in Annex 3 and in the underlying set of evaluative studies and materials.

In health-related research, societal effects were generated in particular in the areas of rare diseases[138], orphan medicines[139] and antimicrobial resistance.[140] Following effective efforts to combat Ebola and Zika outbreaks that were already documented in the interim evaluation, Horizon 2020 and previous FPs also funded research instrumental for understanding and combatting COVID-19 which produced societal impacts. Analysis conducted in 2021 documented the contribution of EU funding to publications on COVID-19 research and to the main discoveries and insights on COVID-19.[141] EU funding has contributed to 3 000 papers on COVID-19 coming from almost all parts of the framework programmes (FP7 and Horizon 2020), with Societal Challenge 1, the ERC, and MSCA accounting for about 80% of the total.[142] The EU is the third most frequently acknowledged funding source for COVID-19-related research, after the US Department of Health and Human Services and the National Natural Science Foundation of China.

The delayed or abandoned implementation of clinical trials negatively affected the benefits from health-related research. In the context of a relatively low share of 79% of Societal Challenge 1 projects meeting all or most of their objectives (compared to 97% under FP7 Health), the area of 'Treating and managing disease' was particularly affected, with a share of only 70%. Apart from Covid-19 emergency measures, the reduction reflects an overall trend affecting the increasingly complex clinical trials[143].

Under Societal Challenge 2, Horizon 2020 research projects **increased knowledge of the marine environment and fishing methods** and supported policy, most notably contributing to the further development of the European Common Fisheries Policy. Examples include the DISCARDLESS[144] and MINOUW[145] projects which contributed towards reducing discards, a practice that wastes resources and poses a threat to the health and stability of marine ecosystems.

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[138] Projects under Pillar 1 Excellent Science (198 projects) and Pillar 3 Societal Challenges (139 projects), contributed towards a better understanding of rare diseases, the development of related therapies (e.g. the BATCure project), diagnostics approaches (e.g. the ChiLTERN project), as well as the aggregation of rare disease patient data (e.g. the UM Cure 2020 project on uveal melanoma patients) for future research.

[139] Horizon 2020 projects were found to be effective in generating results in the development of orphan medicines in a number of designations (titanium dioxide, cisplatin, nitric oxide, doxorubicin and oxytocin) and in bringing substantial results towards the development of treatment of amyotrophic lateral sclerosis, glioma and severe combined immunodeficiency, among others.

[140] Horizon 2020 facilitated European scientific collaboration in the sectors and AMR disciplines of infection prevention and control, monitoring and surveillance, diagnostics, vaccines, clinical studies, novel treatments, and antimicrobial stewardship. Horizon 2020 supported cross-border collaborations, allowing novel methods and interventions to be tested out in high-resistance settings with distinct healthcare systems, were identified as vital to strengthening AMR research capacity across the EU and globally. Resilient Europe, final report, case study 1.

[141] Meeting the Pandemic Challenges Contribution of EU R&I funding to COVID-19 related research, Research Working Paper 2021/01.

[142] Over half of the publications (56%) are internationally co-authored. 66% of publications are co-funded by the EU and other entities. The publications come from several research disciplines: the fields with most publications are virology, cell biology, genetics, and biochemistry. Other noticeable areas are environmental (health) areas, zoology, and nanotechnology.

[143] Stančiauskas, V., Kazlauskaitė, D., Zharkalliu, K., et al., Evaluation study of the European framework programmes for research and innovation for a resilient Europe: final report - phase 1, Publications Office of the European Union (2023), Section 7.1, p. 52, https://data.europa.eu/doi/10.2777/60819.

[144] https://cordis.europa.eu/project/id/633680 and http://www.discardless.eu/

[145] https://cordis.europa.eu/project/id/634495 and http://minouw-project.eu/

As regards the **smart European electricity grid**,[146] projects successfully established an innovation community directed at next generation technologies and tools for grid automation, integration of storage, energy system integration and increasing the share of renewables in the electricity system.

While the **circular economy** has been reflected in Horizon 2020 calls since 2014, it gained in importance and presence in the last work programme (2018-2020)[147], accompanying the successive Circular Economy Action Plans published in 2015 and 2020. The calls for proposals evolved from their initial scope that covered waste management and water innovation to a broader scope aimed at boosting global competitiveness, encouraging sustainable economic growth and generating new jobs. The focus also shifted from supporting SMEs to considering other actors, such as industry, policymakers and the global community for the relevant sectors. This change helped to implement the Circular Economy Action Plan and other high-level EU priorities.

Expenditure on sustainable development[148] **exceeded the Horizon 2020 target of 60%**[149]**, at 64.4% of the total budget.** Societal Challenges performed well above target, with 84.7% of all expenditure going to projects contributing to sustainable development. Except for expenditure on Science with and for Society (62.7%), all parts of the remaining programme were below the 60% target, particularly the EIC Pilot, Spreading Excellence, the Excellent Science pillar and the Industrial Leadership pillar.

While many relevant projects were funded under Societal Challenge 3 (**Secure, clean and efficient energy**), its Horizon 2020 target (KPI 19), detailed in Table 9, was not met.

Table 8: **KPI 19** on % of the overall Energy Societal Challenge funds allocated to renewable energy, end user energy efficiency, smart grids and energy storage activities

Baseline (FP7)	Target at the end of Horizon 2020	Achieved value
Not available	85%	69.6%

Source: Commission monitoring systems (CORDA), data on 24/04/2023. Based on policy monitoring flagging by project officers.

In the area of **offshore renewable energy**, funded projects contributed to an increase in publicly available knowledge and evidence, technical innovations enabling future cost reductions and upscaling, upskilling and training, as well as the diffusion of offshore renewable energy to a wider geographic area.[150] An important contribution was to inspire confidence in policymakers about the feasibility of offshore renewable technologies and the role they can play in the energy system.[151]

In the area of **urban transport** (under Societal Challenge 4), many projects contributed to the refinement of Sustainable Urban Mobility Plans (SUMP).[152] For example, thanks to the work of the Park4SUMP project, cities could implement well-tailored parking measures and integrate them into sustainable urban mobility planning which improved parking policies in 16 partner cities. The multiple strategies supported by Horizon 2020 contributed to more sustainable and healthy urban transport in different EU cities through a concerted push towards measures such as improving cycling infrastructure.

[146] Green Transition evaluation study (2023), Annex IX, case study 5, section 5.1.
[147] Green Transition evaluation study (2023), op. cit., pp. 105-109.
[148] This is calculated on the basis of the RIO markers methodology developed by the OECD, and based on eCorda data analysis (September 2021) in Annex C of the Evaluation Study on the Relevance and Internal Coherence of Horizon 2020 and its Policy Mix (2023), https://data.europa.eu/doi/10.2777/95070, p. 3.
[149] Regulation (EU) 1291/2013 establishing Horizon 2020.
[150] Green Transition evaluation study (2023), Annex IX, section 6.1.
[151] Green Transition evaluation study (2023), Annex IX, section 6.3.5.5.
[152] Green Transition evaluation study (2023), Annex IX, section 10.3.5.4.

Projects funded via partnerships played a central role in Horizon 2020 supporting the ambition to make European transport systems sustainable and seamless for all to use[153]. For example, the Fuel Cells and Hydrogen JU[154] drove forward the deployment and scalability of fuel cell buses, as well as the design of key solutions necessary for low-emission air travel also supported by Clean Sky 2[155].

The Horizon 2020 project IMPACT-SC5 (**Climate action, resource efficiency and raw materials**) evaluated the progress of 87 projects funded under the Societal Challenge 5 Work Programme for 2014-2015. It found that most of the projects produced policy-related outputs addressing EU policy priorities and the SDGs, particularly in the portfolios of climate, waste, and environment, ecosystems and biodiversity.[156] Climate change mitigation and adaptation, as well as the reduction of waste generation and environmental depletion, were the focus of policy contributions produced by the projects.[157]

Horizon 2020 devoted 32% of its investment to climate-related research, falling short of the 35% target.[158] The situation was different in each of the three pillars:[159] Societal Challenges spent around half of its budget on climate action, while Excellent Science and Industrial Leadership fell well below the 35% target (with 17.5% and 21.2% respectively).[160] An aspect to be considered in this context[161] is the over-estimation of the climate contribution from the bottom-up parts of the programme, due to the difficulty to accurately estimate and quantify in the form of *ex-ante* figures the extent to which programme parts, which aim for excellence and competitiveness of the R&I system, should also address political priorities regarding societal challenges – when some of them, in particular the ERC, are not geared towards specific thematic needs, but provide a bottom-up funding mechanism open to all thematic domains. The lessons learnt in Horizon 2020 should be used to avoid repeating the same underperformance in Horizon Europe where the 35% target has been maintained.

The EU is the second most frequently acknowledged funding source of the research referenced in the **Intergovernmental Panel on Climate Change (IPCC)**'s 6th Assessment Cycle reports, after the National Science Foundation of the United States.[162] FP7 and Horizon 2020 supported over 4 500 publications cited by the IPCC, coming from over 1 200 projects. These correspond to about 10% of all references cited in the reports. The **IPCC** was instrumental in creating a broader, evidence-based consensus on climate-related knowledge with a tangible contribution from research funded by the programme.

On **migration** research (within Societal Challenge 6), interviewees said the programme is the most important funding source on the topic worldwide and a major factor in the emergence of new networks and the increase in the number of young people entering the field of migration

[153] Green Transition evaluation study (2023), pp. 136-137.
[154] https://www.clean-hydrogen.europa.eu/media/publications/2021-success-stories_en
[155] https://cleansky.paddlecms.net/sites/default/files/2021-08/Highlights-2020_en.pdf.
[156] Assessing the Impact Pathways of IA/RIA SC5 Projects through the Use of Portfolio Analysis, D4.1.1 Synthesis report, 30 April 2021, p. 17. https://impact-sc5.eu/wp-content/uploads/simple-file-list/D4_1_Synthesis-Report-Final.pdf
[157] Ibid, p. 37.
[158] According to the 2022 Programme Statement and the study on Relevance and internal coherence of Horizon 2020 (2023), https://data.europa.eu/doi/10.2777/058655.
[159] Evaluation study on the relevance and internal coherence of Horizon 2020 and its policy mix, Annex C, Analysis of eCorda data, https://data.europa.eu/doi/10.2777/95070. Calculation made on the basis of the RIO markers methodology developed by the OECD. Projects are assigned a score of 0% (not targeted), 40% (significant objective), 100% (principal objective), which is then applied to the EU budget contribution.
[160] Ibid, Annex C, table 1, p. 62. NB: Data from eCORDA submitted to project team by the EC on 7 September 2021.
[161] Ibid, main report, p. 31.
[162] Contribution of the framework programmes (FP7 and Horizon 2020) to the knowledge base of IPCC reports based on openly available data, EC Monitoring & Evaluation Flash, March 2023, https://data.europa.eu/doi/10.2777/235579

research. Of the 41 migration projects, 12 projects have published a total of 44 publications to date, including two that were highly cited. In contrast, determining the policy[163] influence of the programme was challenging. This is because statements about the influence of projects on political agenda-setting are largely based on anecdotal evidence.

Social Sciences and Humanities in Horizon 2020 were addressed both as a programme part (SC6 Europe in a Changing World: Inclusive, Innovative and Reflective Societies), and as a cross-cutting issue. Evidence shows the value of integrating SSH[164] into R&I projects to achieve a multi-disciplinary and/or inter-disciplinary approach in the programme.[165] Horizon 2020 was the first EU research and innovation framework programme into which SSH was systematically integrated[166], with over 20% of total call budget allocated to SSH-flagged topics.[167]

A lack of a well-established monitoring process and clear definitions acted as barriers to efficient implementation of SSH in addressing societal needs.[168] The work on SSH integration under Horizon 2020 produced some positive results, but also revealed such limitations.[169]

SC6 funded a variety of themes spanning from migration and socio-economic inequalities to topics on culture and cultural heritage.[170] SC6 projects were reported to have performed well[171] and, in most instances, delivered high-quality results. They were particularly strong in generating outputs that allowed immediate exploitation. Key outputs included peer-reviewed papers, as well as books, online databases, support for evidence-based policymaking and policy advice – a significant share of SC6 projects produced policy evidence and knowledge that was also taken up by EU institutions, agencies, and other organisations.[172] Actions from the culture and cultural heritage sector proposed market-ready products and services.[173] For example, the project ARCHES[174] developed technological solutions that enable inclusiveness so that people with special needs can access and engage with heritage content in cultural spaces.

SSH integration increased over the lifetime of the programme and the budget allocated to SSH partners grew significantly, especially for the 2015-2018 period.[175] Furthermore, the quality of

[163] For example, New Pact on Migration and Asylum, EU blue card, Migration policy in the strategic agenda 2019-2024, EU visa policy, Malta Declaration, EU asylum agency.
[164] Social sciences and humanities encompass various disciplines such as social sciences, education, business, law, and humanities and the arts, notably including economics, sociology, demography, anthropology, psychology, geography, human rights, journalism, library and museum science, religion and theology, foreign languages and cultures, history, philosophy, fine arts, performing arts, graphic and audio-visual arts, design.
[165] Cross-cutting issues evaluation study (2023), Annex 3, section 4.5, referring to the Interim evaluation of Horizon 2020 (European Commission, 2017) and the five periodic monitoring reports on the integration of SSH in Horizon 2020, https://op.europa.eu/en/publication-detail/-/publication/f094a641-30dd-11e9-8d04-01aa75ed71a1.
[166] European Commission, Directorate-General for Research and Innovation, Integration of social sciences and humanities in Horizon 2020 – Participants, budgets and disciplines 2014 - 2020 – Final monitoring report, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2777/075642, p. 58.
[167] Ibid, p. 9.
[168] Cross-cutting issues evaluation study (2023), Annex 3, sections 4.8 and 4.9.
[169] European Commission, DG for Research and Innovation, Kania, K., Bucksch, R., Integration of social sciences and humanities in Horizon 2020: participants, budgets and disciplines, Publications Office of the European Union, 2020, https://data.europa.eu/doi/10.2777/141795, p. 66.
[170] Resilient Europe evaluation study, op. cit., p. 22.
[171] Ibid, p. 45.
[172] Ibid, p. 43.
[173] Ibid, p. 50.
[174] https://cordis.europa.eu/project/id/693229 and https://www.arches-project.eu/. Among other achievements, the project filed a patent application for a portable visual perception 2.5D printer that could create replications of museum masterpieces.
[175] Cross-cutting issues evaluation study (2023), Annex 3, p. 60. Percentage of EU financial contribution allocated to SSH in the SSH-tagged projects increased from 62.7% in 2015 to 67.4% in 2018. Moreover, according to the 5th monitoring report on Integration of Social Sciences and Humanities in Horizon 2020 (p. 5), budget allocated to SSH partners in projects funded under SSH flagged topics was EUR 197 million in 2015 and EUR 415 million in 2018. More details on the two last funding years of Horizon 2020 are presented in the Final Monitoring Report on Integration of SSH in Horizon 2020, https://data.europa.eu/doi/10.2777/075642, p. 11.

integration – although still uneven between programme parts and in need of improvement in terms of countries and SSH disciplines – was identified to have improved overall over time.[176]

Notably, frontier research funded by the ERC has supported social sciences and humanities via 1 595 grants, with a total value of EUR 2.8 billion.[177] SSH have also been addressed by calls for proposals in the last phase of Horizon 2020, but interviewees reported that their integration into multidisciplinary projects remained challenging, as they were often perceived as an add-on element in the research design.[178] This was confirmed by respondents in the stakeholder consultation.

What messages emerged from the stakeholder consultation?

Overall, 37% (656) of respondents indicated in the public consultation that they either agree or strongly agree with the notion that **calls for proposals sufficiently took Social Sciences and Humanities into account.** It is important to mention that 29% (527) of respondents did not answer this survey question or indicated that they do not know or have no opinion. This indicates that a significant share of respondents has rather limited knowledge of the integration of Social Sciences and Humanities in the programme. Bearing this caveat in mind, 36% of respondents representing companies and businesses (110), 33% (306) of respondents from academia, 32% (29) of respondents from public authorities deemed that the calls for proposals did indeed sufficiently take Social Sciences and Humanities into account. Among both EU and non-EU citizens, 30% believe Social Sciences and Humanities were sufficiently taken into account (68 and 18 respectively). Still, respondents that neither agree nor disagree with the abovementioned statement include representatives from NGOs (26%; 17), research institutions (24%; 218), companies and business associations (both 22% 7 and 69 respectively). Notably NGOs (31%; 20) and public authorities (26%; 24) either disagree or strongly disagree with the notion that Social Sciences and Humanities were sufficiently taken into account.

In **civil security research** (under Societal Challenge 7), societal impacts relate both to policy uptake and the fact that security research supported the development of an end-product or service (capability driven approach)[179] in areas such as the fight against crime and terrorism, travel facilitation and border surveillance as well as in the field of disaster resilience[180]. While the contribution of specific projects to policy development and implementation is difficult to assess, the positive contribution of security research has been recognized in strategic EU security policy documents[181] and resulted in specific research and innovation provisions in the new mandates of relevant EU Agencies (Frontex, Europol, eu-LISA).

The LEIT programme parts supported advances with societal relevance in the **Key Enabling Technologies**..[182] For example, human-centric approaches were espoused by projects like SHERLOCK (under the Factories of the Future cPPP), which enhanced worker satisfaction by developing user-friendly robotic technologies suited to different production environments.[183] Other applications are relevant for sustainability and decarbonisation: for example, the CORALIS project (under the SPIRE cPPP), aimed at optimising use of energy and resources in three industrial parks[184]. These societal goals were addressed by the nanotechnology area as well:

[176] Cross-cutting issues evaluation study (2023), Annex 3, section 4.7, see dedicated case study on the cross-cutting issue of social sciences and humanities in Horizon 2020.
[177] Commission monitoring systems (CORDA) data based on all signed grants in Horizon 2020 in the ERC Starting, Consolidator and Advanced Grant calls.
[178] Evaluation study on the relevance and internal coherence of Horizon 2020 and its policy mix (2023), op. cit., p. 7; Case Study 18.
[179] Resilient Europe evaluation study, op. cit., p. 51.
[180] Commission staff working document 'Enhancing security through research and innovation, SWD(2021) 422 final of 15.12.2021.
[181] Inter alia, the 2020 Security Union Strategy, the 2020 Counter-Terrorism Agenda, the EU Maritime Security Strategy.
[182] Digital and Industrial transition evaluation study, op. cit., section 9.1 (key findings on the performance of the LEIT programme part), p. 76.
[183] https://cordis.europa.eu/project/id/820689
[184] https://cordis.europa.eu/project/id/958337

for instance, the Open Innovation testbed NewSkin facilitated industrial uptake of more efficient water-repelling surfaces for solar panels.[185]

Contribution to the Sustainable Development Goals (SDGs)

There were no specific requirements within Horizon 2020 to meet targets with respect to the SDGs. Compared to FP7, contributions to SDGs have remained largely stable, with most contributions aligning with SDG 3 (Good health and well-being), SDG 7 (Affordable and clean energy), as well as SDG 13 (Climate action).[186] An analysis of LEIT project outputs suggests strong alignment also with SDG 9 (Resilient infrastructure, sustainable industrialization and innovation) for publications, and with SDG 8 (Inclusive and sustainable economic growth) for innovation outputs.[187]

A Horizon 2020 monitoring report[188] discloses the results of a similar analysis[189] conducted by the Commission services: looking at 20 994 projects, accounting for EUR 37.7 billion, the report concluded that **up to 84% of the current Horizon 2020 investments relate to at least one SDG**.[190] Specifically, the Green Deal Call, which was launched in 2020, included EUR 350 million that directly link with the SDGs.[191]

The Joint Research Centre' direct research actions – Science for policy

The panel of external experts for the ex post evaluation of the **Joint Research Centre (JRC)** observed that "the JRC has made important contributions to key policy goals and contributed significantly to the Commission's working methods and funding instruments."[192] Horizon 2020-funded research by the **Joint Research Centre** (JRC, representing 2% of the Horizon 2020 budget) was found to have helped shape selected European policies. At the end of FP7, in 2013, JRC's monitoring data recorded 248 tangible specific impacts on European policies[193] that resulted from the technical and scientific support it provided. By 2020, JRC had surpassed its target of 330 and recorded 513 impacts[194] (see KPI 22 in Table 3).

An analysis of 39 Horizon 2020 case studies evaluated by external experts[195] found that in 82%[196] of the studies, the JRC was instrumental in shaping and implementing EU policies. For example, the JRC's support for chemicals policy helped translate risk assessments into regulatory limits

[185] https://cordis.europa.eu/project/id/862100
[186] PPMI, Ontotext, Fraunhofer & Intrasoft. *Tracking of Research Results: Measuring the contributions of the EU FPs to SDGs: data, insights and lessons learned.*
[187] Digital and Industrial transition study (2023), op. cit., Section 6.2.3, p. 55-56.
[188] European Commission (2020), Monitoring report "Keeping our eyes on the Horizon", p. 84.
[189] Searching keywords throughout the Horizon 2020 proposals and project deliverables.
[190] European Commission (2020), Monitoring report "Keeping our eyes on the Horizon", p. 84.
[191] European Commission (2020). *News article: €350 million in support of the green deal.*
[192] European Commission, Joint Research Centre, *Ex post* evaluation of the activities of the Joint Research Centre under Horizon 2020 and Euratom 2014-2020: final report of the ex post evaluation panel (p. 69), Publications Office of the European Union, 2022, p. 4 https://data.europa.eu/doi/10.2760/257315.
[193] Revised after data checks from the original baseline of 211 reported in the DG RTD 2015 publication 'Horizon 2020 indicators: assessing the results and impact of Horizon', p. 15, https://data.europa.eu/doi/10.2777/71098.
[194] Impact is defined as "the use of JRC results for policy preparation (e.g. impact assessments), monitoring (e.g. COM reports), implementation (e.g. methods, materials, guidance) and evaluation". See European Commission, Joint Research Centre, *Ex post* evaluation of the activities of the Joint Research Centre under Horizon 2020 and Euratom 2014-2020: final report of the ex post evaluation panel (p. 69), Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2760/257315.
[195] In 2021, a new impact evaluation methodology was applied to assess the JRC's work. It is based on research impact assessment by tracing impact pathways of activities. Case studies describing activities in 2014-2020 were produced and evaluated against 11 criteria by experts from academia, businesses, NGOs and national administrations. This sample of case studies represents 20% of JRC human resources allocated to the work programme projects and 10% of the JRC budget.
[196] In the above-mentioned '*Ex post* evaluation of the activities of the Joint Research Centre under Horizon 2020 and Euratom 2014-2020', the percentages and number of case studies are different because they also cover Euratom.

for the development of legislation on nanomaterials[197], endocrine disruptors[198], tattoo inks and permanent make-up[199], and chemical mixtures.[200] Similarly, the JRC's evidence on the costs of climate inaction played a significant role in the developing the European Green Deal by providing evidence of the need for more ambitious actions on climate adaptation and urgent steps toward climate neutrality.[201]

In addition, most of the Horizon 2020 case studies (67%) demonstrated long-term societal impacts where the JRC contributed to increasing quality of life and community well-being through consumer protection, reducing costs for firms by fighting fraud, and increasing public awareness about worldwide concerns such as climate change. For example, EU legislation on energy labels and eco-design – whose implementation has been largely supported by the JRC – is estimated to bring energy savings of approximately 230 million tonnes of oil equivalent by 2030. For consumers, this means an average saving of up to EUR 285 per year on their household energy bills. Energy efficiency measures will also create EUR 66 billion in extra revenue for European companies.[202]

Promotion of gender equality in Horizon 2020

While gender equality has been increasingly addressed since FP5, Horizon 2020 has encouraged gender balance in research teams at all levels, integrating the gender dimension in the content of research and innovation, as a cross-cutting issue.[203]

To **ensure gender balance in research teams at all levels**, project proposals that had a more gender-balanced team were favoured if two projects were given the same evaluation score.[204] Only unstructured data in the call evaluation reports is available relating to how many projects were granted preferential treatment following the measures introduced to foster gender equality across the framework programme.

Table 9: Women participants across the framework programmes	**FP7**		**Horizon 2020**	
	n	%	n	%
'Coordinators' (main contact)	11 369	44%	6 486	23%
Contact person for scientific aspects (collaborative projects)	3 657	20%		
Principal Investigators (ERC)	1 283	21%	2 241	28%
MSCA fellows	3 235	36%	21 970	42%
Researchers	99 211	39%	417 230	37%
Other than researchers	52 099	43%	446 313	49%
Women among the workforce	161 310	41%	876 664	42%

[197] As recognized in the impact assessment on 'Possible amendments of Annexes to REACH for registration of nanomaterials' [SWD(2018)474] – footnote 2 on p. 6.
[198] Commission staff working document [SWD(2020) 251 final] fitness check on endocrine disruptors accompanying the Communication from the Commission on Chemicals Strategy for Sustainability.
[199] Commission Regulation (EU) 2020/2081 amending Annex XVII to Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards substances in tattoo inks or permanent make-up, C/2020/8758. OJ L 423, 15.12.2020, footnote 2 on p. 1.
[200] Commission staff working document [SWD(2020) 250 final]: Progress report on the assessment and management of combined exposures to multiple chemicals (chemical mixtures) and associated risks, accompanying the document 'Communication from the Commission on Chemicals Strategy for Sustainability: Towards a toxic-free environment', footnote 17, p. 3.
[201] Communication from the Commission: Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change" COM(2021) 82 final, footnote 5, page 1. And SWD(2021) 25 final, footnote 105, p. 17.
[202] JRC, "Evaluating the impact of JRC's scientific activities under Horizon 2020 and Euratom - case studies 2014-2020, report to the ex post evaluation panel" (2021), Box 5 – Examples of societal impact of JRC's activities, p. 15.
[203] Gender equality as a cross-cutting issue. Horizon 2020 online manual. Retrieved 12/04/23 from https://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/gender_en.htm
[204] Horizon 2020 – Work programme 2018-2020 (General annexes) – retrieved 12/04/23 from https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

Expert evaluators	14 965	36%	55 644	42%
Among potential experts	7 310	29%	16 414	38%

Source: FP7 - H2020 Gender Dashboard - Gender in EU R&I Programmes | Sheet - Qlik Sense (testa.eu) retrieved on 02/08/2023 for all data except data on the contact person for scientific aspects which is from CORDA (cut-off date 07/07/2023)

Throughout Horizon 2020, 42% of **project participants** (in any role) were women. This corresponds to a slight increase of 1 percentage point compared to FP7, as shown in Table 9.

Comparing the women **main contacts (coordinator)** figures across FP7 and Horizon 2020 proves difficult due to changes in the reporting system. In FP7, there was a distinction between scientific and administrative contacts which was discontinued in Horizon 2020:

- Throughout FP7, applicants were requested to indicate both a main "contact person" and, in collaborative projects[205] also a 'contact person for scientific aspects'.
- In Horizon 2020, the application form probed for a 'main contact' (only) instead, which corresponds to a primarily scientific role.
- Moreover, to minimise administrative burden, in the Horizon 2020 programming period, beneficiaries were not obliged to provide information on the gender of said main contact, which further complicates a meaningful comparison[206].

Therefore, the best way to assess the evolution of women coordinators is to compare the Horizon 2020-reported figure of 23% of women coordinators with the FP7-related figure on women contact persons for scientific aspects in collaborative projects (20%) - showing a slight increase of 3 percentage points.

The share of **women researchers** in Horizon 2020 decreased by 2 percentage points compared to FP7, whereas at European level the proportion of women among Grade A academic staff did show incremental increase between 2010 and 2018 (see box below). Nevertheless, the absolute number of women researchers increased strongly across the programme as a whole.

During both FP7 and Horizon 2020, women's participation in roles marked as **'other than researchers'** (potentially administrative, financial or legal) was also monitored: this share increased from 43% in FP7 to 49% in Horizon 2020 (as shown in Table 9).

Gender Equality in Research in the EU

Data from the "She Figures" Report[207] suggests that the under-representation of women in senior academic and decision-making positions in the EU continues to be a significant challenge:

- At European level, the proportion of **women among Grade A academic staff**[208] increased from 20.0%[209] in 2010 to 24%.1 in 2015 and 26.2% in 2018. In each field of R&D, women represented no more than around one third of Grade A staff at the European level in 2018. The highest proportion of women among grade A staff was observed in Humanities (35%) and Social Sciences (30.9%) and Engineering & Technology (17.9%). **Among researchers** generally, the average percentage of women was 33.8% in 2018, up from 33.4% in 2015 and 29% in 2010.[210]
- When looking at the evolution of **women who acted as heads of institutes**, it becomes clear that some progress has been made in improving women representation in decision-making and

[205] In ERC and Marie Skłodowska-Curie Actions the scientific lead in projects was instead represented, respectively, by the Principal Investigator and by MSCA Fellows. Both figures also exist in Horizon 2020, shown in Table 9.
[206] The gender of Horizon 2020 main contacts is provided at time of proposal instead. Figures presented here take into account all successful proposals, but due to the said limitations, they cannot acknowledge any changes in project roles that took place after that time.
[207] European Commission, DG for Research and Innovation, She Figures 2021: Gender in research and innovation – statistics and indicators, Publications Office (2021), Ch. 6, pp. 176-203, https://data.europa.eu/doi/10.2777/06090
[208] The single highest grade/post at which research is normally conducted (as defined in the 2012 She Figures Report).
[209] She Figures Report 2012 (2013), Chapter 6, p. 90, https://data.europa.eu/doi/10.2777/38520
[210] She Figures Report 2021 (2021), pp. 96-98, for EU-28 countries, https://data.europa.eu/doi/10.2777/06090.

leadership positions in this sector: In 2019, 23.6% of women were heads of institutes in higher education which corresponds with 2.4 percentage point increase compared to 2016 (21.3%).

Gender equality analysis for mono-beneficiary programmes, where outcomes can be more easily associated to one individual, shows the following results:

- The ERC has had a gender equality plan in place since 2009 and the various actions in this plan have succeeded in raising the **success rate of women responding to the ERC's calls** for proposals from 8% in all FP7 calls (as opposed to 11% for men) to 13% in Horizon 2020 calls (and with an equal success rate for men and women). The share of **principal investigators** who are women remains lower than parity at 28% but did increase by 7 percentage points compared to FP7, as shown in Table 9. This reflects the underrepresentation of women in senior academic staff Europe-wide (see box above).
- The MSCA were successful in removing barriers to the mobility of women researchers[211]: 42% of MSCA fellows under Horizon 2020 were women, which is not only higher than the average percentage of women researchers in the EU (33.8% in 2018)[212], but also corresponds to a 6 percentage points increase from FP7 (36%).[213]
- In the SME instrument, women represented 17% of successful applicants.[214] Data on companies started by women that were supported by the EIC pilot is not available to this evaluation. Targeted initiatives encouraging women to engage in innovative entrepreneurship, such as the EIC Prizes and the EU Prize for Women Innovators, were introduced in 2011 with the aim of highlighting women entrepreneurs behind Europe's most ground-breaking innovations. The number of Women Innovators prize applications rose over time, reaching 64 in 2016[215] to 197 applicants in 2020.[216] This aspect is important to monitor because the ratio of men to women involved in business creation in 2016-20 was 1.61[217] and women remain disadvantaged in view of raising capital in Europe (men accounted for 91% of all capital raised for deep tech in 2020).[218]

To ensure gender balance in decision-making[219], the targets of 50% for *advisory panels* and 40% for *evaluation panels* in terms of the representation of women.[220] This was accompanied by a requirement to have at least three women present on each panel.[221] In Horizon 2020, women constituted 43% of advisory group members, so the target of 50% was not met but this still corresponds to a 10 percentage point increase compared to FP7. At the same time, 42% of evaluation panel members were women, thus surpassing the 40% target (a 6-percentage point increase from FP7).[222]

[211] Excellent Science Evaluation Study (2023): case study 4: Inclusiveness and gender dimension in the MSCA.
[212] She Figures Report 2021, pp. 96-98, https://data.europa.eu/doi/10.2777/06090. Figure is for EU-28 countries.
[213] As reported in the FP7 – Horizon 2020 Gender Dashboard FP7 - H2020 Gender Dashboard - Gender in EU R&I Programmes | Sheet - Qlik Sense (testa.eu) retrieved on 02/08/2023.
[214] European Commission, DG for Research and Innovation, Rodriguez-Rincon, D., Feijao, C., Stevenson, C., et al., Study on the proposal evaluation system for the EU R&I framework programme: final report, Publications Office of the European Union, 2022, p. 24-25, https://data.europa.eu/doi/10.2777/16211
[215] Data from CORDA, extracted on 10/08/2023.
[216] Data from the homepage of the European Prize for Women Innovators, "Statistics 2019-2022" https://eic.ec.europa.eu/eic-prizes/european-prize-women-innovators-powered-eic-eit_en#statistics-2019---2022, retrieved on 10/08/2023.
[217] OECD/European Commission (2021), The Missing Entrepreneurs 2021: Policies for Inclusive Entrepreneurship and Self-Employment, OECD Publishing, Paris, p. 5, https://doi.org/10.1787/71b7a9bb-en.
[218] Atomico, The State of European Tech 2020, https://2020.stateofeuropeantech.com/chapter/diversity-inclusion/.
[219] Staff Working Document: Interim evaluation of Horizon 2020 (SWD(2017)221), p. 38.
[220] Article 16 (Gender Equality) of the Horizon 2020 Regulation.
[221] *Ex post* evaluation of the seventh framework programme (SWD(2016) 2 final), p. 18.
[222] Horizon 2020 Dashboard: Cross-cutting issues. Retrieved 08/09/22; Gender Dashboard, Retrieved on 02/08/23.

Incorporating the gender dimension into research and innovation content was measured by tracking the number of 'gender-flagged' topics across the programme[223]: the share of projects that explicitly indicated in their project proposals that the gender dimension is reflected has increased in every work programme and overall 23% of projects took the gender dimension into account. Comparatively, gender was most comprehensively addressed in relation to Societal Challenge 1 (Health), where 58% of projects incorporated gender-related issues.[224] This monitoring system was introduced in Horizon 2020 so comparable data from FP7 is not available.

What messages emerged from the stakeholder consultation?

48% of respondents (849) either agreed or strongly agreed that gender equality as a cross-cutting issue has been effectively implemented. 27% (478) neither agreed nor disagreed, while 11% (204) disagreed or disagreed strongly. 14% (248) did not express an opinion.

The stakeholder groups that were most positive about the implementation of gender equality as a cross-cutting issue were academia (50%; 455), followed by public authorities (49%; 45), companies (47%; 143) and non-EU citizens (47%; 28). EU citizens (45%; 98), NGOs (44%; 29) and business associations (31%; 11) on the other hand were less positive: the difference between academia and business associations showed a 19 percentage point difference which might be rooted in the smaller variation within the stakeholder group – only 32 business associations replied to the related question overall, whereas the figure was significantly higher for respondents from academia (919).

How did international cooperation contribute to the impacts of the programme?

In Horizon 2020, **international cooperation** was mainstreamed across the programme as a **cross-cutting priority**, in contrast to FP7, which had dedicated international cooperation schemes with ring-fenced budgets. The ambition of Horizon 2020 was to maintain international cooperation at least at the level of FP7.

International cooperation decreased in the first half of the programme due to the discontinuation of dedicated international cooperation schemes, specific eligibility conditions for certain countries, increased competition and geopolitical challenges. Corrective measures, such as clearer emphasis on international cooperation in work programmes, the introduction of co-funding mechanisms, and more awareness raising and support actions, resulted in a recovery of third country participations in the second half of the programme.

As Table 10 illustrates, the 4.1% participation rate of non-associated third countries in collaborative Horizon 2020 projects **slightly exceeds the FP7 baseline** of 3.6%. In contrast, the share of EU contributions granted to third country parties decreased from 1.3% to 0.8%, mainly due to the discontinuation of the automatic funding for certain countries.[225]

Table 10: International cooperation in collaborative projects

Indicators	Share of non-EU participations			Share of EU contributions to non-EU participants		
	Horizon 2020	Mid-term Horizon 2020	FP7	Horizon 2020	Mid-term Horizon 2020	FP7
Third countries	4.1%	1.9%	3.6%	0.8%	0.6%	1.3%
Associated countries	7.7%	7.0%	8.2%	8.9%	6.5%	8.9%

Source: R&I Projects Dashboard, data cut-off date 01/01/23

The extent of international cooperation varied across programme parts and topics:

[223] Regulation (EU) No 1291/2013 Establishing Horizon 2020 (Art. 16). When submitting a project proposal, (potential) beneficiaries have the possibility to "flag" specific issues tackled/addressed – "gender flagging" in this case relates to projects that indicated that there is a gender-dimension in their respective project proposals.
[224] Cross-Cutting issues evaluation study, Annex A (2023), p. 57.
[225] Brazil, Russia, India and China were no longer automatically funded under Horizon 2020 as was the case in FP7.

- Under **the Excellent Science pillar (Pillar 1)**, MSCA[226] and ERC[227] remain attractive to international researchers due to their prestige in academic environments. By supporting researchers of 160 different nationalities and the participation of organisations from 139 countries worldwide, the MSCA constituted the most international component of Horizon 2020, accounting alone for over half of all third country participations in the programme.
- In contrast, **participation of third countries in SEWP** actions remains limited. SEWP beneficiaries from widening countries report that they often experience difficulties in attracting international talent to their projects.
- Participation of non-EU organisations in Societal Challenges related to Climate, Food, Health, and Inclusive Societies was above the Horizon 2020 average since these **topics were perceived as addressing global challenges**.[228]
- Conversely, **international partnerships were more limited in the LEIT programme** due to geopolitical considerations. A survey carried out among the LEIT programme participants revealed that, in their opinion, the programme did not provide sufficient funding opportunities for international collaboration.[229] Interviewed participants reported that developing more structured cooperation with non-EU partners was hindered by lack of interest from large industrial players, as well as by the broader geopolitical developments after 2017, which raised increasing concerns about Europe's technological and data sovereignty, for instance in the field of 5G.[230]

International cooperation contributed to the achievement of various Horizon 2020 objectives by improving the quality of research. It contributed to **scientific impact** by attracting world-class talent to the programme. Peer-reviewed FP7 and Horizon 2020 publications, involving a contributor from at least one associated or other non-EU country, have a higher scientific impact (cited more than Member State-only publications and cited three times more than the world average).[231] Also, the success rate of the proposals increases when the consortium includes international partners.[232] Moreover, international cooperation facilitated access to and increased the participation of EU companies in international value chains, especially through the involvement of participants from countries with advanced R&I capabilities (e.g., Norway, Israel, Switzerland, and the United States).[233]

International cooperation also contributed to the **societal impact** of the programme by increasing the EU's focus on and role in tackling global challenges.[234] In the case of PRIMA, strengthening the Mediterranean area was at the core of the partnership, with participating states from European, Associated and third countries.[235] Funded projects specifically addressed the needs of the Mediterranean region in terms of ecological, economic and social conditions, leading to valuable solutions for the EU Mediterranean states as well as enabling market expansion of technology providers from all EU member countries of PRIMA.

[226] MSCA has supported researchers from 160 nationalities (40% of all researchers involved are nationals of non-EU countries) and participations of organisations from 139 countries worldwide.
[227] The ERC research teams include 18% of non-ERA nationals coming from 90 countries: India (18%), China (17%), US (12%) and Russia (7%). These shares are similar to the ones under FP7, with two notable changes: the decrease in the share of US team members (from 16% to 12% in Horizon 2020), and the increase in the share of Indian team members (from 13% to 18%).
[228] Resilient Europe evaluation study (2023), op. cit., p.50.
[229] From the 703 respondents, 7% stated that the adequacy of the EU funding opportunities for internationalisation was not good at all, 29 % stated it was sufficient to a limited extent and 33% stated it to be sufficient to a moderate extent. Digital and Industrial Transition evaluation study, Annex VII, Figure 40.
[230] Ibid, section 6.3.1 and Annex VII.
[231] Cross-cutting issues evaluation study (2023), op. cit., case study international cooperation, p. 91.
[232] Monitoring flash series "Keeping our eyes on the Horizon", Flash #3, p. 47.
[233] Monitoring flash series "Keeping our eyes on the Horizon", Flash #3, p. 61.
[234] Green Transition evaluation study (2023), op. cit., p. 76; Resilient Europe evaluation study (2023), op. cit., p. 65.
[235] Green Transition evaluation study (2023), op. cit., pp. 52-53.

4.1.3. Effectiveness: **Economic impacts** – To what extent has Horizon 2020 boosted Europe's leadership in enabling and industrial technologies and competitiveness?

As outlined in the programme's impact assessment, Horizon 2020 was designed to support industrial research and innovation 'from idea to market', with a view to improving innovation diffusion in products, processes and services, and thereby improving the attractiveness and competitiveness of industry participants and of the European economy as a whole.

The section describes the main results of Horizon 2020 for innovation: IPR forms and other measures of innovation diffusion, effects on capital raised and on the economic performance of industrial participants, with a particular focus on SMEs.

Horizon 2020's innovation outputs

Innovation outputs can be measured notably based on **IPR**[236] reported by project participants. IPR remains a widely used indicator of innovation **despite several limitations**, both inherent to the IPR process[237] and related to how these outputs are monitored under the programme (see Annex 2, Methodology).

Horizon 2020 has produced a substantial number of IPR applications and is expected to continue to do so in the future. Horizon 2020 participants reported 3 898 IPR applications, with a ratio of 0.57 applications per EUR 10 million of EU funding. Three quarters of these applications were for patents (3 012, or 77.3%), with a ratio of 0.44 per EUR 10 million. Trademarks (12.8%) made up most of the rest.[238] Without ERC, the number of IPR applications is 3 210, i.e. 0.58 per EUR 10 million.[239]

In relative terms, the self-reported IPR performance of Horizon 2020 projects is similar to that of FP7 at the same stage. Around two years after the end of FP7, project participants (excluding ERC projects[240]) had reported 2 266 applications for IPR, of which 1 742 were patent applications.[241] This is roughly equivalent to 0.6 IPR applications per EUR 10 million, slightly higher than in Horizon 2020 at the reference date.

As shown in Section 4.1.5, two years after the end of FP7, the number of IPR applications in Horizon 2020 was significantly lower than FP7's overall production as measured at the end of 2022. Comparative performance between Horizon 2020 and FP7 is to be reassessed at a later point, when more Horizon 2020 projects will have closed.[242]

Horizon 2020 had three new measurable targets with reference specifically to patent applications, shown in Table 11. As the target values below were set for end 2020, it is clear that these were

[236] Including patents, trademarks, registered designs, and utility models.
[237] Patents are useful instruments to codify knowledge and help its transfer to the wider economy. However, not necessarily all innovations are patented – e.g. for reasons of secrecy – nor do they reflect all the research and innovative efforts behind an invention. Moreover, the propensity to patent varies notably across sectors and countries, as well as the quality of the data generated by the patenting process.
[238] Commission monitoring systems (CORDA), data at 24/04/2023.
[239] Calculations based on European Commission, *Ex Post* Evaluation of the seventh framework programme, Commission Staff Working Document, SWD(2016) 2 final, 19 January 2016, p. 12.
[240] A rigorous comparison between IPR output in FP7 and Horizon 2020 is complicated by methodological issues, which prevent setting an appropriate baseline now. FP7 figures presented at the time of the *ex post* evaluation do not include European Research Council applications. Due to limitations of the monitoring system used at the time, the exact status of IPR applications in ERC at the reference date cannot be reconstructed, and is hence not possible to compare the whole of FP7 with the whole of Horizon 2020. These limitations have been since overcome, and *current* FP7 figures on project outputs include ERC.
[241] European Commission, *Ex post* Evaluation of the seventh framework programme, Commission staff working document, SWD(2016) 2 final, 19 January 2016, p. 20.
[242] 18% of all Horizon 2020 projects will close in 2024 or later.

overly optimistic[243], particularly with reference to the Industrial Leadership and Societal Challenges pillars.

Table 11: **KPI 3, KPI 6 and KPI 15** on patent applications

Key Performance Indicators	Target value	Current result (2022)[244]
KPI 3: Patent applications in Future and Emerging Technologies per EUR 10 million funding	1 per EUR 10 million EU funding	0.84 patent applications per EUR 10 million 0.55 patents awarded
KPI 6: Patent applications in the different enabling and industrial technologies (LEIT) per EUR 10 million funding	3 per EUR 10 million EU funding	0.56 patent applications per EUR 10 million 0.38 patents awarded
KPI 15: Patent applications in Horizon 2020 Societal Challenges per EUR 10 million funding	2 per EUR 10 million EU funding	0.35 patent applications per EUR 10 million 0.26 patents awarded

Source: R&I Results Dashboard, data frozen on 01/01/23.

Industrial Leadership was the pillar with the highest number of IPR applications (1 441). Analysis of a subset of patents (end 2021) shows that Pillar 2 also had the highest average number of patent citations and number of claims, which are indicators of the quality of the protected invention[245]. Around 40% of patents self-declared by LEIT participants contributed towards key enabling technologies such as photonics, with high shares also for micro- and nanoelectronics.[246] The ratio is low for the Space objective (23 patent applications, 0.2 per EUR 10 million), as it was under FP7 (0.3 applications per EUR 10 million[247]).

The SME instrument is more likely to produce IPR applications.[248] It is expected that SME instrument projects will have high patent productivity relatively soon after the end of Horizon 2020, due to their shorter duration[249] and the high technology-readiness (TRL) level supported (TRL 6, demonstration).[250] SME instrument brought about an increase of 8 to 15 percentage points in the probability of a patent application.[251] Moreover, beneficiaries of Horizon 2020 show a 15% to 31% increase in citation-weighted patents.

The low number of IPR applications suggests that most are at a low maturity level: high-potential ideas were supported by the programme, but their low exploitation readiness means that their inventors do not yet consider them ready for patenting.[252] This finding is confirmed by

[243] These targets were set for 2020 already, when many Horizon 2020 projects will not have been yet completed, and IPR FP7 levels at the current day (9 years after its end) for thematically similar programme parts are much below these targets.
[244] If only *foreground* patent applications (see Annex 2) are considered, the ratios to EUR 10 million are: Future and Emerging Technologies: 0.67; Leadership in enabling and industrial technologies: 0.44; Societal challenges: 0.20. Figures from Commission monitoring systems (CORDA), reference date 24/04/2023.
[245] Naujokaitytė, R., Stančiauskas, V., Cakić, M., et al., Evaluation study of the European framework programmes for research and innovation for an Innovative Europe, Publications Office of the European Union (2023), https://data.europa.eu/doi/10.2777/467162, Table 18, p. 51.
[246] Digital and Industrial transition evaluation study (2023), op. cit., section 6.2.2, p. 35. Some parts of LEIT NMBP have relatively high patenting propensity: the nanotechnologies programme part under LEIT has a patent applications-to-funding ratio of 2.0 per EUR 10 million.
[247] Ibid, section 6.2.2, Table 9, p. 52.
[248] Ibid.
[249] Phase 1 runs for up to half a year, Phase 2 up to two years.
[250] European Commission, "Interim evaluation of Horizon 2020", Commission staff working document, published 16 August 2017, doi: 10.2777/220768.
[251] According to a study focusing on the first years of SME instrument, Pietro Santoleri, Andrea Mina, Alberto Di Minin, Irene Martelli; The Causal Effects of R&D Grants: Evidence from a Regression Discontinuity. *The Review of Economics and Statistics* 2022; doi: https://doi.org/10.1162/rest_a_01233
[252] Digital and Industrial Transition study (2023), op. cit., section 6.2.2, p. 53.

Innovation Radar[253] data, showing that over half of all innovations recorded are in an 'Exploring' stage (53%) and only 17% are considered ready for market introduction[254]. High-readiness innovations stem mostly from the Industrial Leadership pillar[255] and specifically LEIT projects, where a few areas have a slightly higher proportion of market-ready innovations, such as the internet of things, advanced computing and advanced materials.[256] The Societal Challenges pillar produced around 20% of all innovations under Horizon 2020; the Excellent Science pillar contributed 31%, most of which were assessed to have a low level of technological readiness.[257] **Nonetheless, Innovation Radar data also suggest that the programme has funded potentially ground-breaking technological innovations**.[258] Most innovations were categorised as 'Obviously innovative with easily appreciated advantages for the customer' (47%) or 'Innovative but could be difficult to convert customers' (29%). Moreover, most involve the development of a new product (31%), followed closely by a significantly improved product (28.6%).[259]

Encouraging European leadership in enabling and industrial technologies – key factors in LEIT programmes

Participation analysis shows that **the LEIT programme part was successful in setting up the desired cross-sectoral collaboration dynamics involving industry actors**[260]**, aimed to bridge exploratory science and the development of applications addressing Societal Challenges**. The NMBP programme stands out for the broad range of sectors involved, mainly in the manufacturing and processing research areas (Factories of the Future and SPIRE cPPPs). Large enterprises participating in the LEIT ICT key digital technologies areas also tended to participate in NMBP intervention areas, such as advanced materials and processing technologies. The LEIT Space programme, however, was characterised by rather limited integration with other LEIT areas.[261]

The Digital and Industrial transition evaluation study highlighted the value of the creation of **technology infrastructures** (such as European Digital Innovation Hubs and open innovation test beds). A clear success, according to stakeholders, is the effort to increase availability to technology infrastructures throughout Europe, which has facilitated and accelerated the development of piloted, demonstrated, and tested research result. The LEIT programme parts also put emphasis on supporting projects involving actors across the entire value chain. This trend also resulted in an **increase in the number of partners involved in consortia, as well as higher average project budgets**. Overall, LEIT project applicants appreciated the focus on the structuring of R&I communities. Some, however, pointed out that this approach places higher demands on project management in terms of the skills and resources needed. This carries the risk that larger and more complex projects may become less attractive to SMEs.[262] Still, SME participation remained high in LEIT programmes throughout the lifetime of Horizon 2020.[263]

In line with the 'closer-to-market' focus of the programme as a whole, projects under LEIT NMBP demonstrated a **shift from an 'enabling' perspective towards 'product-oriented' perspectives**[264]. This trend is perhaps linked to an increase in the influence of industry partners in agenda setting, particularly through cPPPs).[265] Nonetheless, evaluation studies highlighted the continued importance of research with low or mid-level

[253] An in-house tool of the European Commission, the Innovation Radar (https://www.innoradar.eu/) is aimed at identifying high-potential innovations in EU-funded programmes, with particular reference to their level of commercial and technological readiness. This survey-based tool, which covered only a part of Horizon 2020 projects, identified around 8 000 distinct Horizon 2020-funded innovations by November 2021 (https://www.innoradar.eu/resultbymaturity/0).
[254] Innovative Europe evaluation study (2023), Annex 7, p. 270.
[255] Excellent Science evaluation study (2023), op. cit., p. 53.
[256] Digital and Industrial Transition evaluation study (2023), op. cit., executive summary and section 6.2.2.
[257] Innovative Europe evaluation study (2023), Annex 7, p. 270.
[258] Most innovations are categorised as "Obviously innovative and easily appreciated advantages to customer" (47%) as well as "Innovative but could be difficult to convert customers" (29%).
[259] Innovative Europe evaluation study (2023), Annex 7, p. 270.
[260] Digital and Industrial transition evaluation study (2023), op. cit., section 6.3.1, p. 61.
[261] Ibid.
[262] Based on interviews and participation trends, the Digital and Industrial Transition evaluation study, section 6.1.2.
[263] Digital and industrial transition evaluation study (2023), op. cit., chapter 3 ("Beneficiaries").
[264] Ibid, section 4.1.1.
[265] In the LEIT ICT programme, cPPPs steered half of the funding, showing an ongoing increase over time (from 22% in 2014/15 to 66% in 2018/20). In the NMBP programme, cPPP-based projects accounted for about 40% of the total funding, encompassing close to 100% of the projects in the advanced manufacturing and processing technologies area. Source: Digital and industrial transition study (2023), section 6.3.2.

technological readiness for capacity-building to meet longer-term needs.[266] Across the FP, some stakeholders, including the Expert group on the economic and societal impact of research and innovation (ESIR)[267], see a risk of upsetting the balance between industry-oriented R&D and more fundamental research, which could damage Europe's innovation and transition potential.[268]

When looking at the economic and innovation outputs of the Knowledge and Innovation Communities (KICs) of the European Institute of Innovation and Technology (EIT), the number of organisations from universities, business and research that were integrated in the **EITKICs** increased from 200 organisations in the 2010-2013 period to 2 153 in 2020, almost double the programme target (of 1 200 partner organisations). The collaboration inside the knowledge triangle led to the development of innovative products, services and processes, including the creation of start-ups and spin-offs. The target number of active partners collaborating in the EIT KICs – representing the core indication of effectiveness in developing innovation ecosystems and integrating the knowledge triangle – was exceeded by a factor of two.

The EIT KICs fostered the launch of 1 501 new or improved products and processes on the market across the whole period.[269] Table 12 shows results for the different KICs.

Table 12: Core EIT KICs key performance indicator totals across the period 2010*-2020 (*=or starting year of the respective KIC)[270]

	Climate	Digital	Inno Energy	Health	Raw Materials	Food	Manu-facturing	Urban Mobility	**Total**
Products (goods or services) or processes launched on the market	628	437	142	68	175	36	4	11	**1 501**
Start-ups supported by EIT KICs	1 190	297	379	1 230	299	350	57	60	**3 862**
Investment attracted by start-ups supported by EIT KICs (EUR millions)	552.3	400.9	2 078.4	522.3	156.6	198.1	0	9.3	**3 918**

Source: EIT monitoring data reported in Naujokaitytė, R., Stančiauskas, V., Cakić, M., et al., Evaluation study of the European framework programmes for research and innovation for an Innovative Europe, Publications Office of the European Union (2023), https://data.europa.eu/doi/10.2777/467162 (2023), section 7.1, p. 43.

The number of start-ups created by the EIT KICs is another indicator of effectiveness. The baseline number in 2012 was 33.[271] Progress values are reported by EIT in two batches, with one indicator serving from 2010-2016, which was subsequently replaced with two indicators for the period 2017-2020.[272] While numbers were generally low in the early years, **an increase in the number of start-ups created is evident** over the observed period[273], resulting in 305 start-ups and spin-offs created across Climate KIC, EIT InnoEnergy, EIT Digital, EIT Health and EIT Raw Materials from 2010 to 2016. From 2017-2020, an additional 36 start-ups were created by students enrolled on and graduates of EIT-labelled MSc and PhD programmes. Over the same period, 99 start-ups were created as a result of innovation projects for the indicated KICs. Taking

[266] Digital and Industrial transition evaluation study (2023), op. cit., section 6.3.2, pp. 68-69.
[267] European Commission, DG for Research and Innovation, Dixson-Declève, S., Dunlop, K., Renda, A. et al., Research and innovation to thrive in the poly-crisis age, Publications Office of the EU, 2023, https://data.europa.eu/doi/10.2777/92915, p. 15: "In a context of crisis and urgent transformation, **investment in innovation and innovation policy needs just as much focus on the design of change and support for change and adoption processes**." Use of TRLs places an emphasis on the deployment of solutions with a high private sector interest, which can affect the evaluation.
[268] Digital and industrial transition evaluation study (2023), op. cit., p. 80.
[269] Innovative Europe evaluation study (2023), op. cit., section 7.1, p. 44.
[270] Ibidem.
[271] European Commission, Programme statement 2022, COM(2021) 300 – June 2021, p. 71, https://commission.europa.eu/system/files/2021-07/db2022_wd_1_programme_statements_web_0.pdf
[272] Innovative Europe evaluation study (2023), op. cit., pp. 44-45.
[273] Ibidem.

all this into account, the cumulative target of 600 start-ups and spin-offs created[274] was not reached by 2020. The lack of achievement of the target for start-ups created by the intervention of EIT KICs can be explained by the fact that the EIT Impact framework has been revised in 2017, the methodology for calculating the indicator on number of start-ups created has changed and for this reason the increase of start-ups created has slowed down from 2017. The KPI 'Number of start-ups/spin-offs created' was tracked until 2016 only and according to the different methodology as compared to the post-2017 tracking. From 2017 onwards, the start-ups created were tracked in two ways, i.e. (1) as a result of the EIT KICs supported innovation projects or (2) as a result of creation by students enrolled and graduated from EIT-supported education courses.

One of the main objectives of Knowledge and Innovation Communities was to obtain financial autonomy from the European Institute of Innovation and Technology. The KICs should become sustainable after 15 years of operation. The EIT KICs' budgets were growing, but most of the funds still come from EIT.[275] The first-wave KICs (EIT Digital, EIT InnoEnergy, and EIT Climate established in 2010) show a positive trend in financial sustainability – external investments increased in proportion to EIT funding. Start-ups supported by the EIT KICs received more than EUR 3.9 billion in investments[276] for the period of 2010-2020. Start-ups supported by EIT Inno Energy attracted the biggest amount of investments, around EUR 2.1 billion, followed by Climate KIC (EUR 552.3 million), EIT Health (EUR 522.3 million), EIT Digital (EUR 400.9 million), EIT Food (EUR 198.1 million) and EIT Raw materials (EUR 156.6 million).

When looking specifically at SMEs, so far, Horizon 2020 exceeded its target of at least 20% of EU financial contribution going to SMEs. Around one third of funding to SMEs was provided through the SME instrument. This represents 7.1% of overall Horizon 2020 funding, which is above the 7% target set at the start of the programme.[277]

Table 13: Cross-cutting key performance indicators (KPIs) on SME participation in Horizon 2020

#	INDICATOR DESCRIPTION	TARGET	INTERIM EVALUATION VALUE	FINAL VALUE
KPI 3.1	Percentage of EU financial contribution going to SMEs (LEIT and Societal Challenges)	**20%**	23.9%	**22.2%**
KPI 3.2	Percentage of EU financial contribution committed through the SME instrument (LEIT and Part III of Horizon 2020)	**7%**	5.6%	**7.1 %**

Source: Cross-cutting issues study (2023), elaboration on CORDA data (2022).

Horizon 2020 was also successful in attracting new SME participants. Around half (50.3%) of all EU funding to private for-profit businesses went to newcomers, and two thirds of this amount to SMEs. In general, actions that attract more SMEs – the SME instrument, as well as innovation actions – have high rates of newcomer participation. Conversely, actions that target collaboration with the private sector, but not necessarily SMEs, had fewer new participants[278].

[274] Target set in Programme Statement, p. 32, https://commission.europa.eu/system/files/2022-07/ps_db2023_he_h1_1.pdf.
[275] Innovative Europe evaluation study (2023), op. cit., p. 42.
[276] Ibid, section 7.
[277] Ibidem. Figures as of 8 February 2022.
[278] European Commission (2023), "Newcomers in EU R&I programmes – Main trends in Horizon 2020, first evidence from Horizon Europe", https://data.europa.eu/doi/10.2777/911220.

Facilitating access to risk capital

Private organisations participating in Horizon 2020 have been generally successful in raising risk capital.

If we could attribute this success directly to participation in the framework programme, this would be a very important finding: innovative enterprises in the EU have historically lagged behind international comparators in collecting equity finance. The 2020 report on "Science, Research and innovation performance of the EU" (SRIP) [279] points out that as much as '8 times more venture capital (VC) funds are raised in the US than in the EU', given that, in the EU, lower access to risk capital impedes scaling up.[280]

However, very limited data available to this evaluation is suitable to draw systemic conclusions. As equity funding rounds are often confidential, and therefore not easily monitored, the evaluation relies on partial estimates of amounts collected. This type of data is not tracked by the Commission monitoring systems, and no "official" repositories of VC funding and risk capital exist.

External evaluation studies have attempted to analyse additional capital collected by Horizon 2020 participants (across the entire FP), by using open specialised data sources, such as Dealroom[281] and Crunchbase.[282] One of these studies found that Horizon 2020 beneficiaries received more risk capital investment than unsuccessful applicants: private companies across the FP matched to the Dealroom investment database received around EUR 10 million each, against around EUR 3 million for comparable non-funded entities.[283] However, these figures must be interpreted with caution and as rough estimates, as this study did not control for the origin of the funding rounds recorded in Dealroom – which might include EU funding in some cases.

Detailed figures on equity funding collected after FP participation are available for LEIT programmes, where SME participants attracted at least EUR 9.36 billion of private funding overall, spread over 1 232 funding rounds between 2014 and 2022 – mostly from venture capital and private equity. SME participants active in the high-value-added service industries, such as computer programming, and participants in the SME instrument, accounted for most private funding.[284] These figures are relevant if compared to the EUR 1.7 billion in EU funding these entities have collected (cfr. section 4.4.1); however, the analysis method used cannot determine causality of this additional funding.

Some research available to this evaluation was conducted with a design suitable to assess causal effects. A study on the SME instrument participants between 2014 and 2017 suggests that its beneficiaries attracted more subsequent investment with respect to a comparable control group (between 46% and 97% increase).[285] Moreover, a '**signalling effect**' of the programme funding, which facilitates access to finance from financial institutions by demonstrating the quality, relevance and potential of the supported projects was observed.

[279] European Commission, DG for Research and Innovation, Science, research and innovation performance of the EU, 2020: a fair, green and digital Europe, Publications Office, 2020, https://data.europa.eu/doi/10.2777/534046
[280] Ibid, p. 26.
[281] https://dealroom.co/
[282] https://www.crunchbase.com/
[283] Innovative Europe evaluation study (2023), Annex 4, tables 23 and 24.
[284] Digital and Industrial Transition study (2023), executive summary and section 6.2.2, p. 54. Data based on participant SMEs that could be matched to the Crunchbase company database (https://www.crunchbase.com/). Note that the coverage of the Crunchbase platform is not exhaustive: not all SME participants in Horizon 2020 are listed on the Crunchbase platform, hence some private funding rounds raised by Horizon 2020 participants might not be accounted for in this analysis.
[285] Santoleri et al. (2022) The Causal Effects of R&D Grants: Evidence from a Regression Discontinuity, op. cit.

Horizon 2020 also funded – with EUR 3.7 billion as of 2021[286] – an EIB Group financial facility, **InnovFin**, aimed at facilitating and accelerating access to private finance (debt and equity) for innovative businesses in Europe – ranging from start-ups to large research facilities.[287] InnovFin is perceived as an effective instrument to channel debt and equity funding towards innovative organisations. Three performance indicators of Horizon 2020 refer to the funding operations facilitated by InnovFin, as well as to the organisations they reached (see Tables 14 and 15). The latest figures available indicate that the total volume of investments mobilized via debt financing and venture capital investments since the launch of the programme reached EUR 77.5 billion (of which EUR 43.6 billion are specifically private non-bank funds), and reached around 38 000 organisations. Both figures exceed by a large factor the operational targets set for these indicators.

Table 14 : **KPIs 9-10** on total investments mobilised via Horizon 2020's equity and debt facilities (InnovFin)		
Baseline (FP7)	Target at the end of Horizon 2020	Achieved value
Not available	EUR 25 billion (either source)	EUR 77.5 billion, as of April 2022

Source: EIB group estimate based on implementation data (2022 annual report). Figures reported in European Commission, DG Research and Innovation Annual Activity Report 2021, p. 47. Available at https://commission.europa.eu/system/files/2022-05/annual-activity-report-2021-research-and-innovation_en.pdf

Table 15: **KPI 11** on the number of organisations funded – entities supported by Horizon 2020's equity and debt facilities (InnovFin)		
Baseline (FP7)	Target at the end of Horizon 2020	Achieved value
300 organisations funded	5 000 organisations funded EUR 35 billion in private funding	37 921 (as of April 2022) Private funding leveraged: EUR 43.6 billion

Source: Baseline from: European Commission, Programme Statement 2022, COM(2021) 300 – June 2021, https://commission.europa.eu/system/files/2021-07/db2022_wd_1_programme_statements_web_0.pdf. Achieved: EIB group estimate based on implementation data, reported in the 2021 Annual Activity Report, p. 47, https://commission.europa.eu/system/files/2022-05/annual-activity-report-2021-research-and-innovation_en.pdf

Besides facilitating funding flows, InnovFin also fostered the development of venture capital (VC) ecosystems and networks. An analysis of the InnovFin equity facility (IFE) showed that it has been contributing to a growing maturity as well as a growing competitiveness of the European VC ecosystem, helping emerging investors reach a minimum critical fund size. Without the EIF's involvement via the InnovFin IFE, some VC funds could not have been set up, and others would have had less equity capital to their disposal (see also section 4.4.3).[288]

Improving Europe's economic growth and competitiveness

Micro-econometric modelling generally shows that Horizon 2020 funding has a positive and causal impact on beneficiary companies' growth. A counterfactual study[289] on all Horizon 2020 participating firms[290] estimates that **companies receiving Horizon 2020 grants increased on average their employment level by 20% compared to comparable non-funded firms with high quality proposals, and their total assets and revenues by about 30% in the years following the receipt of the first grant**. To ensure comparability, the control group includes only non-funded applicants with high quality proposals. Additional characteristics, such as country of origin, NACE code, number of submitted applications, are controlled for. In line with

[286] Delegation agreement between the EU, the European Investment Bank and the European Investment Fund, dated 12/6/2014, 10th amendment (C(2020) 4483 final), Annex I, p. 24.
[287] https://www.eib.org/en/products/mandates-partnerships/innovfin/index.htm
[288] Innovative Europe evaluation study (2023), op. cit., section 7.2, p. 45.
[289] European Commission, DG for Research and Innovation, Mitra, A., Niakaros, K., The Horizon effect – A counterfactual analysis of EU research & innovation grants, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2777/584781.
[290] SME Instrument. Analysis focuses on Phase II of the SME Instrument, accounting for more than 90% of the funding.

the literature, companies are tracked 5 years before and up to[291] 5 years after the receipt of the grant. The above-mentioned effects are on average present even after 2.5 years of the receipt of the grant, which is the average duration of a project in the sample – meaning that companies can sustain the positive effects even after Horizon funding. With projects still ongoing, to have a complete picture for the whole Programme such analysis could be repeated in the future when additional data on post-grant outcomes is available.

Another paper[292] - focusing only on the SME instrument phase 2 - studied the variation in firm-level outcomes. It suggested that these grants lead to an increase in subsequent firm investment, particularly in intangible assets, and a boost in innovation output, as indicated by a **rise of between 15% and 31% in citation-weighted patents**. R&D grants do not only affect firms that are already involved in innovative activities but also lead to more firms engaging in patenting. Moreover, these grants have a positive impact on the rate of firm growth and reduce the probability of failure, bringing it to almost zero.

Several other counterfactual analyses have been published but given the method used (Difference-in-Differences), causality cannot be definitively claimed due to the short time lag or lead (years of data available before or after the intervention) of the analysis:

- A 2023 counterfactual analysis[293] investigated the effects of Horizon 2020 on SMEs, confirming **positive impacts on employment** (4% more than control group) and **turnover** (10%, more than control group) but no effects on productivity.
- A counterfactual analysis[294] of calls for proposals under the EIC Pilot 2018 Accelerator programme showed a **significant effect on employment** within a year of launching the scheme. On average, beneficiaries hired two additional employees thanks to Horizon 2020.[295] The short-term positive impact on beneficiary companies' turnover and staffing levels, however, reflects the immediate impact of the grant and may not predict successful product commercialisation or sustained growth.[296]

Moreover, **non-counterfactual analysis** provides similar findings, of course limited to correlation. A multiple regression analysis of economic outcomes of private companies participating in LEIT programme parts shows a positive correlation between EU funding and post-participation performance and growth.[297] Companies that successfully applied for EU funding under the LEIT programmes have on average a higher turnover per employee (interpreted as higher productivity) and especially, higher EBITDA[298] (interpreted as higher profitability) than unsuccessful applicants. This difference is even more pronounced when comparing successful applicants with firms with similar characteristics who did not apply for EU funding under LEIT. The positive effect of EU funding is more pronounced for SMEs than for large enterprises.[299]

Macroeconomic effects include the programme's impact on EU's GDP and employment. While these variables are essential indicators of a thriving economy, it should be noted that their evolution is not a *guarantee* of competitiveness. Data for KPIs used to monitor the competitiveness of EU industry with focus on research and innovation are reported: (a) in the

[291] Depending on data availability. For companies that applied in the later years of the Programme (e.g., in 2020), 5 years after the grant were of course not available for the analysis.
[292] Santoleri et al. The Causal Effects of R&D Grants: Evidence from a Regression Discontinuity, op. cit.
[293] Innovative Europe evaluation study (2023), Annex 4. More methodological details in SWD Annex 2.
[294] The EIC Pilot Evaluation (2022), op. cit., section on economic impacts, pp. 57-58, https://data.europa.eu/doi/10.2777/261324.
[295] EIC pilot evaluation study (2022), methodological annex, https://data.europa.eu/doi/10.2777/645064.
[296] A more revealing analysis could be repeated in the future on a longer time horizon (time lead).
[297] Digital and Industrial Transition evaluation study (2023), op. cit., section 6.2.2, p. 53-54.
[298] Earnings Before Interest and Taxes, Depreciation and Amortization.
[299] Digital and Industrial Transition evaluation study (2023), op. cit., p. 53-54.

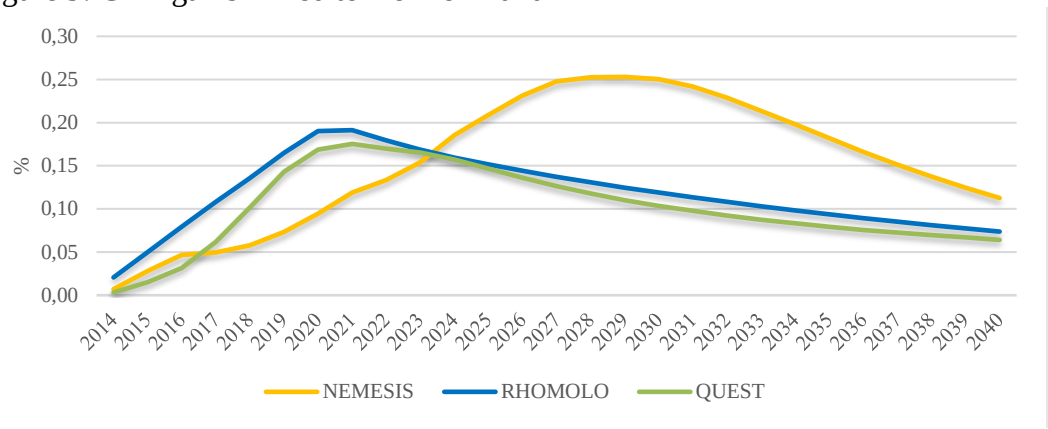
section on Horizon 2020's innovation outputs above (in terms of patent applications supported by Horizon 2020) and (b) towards the end of the current section – on R&D intensity as a percentage of GDP[300].

The impact of the Horizon 2020 on EU GDP was estimated using three macroeconomic models.[301] All models show that the **impact on GDP began to increase steadily during the Horizon 2020 implementation phase** up to 2021[302] relative to the baseline[303] (Figure 9). During the period 2021-2030, with the **gradual arrival of innovations in processes and products in the economy**, impacts on GDP reach their highest point. This pattern is most pronounced in the results of the NEMESIS model with a peak GDP gain of +0.25% in the four years between 2027 and 2030. The other two models suggest an earlier peak in 2021, with a lower maximum GDP gain of +0.18% (QUEST) and +0.19% (RHOMOLO). After 2030, the annual impact starts to diminish in all three models due to the **gradual obsolescence of the new knowledge and innovations** the programme has helped to generate. A positive impact is also reported at sector level.[304]

Considering the period to 2040, the **total wider economic impact of Horizon 2020**, in terms of increases in GDP, add up to **EUR 429 billion** (RHOMOLO)[305]. The estimated **average annual GDP impact is EUR 15.9 billion**[306]. Only NEMESIS results[307] are in line with the expectations in the interim evaluation[308,309], which estimated an average GDP gain, for the period up to 2030, of between EUR 24 billion and EUR 35 billion per year.

[300] COM(2023)168 final, "Long-term competitiveness of the EU: looking beyond 2030", Annex, p. 22, https://commission.europa.eu/system/files/2023-03/Communication_Long-term-competitiveness.pdf.
[301] RHOMOLO, QUEST and NEMESIS. Results from NEMESIS were produced by a team of external experts, while RHOMOLO and QUEST results were produced by the European Commission services (DG Joint Research Centre for RHOMOLO and DG Economic and Financial Affairs for QUEST). More information on the models' specificities can be found in Annex 2.
[302] GDP gain estimated for 2021 vary between 0.12% (NEMESIS), 0.17% (QUEST) and 0.19% (RHOMOLO).
[303] A hypothetical scenario without Horizon 2020.
[304] Results based on RHOMOLO simulation. Please refer to Annex 2 for more detailed information.
[305] 2014-2040, 2020 prices, with range between EUR 421 billion (QUEST) and EUR 798 billion (NEMESIS).
[306] 2014-2040, 2020 prices, with range between EUR 15.6 billion (QUEST) and EUR 28.5 billion (NEMESIS).
[307] Average annual GDP gain until 2030 of NEMESIS EUR 24.7 billion, 2020 prices; (RHOMOLO) EUR 18.2bn; (QUEST) EUR 16.9 billion.
[308] The assumptions of the models run for the Impact Assessment of Horizon 2020 were completely different, hence it is not sensible to do comparisons. For an overview of the different assumptions, see Table 49, "Study to support the monitoring and evaluation of the framework programme for research and innovation along key impact pathways", https://op.europa.eu/s/yzOL.
[309] For the NEMESIS results, a sensitivity analysis has been performed identifying *low*, *medium*, and *high* scenarios depending on the stringency of assumptions on the crowding-in effect of the FP on applied research, and the EAV of the FP (see Annex II). The reported annual average GDP gain (2014 -2030) corresponds to the *medium* scenario; with a *low* estimate of EUR 14.4 billion and a *high* one of EUR 30.8 billion.

Figure 9: GDP gains linked to Horizon 2020[310]



Source: European Commission, DG Research and Innovation, 2023.

The higher GDP gain in the simulations of the NEMESIS model can be explained by the fact that the three models use different sets of innovation channels and elasticities.[311] Notably, NEMESIS uses higher leverage and performance expected from EU funding of R&I compared to national funding as an illustration of the EU added value of the framework programme. This can potentially explain a significant part of the difference between the results from NEMESIS and the other models. Several studies[312] provide empirical evidence that shows that EU funding could be expected to perform 'intrinsically' better at EU level compared to national level due to factors that are not directly captured by these models, such as multidisciplinary transnational collaborations or critical mass. However, the way this EU added value is translated in a model, i.e. the size of the effect, is not trivial and requires caution in its interpretation.

In short, the three models used here are based on different modelling strategies, assumptions and parameter specifications and values, which results in different quantitative estimates of the economic impact. Nevertheless, the comparison of results across different models is essential to ascertain the consistency of a policy intervention. This comparison is also required to understand the different aspects and mechanisms at play within the models, which partially mirror those determining the actual impact of framework programmes.

As regards **employment** (see Figure 10 and details in Annex 2):

- According to the **NEMESIS** model, the investment phase (up to 2020) is characterized by an average rise of about 85 000 jobs compared to the situation in the reference scenario (Figure 10), and a significant increase in the number of people employed in the research sector, with the creation of up to 100 000 jobs in research by 2019-2020 (see Annex 2) as Horizon 2020 grants stimulated innovation by helping R&D intensive companies to attract more high-skilled labour from traditional production activities into research, which offers higher wages. Between 2021 and 2030, the average employment gain produced by the programme is estimated at approximately 123 000 additional jobs. The **maximum impact is expected to be reached in 2030 (+229 000 jobs),** exceeding projections in the interim evaluation, where EU contributions via Horizon 2020 were forecast to increase the level of employment by between 110 000 and 179 000 units (FTEs) in the period 2014-2030. After 2030, the employment gains lessen gradually to +36 000 in 2050.

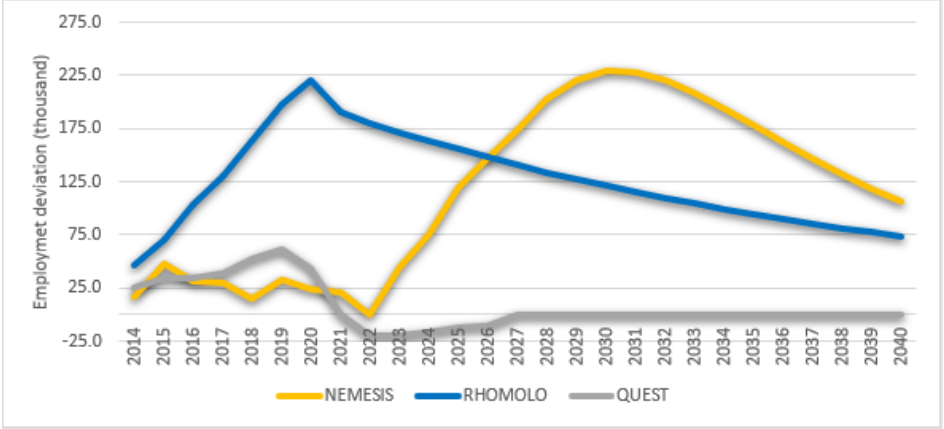
[310] Percentage change relative to the reference scenario, i.e. a situation without the FP.

[311] Macroeconomic Modelling of R&D and Innovation Policies, edited by Ufuk Akcigit, Cristiana Benedetti Fasil, Giammario Impullitti, Omar Licandro, Miguel Sanchez-Martinez, chapter 8 "Taking Stock" by Cristiana Benedetti Fasil, Miguel Sanchez-Martinez and Julien Ravet, 2022, p. 159, https://doi.org/10.1007/978-3-030-71457-4.

[312] Delanghe et al., 2011, "European research policy and bibliometrics indicators, 1990–2005", Scientometrics, 87(2); Vullings et al., 2014, "European added value of EU science, technology and innovation actions and EU-member state partnership in international cooperation"; Rosemberg et al., 2016, "*Ex post* evaluation of Ireland's participation in the 7th EU framework programme"; ECDG & Elsevier, 2017, "Overall output of select geographical group comparators and related FP7- and H2020 -funded publication output"; PPMI, 2017, "Assessment of the Union added value and the economic impact of the EU framework programmes (FP7, Horizon 2020)".

- According to the **RHOMOLO** model, the programme also leads to improvements in employment. The impact rises during the investment phase to peak at **220 000 additional jobs in 2020**, after which the annual employment gains again become gradually weaker until 2050.
- Concerning **QUEST**, given the specific features of the model and the way the policy interventions are simulated as productivity enhancing measures, the results suggest only a **slight short-run increase in employment** during the demand boost (up to 2020), which disappears with rising real wages in the medium to long-run, after the end of the implementation period.

Figure 10: The impact of Horizon 2020 on employment



Source: PPMI - NEMESIS simulation, Innovative Europe evaluation study (2023). RHOMOLO model by Joint Research Centre. QUEST MODEL by DG Economic and Financial Affairs.

When using and interpreting the results produced by these models, it is essential to acknowledge their main limitations. Any model allows only for a partial representation of reality, subject to the assumptions made. RHOMOLO balances its detailed spatial and regional dimensions by keeping optimisation problems static and, hence, not capturing the inter-temporal consequences of innovation decisions. These are binding constraints for ensuring the tractability of the model. In addition, it does not distinguish between private and public innovation or between different types of endogenous innovation. On the other hand, QUEST, not being a multisector macroeconomic model, groups all R&D activities in a unique R&D sector without capturing the complexity and diversity of the type of R&D investments, such as private and public R&D activities, product and process innovation, non-R&D and disruptive innovations. These elements are also not present in RHOMOLO, albeit the latter features more extensive sectoral and geographical details. Lastly, NEMESIS is based on empirically observed relationships among variables as well as on adaptive expectations instead of forward-looking ones, allowing for more degrees of freedom in behaviour than in other models. This may generate inconsistencies with recent developments in macroeconomic theory. As opposed to the other two models, however, NEMESIS incorporates private and public R&D activities, product and process innovation, and non-R&D investments.[313]

Horizon 2020 also had two high-level indicators where changes cannot be attributed to its effects but which serve to monitor Europe's competitiveness:

- Investment in research and development is part of the Horizon 2020's general objective and was also identified as one of the KPIs to monitor the competitiveness of EU industry, with focus on research and innovation.[314] In 2020, the rate of **research and development**

[313] Macroeconomic Modelling of R&D and Innovation Policies, op. cit., p. 158.
[314] COM(2023)168 final, "Long-term competitiveness of the EU: looking beyond 2030", Annex, p. 22, https://commission.europa.eu/system/files/2023-03/Communication_Long-term-competitiveness.pdf. Also one of the main indicators of economic competitiveness in COM(2021)350final, p. 6, https://commission.europa.eu/system/files/2021-05/communication-industrial-strategy-update-2020_en.pdf

expenditure driven by both private and public (national and EU) investments **as a proportion of GDP stood at 2.32%, an improvement of 15% compared with the 2013 figure of 2.02% but below the 3% target** referred to in the Horizon 2020 general objective.

The budget of Horizon 2020 represents about 10% of governments' budget allocations for R&I in EU28[315] and therefore its contribution to reaching the target of 3% of EU GDP spending on R&I is limited (although augmented by its capacity to leverage other sources of funding, see section 4.4.1).

- Against the general Horizon 2020 objective of building a society and world-leading economy based on knowledge and innovation across the whole Union, the Horizon 2020 Regulation[316] envisaged the monitoring of the **EU innovation output indicator (IOI)**,[317] a measure of innovation diffusion developed by the European Commission.[318] This is a synthetic measure indexed to 100, representing the value observed in 2011. Over the period 2013 to 2020, **the IOI increased in the 27 EU Member States,** from 100.2 **to 105.2**.[319] The EU improved its IOI performance during the Horizon 2020 period, slightly reducing the gap with main international comparators (e.g. the United States).[320] The IOI is reported in this evaluation for completeness but its link to Horizon 2020 is indirect.

In spite of these improvements, Europe's overall **competitive position has not fundamentally changed** over the duration of Horizon 2020. The EU still ranks third in terms of overall R&D investment[321], behind the US and China. Its long-standing growth and productivity gap with the US has so far also not been reduced. Business investment remains concentrated: almost half of all EU R&D investment goes to the automotive and other transport sectors. There is also a lag in terms of venture and growth capital - as a result, there is a pronounced scaling-up gap to the US and China.[322]

It is not because the EU's overall competitive position has not changed during 2014-2020 that Horizon 2020 did not contribute to EU competitiveness. There is extensive literature[323] on how R&I improves competitiveness and productivity. Innovation is a crucial driver of productivity as it boosts it through the development and deployments of new products and processes. But there are other factors at play, and the overall global landscape is also evolving over time. There are both firm level and institutional drivers of productivity and competitiveness. At the firm level, it has been found that innovation, management practices and human capital are key determinants of higher productivity and competitiveness. In the aggregate, a stable

[315] GBARD based on Eurostat data for 2020; Spending and revenue (europa.eu)

[316] Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020, Annex I, "Broad lines of the specific objectives and activities".

[317] The IOI has four components: patent-based technological innovation, skilled labour force feeding into the economic structure of a country, competitiveness of knowledge-intensive goods and services, and employment in fast-growing enterprises in innovative sectors. The index and its underlying indicators are calculated for 40 countries, including European Union Member States and selected third countries.

[318] Legal basis: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, "Measuring innovation output in Europe: towards a new indicator" (COM/2013/0624 final).

[319] European Commission, Joint Research Centre, Bello, M., Caperna, G., Damioli, G., et al., The innovation output indicator 2021, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2760/802325, p. 26.

[320] Ibid., p. 24, and European Commission, DG for Research and Innovation, Science, research and innovation performance of the EU 2022: building a sustainable future in uncertain times, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/78826, p. 472.

[321] Gross domestic expenditure on R&D (GERD), 2021, Eurostat (rd_e_gerdtot) and OECD database. Eurostat article on R&D expenditure.

[322] Evaluation study on the Relevance and Internal Coherence of Horizon 2020 and its Policy Mix (2023), op. cit. Based on Elsevier SCOPUS, EPO PATSTAT, Eurostat and OECD data, EU Industrial R&D Investment Scoreboard, broad-based review of further studies, see References in Annex A.

[323] The positive impact of R&I on these variables is assessed in the Science, Research and Innovation Performance of the EU report (chapter 4.1: https://research-and-innovation.ec.europa.eu/system/files/2022-07/ec_rtd_srip-2022-report-chapter-4.pdf).

macroeconomic environment, property right enforcement, openness to trade, effective government, and properly regulated markets are other key factors.[324]

The EIC pilot (2018-2020) tackled the persistent difficulty to translate research breakthroughs into innovation[325], which were acknowledged at the start of the programme[326] and again in more recent analyses.[327] In this context, the first phase of the EIC pilot was launched in the last two years of Horizon 2020 to strengthen breakthrough and disruptive innovations and sustain the scaling-up of European high-growth innovative companies[328]. To this end, the EIC Pilot brought together pre-existing Horizon 2020 instruments: the Future Emerging Technologies Open (FET), the SME Instrument (SMEI), the Fast Track to Innovation (FTI) and Horizon 2020 Prizes.

The EIC support filled a gap as limited breakthrough schemes existed at national level. Survey results for both successful and unsuccessful applicants to the EIC show that there are limited alternatives to the EIC.[329] Stakeholders and beneficiaries interviewed for this evaluation agreed that the EIC, with its focus on deep tech, breakthrough innovation, European dimension and substantial funding, offers unique advantages to beneficiaries that other national or regional programmes cannot match. National and regional schemes, often supported by the EU structural funds, have a limited geographical dimension and a focus on incremental innovation.[330] Even in countries where support to innovative companies through a mix of grants and financial instruments is available, the EIC stands out as the only programme having sufficient breadth and providing substantial support to deep tech companies, requiring investment in equipment, facilities and new staff. Some stakeholders consider that even if there were some overlaps, these should not be regarded as a major issue given the existing gaps for innovation financing compared to China and the US.[331]

4.1.4. Dissemination and exploitation of results

The exploitation and dissemination of results is a best effort obligation in Horizon 2020, but implementation varied:[332]

- In programme parts where projects are more business-oriented, dissemination was typically carried out via non-scientific publications. For such beneficiaries it is often important to give publicity to investments received and market potential: private platforms such as Dealroom already play an important part. Examples are provided in the box below. However, they often lack incentive to communicate the findings of their research activities, due to concerns about confidentiality and protecting market potential.[333]

[324] Grifell-Tatjé et al. 2018, Syverson 2011, Bartelsman and Doms 2000.
[325] Horizon 2020 Work Programme 2018-2020, "Towards the next framework programme for research and innovation: Enhanced European Innovation Council (EIC) Pilot", https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-eic_en.pdf.
[326] Already in 1995, the Green paper on Innovation addressed this issue as "the European paradox", stating that "one of Europe's major weaknesses lies in its inferiority in terms of transforming the results of technological research and skills into innovations and competitive advantages." European Commission, Green paper on Innovation, Bulletin of the European Union, Supplement 5/95, 1995.
[327] See SRIP report 2020 which suggests that the EU is lagging with a view to an environment that facilitates investment in relevant intangibles and scale-up funding. The SRIP 2020 also highlights the insufficient availability of risk finance for innovative investments in the EU – although there has been improvement after the Eurozone crisis – and deplores the fact that the European system still mainly relies on bank financing.
[328] Horizon 2020 Work Programme 2018-2020, "Towards the next framework programme for research and innovation: Enhanced European Innovation Council (EIC) Pilot", op. cit.
[329] European Commission, DG for Research and Innovation, Evaluation study on the European Innovation Council (EIC) pilot, Publications Office of the European Union (2022), p. 62, https://data.europa.eu/doi/10.2777/261324.
[330] Ibidem.
[331] Ibidem.
[332] Article 28 of Horizon 2020 regulation provides that "activities to disseminate information and carry out communication activities shall be an integral part of all actions supported by Horizon 2020" and that specific actions shall be supported in order to "optimise the communication, exploitation and dissemination of results".
[333] Innovative Europe evaluation study (2023), op. cit., section 7.4, p. 53.

- For Societal Challenge 1 (Health, demographic change and well-being), the monitoring data revealed that over **half (53.4%) of SC1 projects reported carrying out dissemination activities**.[334]
- The results of the bibliometric analysis for SC2 (Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy), SC3 (Secure, clean and efficient energy), SC4 (Smart, green and integrated transport) and SC5 (Climate action, environment, resource efficiency and raw materials) concluded that Horizon 2020 **failed to reach satisfactory levels of dissemination of scientific results within the scientific community and to policymakers**.[335] The beneficiaries surveyed[336] highlighted limitations in dissemination when it came to reaching out to policymakers and end users. They raised concerns about the resources and skills needed for dissemination and the need for continued knowledge management after the end of a project.

Despite the above-mentioned challenges, a bibliometric analysis indicated a satisfactory level of dissemination of scientific results within the scientific community and towards policymakers in certain fields.[337]

Example of dissemination practice for EU-funded innovations: Innovation Radar prize

Since 2015, the Commission has been awarding an annual Innovation Radar Prize, putting a spotlight on the innovations funded by the programme.[338] Innovators are shortlisted based on technological and business readiness of innovations developed in collaborative projects.[339] Examples of award-winning Horizon 2020 innovations:

- A new method for magnetic resonance imaging (MRI) based on quantum technology, paving the way for better treatment of cardiovascular diseases (NVision, Germany – MetaboliQs project[340]).
- A machine system generating all type of construction elements and architectural surfaces, 40 times faster than the methods used today (Svelte, Romania – SVELTE project[341]).
- A thermophotovoltaic battery that stores surplus renewable generation at ultra-high temperatures and produces combined heat and electricity on demand (Univ. Politecnica de Madrid, NATHALIE project[342]).
- A bio-based solution to replace petrochemical solutions used in cardboard packaging boxes, making the products stronger and easier to recycle (MetGen, Finland, FALCON project[343]).

The winner of the prize is featured in a special broadcast on Euronews[344] and receives wider support (via the dealflow.eu platform) to help increase their visibility for investors.

Shortcomings in dissemination may contribute to the scant uptake of the findings of Horizon 2020 projects.[345] The main challenge lies in the amount and consistency of the information available on the exploitable results of Horizon 2020 projects. On the one hand, many projects produce a wealth of research findings and data. On the other hand, the information that is published on project results is often incomplete and inconsistent, either due to objective reasons (e.g. pending patent applications) or to an incomplete understanding of what type of information is useful for which target group.

[334] Resilient Europe evaluation study (2023), op. cit., p. 48.
[335] Ibid, pp. 41 and 129. Analysis in Annex V.
[336] Green Transition evaluation study (2023), op. cit., section 3.1.5.2.
[337] Ibid, pp. 41 and 98.
[338] https://www.innoradar.eu/innoradarprize
[339] https://www.innoradar.eu/methodology
[340] https://cordis.europa.eu/project/id/820374
[341] https://cordis.europa.eu/project/id/887858
[342] https://cordis.europa.eu/project/id/945858
[343] https://cordis.europa.eu/project/id/720918
[344] For example, for the 2021 overall winner, MetGen: https://www.euronews.com/next/2021/11/19/enzymes-and-wood-biomolecules-a-winning-combo-for-sustainable-packaging
[345] External Coherence study (2023), op. cit., pp. 28 and 69.

What messages emerged from the stakeholder consultation?

Respondents indicated scientific publications, workshops or other events, project websites and social media (especially LinkedIn) as the initiatives that mostly helped dissemination, exploitation and access to research and innovation results – in particular, 69% (1 213) and 62% (1 083) of respondents stated that scientific publications and workshops/other events were helpful 'to a great extent'.

Regarding the helpfulness of dissemination and exploitation support services initiated by the Commission, a significant share of respondents did not have an opinion or did not know: over 50% for the Innovation Radar and IPR Helpdesk, 30-40% for the Horizon Dashboard, Horizon Results Platform and Horizon Results Booster, and 22% for CORDIS. For publications, the project website, social media and workshops, this share is 6-11%.

Overall, this indicates that particularly in view of the **Innovation Radar** and the **IPR Helpdesk**, stakeholders are not sufficiently convinced of these tools' usefulness for dissemination and exploitation. Nevertheless, while EU citizens (15%; 31), non-EU citizens (14%; 8) and respondents from academia (12%; 111) favour the IPR Helpdesk over the Innovation Radar (7%; 15, 11%; 6 and 9%; 80 respectively), only 16% of business associations (5) and 12% of companies (36) hold the belief that the IPR Helpdesk fosters dissemination and exploitation of results to a great extent.

Among all stakeholder categories, **CORDIS** is deemed the most relevant EU-wide exploitation support service: 32% of non-EU citizens (18), 29% of EU citizens (61), 28% (255) of respondents from academia, 28% (85) from companies and 24% (22) from public authorities indicated that CORDIS helped disseminate and exploit results to a great extent.

Following CORDIS, the **Horizon Dashboard** is most used among business associations (16%; 5), companies (16%; 48), non-EU citizens (16%; 9), EU citizens (15%; 33) and public authorities (15%; 14), similar to the **Horizon Results Booster** which was assessed by business associations (16%; 5), NGOs (14%; 9), non-EU citizens (14%; 8), companies (13%; 38) and EU citizens (12%; 25) as helpful to a great extent.

Among respondents from research or academia, 14% (122) found that the **Horizon Results Platform** helped dissemination and exploitation to a great extent, whereas only 9% (85) among them shared the same view regarding the **Horizon Results Booster**. A similar trend is also pronounced in the responses of companies with 16% rating the **Horizon Results Platform** (48) as helpful to a great extent, while only 13% (38) said the same about the **Horizon Results Booster**.

4.1.5. Analysis of the long-term impact of previous framework programmes

As requested in Council conclusions[346], this evaluation addresses the long-term impacts of the seventh framework programme, especially with regards to IPR and effects of ERC grants.

IPR outputs from Horizon 2020's predecessor, FP7, increased significantly after its end. As of 1 January 2023, FP7 projects reported 6 328 IPR applications. This is almost three times higher (+179%, 2 266) than the figure available at the time of the final evaluation of FP7.[347] Specifically for patents, FP7 projects produced 5 545 applications, which is more than double the number recorded on 1 January 2017[348] (2 669, +108%), three years after the end of FP7.[349]

Another advantage of analysing IPR outputs several years after the end of a framework programme is that most patent applications (95.4% for FP7[350]) have been eventually awarded. A wide enough evidence base on awarded patents enables reporting on more refined indicators, such as technological relevance, economic value and their propensity to spur additional patented innovations. The majority of self-reported FP7 inventions were patented in health-related areas, such as biotechnology (accounting for 14% of all FP7 patents, while just 1.5% of all inventions

[346] Council conclusions on the interim evaluation of Horizon 2020, https://www.consilium.europa.eu/media/31888/st15320en17.pdf, 1 December 2017.
[347] The figure, also reported in section 4.1.3, dates to 1/12/2015 and did not include IPR output of ERC projects. Even if ERC outputs are omitted, the increase over 2015 is still more than twofold (4567 applications, +102%).
[348] Reference date for Horizon 2020's interim evaluation, which also reported on FP7 IPR applications as baselines.
[349] All figures are from R&I Project Results Dashboard, frozen at 31/12/2022.
[350] Ibid.

at global level are in this field) and pharmaceuticals (9%). Lower shares were observed for ICT-related and environmental technologies.[351]

The estimated value of the patents[352] is not homogenous across sectors, ranging from EUR 1.1 million for macromolecular chemistry to under EUR 100 000 for audio-visual technologies. The valuation of FP7 patents was above the global average in most cases, with a few exceptions: even if many in number, numerous medical patents had a lower value than global average, while ICT patents are not just valued below the global level but are also less valuable compared to other framework programme patents. Almost half of all inventions were flagged as 'interdisciplinary' – i.e. they relate to more than one technology class – which is twice the world average. Patenting in multiple patent offices is common, as almost as many patents are protected at the European patent office (75%) and in the United States (74%). An analysis of patent owners shows that more than half (52%) are SMEs. This is important towards the objective of improving the competitiveness of the European economy: companies that hold patents or other forms of intellectual property are more likely to grow and experience high growth than those that do not.[353]

Qualitative analysis of **ERC-funded work** shows that since its creation in 2007, 81% of projects funded by the ERC resulted in a scientific breakthrough or major advance.[354]

Counterfactual analysis[355] showed that **in FP7 ERC grants increased research productivity (quantity and quality of publications**, i.e., on H-Index and publications in top 1% and top 10% ranked journals) **in the long term**, namely up to 9 years after receiving the grant, in some fields and depending on the type of grant received (i.e. Starting or Advanced Grant). Positive results are visible for the top-ranked project proposals as bottom rank winners have similar productivity to the unsuccessful applicants in the control group (proposals around the funding threshold).[356]

This analysis confirmed the existence of a "Matthew effect" across all fields and grants, i.e. **researchers who received an ERC grant were more likely to obtain other EU grants** by themselves (or through their co-authors) even if the total number of funds they received was similar to the one of non-beneficiaries. However, this does not imply biased and unfair selection in EU grants. Having successfully run an ERC grant would likely be considered an asset in subsequent selections given that it may be seen as a signal of experience accumulated in managing large competitive funds.

[351] European Commission, "Patents in the framework programme – From Horizon 2020 to Horizon Europe", looking at FP7 patent applications for the 2009-2018 period, R&I monitoring and evaluation flash, Aug. 2020, p. 5.
[352] Estimated in "Patents in the framework programme" monitoring flash using IP-BI method, retrieved from Orbis Intellectual Property database. This methods takes into account the following 26 indicators: Community application, R&D strength of the invention, R&D applicant ratio, Technology in different term trend, Sustainability of technology trend, Total size of activity, Family size, Transferability to different industries, Heterogeneity of potential applications, Exploitation in different technologies, Total amount of exploitation possibilities, Evidence of use, Relevance for other technologies/applications, Differentiation to the state of the art, Differentiation from direct competitor technologies, Interfering with competitors technologies, Validity level, Patent maturity, Claim width and coverage, Validity in certain countries, Intended worldwide protection, Procedural State and Grant lag.
[353] Meniere, M., Rudyk, Y., Wajsman, I., Kazimierczak, N. (2019). High-growth firms and intellectual property rights. IPR profile of high-potential SMEs in Europe. EPO & EUIPO Report, May 2019. ISBN 978-3-89605-228-5
[354] Based on the qualitative evaluations (annual independent reviews) of completed ERC- funded projects carried out during 2016-2021. The evaluation was carried out each year on a sample of completed projects from all three ERC scientific domains. This sample was randomly selected from a pool of ERC projects funded under FP7.
[355] For details of the counterfactual analysis see Annex 2, section 10.
[356] Ghirelli C., Havari E., Meroni E. and Verzillo S. (2023) "The Long-Term Causal Effects of Winning an ERC Grant", IZA discussion paper 16108.

4.2 Efficiency

This section reports on the actual costs of Horizon 2020 for different stakeholder groups. It also assesses how benefits compare to costs, how simplification measures performed relative to targets and objectives, and discusses the main opportunities for further simplification.

4.2.1 Costs, affected stakeholder groups, and overall value-for-money of Horizon 2020

Horizon 2020 and the processes through which it was implemented gave rise to several types of costs incurred by different stakeholder groups.

1. The operational expenditure of Horizon 2020 is EUR 71 195 million. It is the programme's input cost, incurred by EU society and funded mainly through the Union's budget. The part that was allocated to research and innovation projects following calls for proposals amounted to EUR 68.3 billion and has been fully committed. EUR 62 133.6 million have already been paid out.[357]

2. The administrative expenditure of Horizon 2020 is EUR 4 428 million. It is the **administrative cost of the European Public Sector** funded through the EU budget. EUR 4 292.3 million have already been paid out.[358]

3. Beneficiaries' administrative costs are compensated by grant payments and included in the operational expenditure (point 1). They have the potential to introduce inefficiencies (disproportionate administrative burden) into the programme from the point of view of society. Feedback from beneficiaries suggests that the overall costs to participate in Horizon 2020 are at least similar or even higher than those of other R&I programmes. Indicated time cost range between **4.5 to 7 person-days per month of project duration**. This implies that, if expressed as indicative money value, the total cost amounts to between EUR 135 million and EUR 215 million.[359] Beneficiaries' administrative costs were explicitly targeted by Horizon 2020's simplification measures.

4. Application costs (the cost of preparing and submitting proposals) are faced by successful and unsuccessful applicants up front. To some extent they are necessary to maximise benefits by ensuring the most competitive proposals can be identified - but application costs also have the potential to introduce inefficiencies into the programme, particularly given low success rates. The evaluation **estimates that an average cost of a proposal** falls into the range of **EUR 18 000 to EUR 37 000**, which suggests that **successful proposals** in total may have cost **EUR 609 million to EUR 1.25 billion** to prepare. The total application cost embodied in the large number of **unsuccessful proposals** is likely even more substantial and may well reach a value in the **order of EUR 5 billion to EUR 10 billion.**[360]

The costs and benefits reported in the evaluation have been used to assess Horizon 2020's societal value-for-money by calculating an **approximate public sector benefit cost ratio (BCR).** Conceptually, this metric relates the total welfare benefits of the programme to the total cost associated with it.[361]

[357] Actual paid operational expenditure as of 01.01.2023; The amount paid out is lower than the budget figure, primarily as projects are still ongoing and are yet to receive payments; Source: MFF Performance Dashboard.
[358] Actual paid administrative expenditure as of 01.01.2023; Source: MFF Performance Dashboard.
[359] The confidence in these values is very low due to the small sample of respondents and the non-representative nature of the survey. See also Annex 4.2 for further information on monetisation of the total cost.
[360] The confidence in these estimates is very low due to a lack of systematic and robust evidence. The estimates should be read as rough illustrative figures only. See Annex 4.2 for further information, including on the question of proportionality, on oversubscription and on the involvement of consultancy firms in consortia.
[361] The difference between a (public sector) benefit cost ratio of a programme and a (private sector) return-on-investment is that the BCR takes the wider perspective of EU society and should include all costs and benefits that affect welfare. A BCR of 1 (break-even) indicates that each euro of costs that the programme generated welfare benefits equivalent to one euro.

While the costs associated with Horizon 2020 are incurred early on, its **benefits**[362] only emerge over a long period of time. A meaningful assessment of their overall relationship at this point thus has to involve estimates of benefits that have not yet materialised. The closest available proxy for a total welfare benefit of Horizon 2020 is the macro-economic forecast of its long-term GDP impact (section 4.1.3). It is likely an underestimate of the overall welfare benefits of Horizon 2020 in that not all welfare impacts on society are fully captured by GDP.[363]

Quantified benefits other than GDP (e.g., number of patents, effects on employment) are not added again to avoid double-counting. The forecast GDP value excludes any impacts on countries outside of the EU. The period of up to 2040 allows for all projects to be completed and benefits to channel through to a marketable impact. As the last projects end in December 2028, GDP impacts had at least 13 years to materialise. To anchor the forecasts to *ex post* evidence, observed Horizon 2020 dashboard information was used as modelling input data. The output of models, particularly those forecasting the future, is inherently uncertain and subject to multiple assumptions and limitations.[364] Consequently, the total benefit value used in the BCR calculations[365] is more uncertain in nature than the total cost estimate, which is dominated by the programme's budget.

For the total cost value, the **administrative and operational expenditure** invested in Horizon 2020 and the **application costs** invested by successful and unsuccessful applicants are added up. The evidence underpinning the application cost estimates is not robust, however, ignoring this type of cost would knowingly underestimate the total costs. Beneficiaries' administrative costs are not added again to avoid double counting because these costs are compensated and thus already included in the operational expenditure figure. As the BCR calculation considers a very long time horizon, the conservative assumption was made that all of the available budget will be spent by 2040.[366]

Based on the above, the **benefit cost ratio** (dividing total benefit by total cost) is around 5, consistent with a high value-for-money that reflects the potential of R&I support to generate substantial benefits over a long time horizon.[367] It suggests that **one euro of costs to society associated with the programme (programme costs and costs to applicants) is estimated to bring about five euros of benefits for EU citizens (measured through GDP impact) in the period up to 2040.**

[362] Benefits are reported in Section 4.1 (Effectiveness) and in the summary table Annex 4 Table 1.
[363] Gross Domestic Product (GDP) accounts for goods and services bought and sold in markets. Other factors, not traded in markets, can also change due to R&I impacts and raise the welfare of society, e.g. in the areas of health, leisure, non-market services, and a reduction in negative environmental externalities.
[364] The limitations and assumptions of the macro-modelling are presented in detail in section 4.1.3 (Improving Europe's economic growth and competitiveness) and in Annex 2.1.
[365] The total benefit value used in the calculation is EUR 491.967 billion in current prices (to match the price base of the available budget cost data). This differs from the one reported in Section 4.1.3, which shows 2020 prices.
[366] Please note that this differs from the assumption used in the benefit estimate, which is limited to the observed Horizon 2020 dashboard data. In both cases the approach is conservative, as the higher the cost and the lower the benefits, the lower the resulting benefit-cost ratio and value-for-money. The total cost value range used in the calculation is EUR 81.233 billion to EUR 86.874 billion (see Annex 4.5 Table 14 for a split by components).
[367] See Annex 4.5 Table 14 and Figure 8, for further reporting, illustration, and additional calculations that vary the assessment period and the macro model output used for benefits. The BCR value should be treated as indicative.

4.2.2 Performance of Horizon 2020's simplification measures

Optimising programme delivery has been one of Horizon 2020's specific objectives.[368] Simplification[369] aimed at:

1. Reducing **administrative costs of applicants and beneficiaries** in terms of the time, money and effort involved in participating in Horizon 2020[370], thus increasing the overall programme efficiency.
2. **Accelerating all processes relating to proposal and grant management**[371], thereby increasing the efficiency of administering the programme.
3. **Decreasing the financial 'error rate'** for Horizon 2020[372] thus increasing the efficiency of the programme's administration by the EU public sector and reducing administrative costs for beneficiaries.

Two main strands of simplification measures were introduced:

- **Structural simplification and a general overhaul of implementation processes**, primarily targeting simplification objectives 1 and 2, and as a secondary effect, objective 3 above.
- **Simpler funding rules and a revised 'control and risk strategy'**. These measures primarily set out to optimise the balance between the administrative costs of beneficiaries (objective 1) and the benefits of reducing financial errors (objective 3).[373]

4.2.2.1. Structural simplification and revision of implementation processes

Horizon 2020's programme architecture **brought together previously separate support programmes**[374] in one framework, governed by a **single set of rules**, **requirements and processes** with common **guidance documents** and **support services** (Common Implementation Centre or CIC). Various mechanisms were devised[375] to increase awareness and facilitate participation in Horizon 2020. Intensifying simplification efforts under FP7[376], Horizon 2020 also introduced **new management modes**, which saw the extensive delegation of programme implementation to specialised Executive Agencies and Joint Undertakings[377], to increase the quality, efficiency, and consistency of Horizon 2020's implementation[378], leaving the European Commission to focus on core policy and institutional tasks.[379]

The European Court of Auditors' report[380] collected extensive and detailed qualitative feedback from programme participants[381] to assess their effects 4 years into the programme. Its overall finding was that '**the majority of the simplification measures have been effective in reducing**

[368] Regulation No 1291/2013, Framework Programme for Research and Innovation, Preamble 20.
[369] Horizon 2020 - The Framework Programme for Research and Innovation, COM(2011) 808 final.
[370] Simplifying the implementation of the research framework programmes, 2010/2079 (INI); Horizon 2020 - The Framework Programme for Research and Innovation COM(2011) 808 final.
[371] Horizon 2020 - The Framework Programme for Research and Innovation, COM(2011) 808 final, p. 7.
[372] COM(2011) 808 final. Management Measures, simplification p. 97; Regulation(EU) 1291/2013, Framework Programme for Research and Innovation, Preamble 20.
[373] Horizon 2020 - The Framework Programme for Research and Innovation, COM(2011) 808 final, p. 8.
[374] FP7, CIP, EIT.
[375] For instance, the participant portal, the annotated model grant agreement (AMGA), the Horizon 2020 online manual, FAQs and National Contact Points (NCPs).
[376] Evaluation of FP7, Section 6.2.3.
[377] In contrast to FP7, where 30% of the budget was implemented by Executive Agencies (REA, ERCEA).
[378] COM(2011) 808 final.
[379] See also Horizon 2020 Interim Evaluation (2017), Section 7, for an assessment of measures and application processes, and an analysis of participation patterns and 'thematic' assessments of programme parts at interim stage.
[380] Court of Auditors, Special Report. No28 (2018).
[381] Including an online survey of 59 questions, covering 2014 (start of programme) to January 2018, sent to 32 918 contacts from 20 797 organisations granted funding. With 3598 respondents, despite not being representative by design, the survey is an important source of evidence on beneficiaries' views on the effectiveness of the simplification measures. Interviews of 8 beneficiaries (2 SMEs, 2 universities, 1 large private enterprise and 3 Research and Technology Organisations) collected further detail.

the administrative burden for beneficiaries in Horizon 2020' it but also pointed out that '**not all actions produced the desired result and opportunities to improve still exist**'.[382] New organisational and horizontal structures had led to a more consistent implementation of the programme. The creation of a common implementation centre for Horizon 2020 was highlighted as a 'major contribution' to simplification, as were the harmonisation of rules for participation and IT solutions for grant management and reporting.[383] Particularly, the introduction of electronic signatures and the annotated model grant agreement were found to have had a notable effect.[384]

What messages emerged from the public stakeholder consultation?

Regarding the structure and available information of Horizon 2020 calls, most respondents (both successful and unsuccessful applicants) agreed or strongly agreed that '**the descriptions of Horizon 2020 call for proposals were clear**' (63%; 1170), that '**the priority setting via the work programmes was adequate**' (61%; 1 091) and that '**the communication activities to attract applicants were adequate**' (58%; 1 029). However, over a quarter of respondents (27%; 478) disagreed or strongly disagreed that **finding the right call for proposals was easy**. **Lack of knowledge about the framework programme** was selected as a factor preventing participation by over a third (39%; 637) of Horizon 2020 beneficiaries, similarly to unsuccessful applicants (33%; 15), coming in fourth place after other aspects of application costs.

Among the different types of stakeholders, 31% (286) of research institutions as well as business associations disagreed or strongly disagreed that it was easy to find the right call, whereas companies and business organisations indicated that they had slightly less difficulties (26%; 81). Likewise, 42% (384) of research institutions, 50% (16) of business associations and 47% (145) of companies and business organisations, 47% of EU citizens (104) and 39% (23) of non-EU citizens found it easy to find the right call for their proposals.

Regarding the implementation processes of the calls, stakeholders indicated that '**using an electronic-only management system**' (82%; 1 403) and having '**harmonised processes and guidance documents across the framework programme**' (72%; 1 220) were understood to have reduced at least 'somewhat' the administrative burden for respondents. Likewise, most respondents think that **effective simplification measures** included: **removing the negotiation stage** during grant preparation (67%; 1 133) and '**using a funding model with a single reimbursement rate and a single flat rate**' (59%; 1 033)**.** The measure with the **highest number of negative views** was the 'to further use of the **two-stage application process**', although overall positive responses still outnumber negative ones, three to one.

A 2022 study on the **proposal evaluation system**[385] found evaluation processes were **fair and transparent**, although the **overall consistency** and the **feedback provided to applicants** could be improved. Stakeholder feedback also suggests that the positive effects on the **proposal submission processes**, and thus on application costs, were limited. While participants indicated an overall high satisfaction with the process itself[386], the **burden imposed on applicants** remains an area for improvement.[387] According to the ECA survey, the **proposal preparation effort has not substantially changed for applicants since FP7**.[388] Around half of the respondents reported no difference at all, 20% a lower workload and 30% an increased workload. Newcomers to EU funding schemes, in particular SMEs, found it difficult to deal with the complexity of the Commission's IT tools.[389]

What messages emerged from the public stakeholder consultation?

Views on how the **effort involved in participating in Horizon 2020 compared to FP7** were not uniform: 39% (692) of respondents think the effort was similar, 12% (219) that it was lower, and 17% (303) that it had increased since FP7. One third of respondents did not provide an opinion. **Relative to other research and innovation**

[382] Ibid. Executive Summary.
[383] Court of Auditors, Special Report. No 28 (2018), Conclusions, p. 48.
[384] Court of Auditors, Special Report. No 28 (2018).
[385] Study on the proposal evaluation system for the EU R&I framework programme (2022), op. cit.
[386] Ibid.
[387] Study on the Proposal Evaluation System (2022), Horizon 2020 evaluation support studies on Excellent Science, Resilient Europe, Digital and Industrial Transition, Innovative Europe and Green Transition (2023), op. cit.. Evaluation of Research Executive Agency (REA) 2015-18; Evidence gathered through interviews and (non-representative) surveys. Beneficiaries dominate the responses of participants.
[388] Court of Auditors. Special Report. N.28 (2018).
[389] Ibid.

funding programmes, the effort to participate in Horizon 2020 is deemed greater (43%; 771, particularly academic and research institutions) **or similar** (39%; 692) **by most**. Only a small minority of respondents (7%; 219) consider it lower.

The **main reasons that held back potential beneficiaries** from Horizon 2020 were all linked to application costs, namely the **low success rates of applicants**, which both successful and unsuccessful applicants agree on (57%; 924 and 69%; 31 respectively), the **cumbersome application process** (42%; 681 among successful and 53%; 24 among unsuccessful applicants, and 50%; 67 respondents from associated countries), as well as the **lack of resources:** Interestingly, a larger fraction of successful applicants (41%; 670) than unsuccessful candidates (27%; 12) deemed the potential applicant's lack of resources to prepare a proposal as a reason negatively affecting participation. Compared to EU-13 respondents, respondents from associated countries are 10 percentage points less likely to identify limited resources as a deterring factor for participation.

Low success rates were also considered a further deterring factor to participation by 59% (830) of EU-15 respondents, 64% (115) of EU-13 respondents and 40% (54) of respondents from associated countries.

Two quantitative targets allow to track the aggregate impact of the simplification measures on **EU public sector administrative efficiency** and can be assessed.

First, the Horizon 2020 Regulation set out an overall **efficiency benchmark** for the programme's administrative expenditure of no more than **5% of the specific programme budget envelope, excluding JRC and EIT actions**. Throughout the programme, the administrative expenditure was also to decrease, aiming at a **target of 4.6% or less in 2020**.[390] Horizon 2020's **administrative expenditure implemented to date** suggests that the programme overall performs well against these benchmarks: excluding the JRC and EIT[391], the total administrative expenditure implemented reached **3.90%**[392] (EUR 2 783.3 million) of the budget in current prices.[393] The percentage stayed approximately constant between 2014 to 2020, reaching **3.37%** in its last year, well under the 2020 target.

Second, several time targets were set for specific administrative processes[394], in particular the **time-to-grant (TTG) target**.[395] Except for ERC calls[396], **each grant agreement had to be signed 8 months (245 days) after the deadline for submission of proposals**. On average and overall, Horizon 2020 was expected[397] to reduce the average 'time to grant' by 100 calendar days relative to FP7. The European Commission and the Executive Agencies were able to process Horizon 2020 proposals and grant agreements faster, without a corresponding increase in the human resources involved: **Achieved time-to-grant** periods[398] show that Horizon 2020 clearly outperformed FP7, even relative to its more stringent target. **Under Horizon 2020, 90% of grants were signed on time, compared to 41% under FP7. The average time-to-grant period was 187 days. This means that 126 days were saved per grant on average compared to FP7**, which had an average TTG value of 313 days. FP7 calls on average had missed the 270 day-target at the time by 43 days. Given Horizon 2020's total of 27 576 grants signed (excluding ERC grants), this means in aggregate **over 9 500 years** of working time in the EU public sector

[390] Art.4.3, Council Decision of 3/12/2013 (2013/743/EU) establishing the specific programme implementing Horizon 2020 (O.J. L347/965 on 20.12.2013. "No more than 5 % of the amounts referred to in Article 6(2) of Regulation (EU) No 1291/2013 for Parts I to V of the specific programme shall be for the Commission's administrative expenditure. The Commission shall ensure that during the programme its administrative expenditure will decrease and it will endeavour to reach a target of 4,6 % or less in 2020."

[391] In the case of non-nuclear direct research actions of the JRC, the administrative expenditure (EUR 1636.8 million) is not directly comparable, as it includes the cost of staff and scientific infrastructure to carry out research. EIT's administrative expenditure amounts to EUR 8.5 million. Figures as of 01/01/2023.

[392] Based on committed budget; Admin. Expenditure 2014-2020, point 5.1 of Statement of Estimates of the EC for financial year 2020. Figures account for 2020 annual budgetary procedure, amendments, and transfers.

[393] FP7 does not lend itself as a point of comparison, as a comparable assessment of the ratio was not reported.

[394] Regulation 2021/695, Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013. Art 31.

[395] Annex 4.4 provides further detail on TTG performance, as well as related time cost targets.

[396] ERC: TTG may exceed the target if justified (e.g. complex actions, many proposals, and request by applicants).

[397] COM/2011/0808 final; The Framework Programme for Research and Innovation.

[398] Monitoring data on FP7 and Horizon 2020 (as of 1 January 2023).

were saved, relative to the time it would have taken if FP7's average TTG performance had continued. The performance was, however, not uniform throughout, with some **programme parts experiencing delays**. This applies in particular to the initial period of the **EIC pilot**, when companies faced delays of up to 12 months and considerable uncertainty.[399] The introduction of an **electronic grant management** workflow and the **withdrawal of the negotiation stage** were identified[400] as key factors behind the sizable reduction, with beneficiaries broadly welcoming the withdrawal of the negotiation stage.

What messages emerged from the public stakeholder consultation?

A majority of respondents agreed, or strongly agreed, that it took 'adequate time' to **evaluate the proposals** (66%; 1175) and to **sign the grant agreement** (69%; 1230). The feedback provided on the **evaluation was seen as 'clear and informative**' by half of the respondents (769), however nearly a quarter (24%; 426) of respondents disagreed or strongly disagreed with this assessment. For both aspects, no significant difference was identified between different stakeholder groups – the averages presented above provide a balanced view.

4.2.2.2. Simpler funding rules and revised control and risk strategy

As a second strand of simplification measures, Horizon 2020 changed funding rules and its approach to controls and risks.

The **rules on reimbursement of costs and time-recording** were amended, to better account for beneficiaries' established practices, including those of SMEs. The measures thus responded to previous evidence[401] that rules on cost reimbursements were complex and a persistent source of unintentional financial errors. While overall Horizon 2020 funding rules became simpler than under FP7, specific aspects of the methodology for calculating personnel costs did not and even increased in complexity.[402]

What messages emerged from the stakeholder consultation on funding rules?

A large majority of respondents 'agreed' or 'strongly agreed' that their 'organisation's **usual accounting practices** were accepted' (69%; 1 227). The agreement among respondents from NGOs and companies was even higher, both at 74% (49; 651) respectively. EU citizens (61%; 135) and non-EU citizens (51%; 30) agreed to a lesser extent. Only a small fraction of respondents found that their usual accounting practices were not accepted, namely public authorities (2%; 2), NGOs (8%; 3), companies (7%; 23), business associations (6%; 2) and academia (8%; 77).

Beyond that, stakeholders agreed that '**the mechanisms for project monitoring and reporting were adequate**' (69%; 1 214), showing the highest level of agreement among companies (74%; 226), followed by respondents from academia (70%; 634), business associations (68%; 21), EU citizens (66%; 143), non-EU citizens (60%; 35) and NGOs (58%; 38) . At the same time, another fraction of respondents from academia were of the opinion that the monitoring and reporting mechanisms were not adequate (10%; 93), followed by NGO-associated respondents (17%; 11), respondents on behalf of companies (9%; 28) and business associations (3%; 1).

Overall, respondents agreed with the statement that '**the cost calculation rules were clear**' (66%; 1 177). Nevertheless, there was some variation between the different stakeholder groups: business associations agreed to the greatest extent (74%; 23), followed by companies (72%; 224), academia (68%; 620), NGOs (62%; 41) , EU citizens (61%; 120), public authorities (57%; 52) and non-EU citizens (54%; 37) respectively. At the same time, the level of dissatisfaction with the clarity of cost calculation rules varies to a smaller extent among the different types of stakeholders, ranging from 9% of companies (27), up to 13% for academia (118), public authorities (12) and business associations (4) respectively.

More than half of respondents were **'satisfied with the support received by the EC services (including agencies) during grant preparation and implementation**' (58%; 1 022): business associations are beyond the average of all respondents satisfied with the support received by the EC services (67%; 21), along with companies (64%; 199). At the same time, respondents from academia (57%; 524) and NGOs (48%; 32) were less satisfied. Interestingly, the level of satisfaction between EU citizens and non-EU citizens differs: **non-EU citizens** (64%; 27) **are less satisfied[403] with the support received by the EC services, compared to EU citizens** (55%; 122).

[399] EIC pilot evaluation (2022), op. cit. Please refer to Annex 4.4 for more detail.
[400] Court of Auditors. Special Report. N.28. Evidence from survey and interviews, primarily from beneficiaries.
[401] *Ex Post* Evaluation of the 7th EU framework programme (2007-2013), Commitment and Coherence
[402] As pointed out by ECA Annual Report on the implementation of the budget for years 2018 (5.16) and 2020 (4.13)
[403] By 9 percentage points.

The revised approach of the '**control and risk strategy**' was designed to optimise the balance between the beneficiaries' enforcement costs from controls and auditing[404] and the benefits of audits, which reduce the risk of misallocation of public resources. The new approach[405] **shifted the focus from a minimisation of financial error rates under FP7** associated with high costs of controls, **to one that a priori trusted beneficiaries, combined with lighter auditing *ex post***.

The evaluation assesses the new approach using two observable outcomes: the number of beneficiaries with control burden from audit (as a proxy for their enforcement costs) and the error rate performance of Horizon 2020.

The trust-based approach achieved the **intended direct positive effect of lowering the control burden (enforcement cost) on beneficiaries**. The actual share of unique beneficiaries (PICs) affected by an audit to date, fell from 11.76% under FP7 to 6.02% under Horizon 2020[406], staying well under the targeted 7% maximum[407] (lowered from 20% under FP7) and **generating savings for approximately 2 500 unique beneficiaries** which would have been audited otherwise.

To gauge the extend of the new control and risk strategy's potential unintended negative effect on financial errors, the assessment looked at the performance of Horizon 2020 with respect to two error rates. The **Representative Error rate** (RepER) is an error metric that relates the money lost due to errors (amount at risk) to the programme expenditure, using audits completed during several years.[408] The **Residual Error rate** is a comparable rate that, in addition, accounts for corrective activities by the administration.

This shift of focus[409], away from a minimisation of error rates, took place in a context of traditionally high error rates in R&I funding. FP7's error rates had consistently exceeded a 2% target[410] with a cumulative multi-annual Representative Error Rate of 4.95%.[411] The FP7 ex post evaluation considered the elevated error rate a significant shortcoming in its implementation and attributed it in parts to the lack of consistency between programme parts and the programme's overall complexity.[412]

Despite this context, the expectations for **Horizon 2020**'s error rate had been further relaxed. This change was the outcome of negotiations accounting for the "trust-based approach". While the approach allows for fewer audits and controls to reduce beneficiaries' burden it also increases the risk of financial errors. A new **target range of 2% to 5%** was therefore set for the programme period of Horizon 2020.[413] According to the Common Audit Service, the **achieved cumulative Residual Error rate of Horizon 2020 up to now is 1.67%**, **with a cumulative RepER of 2.71%**.[414] This means **Horizon 2020's error rates stay within the targeted range and are also an improvement relative to FP7.** Although an attribution can only be reasoned, this reduction in spite of the shift away from control and audit, is plausibly a positive effect of the simplification of funding rules.

[404] Regulation No. 1291/2013 Framework Programme for Research and Innovation, Preamble 44.
[405] *Ex post* Audit Strategy Horizon 2020 for 2016-2025; COM(2011) 808 final.
[406] Figures provided by Common Audit Service; Horizon 2020 figure 2 years after closing of programme.
[407] Common Audit Service, KPI 14 (total percentage of H2020 unique beneficiaries (PIC) audited, target 7%)
[408] Horizon 2020 *Ex post* Audit Strategy (February 2016)
[409] Regulation No 1291/2013, Framework Programme for Research and Innovation, Preamble 44.
[410] Declaration d'assurance methodology DAS (1994), European Court of Auditors.
[411] European Court of Auditors Annual reports concerning the financial year 2017, section 5.2.4; Residual error rates, reported at the level of the involved DG, varied between 2.79 % and 3.55 %.
[412] *Ex post* evaluation of the seventh framework programme (2016), Section 7.1 Lessons Learned. The FP7 evaluation did not assess the value for FP7's error rate.
[413] Legislative Financial Statement in 2011 Commission proposal for the Regulation on Horizon 2020 (COM/ 2011/809) of 30 November 2011, p. 98-102; COM(2011) 808 final;.2.2 Management and control system. P. 99.
[414] Both cumulative error rates for Research and Innovation, DG RTD Annual Activity Report 2022; The Common Audit Service reports the (multi-annual) error rates at programme level only, without any further breakdowns.

Despite this positive development, the evaluation does not draw an overall positive conclusion on Horizon 2020's error rate performance. Between 2018 and 2021, each **European Court of Auditors** annual report concluded that the **level of error remains high** for research and innovation expenditure.[415] The ECA reports annual average error rates of R&I support of 3.97% for 2018, 6.64% for 2019, and 5.29% for 2020.[416]

The ECA also found that Operational Expenditure on R&I support (of FP7 and Horizon 2020 together) continued to be 'an area of above-average risk and errors', and that the detected **financial errors were of a repeated and avoidable nature**.[417] Errors mainly concerned the erroneous reimbursement of ineligible costs declared by beneficiaries, particularly costs relating to human resources (personnel costs), incorrectly declared subcontracting costs, and costs that had not actually been incurred.

The simplification measures introduced by the new 'control and risk strategy' were successful in that they achieved the expected fall in beneficiaries' control burden (enforcement cost). Although the measures reduced financial controls and audits, Horizon 2020's cumulative error rate did not rise but could even be lowered - presumably an effect of Horizon 2020's simplified funding rules. The persistence of frequent financial errors, however, remains an ongoing challenge for the framework programme and underlines the complexity involved in trade-offs between simplification of financial controls and auditing, and the risk of misallocation of public resources.

To keep the advantages of the "trust-based approach" but, at the same time, tackle avoidable financial errors, the use of lump sum funding was piloted in the last years of Horizon 2020. Its simplification potential is discussed below.

4.2.3 Potential areas for further simplification

Lump sum funding

Lump sum funding means that beneficiaries are paid out a lump sum for each delivered work package, which are fixed in the grant agreement. It is expected to substantially reduce the reporting costs of beneficiaries, by essentially removing all financial reporting requirements, and to shift the focus of project monitoring away from financial checks to project performance and content. It also has simplifying effect on some grant management processes and is ultimately expected to bring down the elevated rates of financial errors.

A comprehensive **pilot of lump sum funding for R&I projects** was carried out between 2018 and 2020 under Horizon 2020. It included 16 topics, over 1 500 proposals and covered grants of all main types, different sizes and levels of complexity. EUR 454 million were allocated to 525 lump sum grants.

In 2021, the findings of the pilot's ex post assessment[418] suggested that lump sum funding was a possible means of further simplification and generally fit for all types of organisation and types of grants. It found qualitative evidence on lower administrative costs of beneficiaries at reporting stage and no evidence for a rise in application costs. Initial concerns, participants could artificially increase the number of work packages to trigger more frequent payments in the interest of cash flow, and in this way counteract the achievable reporting cost savings, were not substantiated by evidence.[419] The *ex post* analysis found that a majority of beneficiaries welcomed

[415] European Court of Auditors Annual reports concerning the financial years 2018, 2019, 2020 and 2021.
[416] European Court of Auditors, Statistics audited transactions R&I (SoA2020 Vs SoA2019).
[417] European Court of Auditors, Annual Report 2020, Chapter 4, MFF 1a.; The ECA concluded the that 'the level of errors in spending on Competitiveness for growth and jobs' MFF1a (covering Horizon 2020) was 'material'.
[418] Assessment of the Lump Sum Pilot 2018-2020: Analysis of qualitative and quantitative feedback (2021).
[419] Commission guidance for applicants and beneficiaries of lump sums addresses the concern and makes clear that splitting work packages should not lead to the subdivision of the project into many small work packages. The added work packages would have introduced avoidable reports (associated with reporting costs) as an unintended negative side effect. The number of work packages of submitted projects did not confirm such a pattern.

lump sums and considered the tool effective in reducing their administrative work. The stakeholder feedback was collected from a comprehensive set of affected groups (applicants, beneficiaries, evaluation experts, EU Commission staff and National Contact Points). As with any larger simplification measure, there are clear indications of the presence of adjustment costs in stakeholder feedback (e.g. applicants, beneficiaries and evaluators adapt and require information, training and guidance).

The analysis had some limitations: While the pilot's design, and therefore its transferability, and the collected qualitative information were overall good, it did not allow for a quantitative assessment of the overall net effect of costs associated with the introduction of lump sums. The pilot did not collect any quantitative evidence on changes in costs of applicants and evaluators. As lump sum grants are not subject to financial audits their wider use will change the composition of audited grants and so affect indicators linked to financial audits. Due to its size, the pilot did not allow for an analysis of the overall effects of lump sum funding on the programme's error rates or the total costs from auditing (to beneficiaries and EU public sector). Finally, the one-off nature of the pilot did not lend itself to observe any potential for strategic behaviour of applicants and beneficiaries over the medium term.

What messages emerged from the stakeholder consultation on funding rules?

Across all stakeholder groups, the support for the lump sum pilot is held the most with respondents associated with public authorities (38%; 35), which is followed by respondents from companies (36%; 110), EU citizens as well as non-EU citizens alike (36% respectively; 78, 25) As expected, respondents from companies favour the introduction of the lump sum pilot to a greater extent compared to respondents from academia (33%; 299) however not significantly (only 3 percentage points). Similarly, 16% of respondents from academia (144) are negative about the introduction of the lump sum pilot, compared to 13% of respondents from companies (37) once again showing a difference of 3 percentage points.

A 2022 study by the European Parliament Research Service[420] equally found that beneficiaries overall preferred the use of lump sums, however, not necessarily in all programme parts (32% of respondents expressed a general preference, whereas 57% preferred it for some funding schemes and 7% preferred the traditional funding system). The study highlighted a few practical challenges relevant for the tool's design. Beneficiaries raised concerns about an increase of their own financial risk. As of September 2023, it is too early to draw a robust conclusion, however, current data does not confirm a change in risk, with more than 99% of requests for payments under the lump sum funding having been paid out in full to beneficiaries so far.

The scale of the simplification potential from extending the use of lump sums in the future will depend on details of implementation. Administrative cost reductions (due to the removal of all financial reporting requirements) are expected to benefit beneficiaries. Risks exist around additional (transitional) costs, including to applicants (who submit an additional budget table with lump sums), evaluators (who assess proposed lump sums), and to a lesser extent for administrators (who adjust to a change of focus away from financial reporting towards content). Lump sum funding can also be expected to have an effect on the approach to financial auditing, as lump sum projects cannot be covered by the established audit practice. The overall net effect on costs and benefits will strongly depend on the extent to which risks can be mitigated through details of implementation. Monitoring and further evidence-based adjustments to an evolving practice over time will be required to ensure and maximise a net savings effect. This means it will be necessary to continue to collect and assess (quantitative) evidence and feedback from current applicants, beneficiaries, evaluators, and administrators involved in lump sum funded grants under Horizon 2020 and Horizon Europe.

[420] A reimbursement system based on a fixed lump sum, European Parliamentary Research Service (2022).

Seal of Excellence

The low success rates in some parts of Horizon 2020 bring with them that the efficiency of the framework programme is sensitive to any changes that influence the costs of applicants, as most of this cost is a net loss to EU society. While administrative details of the proposal preparation and submission process will always remain a valid area for simplification efforts, many key drivers of the cost of application, such as developing a high-quality idea or setting up a consortium, cannot be reduced. In this context, any effective measure with a potential to lessen the loss of effort invested in unfunded proposals has potential to increase the programme's efficiency.

One such measure is the **Seal of Excellence** (**SoE**), a quality label awarded under Horizon 2020, which attempts to capture the value embodied in successful yet unfunded proposals from mono-beneficiaries with the aim to facilitate their resubmission to alternative funding programmes. Its value also extends to the proposal evaluation carried out under Horizon 2020. Other funding bodies can reduce their future evaluation costs, by partially avoiding the reassessment of the content of the proposals. Of the 97 403 high quality proposals not retained for funding, 20 890 received a Seal of Excellence certificate under Horizon 2020, where it was available for the SME Instrument (later called the EIC Accelerator), for MSCA, for Teaming actions and for the ERC Proof of Concept. The SoE has shown some first signs of promise in encouraging alternative funding. As managing authorities were not obliged to report on the funding of SoE proposals, complete figures are not available. However, data from three countries known to have funded SoE SME Instrument proposals under ESIFs, show that an average of 26% were successful in subsequently securing funding.[421] Member States' lack of access to information on awarded Seals of Excellence was flagged as a hindering factor[422]. Further, Czechia, Cyprus and Lithuania have designed support from ESI funds for SoE holders from MSCA Individual Fellowships.

The current SoE is restricted to mono-beneficiary actions. Other limiting factors are the voluntary nature of recognising the seal in regional and national funding programmes, the information flow, and the still to be strengthened 'Seal of Excellence community of practice'. Addressing these constraints would strengthen the measure's potential to increase the programme's efficiency. An *ex post* evaluation does not provide the necessary evidence for a quantification of the simplification potential of an adjusted Seal of Excellence, which will be a task for the impact assessment of the next framework programme.

Two-stage application process

The evaluation of **proposals** in two separate stages is a recurrent measure discussed in the context of further potential for simplification: after an initial evaluation of a shorter proposal only a subset of applicants is asked to prepare a full proposal, which is why the process **has the potential to reduce the costs of applicants**, **specifically that of the many unsuccessful applications**. Two-stage evaluations also change the costs of evaluating proposals that fall on the EU public sector. A smaller number of proposals is evaluated in detail (by experts), but a larger number of proposals has to be handled overall and over a longer period of time. The net effect can be positive or negative, as the cost is driven by the number of applications submitted in the first phase and the number remaining in the second phase.

The European Court of Auditors[423] pointed critically at the fact that, as of 2018, only a fraction of Horizon 2020 calls made use of two-stage evaluations. A wider introduction had a **potential**

[421] ECA Special Report 23/2022, p. 30, Table 2, PL 26% (20 proposals), PT 32% (35), SI 28% (15), from sample of 5 Member States selected on basis of R&I performance, availability of ESIF for R&I, and H2020 participation.
[422] Portugal proactively set up a system for obtaining information about national SoE grantees, which allowed it to target existing national calls for proposals and thus attract 108 SoE applicants, of which 32% secured ESI funding.
[423] Court of Auditors. Special Report. N.28 (2018), Conclusions, p. 48.

to reduce the application costs for many unsuccessful applicants. A survey of beneficiaries[424]suggests that most respondents, across all **stakeholder groups, generally supported two-stage evaluations**, with the relatively lowest support coming from large private companies.

What messages emerged from the stakeholder consultation on funding rules?

Among the simplification measures sought feedback on in the public consultation, the notion of extending the use of the two-stage application process has received the highest number of negative responses, although positive responses (42%; 711) still outnumber the negative ones (15%; 255). The majority of respondents agrees with the idea of further expanding the two-stage application process for some programme parts, notably respondents from academia (56%; 433), non-EU citizens 52% (27), public authorities (49%; 36), business associations (48%; 11) and EU citizens (48%; 87) were in favour.

From the perspective of the applicants, it is essential that any further roll-out of two-stage evaluations takes the procedure's limitations into account. The process lasts approximately **3 months longer**.[425] This introduces a potentially critical delay, which risks reducing the positive impacts of R&I funding, for instance, in a competition for first-mover advantage. At the same time, key factors that influence the application cost cannot be reduced through a two-stage process. Applicants still must set up a consortium, develop a detailed idea, and prepare for a potential second stage. The study on the proposal evaluation system[426] found that the two-stage application processes may overall even increase the burden. It pointed out that, considering costs and downsides for applicants, **around 75–80% of the applications would have to be rejected at the first stage for the overall net effect to effectively lead to simplification.** Particularly the costs associated with the first stage had the potential to increase, rather than reduce the overall applicant burden. The study, however, also acknowledges that two-stage evaluations may still be appropriate in some cases.

In summary, there may still be further potential for simplification in a wider application of two-stage evaluations in areas of the framework programme, where the success of a project (i.e. the potential benefit) is **not strongly affected by a 3-month delay of the project start date and proposals typically have a success rate of under 20%, and the absolute number of unsuccessful applicants is high**. In such cases, the total net effect on applicants' costs will more likely be positive. As two-stage evaluations also substantially change the costs of evaluating proposals that fall on the EU public sector, a careful ex-ante assessment will be necessary on a case-by-case basis to ensure that the overall net effect on the costs of the framework programme is negative or that an informed decision on trade-offs can be taken.

4.3 Coherence

4.3.1. Internal coherence

The interim evaluation of Horizon 2020 judged the **number of instruments excessive**, making 'the landscape for EU R&I support difficult to navigate and [potentially leading] to less coherent interventions'. This issue continued to be a concern right up to the end of Horizon 2020. Several interviewees highlighted this issue – either from their perspective regarding the programme parts or from the beneficiary perspective – adding that it necessitates highly professional support structures to assist the applicants.

However, **different approaches to grants** (mono-beneficiary and collaborative, more research-oriented vs more innovation-oriented) interacted in a complementary way.[427]

[424] Court of Auditors. Special Report. N.28 (2018), p. 35.
[425] Commission estimation, Horizon 2020 SWD(2017) 220 final – "In-depth interim evaluation of Horizon 2020".
[426] Study on the Proposal Evaluation System for the EU R&I framework programme (2022), op. cit.
[427] Study on the Relevance and Internal Coherence of Horizon 2020 and Its Policy Mix (2023), op. cit. The examples from different pillars include: the complementarity of ERC and MSCA (and FET) in pillar 1 (p. 56),

Under Pillar 1, MSCA and ERC form the most coherent set of actions. As reported in the interim evaluation, 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.[428]

Findings from the interviews also support the overall internal coherence of the Horizon 2020 policy mix (in Pillar 2). The fact that SME Instruments (and EIC) are primarily mono-beneficiary instruments – compared to the emphasis on collaborative projects in other Horizon 2020 parts – was highlighted, along with the introduction of equity financing as part of the EIC Accelerator. The importance of non-financial support (most notably INNOSUP actions and EEN) in accompanying financial instruments was also highlighted in the interviews.

Pillar 2, together with many other parts of Horizon 2020 (except for Pillar 1), are focused on research and innovation at higher Technology Readiness Levels. In LEIT, research and innovation activities (RIA) account for EUR 5.4 billion (45%) and innovation activities (IA) for EUR 4.2 billion (35%). Thus, when looking at the pillar as whole, funding has focused more on research-focused projects than on innovation-focused ones. There are, however, differences in emphasis between different thematic areas. Emphasis on science-driven activities is the most evident in the case of biotechnology: RIA accounts for EUR 238 million and IA 46 million. Space follows biotechnology with EUR 485 million invested in RIA and EUR 226 million in IA. Only in advance manufacturing and processing investments in innovation outweigh the investments in research activities (RIA: EUR 632 million, IA: EUR 1.1 billion).

New types of action were introduced in Horizon 2020 to realise a broader innovation and impact orientation:

- The SME instrument was – in terms of numbers of projects granted and allocated budget – the most important new type of action. The mono-beneficiary SME Instrument showed good complementarities with other types of action and contributed to realising the turn towards more innovation orientation. Because of this, some stakeholders consulted for the evaluation study on the relevance and internal coherence of Horizon 2020 criticised its termination in favour of the newly set up EIC pilot.[429]
- The EIC Pilot was the only instrument designed to cover almost the entire TRL spectrum, pursuing a portfolio approach that is set to follow the most promising projects through their technology asset development from the very early stage. It supported the commercialisation of game-changing innovations across all sectors and technology domains - offering blended finance for innovative, high risk and not yet bankable entrepreneurial projects. Therefore, the EIC Pilot had a unique target and configuration,[430] enabling it to respond to needs not

complementarity within pillar 2, in particular of SME instrument and EIC with collaborative projects – IA, RIA (p. 57), complementary additions to the policy mix in pillar 2 with equity financing and capacity building support provided by INNOSUP and EEN (p. 57), research and innovation orientation in pillar 2, the policy mix of the societal challenges programme as an example for complementarity in the societal challenges pillar (p. 58). In addition, the examples for the whole Horizon 2020 include complementarities between pillars 1 and 2 (p. 56), the lack of opportunities for collaborative fundamental research (pp. 56-57), the importance of having bottom-up funding (ERC) in the policy-mix oriented towards policy objectives, top-down (p. 34).

[428] SWD on the interim evaluation of Horizon 2020, SWD(2017) 220 final, pp. 151-152, https://op.europa.eu/s/yXiZ.

[429] Study on the Relevance and Internal Coherence of Horizon 2020 and Its Policy Mix, op. cit., p. 57.

[430] EIC Pilot evaluation study (2022, p. 60) found that its uniqueness in the EU R&I policy mix lies in four features. 1) It is the only instrument designed to cover almost the entire TRL spectrum, with a view to converting breakthrough innovations from universities and research centres into commercially exploitable innovations, leading to the scale-up of innovative SMEs. 2) It pursues a portfolio approach that involves following the most promising projects through technology asset development from a very early stage. This aspect was not properly tested in the pilot phase, which lacked a proper instrument to connect the two programme parts. This missing linkage was remedied by the launching of transition calls and the recruitment of programme managers in 2020. 3) It supports the

addressed by other programme parts.[431] The 2022 evaluation of Pilot found that it complemented other parts of Horizon 2020, most notably the 'Innovation in SMEs' (consisting of the SMEI and INNOSUP actions until 2018). Introduction of the EIC pilot helped to create a better distinction between support for actors implementing the innovation – and INNOSUP Actions that strengthen the dynamism and the resilience of the ecosystem in which these actors operate. Nevertheless, one area where the evaluation found weaker performance were synergies with the European Institute of Innovation and Technology, which were "not clearly defined and tested in the Pilot phase".[432]

- Innovation actions were introduced for Horizon 2020. Innovation actions mainly target activities directly aiming at producing plans and arrangements or designs for new, altered, or improved products, processes or services. For this purpose, IAs can include prototyping, testing, demonstrating, piloting, large-scale product validation and market replication. For Pillar 2 these actions focusing on higher TRL levels were highly important, and 87% of all IA projects were funded by Pillar 2.

In terms of programme design, the promotion of selected topics referred to as **cross-cutting issues**[433] (such as international cooperation or widening participation in the programme), without dedicated budgets or instruments, created challenges for implementation. Some issues lacked agents of change, intellectual ownership and/or indicators for tracking progress. In addition, assessing some cross-cutting themes can be problematic because of issues related to data availability and measurability.[434]

The main objective of the **focus areas** (listed in the glossary), bringing together efforts from different Societal Challenges, was to stimulate the development of knowledge and technologies deemed crucial for tackling specific cross-cutting challenges. They increased internal awareness of what was happening in other Commission departments, and focused attention on finding ways to increase the impact of R&I investment[435]. However, coordination issues emerged because focus areas were created on top of other existing initiatives[436] and because there was no clear dissemination and communication plan.[437]

High staff turnover in the Commission had a detrimental effect on the internal coherence of the programme, as staff did not sufficiently accumulate knowledge.[438] Large organisations face challenges in establishing longer-term learning processes internally to an organisation, and the European Commission is not an exception in this regard. Contract Agents[439], which represent a particularly high share in DG RTD compared to other DGs, who coordinate and implement programme activities, have a maximum total contract of six years. Qualified and trained people

commercialisation of game-changing innovations across all sectors and technology domains. 4) Blended finance is available for innovative, high risk and not yet bankable entrepreneurial projects.

[431] Ibid, p. 71.

[432] European Commission, DG for Research and Innovation, Evaluation study on the European Innovation Council (EIC) pilot: final report, Publications Office, 2022, p. 61, https://data.europa.eu/doi/10.2777/261324.

[433] Cross-cutting issues are listed in the glossary. More details are available in the study on the implementation of cross-cutting issues in Horizon 2020 (2023), op. cit.

[434] Cross-cutting issues evaluation study (2023), op. cit., pp. 52-53. When project officers misinterpret guidance on flagging topics, this can also distort figures on how a cross-cutting issue is implemented.

[435] European Commission, DG for Research and Innovation, Bening, J., Bergmans, J., Bieszczad, S., et al., Opportunities and challenges in targeted funding of Research and Innovation: lessons learned from the Horizon 2020: focus areas and implications for Horizon Europe missions, Publications Office of the European Union, 2021, p. 18, https://data.europa.eu/doi/10.2777/59160.

[436] Ibid, p. 20.

[437] Ibid, p. 22.

[438] In DG RTD, 27% of the people in In the Commission's DG for Research and Innovation (DG RTD) are contract staff (source: DG HR and Security, Statistical Bulletin, "Staff by DG, by Location", January 2023, p. 1). The study on Relevance and Internal Coherence of Horizon 2020 (2023, op. cit.) noted that qualified and trained people are lost rather quickly both at managerial level and among those coordinating and implementing the programme.

[439] In DG RTD, 27% of the people are contract staff (Source Statistical Bulletin, October 2022), https://commission.europa.eu/about-european-commission/organisational-structure/commission-staff_en.

are lost in this way – only a fraction of them stays if they manage to pass a 'concours' or get a position in another institution. As a result, Commission Services in the research and innovation field do not sufficiently accumulate knowledge and tend to lose knowledge rather quickly, external evaluation found. Interviewees brought up also arguments in favour of horizontal mobility, in terms of avoiding silo-thinking and enabling learning and cross-fertilisation across domains. While there is no easy solution to this challenge, the various interviews indicated that the balance between continuity and mobility of staff – both at managerial and operational levels – is an issue of concern.

In response, many of the process elements of Horizon 2020 were established to mitigate this loss of knowledge due to high staff turnover:

- The strategic programming, which organised the consultation of stakeholders and experts differently as compared to former FPs and which invested in a broad EC-internal 'co-creation' process across DGs in order to arrive at an overarching strategic document. For the first time, also multi-annual programmes have been set up, which should allow for a better (and more prospective) response to new developments and challenges from the R&I side while contributing significantly to the EU's overall policy objectives. These approaches have been developed during Horizon 2020. For example, after the first WP adoption a lessons-learned catalogue was elaborated: more than 50 lessons learned were collected and fed back in the discussion and processes for the following WP.
- The role of the advisory groups changed during the implementation, giving increasing recognition to the advice of the expert groups (and hence the views of external stakeholders).
- Under Horizon Europe, staff mobility between Commission and executive agencies has been further reinforced through a new pilot staff exchange scheme. The pilot allows, for example, colleagues from executive agencies to work in a DG, or from JRC to work temporarily in DG RTD and thus share different perspectives and experience with the FP.

4.3.2. External coherence

Compared to FP7, greater emphasis was put on the synergetic use of Horizon 2020 and European Structural and Investment Funds (ESIF) funds, with the inclusion of specific references in founding regulations.[440] Within ESIF, synergies with the European Regional Development Fund (ERDF) are of particular importance as ERDF committed EUR 41 billion over 2014-2020 to activities linked with research and innovation. Against an increased focus on synergies among EU programmes their implementation on the ground varied between upstream synergies, downstream synergies, alternative and complementary funding.

As per **upstream synergies**, i.e. using EU funds (especially ERDF) to build capacities needed to compete in Horizon 2020, there is evidence[441] that ESIF was used to a sizeable degree for the specific purpose of **increasing the chances of winning a Horizon 2020 grant** (i.e. support for stakeholders in the application process) and the ERDF was used to upgrade research infrastructure used by recipients of Horizon 2020 funds for their projects. **Also, in research infrastructure**, Horizon 2020 supported strategy development and ensured open access to facilities, while the ERDF[442] funded the construction of the infrastructure and the training of personnel (typically with national funds and EIB instruments).[443] In spite of this good alignment,

[440] Article 21 of Regulation 1291/2013 and Annex 1 to Regulation 1303/2013.
[441] ECA Special report 23/2022, points 50-54.
[442] In the 2014-2020 programming period ERDF provided around EUR 16 billion for building or upgrading research and innovation infrastructures and around EUR 21 billion for R&I support services that foster the exploitation and development of technologies.
[443] Examples of synergies between Horizon 2020 and the ERDF for investment in research infrastructures include: Extreme Light Infrastructure (ELI-ERIC), where FP7 and Horizon 2020 are used for preparation, the ERDF for construction, and members' contributions for operating the facility. The European Spallation Source (ESS) in Lund

when **complementary funding** was targeted (i.e. bringing together funding from horizon 2020 and ESI funds in the same project) difficulties regularly arose with support for research infrastructure due to various legal issues such as the non-eligibility of European Research Infrastructure consortia (ERICs) in national calls or insufficient funding at national level.

However, **downstream synergies**, i.e. using other European programmes to fund actions that capitalise on Horizon 2020 projects, to exploit and diffuse their R&I results were found rarer and unsystematic. Measures to create synergies allowing the ERDF to deploy results of Horizon 2020 projects were hardly implemented,[444] due to technical[445] and administrative barriers[446], and also due to the lack of sufficient information on Horizon 2020 projects results.[447] While processes exist for involving the Commission Directorates-General responsible for ESIF and Horizon 2020 and national and regional players responsible for designing and implementing the two programmes (e.g. the 'Seal of Excellence community of practice'), the European Court of Auditors indicated that these were positive but not regular.[448] Little systematic cooperation happened between managing authorities responsible for the implementation of ESIF funds and the Horizon 2020 National Contact Points (NCPs). The ESIF managing authorities and the Horizon 2020 NCPs focused on the programmes in which they have responsibility, without having the opportunity to prioritise synergies between the two programmes. The absence of a map of projects hampered synergies between the two programmes. Open databases on funded projects were implemented only towards the end of the programming period for both programmes (the dashboard providing information on Horizon 2020 was launched in 2018, Kohesio in 2022).

The **EIT** has been evaluated as having a strong alignment with ESIF, due to its funding model[449] in which 75% of the overall budget of the Knowledge and Innovation Communities (KICs) have to come from either partners or other private or public funding sources.

What messages emerged from the stakeholder consultation?

The question on synergies between Horizon 2020 and other EU programmes received the highest number of 'do not know/no opinion' responses (ranging from 48% (831) of all responses on synergies with ESIF to 28% (484) on synergies with Erasmus +). **Only a minority of respondents believe that synergies between Horizon 2020 and other programmes are fully or partially exploited**: 30% (519) for synergies with Erasmus+, 21% (362) with LIFE, 12% (206) with the Connecting Europe facility, 14.5% (251) with European Structural and Investment Funds, 10% (173) with the common agricultural policy, and 9% (155) with EFSI.

As the Erasmus+ programme as well as LIFE stand out positively across all respondents, further analysis revealed that non-EU citizens (48%; 27) and respondents from the field of academia indicated that synergies with Erasmus+ were either fully or partly exploited (36%; 326), whereas the figure is lower among EU citizens (32%; 67), companies (21%; 65) and business associations (16%; 5). This leads to the assumption that the field of academia leaves greater room for synergies. This should not come as a surprise considering that the two programmes in view of academia have a strong link. In view of LIFE, a similar trend can be seen: 22% of non-EU citizens (12), 21% of EU citizens (43) as well as 21% of respondents associated with academia (191), 18% of respondents associated with a company or business (56) and 13% of respondents associated with business associations (4) indicate that synergies were either fully or partly exploited. At the same time, 20% of respondents

has received funding from 13 Horizon 2020 projects and uses that in complementarity with the ERDF and grants from a broad range of other regional, national and international programs, External Coherence study, op. cit., p. 40.

[444] Court of Auditors, Special Report No. 23. 'Synergies between Horizon 2020 and European Structural and Investment', 2022, p. 4.

[445] Technical and administrative barriers hampered the blending of different sources of funding in the scope of individual projects, such as the need for two separate Grant Agreements, non-existent or unspecified co-funding rules and mismatches in funding cycles and times to grant. Court of Auditors, Special Report No 23. 'Synergies between Horizon 2020 and European Structural and Investment', 2022, pp. 12-13.

[446] External Coherence study, op. cit., pp. 26 and 28.

[447] External Coherence study, op. cit., p. 29. Court of Auditors, Special Report No. 23. 'Synergies between Horizon 2020 and European Structural and Investment', 2022, p. 27.

[448] ECA Special Report 23/2022, pp. 20-24.

[449] The EIT funding model was amended in Horizon Europe: the concept of "KIC complementary activities" has been abandoned.

from academia (178), 22% of respondents from business associations (7) and 13% of respondents associated with a company or business (41) indicated that either few or no synergies were exploited.

Respondents to the stakeholder consultation for the *ex post* evaluation of the ERDF, closed in April 2023, had a more positive perception of synergies with Horizon 2020: **58% believe the ERDF and Horizon 2020 are mutually reinforcing** and 5% believe they duplicate each other, 37% have no opinion. A targeted stakeholder consultation by the European Economic and Social Committee indicated that while most respondents see value in seeking synergies between the ERDF and R&I funding, about half believe these are not fully exploited[450]. In particular, most interviewees believe that National Contact Points (NCPs) could do more to promote synergies between the two programmes.[451]

The potential to roll out research and innovation funded by Horizon 2020 **in other EU programmes**, such as LIFE, the European Fund for Strategic Investments, Connecting Europe Facility, is well acknowledged in the respective regulations[452] but only seldom materialised.

The Connecting Europe Facility (CEF) was complementary to the financial instruments of Horizon 2020: it focused on cross-border transnational projects in the transport, energy and telecom sectors, while the financial instruments under Horizon 2020 do not have transnational requirements and support first-of-a kind projects. By design, complementarities were expected between LEIT-ICT and CEF, as the latter starts when the former stops, but data mining produced no evidence of LEIT-ICT projects translated into CEF projects.

The **LIFE programme** was designed to mildly incentivise exploitation of Horizon 2020 projects by giving two extra points (out of 100) during evaluation to proposals that make use of results of other EU-funded projects, including Horizon 2020. This encouraged projects to move towards implementation by means of demonstration, piloting, and creating conditions for potential upscaling. Almost 40% of LIFE-financed projects received bonus points for demonstrating the uptake of environmental and climate-related research and innovation projects financed by Horizon 2020 (or by previous framework programmes) and the added value of this uptake for the project.[453]

In education, Horizon 2020 complemented **Erasmus+** well. Erasmus+ and **MSCA** offer mobility, training and career development opportunities respectively for students, doctoral candidates and researchers. The guidance on ensuring synergies between MSCA and Erasmus+ actions in the field of higher education also provides examples of such synergies.[454]

Horizon 2020 financial instruments (InnovFin actions) are broadly consistent in design with other EU funds and financial instrument schemes supported by **EFSI**.[455] Synergies with the InnovFin instrument have been established for the construction of and major upgrades to five pan-European research infrastructures. For example, the EIB and the European Organisation for Nuclear Research (CERN) singed EU-backed loan agreements worth up to EUR 228.2 million to finance the High Luminosity Large Hadron Collider (HL-LHC) project, the world's largest and most powerful particle accelerator.[456]

[450] European Economic and Social Committee (2023), '*Ex post* evaluation of Horizon 2020', Evaluation report, INT/974, Conclusion 2.8 and Recommendation 5.6. Adopted on 23/03/2023. Available at https://www.eesc.europa.eu/en/our-work/opinions-information-reports/information-reports/ex-post-evaluation-horizon-2020

[451] Ibid. Technical Annex, paragraph 3.1.

[452] LIFE: Regulation (EU) No 1293/2013, recital 11. EFSI: Regulation (EU) 2015/1017 recital 24. CEF: Regulation (EU) No 1316/2013 recital 34.

[453] LIFE final evaluation, forthcoming, data by DG ENV.

[454] European Commission, DG for Education, Youth, Sport and Culture, Synergies between the Marie Skłodowska-Curie Actions and Erasmus+ in the area of higher education, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2766/958920.

[455] On complementarity of InnovFin and EFSI – see case study 7 in the external coherence study (2023), op. cit.

[456] External Coherence study (2023), op. cit., p. 43.

The **Seal of Excellence**[457], a prime example of **alternative funding**, has received a broadly positive assessment in the final stage of Horizon 2020 as it did in the interim evaluation.[458] It is viewed as a means of facilitating access to other sources of funding for Seal of Excellence holders and of allowing other funding bodies to benefit from the robust and internationally known evaluation system used in the EU framework programmes.[459] The recent revision of the General Block Exemption Regulation facilitated access for SMEs (holders of the Seal of Excellence label) to national research and innovation programmes, or to other funders (when Horizon 2020 recognised theirs as high-quality proposals but could not fund them), hence promoting alternative funding. More analysis is available in section 4.2.3 on potential areas for further simplification.

On **complementarities between Horizon 2020 and national programmes**, research and technological development is a shared competence of the European Union. **Synergies with national programmes** varied depending on the type of research activities supported, the Member States and the programme parts in question.

In fundamental research, the interplay between Horizon 2020 and national funding varied across thematic fields.[460] For example, health-related topics were more often covered by national programmes while topics related to the green and digital transitions are more prominent in research funded by Horizon 2020. In **applied research** (at higher TRLs), Horizon 2020 offered more opportunities than national funding[461] in the sampled Member States and thematic fields. By SMEs active in research, regional and national support schemes are perceived as more suitable for their incubation phase, while Horizon 2020 became more prominent in their expansion phase.

In Member States which offer significant national funding for basic research, like Sweden or Germany, researchers tend to apply more to national schemes; in Member States with more limited resources for basic research, such as Spain, researchers tend to apply more to Horizon 2020. This occasionally leads to funding displacement effects, e.g. the area of concentrated solar power in Spain. However, this effect is not observed in all countries with more limited funds and across all R&I thematic areas.

As yet, there is scant evidence of Horizon 2020 results being further deployed through dedicated national-level programmes. Even when there are dedicated national initiatives (e.g. through the Seal of Excellence), the stakeholders interviewed noted that it was difficult to continue Horizon 2020 projects using support from national schemes, because these tend to be shorter and have budgets deemed insufficient to bring R&I results to the market.[462]

Several Horizon 2020 instruments were designed to play a role in fostering synergies with national programmes, and in particular aligning research agendas, such as **ERANET Cofunds** (i.e. transnational call for proposal launched by national bodies in areas of mutual interest using national funds, sometimes coming from ESIF). There Horizon 2020 strengthened consistency between EU and national programmes. **MSCA** is synergetic with national schemes as it helps early-stage researchers gain relevant knowledge that can later be applied in national research projects. In addition, the fact that MSCA and ERC are well established schemes and are not thematic makes them particularly appealing for researchers who could also apply nationally,

[457] Created in 2015, the Seal of excellence is a label granted to project proposals which ranked above a predefined quality threshold in the project evaluation done as part of the Horizon 2020 application process but which were not funded due to insufficient budget. The label was intended to facilitate alternative funding from ESI funds, as it testifies of a recent positive evaluation by Horizon 2020. However, no obligation to recognise the Seal of Excellence was included in the ESIF Regulation, leaving its application voluntary.
[458] SWD (2017) 221, p. 44.
[459] External Coherence study (2023), op. cit., p. 67.
[460] According to data mining results in the External Coherence study (2023), op. cit.
[461] According to data-mining results in the External Coherence study (2023), op. cit., case study on health-related research in Sweden, Germany, Spain and Poland.
[462] External Coherence study (2023), op. cit., p. 31.

albeit for national, country-centred mobility schemes, which are often relatively small in scope and with national competition. The **MSCA COFUND** is an example of an attempt to create the right conditions for synergies between regional, national and international mobility programmes at both PhD and post-doctoral levels. MSCA COFUND is considered to have enabled many synergies with ESIF and Erasmus+. Participation in COFUND, on average, increases participation of organisations in ESIF (primarily ERDF) projects by over 100% in the 2 years after the COFUND project starts.[463]

4.4 EU added value

4.4.1. Horizon 2020 leveraged additional resources for R&I

Direct leverage

The **direct leverage** factor, which is the ratio of the direct leverage and the EU contribution[464], or in other words the average co-funding rate, of Horizon 2020 is 0.23[465]. This means each euro the EU is investing in Horizon 2020 directly attracts an additional EUR 0.23.

There was **no target** for leverage in Horizon 2020. The direct leverage factor of FP7 is EUR 0.41. However, **benchmarking** against FP7 is not appropriate, as the two programmes have different types of action with different funding rates.[466] Similarly, benchmarking against other funding programmes should be done cautiously, i.e. between same types of leverage (in this case direct leverage, and not investments after the projects), and targeting similar TRLs. Two attempts can be shared:

- Approximately one third of Horizon 2020 funding goes to fundamental science so this was the first benchmark researched. The U.S. National Science Foundation generally does not allow voluntary committed cost sharing in its proposals[467]. This means a funding rate of 100%, and hence a direct leverage factor of 0, similar to Horizon 2020 for this type of research.
- Around 17% of Horizon 2020 funding is allocated to SMEs, so this evaluation also attempted a comparison with the ERDF funding for SME competitiveness[468] (finding a leverage factor of 0.43). However, this funding is distributed to the Member States and regions, rather than directly to the SMEs. For Horizon 2020, the leverage factor of funds going to SMEs is 0.34.

Focusing on Horizon 2020, the direct leverage factor **varies across types of actions** which have different reimbursement rates depending on the type of research funded (e.g. basic research has a higher reimbursement rate than applied research) and on the beneficiary (e.g. non-profit entities have higher reimbursement rate than private for-profit entities).[469] Considering only private for-profit entities (PRCs), the leverage factor of the whole programme goes up to EUR 0.57. For

[463] External Coherence study (2023), op. cit., case study 5.
[464] Definitions and formulas in the glossary.
[465] There is no programme-wide target for the direct leverage factor.
[466] For Horizon 2020 see next footnote, for FP7 see https://ec.europa.eu/research/participants/data/ref/fp7/93289/fp7-ga-annex2_en.pdf, p. 20).
Indicatively, Collaborative Project ToA, which accounts for 53% of FP7 funding, had a funding rate of 50% (75% for non-profit). In Horizon 2020, Research and Innovation Actions and Innovation actions, which account for 29% and 16% of Horizon 2020 funding, have funding rates of 100% and 70% (100% for non-profit), respectively.
[467] https://new.nsf.gov/funding/proposal-budget/cost-sharing
[468] Data source: https://cohesiondata.ec.europa.eu/. Extraction date: 02/08/2023. ERDF funding for SME competitiveness: EUR 41,389,149,516. Total project funding for SME competitiveness: EUR 59,089,742,340.
[469] https://ec.europa.eu/research/participants/docs/h2020-funding-guide/grants/applying-for-funding/find-a-call/what-you-need-to-know_en.htm. For certain Types of Action, the funding rate can be used for comparisons, as it is related to the direct leverage factor (formula in the glossary). However, as different types of participants (e.g. for profit entities) have different funding rates, even within the same type of action, we cannot determine a priori the "expected" direct leverage factor per type of action, as this will depend on the composition of participants.

certain types of actions, like partnerships, this figure can go up to EUR 2.2 of additional investment[470] for each euro that the EU is investing.

Regarding the ability to leverage funding from their members, the Joint Undertakings displayed varying degrees of achievement concerning the contribution targets set by their respective founding regulations for Horizon 2020 activities[471] (Table 16). The total leverage factor (as of 31.12.2021) was EUR 1.43 for the JUs mentioned in Table 16, compared to EUR 1.57 (inferred from the regulation). Bio-based Industries had the highest direct leverage factor with EUR 2.47 for each euro invested, followed by Fuel Cells and Hydrogen (EUR 2.09) and Electronic Components and Systems for European Leadership (EUR 1.65).

In terms of total contributions by partners compared to the regulation targets, FCH2, Shift2Rail and Clean Sky 2 had already met or surpassed the targets. By contrast, European High-Performance Computing was far from reaching the target[472].

However, looking only at in-cash contributions, the picture is different. In most cases, in-cash contributions are only a small part of the total contributions by partners which are mostly in-kind. Electronic Components and Systems and European High-Performance Computing were the only ones with in-cash contributions above EUR 50 million (in both cases most of cash contributions came from participating states[473]).

Table 16: Total members' contribution targets for JUs, as per the founding Regulation and legal decisions, and actual contributions, as of 31 December 2021 (2014-20, in EUR million)

	Expected members' contributions, as per founding Regulation and legal decisions			Actual members' contributions, as of 31.12.2021		
JUs under Horizon 2020	EU contribution, in EUR	Total contributions by partners, in EUR	Expected direct leverage factor	EU contribution, EUR	Total contributions by partners (out of which, in cash), EUR	Actual direct leverage factor
SESAR	585	772	1.32	536	535 (24)	1
CS2 – CA	1 755	2 194	1.25	1536	2 141 (27)	1.39
lMI2 -IHI	1 638	1 638	1	838	889 (32)	1.06
FCH2 - Clean H2	665	380	0.57	546	1 140 (11)	2.09
ECSEL - KDT	1 185	2 828	2.39	1 058	1 741 (472)	1.65
BBI - CBE	835	2 730	3.27	728	1 797 (18)	2.47
S2R - EU-RAIL	398	470	1.18	339	495 (11)	1.46
EuroHPC (3)	536	908	1.69	307	138 (120)	0.45
Total	7 597	11 936	1.57	5 888	8 425 (716)	1.43

Source: ECA Report, Tables 2.4, 3.2, 4.3, 5.3, 6.2, 7.2, 8.2, 9.2, 2.1[474], authors' calculations.
Notes: Definitions provided in glossary. Total contributions include in-cash, in-kind contributions to operational activities and in-kind contributions to additional activities. The direct leverage factor is not part of the regulation per se, though it can be calculated using the first two columns. EU contributions is referred to as "EU Cash" in the

[470] This figure includes both in kind and in cash contributions, whenever data availability permits the evaluation differentiates between the two.
[471] Data reflects the situation from end 2021, thus it is likely that the situation as of end 2022 has improved. Achievement rates also depend on how ambitious the targets of the JUs have been. We relied on the European Court of Auditors Annual report on EU Joint Undertakings for the financial year 2021. There will be a dedicated report for each JU covering Horizon 2020 and Horizon Europe, in the Annex of the interim evaluation of Horizon Europe.
[472] Contributions from the EU come faster, while contributions from the partners other than the Union are likely to be delayed and therefore maybe not visible at the time. In particular, the EuroHPC JU was launched in 2018 under H2020. The first actions with budgetary commitments were only starting in 2020. In 2019, we only launched the calls for expression of interest for the EuroHPC supercomputers and started the procurements. There was only one very small call for proposals in 2019, and a bigger one in 2020. Hence, if the reference period for the calculation stops in 2021, it should not be a surprise if the totality of the budget was not allocated.
[473] ECA (2022) Annual report on EU Joint Undertakings, Tables 6.2, 9.2.
[474] ECA (2022) Annual report on EU Joint Undertakings.
https://www.eca.europa.eu/Lists/ECADocuments/JUS_2021/JUS_2021_EN.pdf

ECA Report. For EuroHPC, the EU contribution includes EUR 100 million from the CEF programme. Additional notes about S2R are provided in the Annex.

With regards to the public-to-public partnerships, for instance:

- the Partnership for Research and Innovation in the Mediterranean Area (PRIMA) had a direct leverage factor of EUR 1.43 compared to a target of EUR 1.[475]
- the Active and Assisted Living research and development programme (AAL2) had a leverage of EUR 2 (EUR 1.12 of additional national contributions and EUR 0.88 of own contributions by the beneficiaries).[476]
- the European Metrology Programme for Innovation and Research (EMPIR) had a direct leverage factor of EUR 1, as EUR 300 million is brought in by participating (member) states and EUR 300 million is from the European Commission through Article 185.[477]
- Eurostar-2 had a direct leverage factor of 3, with EUR 287 million coming from the EU and EUR 856 million from the participating countries.[478]

Looking at specific programme parts, focusing on Innovation Actions[479], it appears that Societal Challenges attract more direct leverage than other programme parts. Ranging from EUR 0.44 attracted for each euro invested by the EU for "Secure, clean and efficient energy", to EUR 0.15 for "Climate action, environment, resource efficiency and raw materials". The only Industrial Leadership part in the top five is LEIT, directly attracting EUR 0.21 for each euro invested by the EU.

Participants in non-associated Third countries leveraged EUR 1.43 billion, while received EUR 1.8 billion, or equivalently for each euro invested by the framework programme they leveraged EUR 0.79.

Additional Investments

Beyond direct leverage, or co-funding, 7% participants of Horizon 2020 can attract **additional investments after the project signature**.[480] The evaluation could track only 7% of Horizon 2020 beneficiaries in investment databases (such as Dealroom or Crunchbase), suggesting that a large majority of firms do not receive additional funding after the project signature. However, it is unclear if this is the case because data are incomplete or extracted too early.

With regards to contractual public-private partnerships (cPPP), the private sides of the cPPPs committed to invest funds in R&I activities specific to the partnership domain. A leverage factor of additional investment[481] for industrial deployment in the range of 5 to 10 was often established between the partners, e.g.:

- leverage factor of EUR 6.3-10 (8.5 on average) for the SPIRE cPPP – compared to a target of EUR 5-10;
- EUR 7.8 for the Big Data cPPP – compared to a target of 4;

[475] Interim Evaluation of the Partnership for Research and Innovation in the Mediterranean Area (PRIMA).
[476] Active and Assisted Living research and development programme (AAL2) final evaluation.
[477] Digital and Industrial Transition study (2023), p. 47.
[478] Innovative Europe Study, (2023) section 4.
[479] Focusing on one type of action facilitates comparability between programme parts. For instance, if a programme part uses more a type of action that has a lower expected funding rate, then it will probably have higher leverage factor compared to another programme part that uses more a type of action that has a lower expected funding rate.
[480] It might be too early to calculate the additional investment. Moreover, this might require tracking through external investment databases. The information we provide is thus only partial.
[481] Note that this figure includes both direct leverage (direct contributions from the industry to the cPPP projects, as predetermined in the projects), and, additional investment, as data cannot be always disaggregated. Indicatively, for Big Data cPPP, the direct leverage is EUR 0.3 for each euro invested, while additional investment is 7 times more than the EU contribution (EUR 448 million, compared to EUR 63.52 million). Source : https ://www.bdva.eu/sites/default/files/MR2018_BDV_cPPP_Main%20Report_and_Annex%201_V1.0.pdf

- Leverage factor of EUR 4.65 for the FoF cPPP –compared to a target of EUR 5–10 at the end of Horizon 2020[482]).[483]

SME participants in the LEIT programmes were successful in raising private funding of EUR 9.4 billion following their Horizon 2020 activities. This is almost four times the EU contribution to the same participants.[484] SME Instrument recipients tend to attract additional investment thanks to the programme, as EU grants represent a catalyst for follow-on equity investment: firms experience a higher likelihood of receiving private equity (over 100% increase), and this is associated with larger funding rounds and a higher number of deals.[485]

Indirect leverage

Lastly, Horizon 2020 is expected to continue to generate **indirect leverage**.[486] Using the NEMESIS macroeconomic model[487], the indirect leverage of the Horizon 2020 for 2014-30 is estimated to be between EUR 4.23 and EUR 12.22 billion.[488] For 2014-50, the estimated amount is between EUR 13.71 and EUR 25.82 billion.

4.4.2. Horizon 2020-supported activities that would not have been possible without EU funding

A majority of Horizon 2020 applicants who responded to surveys in external evaluation studies reported that it would not have been possible to conduct the intended research through other means or funding source[489]. Similarly, only a minority of respondents to the stakeholder consultation declared that they would have secured enough funding from national public sources (12%), private sources (4%) and other EU programmes (3%).

Survey data shows[490] that the majority of unsuccessful applicants did not implement their projects, or implemented them with significant changes after being rejected for Horizon 2020 funding. A small share of unsuccessful applicants indicated that they implemented their projects with minimal or no adaptation.

When asked what prevented them from implementing their project, the overwhelming majority of unsuccessful applicants who did not implement their projects indicated that no alternative

[482] No explicit target for leverage was mentioned in FoF Progress Monitoring Report (https://www.effra.eu/sites/default/files/fof_cppp_progress_monitoring_report_for_2017_online.pdf).
[483] Digital and Industrial Transition evaluation study (2023), op. cit., p. 47 and Annex II.
[484] Digital and Industrial Transition evaluation study, op. cit., p. 54. & Annex IV, p. 394-398. For more information see analysis of risk capital raised under section 4.1.3 of this document.
[485] Santoleri et al. The Causal Effects of R&D Grants: Evidence from a Regression Discontinuity, op. cit. This peer reviewed paper studied the causal effect of receiving an SME-2 grant.
[486] This refers to the additional R&D investment engaged by a research entity, whether financed by the FP or not, as a response to the modification of the overall economic activity that the FP brought about.
[487] For more details on the modelling aspects, see section "Macro-economic impacts: Horizon 2020's impact on employment and GDP".
[488] For the NEMESIS results, a sensitivity analysis has been performed identifying three different scenarios (Low, Medium and High) depending on the stringency of the assumptions about the crowding-in effect of the FP on applied research, and the EAV of the FP (see Annex II).
[489] For Excellent Science: this was the case for 53% of unsuccessful applicants who answered the survey conducted in August-September 2022 (main report, figure 9, p. 52). For LEIT (survey conducted within the Digital and Industrial Transition study, main report, p. 55): In the absence of Horizon 2020 funding, 25% of unsuccessful applicants declared having abandoned their research idea and 70% resubmitted it to other funding sources. When respondents declared having implemented their project either through national funding or their own funding, only one in five declared that they could implement their project as originally planned – for 75% this implied a reduction in scale or ambition. Green Transition survey of successful applicants: over 70% of respondents in Societal Challenges 2-5 said that the project would not have been implemented without Horizon 2020 support (Annex VII, pp. 21, 40, 58 and 74).
[490] Digital and Industrial Transition evaluation study (2023), op. cit., p. 73-74. Evaluation study on Excellent Science (2023), op. cit., Figure 9, p. 52.

funding was available for that type of research.[491] Although promising, the Seal of Excellence label aimed at encouraging alternative funding for excellent but unfunded Horizon 2020 projects proposals remains small, as it is applicable to only mono-beneficiary schemes and national and regional implementing authorities are free to consider or disregard it in their regional and national programmes.

Horizon 2020 supported larger scale, more complex and more ambitious research than would be possible without the programme's support. Compared to national or regional programmes with similar objectives, Horizon 2020 often granted a higher amount of funding.[492] Without the EU support the projects would have been implemented at a smaller scale[493], with less substantial results and benefits. Additionally, Horizon 2020 also **funded research in areas that were relevant from a European perspective** but in some cases less of a priority at national level[494], such as cultural heritage[495], migration[496], emerging and neglected infectious diseases in sub-Saharan Africa[497] and the exploitation of marine resources.[498]

For instance, Horizon 2020 offered opportunities for international collaborations in **civil security research**, on topics not supported in nationally focused funding schemes[499] involving **cross-border challenges and areas of overlapping interest for all Member States and many Associated Countries**. Activities had a Europe-wide scope, relevance or collaborative networks with projects funded through national or regional instruments. It is deemed unlikely that this would have taken place without the EU support.[500] Smaller Member States, which may have more limited research programmes and industrial bases providing solutions to security practitioners, are considered to have benefitted the most from their participation.[501]

Also, Horizon 2020 provided training for researchers across different areas, such as open access, foreign languages, research ethics, IPRs, etc.[502], that would not otherwise be available. When asked which type of training they received as part of their project, only 5% of MSCA Individual Fellowships (MSCA IF) indicated that they did not receive any training, compared with a share of 22% among unsuccessful applicants (those who pursued their projects with alternative funding). 89% of MSCA IF fellows gained opportunities to work abroad as a result of their project (compared to 63% among the control group of unsuccessful applicants) as well as interdisciplinary cooperation opportunities (80% among MSCA IF fellows vs 65% among the control group).

[491] In the Excellent Science evaluation study (2023, Figure 10, p. 54): 78% of ERC applicants, 83% of MSCA organisations, 69% of MSCA IF applicants, 81% of FET applicants, 92% of INFRA applicants, 90% of SEWP applicants and 86% of SwafS applicants. In the Digital and Industrial Transition study, see section. 8.1.
[492] EIC Pilot Evaluation (2022, p. 9), Innovative Europe evaluation study (2023, p. 54), Excellent Science evaluation study (2023, p. 62).
[493] Case studies and survey of EIC Pilot Accelerator unsuccessful applicants (Annexes, p. 76), Survey of LEIT unsuccessful applicants (study on Digital and Industrial Transition, 2023, op. cit., executive summary (p. 15) and section 8.1), Survey of Horizon 2020 beneficiaries and unsuccessful applicants, interviews and case studies on the ERC (Excellent Science evaluation study, 2023, Annex 1, p. 68).
[494] Green Transition evaluation study (2023), op. cit., p. 38.
[495] Resilient Europe evaluation study (2023), op. cit., p. 57.
[496] Ibid, p. 57.
[497] Ibid, p. 65
[498] Green Transition evaluation study (2023), op. cit., p. 31.
[499] Commission staff working document 'Enhancing security through research and innovation, SWD(2021) 422 final of 15.12.2021, p. 2.
[500] Resilient Europe evaluation study, Annex I.3.4, p.106.
[501] Ibid.
[502] Excellent Science evaluation study (2023), Annex 1, p. 120-121.

4.4.3. Horizon 2020 promoted multidisciplinary and European cooperation in R&I

Horizon 2020 supported more than two million collaborations between individual organisations, **helped pull together a critical mass of expertise, skills and resources from different countries** and disciplines and provided a framework for lasting networking and collaboration. None of this would have been possible without the EU support.[503] For example:

- EU funding was the only option for accomplishing cross-border cooperation, as many national funding schemes only allowed for cooperation with organisations within that same country.[504] Also, interviews with ERC grant recipients showed that both the multidisciplinary aspect and the international nature of the ERC have contributed significantly to frontier research.[505]
- Spreading excellence and widening participation actions (SEWP) provided a framework for networking and collaboration between research groups from widening countries and leading research organisations in Europe.[506]
- Collaboration with partner institutions from other countries, organising consortium-level training programmes and obtaining access to international experts in their respective fields would have been difficult or impossible to achieve for most of the beneficiary researchers.[507]
- The FET Human Brain Project (HBP) illustrates well the European scale of the extensive multidisciplinary research efforts involving more than 750 scientific collaborators and engineers from 114 institutions in 24 European countries.[508] This resulted notably in six ICT Platforms, which are the core of the emerging HBP research infrastructure for brain research.

What messages emerged from the stakeholder consultation?

According to 35% (32) of public authorities, 34% of academia (311), 31% of NGOs (20) and 23% of companies (71) deem that the **introduction of international flagship initiatives has boosted international cooperation**.

In view of **facilitating cross-sector and cross-border mobility of researchers**, 88% (804) of respondents from academia, 76% (235) of respondents from companies as well as 71% (22) of business associations either agreed or strongly agreed that Horizon 2020 had a positive effect. Similarly, 73% (666) of respondents from academia, 67% (20) of respondents from business associations as well as 60% (90) of companies deem that the programme is **making Europe more attractive for world class researchers from abroad.** Still, this claim is only supported by 66% (52) of non-EU citizens, contrasting 88% (164) of EU citizens responding to the consultation.

Overall, 74% of respondents (1 324) agreed that participating in Horizon 2020 improved their cooperation with partners from other countries (within the EU and beyond): Particularly EU-associated countries support this claim (77%; 205), followed by EU-15 countries (74%; 1 046) and EU-13 countries (73%; 131). At the same time, only 61% of third countries share this view (36).

Stakeholder interviews indicate that even in countries where other funding instruments support similar types of activities in specific areas (e.g. support for green innovation in Sweden, Denmark and Germany, support for agri-food in Italy), participation in Horizon 2020 is still attractive in terms of the international context of projects, the network of excellent players it brings together and opportunities to share expertise in this network.[509]

[503] External coherence evaluation study (2023).
[504] Excellent Science evaluation study (2023), Annex 6 – case study on achievement of commercial and/or social innovation potential of ERC projects that received ERC Proof of Concept funding, p. 713.
[505] Excellent Science evaluation study (2023), Annex I, p. 33.
[506] Excellent Science evaluation study (2023), Annex 6 – case study on the contribution of SEWP to integrating research groups from widening countries, p. 871.
[507] Excellent Science evaluation study (2023), Annex 6 – case study on the structuring impact of MSCA ITN on doctoral programmes, p. 772.
[508] Excellent Science evaluation study (2023), Annex 1, p. 158.
[509] Case study 1 "Deployment of green innovation" and case study 8 "Coherence in support to agrifood value chains" in the External coherence evaluation (2023), op. cit.

4.4.4. Horizon 2020 increased excellence in research and innovation, by creating EU-wide competition

Horizon 2020 created strong and direct pan-European competition, which guarantees its EU added value. For instance, competition for ERC and MSCA grants is intense, with success rates of 12.9% and 14.4% respectively.[510] Such competition allows the ERC and MSCA to draw on a wider pool of talent and ideas than would be possible for any national scheme. In this way the best researchers with the best ideas received funding, irrespective of local bottlenecks or the availability of national funding.

Interviews with stakeholders confirm that the need to compete for funding with other top researchers from all over Europe boosts the quality of research proposals and general level of research excellence achieved in the projects.[511]

Excellence-based EU-wide competition increased the quality and visibility of R&I output beyond what is possible with national or regional-level competition. This is shown by the fact that Horizon 2020 publications were cited at twice the world average rate (FWCI of 2.03), while 3.9% of these publications were among the top 1% of most cited publications [see section above 4.1.1].

4.4.5. Horizon 2020 helped consolidate the European Research Area

Horizon 2020 has facilitated the emergence of thousands of new collaborations between researchers, having a strong structuring effect[512] on the European Research Area (ERA)[513] – the single, borderless market for research, innovation and technology that is under construction in the EU.

There is stronger intensity of cooperation after a Horizon 2020 project compared to the period before the project, indicating that Horizon 2020 funding helped to build and sustain research teams and build a stronger ERA.[514] The number of co-author pairs counted after the end of Horizon 2020 projects is higher than those counted before.[515]

However, there is mixed evidence on the impact of Horizon 2020 on institutional changes in beneficiary organisations. According to survey data, most beneficiary organisations agreed that their projects contributed across different aspects of institutional growth and developments within the beneficiary institution.[516] The framework programme did improve and align organisational practices and structures, but in different ways and to varying extents:

- Horizon 2020 support in the fight against COVID 19 was part of a coordinated European response, via the **ERAvsCorona Action Plan**.[517]
- The **MSCA had a positive structuring effect on organisations**, by improving the quality of training, career development, human resources practices and procedures and improving working conditions.[518]
- Several institutions argued that, although it is still early to judge the full structuring impact, they have already introduced some changes either because of or influenced by

[510] Excellent Science evaluation study (2023), op. cit., p. 29.
[511] Excellent Science evaluation study (2023), op. cit., p. 56.
[512] Excellent Science Evaluation study (2023): Findings based on the analysis of the indicator SC4: Structuring effect of FP funding (2023), op. cit., p. 42.
[513] Communication on a new European Research Area for Research and Innovation.
[514] Cross-cutting issues evaluation study (2023), Annex 8 – case study "ERA", p. 13.
[515] Excellent Science evaluation study (2023), op. cit., p. 39.
[516] Excellent Science evaluation study (2023): case study "Impact of the framework programme in spreading excellence across the Union", p. 301.
[517] Available at https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/european-research-area_en#eravscorona-action-plan.
[518] Excellent Science evaluation study (2023), Annex 1, p. 416.

their participation in the Horizon 2020 action. These changes concern: recruitment practices, the way supervision is carried out, the monitoring and evaluation of progress by early-stage researchers, the adoption of a doctoral training similar to the ITN training model (e.g. with the identification of transferable skills and competences, to enhance early-stage researchers' employability).

- The interviewed institutions perceive that the MSCA ITN has been working as a framework to **align and standardise doctoral programmes'** requirements and standards in some of the participating organisations.[519]
- The **Research Infrastructures programme shaped the European R&I landscape** through the European Roadmap published by the European Strategy Forum on Research Infrastructures (ESFRI).[520]
- **SwafS actions** have contributed to the emergence of talented new researchers and **opportunities to work in different countries and sectors**, especially through the EURAXESS services and portal.[521] SwafS actions have also played a role promoting the introduction of **Responsible Research and Innovation (RRI)** to the political agenda across Europe. The importance of responsible research and the different dimensions of RRI (ethics, public engagement, governance, gender equality, science education, open access) has been picked up by many Member States. For example, 19 Member States have followed the framework programme's example and now have at least one research funder with a policy on open access for publications.[522] Moreover, programmes have been launched in some Member States that provide funding for RRI, for example through specific calls for citizen science.[523]
- One of the main achievements of SwafS is also its impact on the **advancement of gender equality in R&I across the ERA**, with 206 beneficiaries having developed a Gender Equality Plan through SwafS projects[524]. Through its operating model, the **MSCA** also contributed to the adoption of practices that promote gender balance and inclusiveness, both inside Europe and beyond.[525]

Table 17: **KPI 21** on the number of institutional change actions[526] promoted by the programme		
Baseline (FP7)	Target at the end of Horizon 2020	Achieved value
No baseline	100	381 (total) 348 (Member States)

Source: Commission monitoring systems (CORDA), data on 24/04/2023.

Horizon 2020 catalysed **changes in implementing national R&I reforms** through the periodic review exercises involving leading experts and policy practitioners from the Member States (e.g. mutual learning exercises, the periodic feedback of the Policy Support Facility - PSF).[527] However, often the national implementation plans were not updated and monitoring is limited.[528] At the same time, the ECA report noted (i) the limitations in the PSF's ability to induce needed changes in national systems, which are linked to the limited availability of resources for the PSF,

[519] Excellent Science evaluation study (2023), op. cit., p. 63.
[520] External coherence evaluation study (2023), op. cit., p. 23.
[521] Excellent Science evaluation study (2023), Annex 1, p. 258.
[522] O'Neill, G., & Martziou, S. (2023). Data of Survey on National Contributions to EOSC 2022 (Version V1) [Data set]. Zenodo, https://doi.org/10.5281/zenodo.10155993. Also exploitable in an online dashboard at https://eoscobservatory.eosc-portal.eu.
[523] Excellent Science evaluation study (2023), op. cit., p. 42.
[524] Ibid, Annex 1, p. 275.
[525] Excellent Science evaluation study (2023), Annex 6 – case study on 'Inclusiveness and gender dimension in the MSCA', p. 746.
[526] Institutional change actions towards RRI at MS-level, at RPO-level and at individual scientist level.
[527] Cross-cutting issues evaluation study, Annex 3 – case study "ERA", p. 124.
[528] Ibid, Annex 3, p. 129.

(ii) the fact that not all widening countries request support and (iii) the freedom of the Member States to decide to what extent they will implement the reforms identified under the PSF.[529]

According to participants, Horizon 2020 supported **the development of long-lasting knowledge networks via partnerships**. Partnerships created a place to meet and discuss with European partners, competitors, and other stakeholders, who often lack such a structured channel for regular interactions. Cooperation between public and private parties improved their understanding of each other's goals and ways of operating, creating a stronger base for future cooperation.[530]

For example:

- the **Fuel Cells and Hydrogen Joint Undertaking** managed to attract some of the biggest industrial players in the field, playing a significant part in consolidating a previously scattered and fragmented hydrogen ecosystem.
- Similarly, the **Bio-based industries JU** exerted a structuring effect in organising the value chain across sectors and effectively mobilised key stakeholders across sectors and geographical areas.[531]
- **Public-private partnerships**, in particular, also increasingly aim to anticipate users' needs to improve technology diffusion and uptake by end-users.[532]
- The European Metrology Programme for Innovation and Research public-to-public partnership (EMPIR) has been effective in enabling collaboration between national metrology institutions, reducing fragmentation and duplication, and thereby reinforcing the EU position as a world leader in metrology research.[533]

4.5 Relevance

Interviewees confirmed that Horizon 2020 was highly relevant given the needs, priorities, problems and issues for R&I to be addressed at European level. All three programme rationales (the reinforcement of scientific excellence, the turn towards innovation and the more political and impact-oriented framing of the thematic top-down funding programmes) were anticipated and brought forward by the science, technology and innovation community.

In that way, the three-pillar structure of Horizon 2020 represented the major needs for R&I in Europe at the time when the programme was designed, while also responding more than before to political priorities.[534] In addition, Horizon 2020 contributed to and was relevant for Europe 2020 flagship initiatives, including the "Digital Agenda for Europe" and "Innovation Union", part of the EU 2020 Strategy.[535]

What messages emerged from the stakeholder consultation?

Overall, 70% of respondents (1 483) in the stakeholder consultation conducted for this evaluation agreed or strongly agreed that **'Horizon 2020 helped develop and implement EU policies'** (such as the "Europe 2020" strategy). The strongest support for this statement has been shown among public authorities (78%; 72), followed by business associations (75%; 24), companies (73%; 229) and academia (70%; 644). Only NGOs (66%; 44), EU citizens (66%; 145) and non-EU citizens (60%; 36) have indicated a lesser agreement with the

[529] ECA Special Report No. 15 – Measures to widen participation in Horizon 2020 (2022), p. 38, https://data.europa.eu/doi/10.2865/359822.
[530] Digital and Industrial Transition evaluation study (2023), op. cit., section 8.2, p. 74.
[531] Green Transition evaluation study (2023), op. cit., p. 121.
[532] Digital and Industrial Transition evaluation study (2023), op. cit., p. 74.
[533] Participation of industry in the partnership on Metrology has remained low, particularly in widening countries, and stakeholders have lamented the difficulty of convincing policy-makers about the added value of cooperation in metrology – a field that has wide-ranging impacts on economy and society. Digital and Industrial Transition evaluation study (2023), Annex II - Cross-analysis of the types of partnerships (section 3, p. 203-230).
[534] Evaluation study on the Relevance of Horizon 2020 and its Policy Mix (2023), op. cit., p. 68.
[535] They were both identified as cross-cutting issues for the framework programme.

statement, either agreeing or strongly agreeing that Horizon 2020 helped to develop and implement EU policies.

Overall, few respondents (2%; 37) across all stakeholder groups expressed unfavourable opinions regarding the capacity of Horizon 2020 to help develop and implement EU policies indicating that across all stakeholder groups are indeed overwhelmingly positive about the development and implementation of EU policies by means of Horizon 2020.

Nevertheless, Europe's overall **competitive position has not fundamentally changed** over the duration of Horizon 2020, with a view to its structural strengths and weaknesses. Having an EU R&I programme is therefore still highly relevant.

What messages emerged from the stakeholder consultation?

Overall, 70% (1 248) of respondents stated that "**Horizon 2020 is flexible enough to respond to unforeseen emergencies, such as the COVID-19 pandemic, Zika and others.** Among the various stakeholder groups, respondents generally perceive Horizon 2020 as being flexible enough to respond to emergencies like the COVID-19 pandemic, Zika and others. Most respondents were positive about the flexibility of the programme with 32% of academia (296), 31% of non-EU citizens (18), 30% of public authorities (28), 29% of companies (92), 30% of public authorities (28) and 27% of EU citizens (60) strongly agreeing. The percentages of respondents sharing a more sceptical view on the matter were relatively low: 14% of companies (43), 12% of public authorities (11) and 9% of academia (84) found that Horizon 2020 had little flexibility. Still, the "I don't know / no opinion" option was chosen by 12% of public authorities (11) and 18% of business associations (6).

The possibility to exceptionally award grants without a call for proposals, together with the recently introduced emergency funds, enabled the programme to respond even faster to new emerging challenges such the COVID-19 crisis than it did for Ebola[536] and Zika, thanks to the timely contributions, without which the funding for responding to the COVID-19 crisis would have been too limited.

In addition, two first years of the EIC Pilot reoriented the FP support for innovation by integrating and connecting science with innovation and providing funding for scaling-up. By bringing together the FET and SMEI, the EIC sharpened its focus on deep tech and shifted away from incremental and digitally driven innovation, for which there is already significant public support and private investments.[537] Through the establishment of the EIC Fund, it tackled market failures, such as the insufficient volume of private equity investments in sectors and technologies relevant to addressing the climate and environmental crisis.[538]

The mix of instruments that have been set out to accelerate the transition and time to market objectives was found to be well-designed, and it considers that innovation development and market deployment can occur in multiple ways.[539] The experience of the US DARPA inspired the proactive programme management approach. The evaluation could not fully assess this process since the programme managers were still being recruited and their roles defined at the time of the evaluation.[540]

Many of the **internal process elements** in Horizon 2020 were new, such as the enhanced consultation of stakeholders and experts. Consultation activities included advisory groups, strategic foresight and road mapping, evaluation and monitoring, policy feedback, stakeholder consultations, and the consultation of Member States and Associated Countries in Programme

[536] The EBOVAC 2 – IMI project was launched in response to the Ebola outbreak. The project was considered to have achieved important work in preparing sites and implementing clinical trials with an experimental Ebola vaccine in African and European countries. It has also provided extensive and robust data on the safety, immunogenicity and efficacy of the Ad26.ZEBOV and MVA-BN-Filo vaccine.
[537] European Commission, DG for Research and Innovation, Evaluation study on the European Innovation Council (EIC) pilot, Publications Office of the European Union (2022), p. 66, https://data.europa.eu/doi/10.2777/261324
[538] Ibidem.
[539] Ibid, p. 7.
[540] Ibidem.

Committees.[541] Nevertheless, consultation was perceived by some interviewees as an instrument for legitimising EC priorities, not as an instrument that can open the discussion and bring in new aspects. Stakeholder consultation, in particular the informal channels, favoured the dominant R&I stakeholders - to the disadvantage of newcomers, especially those stakeholders representing the end-users of R&I processes, in particular civil society.[542]

The ambition to generally increase the participation of civil society organisations (CSOs) in projects faced some obstacles. Although their participation increased compared to FP7, the following factors were identified as having an important hindering effect: (1) assessment criteria in research funding were still (too) focused on key performing indicators concerning scientific excellence[543], whereas societal impacts remain difficult to operationalise and assess. Consequently, (2) research programmes and questions appeared highly research-driven and designed toward the needs and interests of the research community. In Horizon 2020, multi-annual programmes were set up (in most cases biennial programmes), to enable applicants to prepare better and earlier, increasing the prospect of high-quality proposals.

What messages emerged from the stakeholder consultation?

66% (1 170) of respondents in the stakeholder consultation conducted for this evaluation either agreed or strongly agreed that '**Horizon 2020 supported cooperation between science and society**'. This objective of Horizon 2020 has been the most controversial one among all objectives, as 6% (99) of respondents maintained that the programme did in fact not do enough to support said cooperation. Nevertheless, this constitutes only a small fraction of respondents within each stakeholder group. It is important to note that the majority of responses were rather favourable, suggesting an overall positive sentiment towards the support of cooperation between science and society. Among the various stakeholder groups, favourable views were shared the most on behalf of NGOs 71% (47), whereas business associations (59%; 19) were the least favourable compared to other stakeholder groups. Non-EU citizens found that Horizon 2020 supported cooperation between science and society to a greater extent (67%; 39) compared to EU citizens (60% 129). .

[541] Evaluation study on the Relevance of Horizon 2020 and its Policy Mix (2023), op. cit., pp. 55-60. More information on the relevance of Horizon 2020 design and strategic planning process were provided in the interim evaluation of the programme, 2017.
[542] Ibid, Pp. 8-9.
[543] Evaluation study on the Relevance of Horizon 2020 and its Policy Mix (2023), op. cit., p. 54. The share of funding awarded to CSOs was lower (4%) than their numerical share of participation (6%), which indicates that civil society actors seemed to generally take on non-core roles in research project consortia and, rather, participated in other parts of the research process like communication, coordination, and dissemination and uptake of research results.

5. WHAT ARE THE CONCLUSIONS AND LESSONS LEARNED?

The overview below proposes a graphic assessment of the extent to which Horizon 2020 achieved or contributed to its objectives/targets using a scale of:

- **--** : the evaluation found the objective is **not achieved** (and is not going to be achieved);
- **-**: the objective is **not achieved** (and is not going to be achieved), but **some positive findings** were also identified;
- **+/-** : the evaluation found positive progress but it is **unclear** whether there will be only partial achievement or the objective will eventually be achieved;
- **+** : the evaluation found the objective is **achieved**, or on its way to being achieved;
- **++**: the evaluation found the objective is **exceeded**, or on its way to being exceeded.

Effectiveness, scientific excellence. Extent to which Horizon 2020 has:	
• promoted numerous, high-quality publications	+
• promoted open access to research publications	+
• spread excellence in 'widening countries'	+/-
• contributed to the advancement of frontier research	++
• boosted researchers' occupational mobility, training and career prospects	++
• strengthened European research infrastructure	+/-
Effectiveness, societal impacts. Extent to which Horizon 2020 has:	
• increased the R&I contribution to social challenges	+/-
• promoted gender equality	+/-
• promoted social sciences and humanities in the funded projects	+/-
• supported research on the environment and climate change	+
Effectiveness, economic impacts. Extent to which Horizon 2020 has:	
• produced innovation outputs, including new technologies, products and services	+/-
• contributed to European leadership in enabling and industrial technologies	+
• enabled the Knowledge and Innovation communities (KICs) of the European Institute of Technology and Innovation to create economic and innovation outputs	+/-
• facilitated access to risk capital	+
• generated macro-economic impacts on GDP and employment	+
• strengthened the competitive position of Europe	+/-
• improved the economic performance and competitiveness of its beneficiaries	+
• promoted international cooperation, contributing to the impacts of the programme	+
• promoted the exploitation and dissemination of results	-
Long term effectiveness, long-term impact of previous framework programmes	++
Efficiency. Extent to which Horizon 2020 has:	
• reduced the administrative costs for applicants and participants, simplifying their participation in the programme	+/-
• performed against overall administrative expenditure targets	+
• improved the "error rate" in project cost reporting	-
• ensured faster processes leading up to the signature of the grant agreement	++
Internal coherence. Extent to which the various components of Horizon 2020 operated well	+
External coherence. Extent to which Horizon 2020 operated well with other relevant EU and national programmes	+/-
EU added value. Extent to which Horizon 2020 has:	
• leveraged additional resources for R&I	+
• supported activities that would not have been possible without EU funding	++
• promoted multidisciplinary and European cooperation in R&I	++
• increased excellence in research and innovation, by creating EU-wide competition	++
• contributed to consolidating the European Research Area	+
Relevance. Extent to which Horizon 2020 has responded to the original needs and these needs are still present now	+

5.1 Conclusions

Horizon 2020 emerges as a successful programme in many different areas. This evaluation occurred at a moment when 41% of funded projects are still ongoing. The cumulative implementation rates were 99.99% for Horizon 2020 commitments and 87.84% for payments. This high rate of financial commitments and payments indicates a solid base for drawing conclusions on the programme. The completion rate of Horizon 2020 projects (59%) is also higher than the one of the preceding programme (FP7) at the time of its final evaluation.

In line with its foundational objectives, **Horizon 2020 was instrumental in nurturing a society and economy rooted in knowledge and innovation.** It played a key role in **mobilising additional R&I funding** and it made a significant contribution to the EU's target of investing 3% of GDP in R&D by 2020. Nevertheless, Horizon 2020 investments only accounted for 10% of public R&D expenditure in the EU, with the majority of funding originating from the Member States and regional bodies. By the end of 2020, the EU's investment in R&D had risen to 2.32% of GDP, a 15% increase since the programme was first launched.

Horizon 2020 has significantly impacted the research and innovation landscape, benefitting a diverse range of participants – from scientists and researchers working within higher education institutions to research organisations and private-for-profit entities such as small and large businesses. The programme launched over 1000 calls for proposals, attracting over 285 000 eligible projects proposals – double the number received by its predecessor, FP7. This surge in interest highlights the programme's appeal and relevance. Even if close to 35000 projects were funded, the success rate remained low at 12%. Notably, 74% of proposals assessed as high quality by independent experts could not be funded due to budget constraints. Horizon 2020, with a budget of EUR 75.6 billion, would have needed an additional EUR 159 billion to fund all high-quality proposals.

To give excellent unfunded proposals an opportunity to find support at national or regional levels, 1 out of 5 high quality proposals not retained for funding received a Seal of Excellence certificate, supporting subsequent funding under European Structural Funds. However, Member States' lack of access to information on awarded Seals of Excellence has been identified as a barrier to maximizing their impact.

Collaborative projects accounted for 78% of the funding, involving an average of 11 participants in nearly 15,000 projects. The average grant size in Horizon 2020 increased to EUR 2.3 million from EUR 1.8 million in FP7. Higher education institutions received the largest share of funding, followed by private-for-profit organisations and research organisations. SMEs received 17% of the funding, amounting to EUR 11.4 billion. Well-established higher education institutions and research organisations received a large share of the funding, showing a degree of concentration, smaller than under FP7. Still, the programme also attracted newcomers, in particular smaller private-for-profit entities. Newcomers received 19% of Horizon 2020 funds, a share rising to a full 50% when considering only funding to private companies across the programme.

The programme's global appeal is evident from the applications coming from 177 countries. Half of the funding went to just four countries (Germany, UK, France and Spain). However, smaller countries like Estonia, Greece, Cyprus, and Latvia showed impressive performance when comparing Horizon 2020 funding to their gross domestic expenditure on R&D. Widening countries saw an 8% share of the total EU contribution, a slight increase from FP7. Although this may seem moderate, all widening countries except two have increased their participation in the programme. The evaluation identified several challenges for widening countries, including limited capacity in managing international R&I projects, brain drain, weak national support systems or easily available funding alternatives. In response, Horizon Europe has tripled the budget for widening country participation to 3% and introduced several measures to enhance

their involvement, including strengthening the National Contact Point system and offering proposal pre-checks and brain circulation grants.

Horizon 2020 was **coherent**: it had a high number of instruments with different approaches to grants (mono-beneficiary and collaborative, more research-oriented and more innovation-oriented) which served different objectives and interacted in a complementary way.

Horizon 2020 is **relevant** as Europe continues to face economic and scientific competition and its positioning has not fundamentally changed compared to other countries and regions.

Scientific impact

Horizon 2020 was strategically designed to strengthen Europe's scientific and technological bedrock by investing in knowledge, skills and infrastructure. These long-term investments are critical for the EU's current and future ability to lead, react or adapt to dynamic changes in scientific and technological advancement and the ever-changing socio-economic environment.

The programme outperformed its predecessor (FP7) on scientific output, as evidenced by the number of **scientific publications**, which **are twice as cited as the global average,** and 4% in the most cited worldwide. At the time of this evaluation, beneficiaries had reported over **276,000 peer-reviewed publications**, with 18% stemming from projects supported with European Research Council (ERC) grants. This number is still expected to increase as more projects reach completion. Horizon 2020 **made substantial contributions** to **scientific breakthroughs and advancements in nascent domains** of science and technology, particularly in medical sciences, quantum mechanics, chemical engineering and composite materials. Funding for transnational R&I projects enabled significant collaborations that might not have been possible otherwise. More than a quarter of the publications are linked **to new, rapidly evolving research areas.** It played a key role in fostering world-class scientific excellence: 33 Nobel Prize winners were supported either before or after they were honoured.

The programme also had a **profound impact on knowledge circulation,** with 82% of its publications being freely and publicly available online, demonstrating a strong commitment to **open access.** Horizon 2020 was also pivotal in **diversifying and enhancing researchers' skills and knowledge**. **It also improved their career prospects, particularly benefiting early-career researchers**. Nearly 50 000 researchers were supported in cross-sector and cross-country mobility.

In addition, Horizon 2020 has enabled the EU to develop and upgrade **large-scale research infrastructures** at both European and global levels. Over 24,000 researchers and organisations gained access to these infrastructures, enhancing collaborative opportunities and scientific advancements. The Leadership in Industrial Technologies (LEIT) programme part facilitated access to **technology infrastructures** such as open innovation test beds, allowing companies to test innovations in realistic conditions. Another important development was the deployment of common research infrastructures under the roadmap for the European Strategy Forum on Research Infrastructures. While these achievements are noteworthy, the evaluation suggests that **synergies between EU, national and regional programmes** supporting research infrastructures could be further improved, in particular to ensure their sustainable operations

Societal impact

Horizon 2020 bolstered research and innovation efforts aimed at **tackling key societal challenges**, including health, food security, energy, transport, environmental sustainability, climate action, inclusive societies and security.

Particularly noteworthy is Horizon 2020's crucial role in **advancing our understanding of climate change**. Its investments, building on the foundations laid by the predecessor programme FP7, have been influential, with 10% of the scientific publications cited by the Intergovernmental Panel on Climate Change originating from these two programmes. With 32% of its funding allocated to climate action Horizon 2020 has also been instrumental in supporting the development of practical solutions. A prime example is the progress made in alternative and low-emission fuels. The programme also demonstrated adaptability in responding to emerging **health crises**. It responded promptly by launching specific calls for proposals during the Ebola and Zika epidemics, and even greater agility in responding to the COVID-19 pandemic. Horizon 2020 and FP7 are recognised as the third most frequently acknowledged funding sources for COVID-19 related research in the world. The programme also funded research to gain a deeper understanding of **rare diseases** and fostered the development of related therapies, contributing to advancements in personalised medicine and patient care.

By improving fishing methods and reducing discards, Horizon 2020 has contributed to more **sustainable fishing** practices, balancing economic interests with environmental conservation. The programme supported the development of a **smart European electricity grid**, funding projects that focus on automation, energy storage integration and the adoption of renewable energy sources to aid the transition to a more sustainable energy system. Horizon 2020 played a role in improving urban transport by supporting **sustainable urban mobility** plans, including well-designed parking measures and cycling infrastructure to help improve urban liveability and sustainability. The programme supported the development of solution addressing the **human aspects of digital transformation**, such as the development of safe and user-friendly robotics. It improved the accessibility and inclusiveness of cultural spaces, enriching **cultural heritage** experiences and giving access to a broader audience. The programme helped make Europe **more secure** by supporting crime prevention and counter terrorism initiatives, improving border surveillance and improving disaster resilience.

Showing commitment to interdisciplinary research, Horizon 2020 significantly raised the role of **social sciences and humanities** disciplines i.e. sociology, economics, psychology, political science, history and cultural sciences, allocating over 20% of its budget to related topics. However, the evaluation reveals that the level of integration of social sciences and humanities was uneven across different parts of the programme areas. As regards **gender equality** the balance improved under Horizon 2020, with the share of women in evaluation panels reaching 42%, surpassing the 40% target. However, the share of women in scientific advisory panels and as researchers in projects remained below the 50% target, at 43% and 23% respectively, showing room for improvement.

Economic impact

Horizon 2020 made a **significant contribution to the European economy**, not only by stimulating employment and economic growth, but also by effectively **leveraging private funds and boosting the productivity of the companies involved**. It has generated the development of **thousands of innovation outputs**. Looking at the long-term effects of the programme it is estimated to contribute an average **annual increase of EUR 15.9 billion to EU GDP**, totalling EUR 429 billion over the period 2014-2040. Horizon 2020 is also expected to have had a notable impact on job creation, with a net gain in employment levels reaching around 220 000 employees at its peak. In monetary terms, **for every euro the programme is estimated to cost society (in programme costs and costs to applicants), it is estimated to yield five euro in benefits to EU citizens** in the period up to 2040.

On top of its nominal budget, **Horizon 2020 contributed to increasing R&D spending in Europe by attracting co-investment from both public and private sectors**. The greatest leverage was achieved in European partnerships: in joint undertakings, private partners

contributed resources (in cash or in kind) that more than doubled or even tripled the volume of EU funding. Moreover, the programme impacted the **economic performance of participating companies**. They saw on average a 20 % employment rise and a 30 % increase in turnover and total assets, compared to the firms that did not receive funding despite high quality applications. The programme also made a significant contribution to **intellectual property rights (IPR)** developments. Programme beneficiaries reported close to 4 000 IPR applications, of which three quarters are for patents, followed by 12% for trademarks. Given the often lengthy patenting process, Horizon 2020 IPR figures are expected to increase significantly even after the programme's end. Long-term analysis has shown that patents stemming from FP7 not only exceed the global average in economic value but also exhibit a strong tendency towards interdisciplinarity.

The Horizon Innovation Radar, a tool for identifying high-potential innovations within the programme, suggests that Horizon 2020 funded **potentially groundbreaking technological innovations.** Notably, the most ready-to-market innovations have emerged from the Industrial Leadership pillar, particularly within the Leadership in Enabling and Industrial Technologies (LEIT) projects. These projects have shown a higher propensity for market-ready innovations, especially in areas like the Internet of Things, advanced computing, and advanced materials. Additionally, about 40% of patents self-declared by LEIT participants have contributed to key enabling technologies, including photonics, as well as micro- and nanoelectronics. On the other hand, the Societal Challenges pillar has generated about 20% of all innovations under Horizon 2020, while the Excellent Science pillar has contributed 31%, albeit mostly at a lower level of technological readiness.

The interim evaluation of Horizon 2020 identified a notable gap in venture and growth capital in the EU to scale up innovations. To help bridge this gap, a pilot started to run the European Innovation Council (EIC) in the last three years of Horizon 2020. Early indications show that **the EIC pilot had a positive impact on the turnover and staffing levels of its beneficiaries**. It also **tackled a critical funding gap** in high-risk areas where limited alternatives are available at national and regional levels. The Horizon 2020 financial facility leveraged EUR 77.5 billion in debt and equity for over 38 000 organisations, well above its targets, and fostered the development of venture capital ecosystems and networks.

While Horizon 2020 made strides in **bridging the gap between high-quality European research and market innovations**, it has not fully closed this long-standing gap. Measures tracking the spread of innovation suggest that the EU improved its performance during the Horizon 2020 implementation period, yet it still trails behind its main international competitors on this aspect.

Efficiency and added value

Horizon 2020 has demonstrated **substantial value-for-money for European society.** In terms of economic impact, every euro spent on the programme (including both programme costs and costs to applicants) is estimated to yield approximately five euros in benefits to EU citizens, as measured through its impact on GDP, up to the year 2040.

A number of simplification measures were **effective in reducing the administrative burden for applicants and beneficiaries.** Notable improvements include the use of electronic signatures and the annotated model grant agreement. These changes helped accelerate the process to award grants, improved error rates and administrative expenditure that performed well against benchmarks. Key supporting factors mentioned were the new electronic grant management workflow and the change to scrap the negotiation stage. However, the evaluation suggests that further tightening the time-to-grant target might not be necessary as it could inadvertently increase financial error risks. Despite these advancements, the evaluation does not present an

overall positive picture regarding the **programme's error rate.** The European Court of Auditors pointed out that, particularly in operational expenditure and personnel costs, the level of error remains high and often avoidable.

Looking ahead, there is **scope to improve the efficiency** of the EU framework programme. Many stakeholders have indicated that participating in Horizon 2020 requires more effort than for other research and innovation funding programmes. This is significant given the programme's relatively low success rate, as it means that a considerable share of the application cost represents a net loss to EU society. Any effective measure that reduces these costs has a strong potential to improve programme efficiency.

Horizon 2020 significantly enhanced the scope and quality of research and innovation in Europe, achieving impacts that extend far beyond what could have been achieved at national or regional level. It supported larger-scale, more complex and more ambitious R&I activities than would have been possible without its support, accelerating the development of solutions to pressing global challenges by pooling efforts and resources from across Europe. This was evident in the difficulty faced by unsuccessful applicants, many of whom were unable to implement their projects or had to do so with significant modifications, primarily due to the lack of alternative funding sources at the national or regional level.

A key strength of Horizon 2020 was its promotion of multidisciplinary collaboration and European cooperation in R&I. This approach effectively consolidated expertise, skills and resources from various countries, creating a critical mass that elevated the quality of research and innovation outputs. The competitive nature of the EU-wide funding process further enhanced this quality, ensuring that research was conducted in areas of significant relevance from a European perspective.

Limitations to the analysis – monitoring and evaluation arrangements

While Horizon 2020 **met some of its targets or key performance indicators, it did not achieve all of them.** This partial success can be attributed to the inherent nature of R&I investments, which often require a lengthy period to yield exploitable results. Many projects initiated under the programme are still ongoing, and there were also shortcomings in the initial setup of the programme's indicators. As shown by the analysis of the long-term effectiveness of FP7, **R&I programmes need a longer cycle to demonstrate their impacts**. This lesson was identified in the interim evaluation, so the *ex post* evaluation follows up on FP7 outputs. Notably, IPR performance can only be fully assessed up to ten years after project completion. This is particularly important for indicators aiming at assessing societal impact – the *ex post* evaluation found that they did not feature prominently in the performance framework for Horizon 2020, and were generally inadequate to offer a useful narrative about the programme's wider effects on society. Selected targets set for Horizon 2020 proved either too close to baseline or wrongly set. Targets, always supported by baseline values, should be set more carefully in the future.

The **lack of monitoring arrangements for societal impacts** and the relatively short time elapsed since the closure of Horizon 2020 projects made it overall difficult to assess the broader impacts on society. Taking lessons from Horizon 2020 weak indicator system, the monitoring and evaluation system of the programme was consequently overhauled in Horizon Europe with an impact monitoring and performance framework covering the whole programme. It is structured around nine **Key Impact Pathways (KIPs), which equally cover scientific, societal and technological/economic impact, including baseline values and targets** and reinforced data quality systems, avoid self-reporting of IPR data [544] Recent improvements in the EC monitoring system allow to distinguish between background and foreground IPR applications.

[544] More detail is available in the SWD(2023)132 final on the Evidence Framework on monitoring and evaluation of Horizon Europe.

5.2 Lessons learned

The interim evaluation of Horizon 2020 performed in 2017 led to some significant adjustments in the latter half of the programme. New measures to increase open science have borne fruit and the level of international participation was maintained. Further enhancements, such as promoting women's participation, better integrating social sciences and humanities and reducing administrative burden have been carried forward and reinforced under Horizon Europe. Additionally, the monitoring and evaluation framework has been revised for a better tracking of impact over time. The effectiveness of these measures will be closely examined in the interim evaluation of Horizon Europe.

This final evaluation of Horizon 2020 highlighted several key areas for further improvement, providing insights for future enhancements:

- **Broadening participation.** There is scope to broaden participation in the programme. It would involve engaging with non-traditional players from multiple sectors, scientific disciplines and countries. While national reforms of R&I systems can influence readiness for European-level project participation, the programme itself can be improved by greater simplification, visibility and accessibility.

  Broadening participation to entities located in the least R&I performing countries improved under Horizon 2020 but only at a modest rate, and with significant differences among countries. This issue was raised already in the interim evaluation and confirmed as still relevant by the findings of the ex post evaluation. In response, the budget for actions on widening participation has been tripled in Horizon Europe with novelties including a strengthening of the National Contact Point system, possibility for participants from widening countries to join already existing consortia (the so-called "hop on scheme"), proposal pre-checks, as well as brain circulation grants. The *ex post* evaluation indicated that national reforms in R&I systems can impact the readiness to take part in excellent collaborative projects at European level in a more structured way than punctual actions funded by the framework programme. The *ex post* evaluation highlighted that spreading scientific excellence in the European Union deserves further attention. There are fewer new entrants in the part of the programme aimed at increasing participation, compared to the share of newcomers in Horizon 2020 overall.

- **Further simplification needed.** The programme can benefit from a targeted use of the two-stage application process, especially in areas with low success rates and a high volume of unsuccessful applicants. Extending the use of the Seal of Excellence certification scheme could also enable more applications to be reused for other programmes, reducing wasted effort. There is also further potential for simplification in extending the monitored use of lump-sum funding, as well as in improving outreach, information dissemination, and the user experience of programme tools.

  In particular, given the low success rates, any effective measure that reduces applicants' costs has a strong potential to increase the efficiency of the programme. The still limited experience with the two-stage application process (put in motion following the interim evaluation conclusion to address oversubscription) suggests that this approach could be extended in a targeted way, subject to careful ex-ante assessment. It would be suited for areas which combine a low success rate, with a high absolute number of unsuccessful applicants, and project start dates that are not time-sensitive.

  The use of lump sum funding was piloted, following the recommendations of the interim evaluation to promote simplification. Apart from reducing reporting costs of beneficiaries, lump sum funding can yield benefits by keeping the financial error rates in check. It was confirmed by this final evaluation as a relevant efficiency measure to be further applied, monitored, and assessed *ex post*, which will require quantitative evidence.

- **Dissemination, exploitation and deployment of results.** The process of disseminating, exploiting and deploying project results has been uneven and requires more attention. Horizon Europe encourages applicants to give greater thought to the pathway to impact in their applications. Improvements are also needed to ensure the visibility, spread and practical use of project results to unlock broader economic and societal benefits.
- **Supporting women in research and innovation.** Despite efforts, it remains a challenge to achieve gender balance in research, entrepreneurship and innovation. Stronger measures are needed to support women researchers, entrepreneurs and innovators both Europe-wide or within the framework programme.

  This evaluation finds that stronger measures are needed to support women researchers, entrepreneurs and innovators as gender balance in these fields is not yet within reach, Europe-wide nor within the FP. Further actions were taken in Horizon Europe, where the gender dimension is required to be integrated into research and innovation content (i.e. sex and gender analysis), across the whole programme. In particular, public bodies, research organisations and higher education establishments are required to have a gender equality plan (GEP) in place (new eligibility criterion and specific funding available). Flagship measures and activities promoting gender equality under the EIC include a target of 40% women-led companies to be invited to pitch their projects, a target of 50% women among members of advisory structures, a prize for women innovators and a dedicated initiative to support women-led start-ups will be introduced.
- **Unlocking more synergies with other initiatives.** Synergies with other EU, national and regional initiatives could be strengthened, particularly to support the uptake and use of project results. This includes better alignment to ensure the smooth operation of research infrastructures.

  Under Horizon Europe, this issue was acknowledged, and a path was paved towards improvement. The regulation was enriched with a dedicated annex listing programmes and funds where synergies are envisioned to ensure complementarities at design stage. Also, in the 2021-2027 MFF, a greater number of programmes are also using e-grants, enabling an automatic identification of potential synergies (entities funded by more than one EU programme). In 2022, a new guidance was published on synergies between Horizon Europe and the ERDF programmes. Efforts will be needed in the future to further streamline the administrative and financial rules with not only the ERDF but also other funding sources.

The evaluation at hand also underlined the need to monitor the EU' programme's **capacity to contribute to EU's priorities and competitiveness**. Representing around 10% of total public R&I spending in Europe, Horizon 2020 is not equipped alone to overcome the long-established challenge for the EU R&I system, i.e. translating the high-quality research developed in the EU into new innovations on the markets. Nevertheless, it can contribute to EU's competitiveness. A reinforced alignment between EU priorities and the programming of EU R&I funding was introduced in Horizon Europe, with multiannual Strategic Plans that are preceded by an analysis of recent developments and future challenges and opportunities for R&I.