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COVER NOTE

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Subject:	COMMISSION STAFF WORKING DOCUMENT INTERIM EVALUATION of HORIZON 2020 ANNEX 2

Delegations will find attached document SWD(2017) 221 final - PART 8/16.

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PART 8/16

COMMISSION STAFF WORKING DOCUMENT

INTERIM EVALUATION of HORIZON 2020

ANNEX 2

{SWD(2017) 220 final}
{SWD(2017) 222 final}

A. EUROPEAN RESEARCH COUNCIL

A.1. INTRODUCTION

A.1.1. Context

In 2000 Commissioner Philippe Busquin announced the European Research Area (ERA), and in March, the Lisbon Strategy was adopted. This started a period of reflection among the European scientific and policymaking communities on how best to support research and innovation (R&I) at the EU level[1]. Since its inception the EU framework programmes had supported transnational collaboration *"on predetermined topics and subjects in applied, finalised or directed research fields, corresponding to the Union's major policies in the fields of health, energy, the environment, etc."*[2]

The emerging debate emphasised instead the central importance of basic research to the relative performance of the innovation systems of the US and Europe. The idea of a mechanism for funding basic research carried out by individual researchers at EU level therefore gradually gained traction[3] resulting in the proposal to set up a European Research Council under the Seventh Framework Programme of the European Community for research, technological development and demonstration activities 2007-2013 (FP7).[4]

The creation of the ERC would help Europe to: reinforce excellence, especially in new, fast-growing research areas where Europe did not perform particularly well; stay ahead in a world of growing scientific and technological competition; link science to technological innovation; compete for talent; and encourage greater investment. Europe needed to produce the very best cutting-edge science in new and rapidly emerging fields which are closely associated with world-leading innovation and the long term growth of advanced economies[5].

The ERC would do this by providing for the first time a European-wide competitive funding structure which would:

- be steered by an independent Scientific Council in charge of the overall scientific strategy and with full authority over decisions on the type of research to be funded guaranteeing the effectiveness of the ERC's scientific programme, the quality of its operations and peer-review process and its credibility in the scientific community;

- channel resources to the most promising researchers selected from a larger pan-European pool;

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[1] *"How the European Research Council came to be"*, December 2016. http://sciencebusiness.net/news/80035/How-the-European-Research-Council-came-to-be

[2] *"The 7th Framework Programme in the history of European research", June 2007. https://ec.europa.eu/research/rtdinfo/special_fp7/fp7/01/article_fp709_en.html*

[3] Europe and Basic Research, *European Commission 2004. http://cordis.europa.eu/pub/era/docs/com2004_9_en.pdf*

[4] *Chronology of Basic Research Policy in the European Research Area. https://ec.europa.eu/research/future/basic_research/brp_era_en.htm*

[5] *The benefits of creating a new European-level funding mechanism to support the very best research carried out at the frontiers of knowledge were examined further by a high level expert group set up by the European Commission as a contribution to the debate leading up to FP7.* Frontier Research: The European Challenge, *ERC High Level Expert Group February 2005: http://erc.europa.eu/publication/frontier-research-european-challenge-high-level-expert-group-report-0*

- support the best new ideas in frontier research;
- confer status and visibility on the best research leaders working in Europe;
- offer attractive funding conditions which would help to attract and retain outstanding researchers in the ERA;
- provide benchmarks for individual countries and research institutions to catalyse changes in national science research funding policies as well as institutional practices to make Europe a more attractive research environment; and
- create economic and societal benefits from the availability of new knowledge and an expanded, higher-quality and more visible pool of talented researchers.

There has been a high degree of continuity in the objectives of the ERC since 2007 and under **Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)** the specific objective of the ERC remains *"to reinforce the excellence, dynamism and creativity of European research"*.

The analysis has been carried out by ERCEA largely based on data from the ERC statistical database taking into account the calls from 2007 to 2013 under FP7 and from 2014 until 19 September 2016 under Horizon 2020.

A.1.2. Objectives and intervention logic

The main role of the ERC is to provide attractive and flexible funding to enable talented and creative individual researchers and their teams to pursue the most promising avenues at the frontier of science, on the basis of Union-wide competition.

A critical feature of the ERC is its autonomy with scientific strategy in the hands of an independent Scientific Council. The FP7 legislation therefore established only the very broad parameters of the ERC's objectives, and the Scientific Council of the ERC first met in October 2005 before the final legislative decisions on FP7, in order to *"develop an imaginative and well thought out strategy for the ERC in advance of its operations and enable a rapid and efficient start-up."* The members agreed that *"research across all fields should be pursued, with lean and non-bureaucratic procedures and flexible grants, and via a peer review process of the very highest quality standard."* They also agreed on *"the importance of adopting an investigator-driven approach, encouraging excellent and innovative frontier research, and giving a real opportunity to young researchers and new teams, by means of competition at a European scale."*[6]

The fundamental activity of the ERC would be to provide attractive, long-term funding to support excellent Principal Investigators (PIs) and their research teams to pursue ground-breaking, high-gain/high-risk research. The evaluation of ERC grant applications would be conducted by a structure of peer review panels composed of renowned scientists and scholars selected by the ERC Scientific Council, on the sole criterion of the scientific excellence of the proposals.

Primary panel structure and description

[6] *ERC Scientific Council inaugural meeting, October 2005:* *http://erc.europa.eu/sites/default/files/press_release/files/erc_statement_2005_scc_inaugural_meeting_19_october_en_0.pdf*

ERC Work Programme 2017

Physical Sciences & Engineering

PE1 Mathematics
All areas of mathematics, pure and applied, plus mathematical foundations of computer science, mathematical physics and statistics.

PE2 Fundamental Constituents of Matter
Particle, nuclear, plasma, atomic, molecular, gas, and optical physics.

PE3 Condensed Matter Physics
Structure, electronic properties, fluids, nanosciences, biophysics.

PE4 Physical and Analytical Chemical Sciences
Analytical chemistry, chemical theory, physical chemistry/chemical physics.

PE5 Synthetic Chemistry and Materials
Materials synthesis, structure-properties relations, functional and advanced materials, molecular architecture, organic chemistry.

PE6 Computer Science and Informatics
Informatics and information systems, computer science, scientific computing, intelligent systems.

PE7 Systems and Communication Engineering
Electrical, electronic, communication, optical and systems engineering.

PE8 Products and Processes Engineering
Product design, process design and control, construction methods, civil engineering, energy processes, material engineering.

PE9 Universe Sciences
Astro-physics/chemistry/biology; solar system; stellar, galactic and extragalactic astronomy, planetary systems, cosmology, space science, instrumentation.

PE10 Earth System Science
Physical geography, geology, geophysics, atmospheric sciences, oceanography, climatology, cryology, ecology, global environmental change, biogeochemical cycles, natural resources management.

Life Sciences

LS1 Molecular and Structural Biology and Biochemistry
Molecular synthesis, modification and interaction, biochemistry, biophysics, structural biology, metabolism, signal transduction.

LS2 Genetics, Genomics, Bioinformatics and Systems Biology
Molecular and population genetics, genomics, transcriptomics, proteomics, metabolomics, bioinformatics, computational biology, biostatistics, biological modelling and simulation, systems biology, genetic epidemiology.

LS3 Cellular and Developmental Biology
Cell biology, cell physiology, signal transduction, organogenesis, developmental genetics, pattern formation in plants and animals, stem cell biology.

LS4 Physiology, Pathophysiology and Endocrinology
Organ physiology, pathophysiology, endocrinology, metabolism, ageing, tumorigenesis, cardiovascular disease, metabolic syndrome.

LS5 Neurosciences and Neural Disorders
Neurobiology, neuroanatomy, neurophysiology, neurochemistry, neuropharmacology, neuroimaging, systems neuroscience, neurological and psychiatric disorders.

LS6 Immunity and Infection
The immune system and related disorders, infectious agents and diseases, prevention and treatment of infection.

LS7 Diagnostics, Therapies, Applied Medical Technology and Public Health

Aetiology, diagnosis and treatment of disease, public health, epidemiology, pharmacology, clinical medicine, regenerative medicine, medical ethics.
LS8 Evolutionary, Population and Environmental Biology
Evolution, ecology, animal behaviour, population biology, biodiversity, biogeography, marine biology, microbial ecology.
LS9 Applied Life Sciences and Non-Medical Biotechnology
Applied plant and animal sciences; food sciences; forestry; industrial, environmental and non-medical biotechnologies, nanobiotechnology, bioengineering; synthetic and chemical biology; biomimetics; bioremediation.

Social Sciences & Humanities
SH1 Individuals, Markets and Organisations
Economics, finance and management.
SH2 Institutions, Values, Environment and Space
Political science, law, sustainability science, geography, regional studies and planning.
SH3 The Social World, Diversity, Population
Sociology, social psychology, demography, education, communication.
SH4 The Human Mind and Its Complexity
Cognitive science, psychology, linguistics, philosophy of mind.
SH5 Cultures and Cultural Production
Literature, philology, cultural studies, anthropology, study of the arts, philosophy.
SH6 The Study of the Human Past
Archaeology and history.

The Scientific Council initially devised two main funding schemes and the associated evaluation processes. ERC Advanced Grants would provide substantial time and resources to established scientists and scholars to pursue frontier research of their choice. These grants were intended to encourage new and unconventional approaches and to promote substantial advances in the frontiers of knowledge.

ERC Starting Grants would address the perceived lack of opportunities for young researchers in Europe to become independent research leaders in their own right and develop their own new ideas. This structural problem was leading to a dramatic waste of research talent in Europe by forcing some highly talented researchers at an early stage of their career to seek advancement elsewhere, either in other professions or as researchers outside Europe. The Scientific Council considered that while some small scale efforts had already been made to address this issue, that the ERC would be much better placed to put in place a large scale, consistent effort to make a real impact on the issue.

Over the course of FP7 three further grant schemes were devised by the ERC Scientific Council and implemented by the ERC leading to a coherent portfolio: Starting Grants, Consolidator Grants, Advanced Grants, Synergy Grants and Proof of Concept. Calls for four of these grants have continued into Horizon 2020 and the reintroduction of the Synergy Grant is envisaged for 2018.

- **Starting Grants (StG)** are designed to support outstanding researchers at the early stage of their careers (2-7 years of post-doctoral research experience) by enabling them to develop an independent research career and to establish their own research team or programme in Europe. The scheme provides funds of up to EUR2 million for a period of up to 5 years. This investment in research careers at their early stages is expected to foster the next generation of research leaders in Europe.

- **Consolidator Grants (CoG)** are designed to support researchers at the stage of consolidating their independent careers in Europe and to help them strengthen their recently created research teams or programmes (7-12 years of post-doctoral research experience). This grant scheme was established in 2013 by splitting up the initial StG scheme (which originally covered all researchers with a post-doctoral research experience of 2-12 years) as a way of addressing the large disparities in research experience among the applicants for the initial StG scheme, as well as an increasing problem of oversubscription. The scheme provides funds of up to EUR2.75 million for a maximum period of 5 years.

- **Advanced Grants (AdG)** are designed to support established and outstanding scientists (with an excellent scientific track record of at least 10 years) in performing transformative, high-risk, and often unconventional and cross-disciplinary research that opens new directions in their scientific fields and expands the frontiers of scientific and technological knowledge. This scheme provides funding of up to EUR3.5 million for a maximum period of 5 years.

- **Synergy Grants (SyG)** was a pilot scheme in 2012 and 2013 to support small teams of scientists (two to four principal investigators and their research teams), who wish to jointly address research problems at the frontiers of knowledge by bringing together complementary expertise, knowledge and resources. It is increasingly recognised that for complex scientific problems, collaboration between different researchers and their teams, often on an interdisciplinary basis and using shared facilities, can lead to outstanding new ideas and unexpected discoveries. The scheme provides funds of up to EUR15 million for a period of up to 6 years.

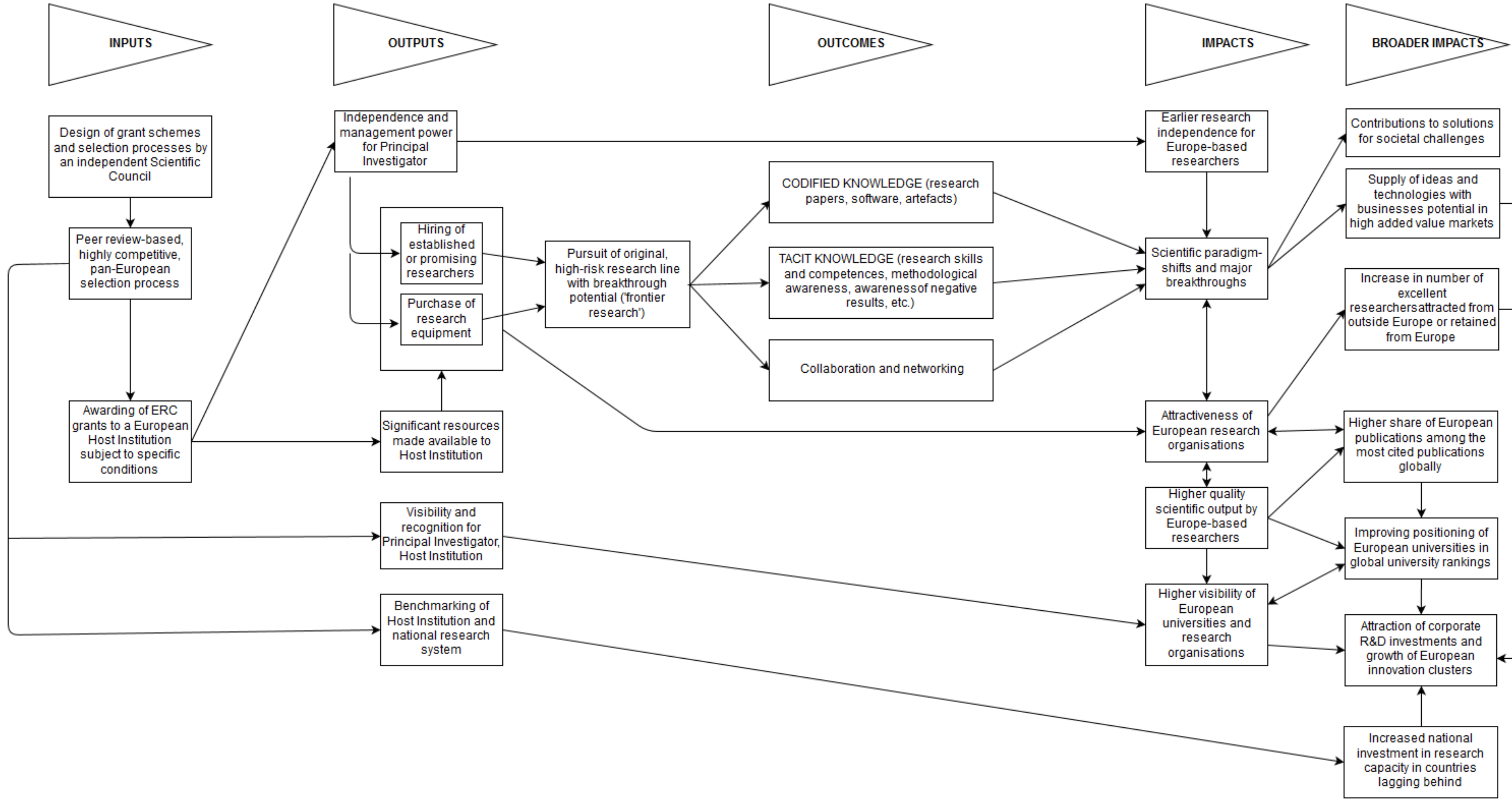
Proof of Concept (PoC) is a grant scheme launched in 2011 with the aim to explore the commercial and social potential of ideas arising from ERC grants. This scheme provides existing ERC grantees with additional funding of up to EUR150 000 for a maximum period of 18 months, which can cover activities such as establishing intellectual property rights, mapping out commercial and business opportunities, and technical validation.

Figure 1 provides an overview of the ERC's expected impacts and intervention logic.

The core of the intervention lies in the peer review-based selection process and the features of the grants awarded, both designed by an independent Scientific Council to be simple and flexible. The selection process is highly competitive, based on the sole criterion of excellence, organised on a pan-European scale and fully bottom-up in terms of research areas and project objectives. The grants awarded are long-term, generous and awarded only to host institutions that commit to provide the selected Principal Investigator with the conditions to independently manage the funding.

These two core features of the funding scheme are instrumental in order to achieve the effects as shown in Figure 1. Some effects such as the visibility and recognition of the Principal Investigator and the Host Institution, or the benchmarking of universities and research systems, result directly from the proposal selection and grant awarding process. Other effects result from the research activities being supported, and from the nature of the projects selected, which are about high risk/high gain, original research with substantial breakthrough potential, termed 'frontier research'.

Figure 1 - Schematic intervention logic of the European Research Council



Source: ERCEA.

A.2. IMPLEMENTATION STATE OF PLAY

A.2.1. Overview of programme inputs and activities

From the start of Horizon 2020 up until 19 September 2016 the ERC has launched ten, and completed eight calls for proposals for its main frontier research grants (StG, CoG and AdG), receiving a total of 20 252 applications and awarding 2 555 grants in the completed calls. There were also three calls launched and finalised for the Proof of Concept top-up scheme.

Table 1 - Applications and funded projects for completed ERC calls for the programming period 2014-2016 (Horizon 2020)

Call	Total number of applications	of which		
		evaluated	selected	success rate
Starting Grant 2014	3 273	3 204	375	11.7
Starting Grant 2015	2 920	2 862	349	12.2
Starting Grant 2016	2 935	2 881	374	13.0
Starting Grant total	**9 128**	**8 947**	**1 098**	**12.3**
Consolidator Grant 2014	2 528	2 485	371	14.9
Consolidator Grant 2015	2 051	2 023	303	15.0
Consolidator Grant 2016	2 305	2 274	314	13.8
Consolidator Grant total	**6 884**	**6 782**	**988**	**14.6**
Advanced Grant 2014	2 287	2 250	192	8.5
Advanced Grant 2015	1 953	1 927	277	14.4
Advanced Grant total	**4 240**	**4 177**	**469**	**11.2**
Proof of Concept 2014	442	426	121	28.4
Proof of Concept 2015	339	323	160	49.5
Proof of Concept 2016	437	405	133	32.8
Proof of Concept total	**1 218**	**1 154**	**414**	**35.9**

Source: ERC Statistical Database.

Under FP7 a total of 4 354 StG, CoG and AdG projects were funded (4 556 projects altogether - see Table 2 below with 3 062 of these projects still running as of 1 September 2016).

Table 2 - Applications and funded projects for completed ERC calls for the programming period 2007-2013 (FP7)

Call	Total number of applications	of which		
		evaluated	selected	success rate
Starting Grant 2007-2013	26 693	25 858	2 332	9.0
Consolidator Grant 2013	3 673	3 604	313	8.7
Advanced Grant 2008-2013	12 756	12 404	1 709	13.9
Proof of Concept 2011-2013	586	538	178	36.9
Synergy Grant 2012-2013	1 159	1 124	24	2.1

Source: ERC Statistical Database.

The EC contribution allocated to the completed calls as of 1 January 2017 has been EUR *4.695* billion, about 37% of total expected budget allocated to ERC in Horizon 2020, which is EUR *12.559* billion for the period 2014-2020. Through the Horizon 2020 Work Programmes 2014-2016, each call was allocated a share of the overall budget as indicated in Table 3 below.

Table 3 - Allocated share of budget dedicated to ERC calls for the programming period 2014-2016 (Horizon 2020)

Call year and call	Requested grant EUR (evaluated proposals)	% of annual requested grant	Awarded grant EUR (selected projects)	% of annual awarded grant	Success rate in terms of budget (%)
2014	**14,528,993,432**		**1,725,609,905**		
StG2014	4,507,692,462	31.0	550,054,161	31.9	12.2
CoG2014	4,645,201,886	32.0	707,926,792	41.0	15.2
AdG2014	5,313,118,983	36.6	449,636,770	26.1	8.5
PoC2014	62,980,101	0.4	17,992,183	1.0	28.6
2015	**12,566,107,073**		**1,771,352,487**		
StG2015	4,112,997,778	32.7	512,978,891	29.0	12.5
CoG2015	3,832,402,645	30.5	586,134,962	33.1	15.3
AdG2015	4,572,571,327	36.4	648,330,731	36.6	14.2
PoC2015	48,135,323	0.4	23,907,903	1.3	49.7
2016	**14,370,600,631**		**1,197,943,164**		
StG2016	4,195,989,431	29.2	559,346,652	46.7	13.3
CoG2016	4,385,457,095	30.5	618,717,843	51.6	14.1
*AdG2016**	*5,729,494,699*	*39.9*			
PoC2016	59,659,406	0.4	19,878,669	1.7	33.3
Total	**41,465,701,136**		**4,694,905,556**		
*) evaluation still in progress					

Source: ERC Statistical Database.

A.2.2. Participation patterns

A.2.2.1. Participation by type of organisation and by host institution.

The ERC supports individual Principal Investigators (PIs) and their teams selected on the sole basis of scientific quality. Grants are awarded to the host institution with the explicit commitment that this institution offers appropriate conditions for the PI to independently manage the ERC funded research.

Table 4 - Distribution of ERC grants by host institution (top institutions) 2014-2016 (Horizon 2020)

Country	Higher-Education Institution	StG	CoG	AdG	Total
UK	University of Cambridge	23	28	15	66
UK	University of Oxford	22	25	14	61
UK	University College London	13	19	12	44
UK	University of Edinburgh	14	13	11	38
IL	Tel Aviv University	26	9	2	37
DK	University of Copenhagen	14	18	3	35
NL	University of Amsterdam	22	11	2	35
CH	Swiss Federal Institute of Technology Lausanne	9	13	11	33
IL	Hebrew University of Jerusalem	15	12	4	31
CH	Swiss Federal Institute of Technology Zurich	15	4	11	30
NL	Delft University of Technology	14	10	5	29
IL	Weizmann Institute	12	13	4	29
NL	Utrecht University	10	14	2	26
UK	Imperial College	11	12	1	24
DE	University of Munich (LMU)	16	4	3	23
FI	University of Helsinki	9	8	3	20
BE	University of Leuven	9	6	5	20
Country	**Research Organisation**	**StG**	**CoG**	**AdG**	**Total**
FR	National Centre for Scientific Research (CNRS)	56	68	17	141
DE	Max Planck Society	41	18	18	77
DE	Helmholtz Association of German Research Centres	17	23	4	44
FR	National Institute of Health and Medical Research	12	14	5	31
ES	Spanish National Research Council (CSIC)	6	15	4	25

Source: ERC Statistical Database. Based on StG 2014-2016, CoG 2014-2016, AdG 2014-2015. Current signatories of the grant agreement taken into account as of 14/12/2016.

In Horizon 2020 ERC grants have been awarded to 533 host institutions in the completed calls so far. The large majority of ERC grants are awarded to PIs hosted by higher education establishments (HES, 73%) and research organisations (REC, 25.1%). 1.4% of ERC grants were hosted by private for profit companies (PRC). Table 4 above shows the host institutions with the highest number of ERC funded PIs in Horizon 2020 so far.

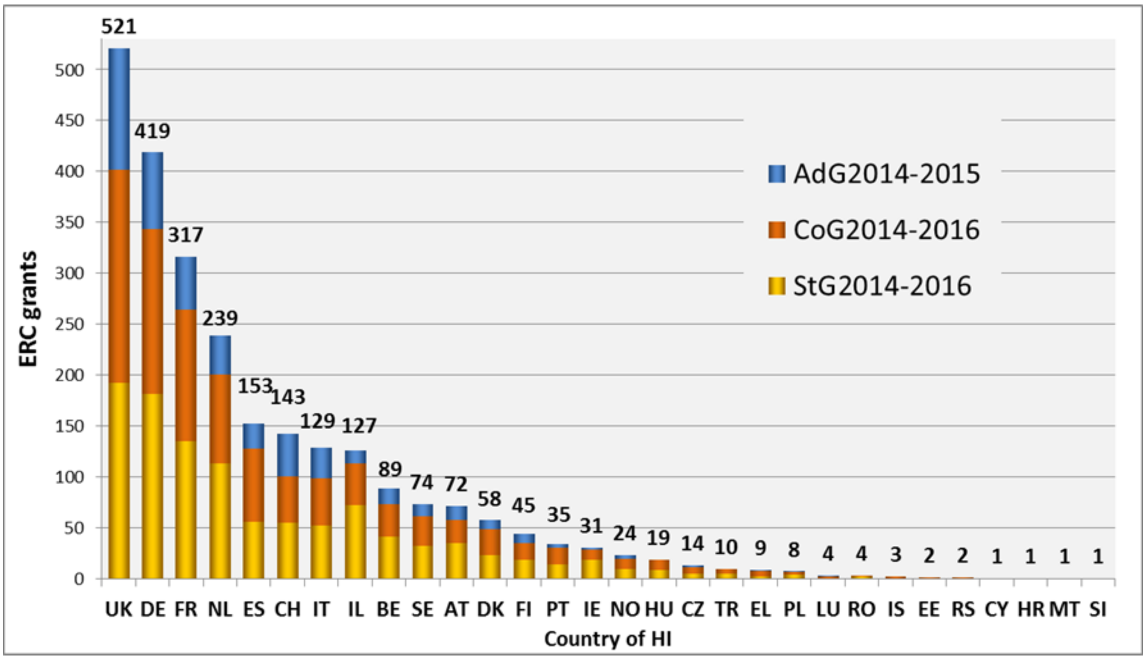
A.2.2.2. Attraction of new participants

162 new Host Institutions signed or were invited to sign grant agreements with ERC in Horizon 2020 compared to FP7 (or 30% of all Horizon 2020 grant signatories). At the same time 87% of the 2 555 Principal Investigators that have received ERC grants in Horizon 2020, were not ERC grantees in FP7. Overall 70% of the Principal Investigators applying to ERC in Horizon 2020 did not apply to ERC during FP7.

A.2.2.3. Geographical participation patterns

The distribution of the main ERC grants for the completed calls under Horizon 2020 by country of host institution is shown in Figure 2 below.

Figure 2 - Distribution of ERC grants by country of host institution 2014-2016 (Horizon 2020)



Source: ERC Statistical Database.

Researchers based in UK have received the highest number of the grants in Horizon 2020 so far, as in the FP7 calls. Altogether UK, Germany and France have received 49% of the grants in Horizon 2020 (the same share as in FP7). However, these are the largest countries by population and size of economy out of the EU Member States and Associated Countries with the highest gross expenditures on research and development (GERD).

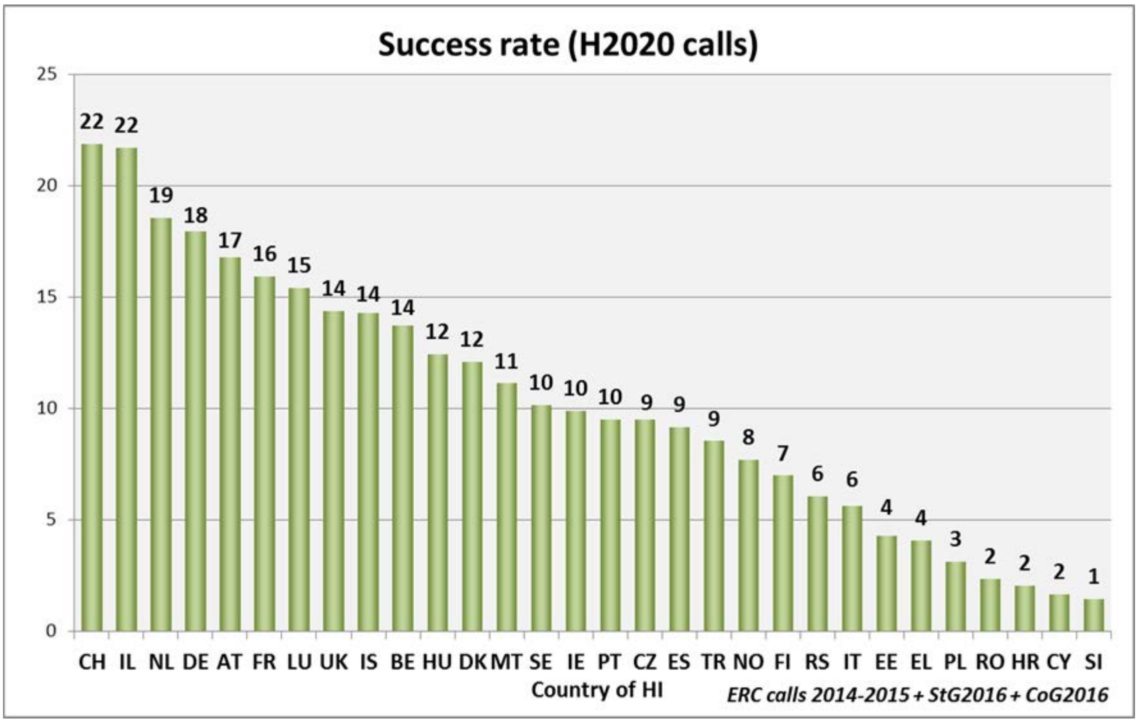
On a normalised basis, since 2007 researchers based in Switzerland, Israel, Netherlands, Denmark, Sweden, UK, Austria, Belgium, Finland, Ireland, France, Iceland, Norway and Germany have received a higher share of ERC grants than their host country's share of the population of all countries hosting an ERC grantee. Researchers based in all other countries have received a lower share of ERC grants than their host country's share of overall population.

Since 2007 researchers based in Cyprus, Netherlands, UK, Israel, Hungary, Switzerland, Greece, Portugal, Spain, Ireland and Belgium have received a higher share of ERC grants than their host country's share of the GERD of all countries hosting an ERC grantee.

Researchers based in all other countries have received a lower share of ERC grants than their host country's share of overall GERD[7].

Overall, the geographical distribution of ERC grants is similar to the one under FP7 (for which a detailed breakdown by country, region and host institution is available[8]). The top ten countries are the same with the first four in the same order and some minor changes in the order of the next six countries which have similar numbers of grants.

Figure 3 - Success rate in ERC calls by country of host institution 2014-2016 (Horizon 2020)



Source: ERC Statistical Database.

Researchers based in Switzerland, Israel, Netherlands, Germany and Austria have the highest success rates in the Horizon 2020 calls so far – see Figure 3 above. In FP7, researchers based in Switzerland, Israel, France, Netherlands and UK had the highest success rates. Overall researchers based in Iceland, Turkey and the Czech Republic have seen the largest increases to their success rates between FP7 and Horizon 2020. Researchers based in Portugal, Hungary, Slovenia, Ireland and Poland have also seen their success rates increase by more than 50%.

A.2.3. Cross-cutting issues

A.2.3.1. Distribution of ERC grants by gender

There are fewer applications from female than male researchers for ERC grants. As Table 5 below shows, female applicants represent 32% of all applicants under the StG and the CoG schemes, and as few as 15% of all applicants under the AdG scheme.

[7] *ERCEA calculations based on ERC Statistical Database and Eurostat figures for population (2015) and GERD (2014).*

[8] ERC funding activities 2007-2013: Key facts, patterns and trends, *ERCEA 2015* https://erc.europa.eu/sites/default/files/publication/files/ERC_funding_activities_2007_2013.pdf

Overall the success rate of women to the ERC calls under Horizon 2020 is 1% lower than men but this varies by scientific domain and call type and women have been more successful than men in the PE domain and the Consolidator Grant calls.

Table 5 - Distribution of ERC grants by gender 2014-2016 (Horizon 2020)

Success rates by domain and gender									
Domain	**Evaluated**			**Selected**			**Success rate**		
	Female	**Male**	**All**	**Female**	**Male**	**All**	**Female**	**Male**	**All**
LS	2,035	4,160	6,195	239	627	866	12%	15%	14%
PE	1,685	7,407	9,092	230	925	1,155	14%	12%	13%
SH	1,898	2,721	4,619	219	315	534	12%	12%	12%
All domains	**5,618**	**14,288**	**19,906**	**688**	**1,867**	**2,555**	**12%**	**13%**	**13%**
Success rates by call and gender									
Call	**Evaluated**			**Selected**			**Success rate**		
	Female	**Male**	**All**	**Female**	**Male**	**All**	**Female**	**Male**	**All**
StG2014-2016	3,079	5,868	8,947	333	765	1,098	11%	13%	12%
CoG2014-2016	1,902	4,880	6,782	284	704	988	15%	14%	15%
AdG2014-2015	637	3,540	4,177	71	398	469	11%	11%	11%
All calls	**5,618**	**14,288**	**19,906**	**688**	**1,867**	**2,555**	**12%**	**13%**	**13%**

Success rates by domain and gender									
Domain	**Evaluated**			**Selected**			**Success rate**		
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All calls	**5,618**	**14,288**	**19,906**	**688**	**1,867**	**2,555**	**12%**	**13%**	**13%**

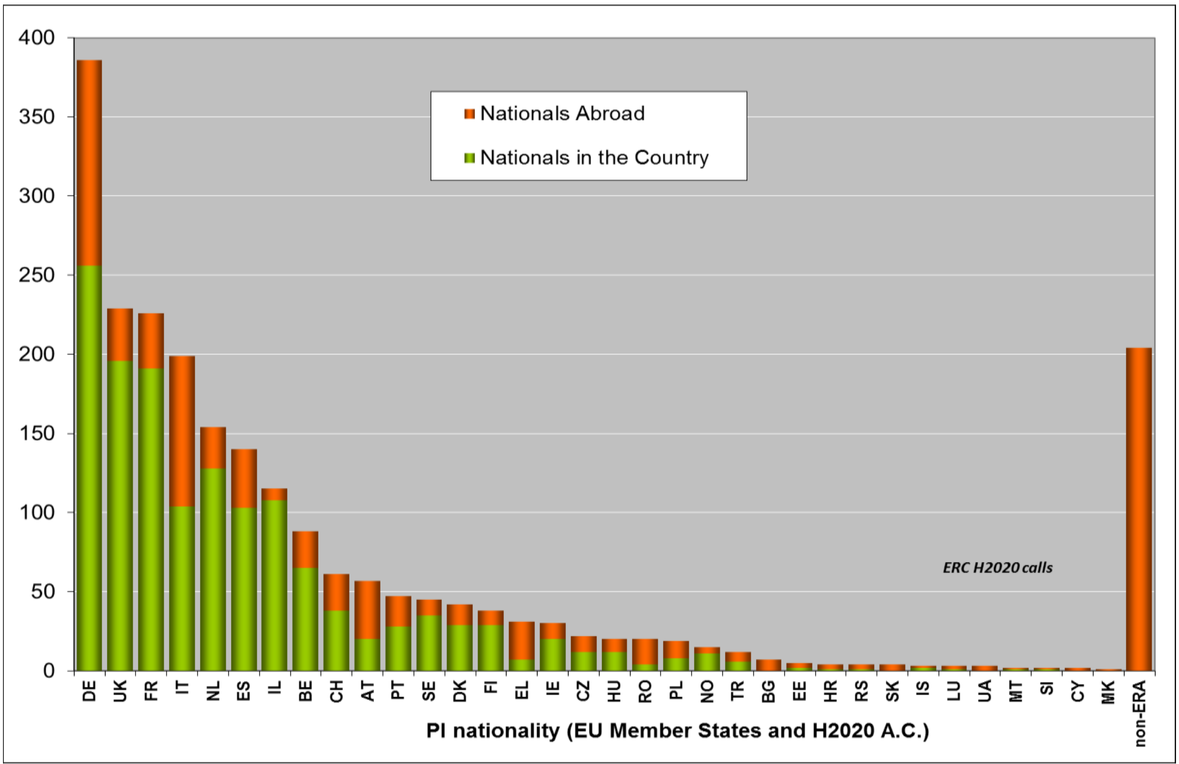
Source: ERC Statistical Database.

A.2.3.2. Distribution of ERC grants by nationality

ERC grants are open to researchers of any nationality who may reside in any country in the world at the time of the application. However the host institution must be established in an EU Member State or Associated Country.

For several countries there are more nationals with an ERC grant outside the country than inside the country. This is the case for Austria, Greece, Poland, Cyprus, Estonia, Luxembourg, Romania, Croatia, Bulgaria, Serbia, Slovakia, Macedonia (FYROM) and Ukraine. The countries with the most nationals abroad in absolute numbers are Germany (146) and Italy (118).

Figure 4 - Distribution of ERC grants by nationality of the principal investigator 2014-2016 (Horizon 2020)



Source: ERC Statistical Database.

In the completed calls so far under Horizon 2020, 1 696 researchers with a nationality not of an EU Member State or Associated Country have applied to the ERC's calls. 226 were successful and received ERC grants. The proportion of ERC grantees with non-ERA nationality is about 9% (compared to 7% in FP7). However many of these were already based in Europe at the time of application. Altogether since 2007, the proportion of ERC grantees that were resident outside ERA at time of application is about 2.7% (most being ERA nationals in US at the time of application).

Table 6 - Distribution of ERC grants to principal investigators based outside the EU or AC at the time of application 2014-2016 (Horizon 2020)

Country of residence	International grantees	EU/AC nationals	Total
Argentina	1		1
Australia	1	6	7
Canada	3	5	8
China		1	1
India	1	1	2
Japan		2	2
Korea		1	1

Country of residence	International grantees	EU/AC nationals	Total
Lebanon		1	1
Malaysia		1	1
Pakistan		1	1
Russia	1		1
Senegal		1	1
USA	43	113	156
Total	**50**	**133**	**183**

Source: ERC Statistical Database.

A.2.3.3. Distribution of ERC grants to third countries

It is expected that ERC funded research projects will be implemented within the territory of the Member States or Associated Countries. This does not exclude field work or other research activities in cases where these must necessarily be conducted outside the European Union or the Associated Countries in order to achieve the scientific objectives of the project/activity.

It is also expected that the host institution will be the only participating legal entity. However, where they bring scientific added value to the project, additional team members may be hosted by additional legal entities which will be eligible for funding, and which may be legal entities established anywhere, including outside the European Union or Associated Countries, or international organisations. Legal entities established outside the European Union or Associated Countries shall be eligible for funding provided that their participation is deemed essential for carrying out the action. On this basis during FP7, EUR 9.6 million was contributed to beneficiaries in third countries.

A.2.3.4. Distribution of ERC grants by scientific domain

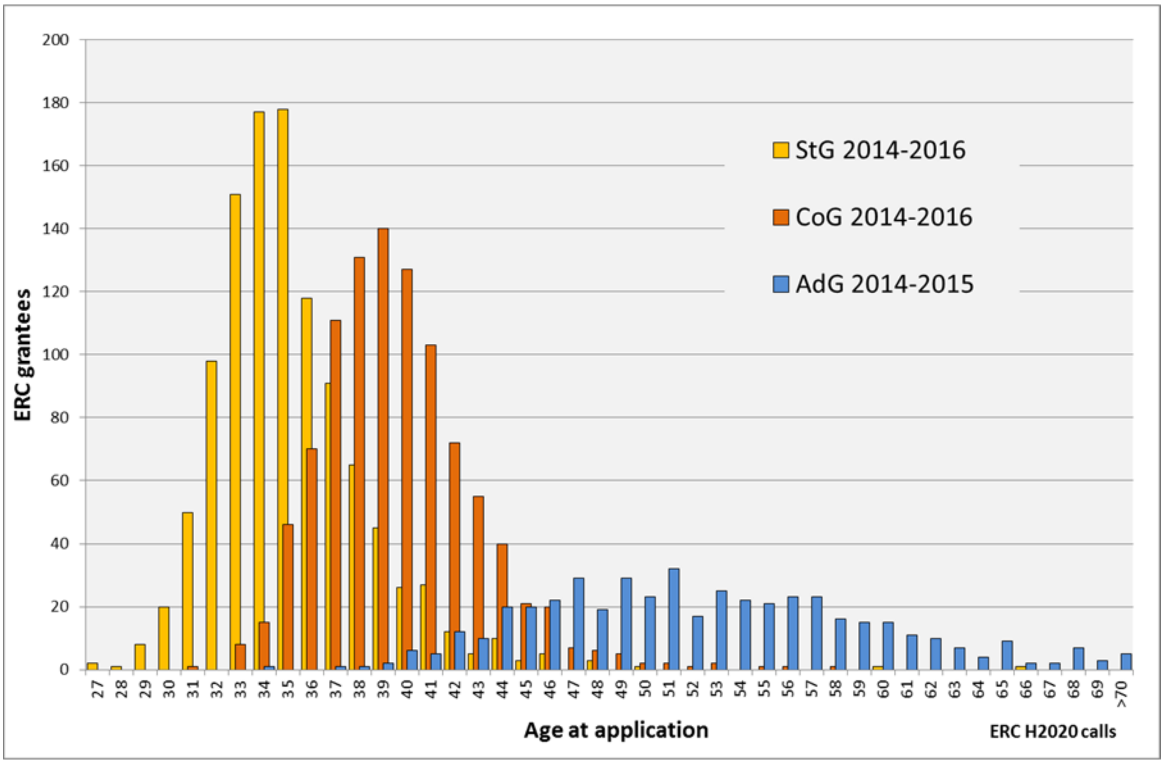
The ERC's frontier research grants operate on a 'bottom-up' basis without predetermined priorities. Applications may be made in any field of research, including the social sciences and humanities. The evaluation of ERC grant applications is conducted by 25 peer review panels. For the Starting, Consolidator and Advanced Grant calls an indicative budget is allocated to each panel in proportion to the budgetary demand of its assigned proposals.

Overall in the eight completed frontier research grant calls so far, 1 155 grants (45%) were awarded in the physical sciences and engineering domain, 866 (34%) in the life sciences domain and 534 (21%) in the social sciences and humanities domain.

A.2.3.5. Distribution of ERC grants by age

Independent researchers of any age and career stage can apply for attractive long-term funding. Figure 5 below shows the distribution of grants to PIs by age at the time of application. This reflects the conscious decision of the Scientific Council to prioritise the Starting and Consolidator grants in order to address the lack of opportunities for young researchers in Europe to become independent research leaders in their own right and develop their own new ideas. The average age of Principal Investigators at the time of application is: 35 years for Starting; 40 years for Consolidator; and 52 years for Advanced grantees.

Figure 5 - Distribution of ERC grants by age of the principal investigator at the time of application 2014-2016 (Horizon 2020)



Source: ERC Statistical Database.

A.2.4. Other issues related to the state of implementation

The results of AdG2016 will be known in April 2017.

A.3. RELEVANCE

A.3.1. Is ERC tackling the right issues?

The ERC was set up with a very ambitious overall objective to reinforce the excellence, dynamism and creativity of European research. The continuing relevance of the ERC's intervention logic must therefore be determined with reference to the latest policy thinking as well as the evolving global research landscape and the characteristics of the European research system, in particular the public sector research system.

There has been considerable debate in academic and policy circles over many decades over the right "policy mix" to support research and innovation. However in this debate there is a broad consensus that government needs to support the knowledge infrastructure of universities and research institutions that are central to innovation systems and in practice very little business expenditure on R&D (BERD) is financed by governments (the OECD average is 7.1%).

Frontier research is predominantly carried out in the public sector research base as, *"while the relationship between science and innovation is complex, public investment in scientific research is widely recognised as an essential feature of effective national innovation systems. Public research plays a key role in innovation systems by providing* *new knowledge and pushing the knowledge frontier. Universities and public research institutions often undertake longer-term, higher-risk research and complement the activities of the private sector. Although the volume of public R&D is less than 30% of the total OECD R&D, universities and PRIs perform more than three-quarters of total basic research."*[9] Industry also recognises that government support for basic research is a critical component of the ecosystem for innovation[10].

The OECD's own latest Innovation Strategy calls on governments to *"Think long-term: Many of the key technologies driving growth today, including the Internet, mobile telephony and genomics, would not have been possible without public funding of long-term research. Yet this investment is now declining in many OECD countries as they engage in fiscal consolidation and focus more on short-term benefits. Innovation policies must look to the long term to answer major challenges like climate change and ageing."*[11]

There are many other roles that governments can and do play in the overall innovation eco-system but the ERC is fulfilling at EU level one of the few roles that is widely seen as indispensable for governments to play.

A.3.1.1. ERC relevance to challenges facing the European research system

The global research landscape is evolving dramatically and becoming increasingly multipolar as a result of a growing number of emerging countries, in particular China, expanding their scientific production. So whereas the EU and the United States accounted for nearly two-thirds of world expenditure on research and development in 2000, this share had fallen to less than half by 2013.

Similarly, the share of scientific publications with authors in the EU and US fell from 33.7% and 28.2% respectively in 2000 to 27.3% and 19.1% in 2013[12]. In the 2016 Shanghai university rankings based on several indicators of academic or research performance, China substantially increased its number of universities in the top 500 (from 16 in 2004 to 54 in 2016), Japan (36 to 16) and the US (170 to 137) fell behind, while Europe (209 to 204) remained stable[13].

In the last decade then, the geographical distribution of knowledge production has changed significantly. In particular China has increased its share of world publications from 6% to 19.5% between 2000 and 2013 overtaking the US.

The fact that the EU has managed to maintain its position as the leading area in terms of the number of scientific publications is therefore positive. However despite, *"a growing number of impressive developments at the frontier of science in Europe and an improving situation of the EU worldwide, indicators of most excellence science show that Europe is not top of the rankings in certain areas."*[14]

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[9] *Chapter 5, The OECD Innovation Strategy - 2015 revision.* http://www.oecd.org/sti/innovation-imperative.htm
[10] *Business Leaders Agree: Federal Funding of Basic Research Advances Prosperity, Security & Well-Being* http://www.annenbergpublicpolicycenter.org/business-leaders-agree-u-s-funding-of-basic-research-advances-prosperity-security-well-being/
[11] *The OECD Innovation Strategy - 2015 revision.* http://www.oecd.org/sti/innovation-imperative.htm
[12] *Science Research and Innovation performance of the EU, 2016.*
[13] http://www.shanghairanking.com/ARWU2016.html
[14] *Science Research and Innovation performance of the EU, 2016.*

For example, 2.3% of publications with a US author are in the top 1% most highly cited in the world as against 1.7% of publications with an EU author. *"Comparing the EU-28, USA, and China at the global level shows a top-level dynamics that is different from the analysis in terms of shares of publications: the United States remains far more productive in the top-1% of all papers; China drops out of the competition for elite status; and the EU-28 increased its share among the top-cited papers from 2000-2010."*[15] *"The US is also more specialised in most strategic areas such as nanosciences and nanotechnologies, ICT, materials and biotechnology."*[16]

A 2016 analysis which looked at the contribution of China, France, Germany, Japan, UK and USA to 180 "hot and emerging research fronts" showed that *"the USA is far ahead of the other five countries"*. The USA has 106 research fronts (~60%) in which the number of core papers with US affiliation ranks 1st, China has 30, the UK 14, Germany and Japan both have 11, and France 8[17].

There are around 3 000 higher education institutions (HEIs) and many research performing organisations (PROs) in Europe. Of these, around half of the HEIs can be considered "research active", around 850 award doctorates and a smaller sub-group of 171 can be considered "research intensive" based on their publication output. Of the PROs, 150 have more than 50 research staff and this group includes very large national institutions such as the CNRS in France, the Helmhotz Association and Max Planck Institutes in Germany, CNR in Italy and CSIC in Spain as well as large parts of the Science Academies in Central and Eastern Europe[18]. In 2012, in the EU-28 there were around 665 000 full time equivalent researchers in the higher education sector and 200 000 researchers in the government sector[19].

By contrast in the US only around 300 out of over 4 000 HEIs award doctorates and federal research funding is heavily concentrated on the most research intensive of these institutions. In 2014, 76% of federal research expenditure for HEIs went to the 108 HEIs classified as "very high research" under the Carnegie classification[20]. In 2012 there were also many fewer researchers in the US public sector (around 400 000) than in the EU even though the expenditure on public sector research is very similar in the EU and US (EUR 104 bn in the EU and EUR 101 bn in the US in 2014[21]).

In the 2016 Leiden rankings (based on the proportion of a university's publications that, compared with other publications in the same field and in the same year, belong to the top 10% most frequently cited) the US has 58 universities in the top 100 while the EU has 30 (with another seven from Switzerland and Israel combined). However only two EU universities are in the top 25 (US has 19) and seven in the top 50 (US has 38). Furthermore, all seven of the EU universities in the top 50 are UK universities and altogether 17 of the 30 EU universities in the top 100 are from the UK with another seven from the Netherlands[22].

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[15] *The European Union, China, and the United States in the Top-1% and Top-10% Layers of Most-Frequently-Cited Publications: Competition and Collaborations, Leydesdorff, Wagner, and Bornmann, 2014.*
[16] *Science Research and Innovation performance of the EU, 2016.*
[17] http://stateofinnovation.thomsonreuters.com/research-fronts-2016-the-hottest-areas-in-science
[18] *Analysis of public sector research institutions in Europe comes from Innovation Union Competiveness Report 2011 Part II Chapter 1.*
[19] *OECD Main Science and Technology Indicators Volume 2013/2.*
[20] *National Science Board Science and Engineering Indicators 2016.*
[21] *Eurostat data on GERD in million euro by sector of performance.*
[22] http://www.leidenranking.com/

There are also important differences which persist between European countries in terms of scientific output. Scientific quality is concentrated in a group of leading countries predominantly in North-West Europe while Southern, Eastern and Baltic countries still rank at the bottom despite some progress in recent years. And while, *"...all the Mediterranean countries and some Eastern and Baltic countries, such as Slovenia, Estonia and Slovakia, are actively catching up, countries such as Poland, Romania and Croatia, which are well below the EU average in terms of scientific quality, have only slightly improved their performance. Moreover, worrisome trends can be observed in Bulgaria and Latvia, the last two countries in the ranking, where the ratio of highly cited scientific publications out of the total number of publications has stagnated between 2000 and 2010."*[23]

This shows that the EU's public sector research system is large and diverse and remains the largest producer of knowledge in the world. However, on average each public sector researcher in the EU has fewer resources, produces fewer publications, and produces less well cited publications than their US counterparts. The EU is essentially a "mass producer" of knowledge with, relative to its size, comparatively few centres of excellence that standout at the world level and with large areas of average and poor performance.

A.3.1.2. ERC relevance to European policy objectives

The first priority of the current Commission is to strengthen Europe's competitiveness and to stimulate investment for the purpose of job creation. And it is now well accepted that technological progress is the critical factor in driving sustained growth in per capita income thanks to intensive study by economists, starting with Robert Solow (who won a Nobel Prize for this work), as well as luminaries such as Ken Arrow, Zvi Griliches, and many others.

Sustained growth in per capita income requires more than incremental improvements in current technologies and knowledge. It requires new knowledge that will create whole new sectors and industries to provide high quality jobs, and drive future productivity and growth. It is essential to lay the foundations for creating the jobs of tomorrow. The foundations of the digital revolution which is still reverberating through our economies were laid over many decades of frontier research overwhelmingly carried out in the public sector[24].

ERC aims to become a key part of Europe's innovation eco-system from which this progress emerges. Allowing researchers the freedom to explore ideas at the frontiers of knowledge as the ERC does is proven to be the best way to generate radical breakthroughs[25]. In this regard the ERC is set up on similar principles to funding bodies such as the Max Planck Society in Germany, the UK Research Councils and the US National Science Foundation. ERC projects should produce a substantial number of the most significant and high impact research findings worldwide leading to breakthroughs and major advances.

The special role of ERC funding was acknowledged during the adoption process for the Investment Plan for Europe where ERC did not receive any reduction in its funding from

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[23] *Science Research and Innovation performance of the EU, 2016.*
[24] *European competitiveness in information technology and long-term scientific performance, Bonaccorsi 2011.*
[25] *Incentives and Creativity: Evidence from the Academic Life Sciences, Azoulay et al, October 2009.*

the levels agreed in the Horizon 2020 legislation along with the Marie Sklodowska-Curie and widening participation actions.

In June 2015 the Commissioner for Research, Science and Innovation gave his assessment of the challenges facing Europe and his objectives and his priorities summarised as: Open Innovation; Open Science; Open World.

The ERC funds "frontier research" in recognition that, *"classical distinctions between basic and applied research have lost much of their relevance at a time when many emerging areas of science and technology (e.g. biotechnology, ICT, materials and nanotechnology, and cognitive sciences) often embrace substantial elements of both."* Frontier research often generates unexpected or new opportunities for commercial or societal application from the immediate term to the very long term providing one of the main pathways to disruptive innovation.

ERC directly addresses the Commissioner's second strategic objective by aiming to boost excellence in cutting-edge, fundamental research. The ERC also supports the principle of open access to the published output of research, including in particular, peer-reviewed publications as a fundamental part of its mission. It also supports the basic principle of open access to research data and data related products such as computer code. ERC also considers that it is essential to maintain and promote a culture of research integrity at all stages of the evaluation and granting process to make ERC competitions fair and efficient and to maintain the trust of both the scientific community and society as a whole.

One of the aims of the ERC is to confer status and visibility on the best research leaders working in Europe and offer attractive funding conditions which help to attract and retain outstanding researchers to the ERA. The ERC actions are open to researchers of any nationality who intend to conduct their research activity in any Member State or Associated Country.

A.3.2. Flexibility to adapt to new scientific and socio-economic developments

Before the start of FP7 a clear rationale, hierarchy of objectives and set of principles for implementation had been articulated for the new ERC. Over the course of FP7 and Horizon 2020, these basic principles remained the same with a focus on simple and flexible processes. However the Scientific Council, which is fully responsible for the development of scientific strategy and work programmes, peer review processes, project selection and funding, and communications, has been able to monitor, modify and tailor the programme through the ERC's annual Work Programme.

Changes introduced included the creation and fine tuning of five specific grant schemes (Starting, Advanced, Proof of Concept, Synergy and Consolidator Grants as well as the option of Co-Investigator projects), the creation of 25 panels covering all of science and the humanities, varied approaches to addressing interdisciplinarity, reallocation of budgets across grants, demand management though restrictions on submissions and ongoing guidance to the panels on the evaluation criteria. Policies on open access, gender balance, innovation and relations with industry, internationalisation, widening participation and research misconduct have also been introduced and in some cases supported through dedicated actions.

The bottom-up nature of ERC funding is also designed to channel funds into new and highly promising research areas, and capitalise on the diversity of European research talent with a speed, agility and focus not always possible within some national funding systems or with top-down programmes which by necessity need sufficient lead-in time to prepare.

Preliminary analysis by the ERCEA shows that the ERC is reinforcing key fronts of research. This analysis was based on an independent study by the Chinese Academy of Sciences and Clarivate Analytics which comprehensively analysed over 12 000 research fronts and identified 20 key hot research fronts and eight key emerging research fronts[26]. As of November 2016, ERC funded grantees were working in 25 out of these 28 key research fronts which are listed below and which show the breadth and depth of ERC funded frontier research.

The key hot research fronts where ERC grantees are working are:

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

[26] http://stateofinnovation.thomsonreuters.com/research-fronts-2016-the-hottest-areas-in-science

17. The internet of things, cloud manufacturing and related information technology services;

18. Research on measurement-device-independent quantum key distribution;

19. DEA (Data Envelopment Analysis) based assessment of environmental and energy efficiency.

The only key hot area where no ERC funded research could be identified was "Impact and effects of U.S. health care reforms".

The key emerging research fronts (whose core papers dated on average to the second half of 2014 or more recently) where ERC grantees are working are:

1. Effects of systemic insecticides (neonicotinoids and fipronil) on non- target organisms and environment;
2. Elemental composition of the North Atlantic Ocean and Southern Ocean;
3. Principles of chromatin looping and evolution of chromosomal domain architecture;
4. Research fronts on perovskite (Organolead trihalide perovskite single crystals with long carrier diffusion lengths; Methylammonium lead iodide perovskite degradation by water; Lead halide perovskites luminescent nanomaterials; Organolead trihalide perovskite photodetectors; The origin of high-performance in perovskite solar cells);
5. Experimental realization of fractional Chern insulators;
6. Studies of Comet 67P/Churyumov-Gerasimenko by Rosetta.

The only two key emerging areas where no ERC funded research could be identified were "Programmed death 1 (PD-1) inhibitors for the treatment of advanced non-small-cell lung cancer" which is a research area which has already reached the stage of going to clinical trials and "Energy management strategies of hybrid electric bus", an area where only papers by Chinese authors were present.

The results of this preliminary analysis will be further developed in future to ascertain the contribution of ERC grantees to the "core papers" associated with these research fronts.

Another example of this type of agility is the rapid take-up by ERC grantees of CRISPR-based (**C**lustered **R**egularly **I**nterspaced **S**hort **P**alindromic **R**epeats) technology. Since the seminal papers by Emmanuelle Charpentier and Jennifer Doudna in 2012 and Feng Zhang in 2013, there are already as of December 2016, 53 ERC grants (some still under negotiation) that mention CRISPR at least once in the title, abstract, free keywords or acronym of the proposal.

The first two grants to use CRISPR were funded in the 2013 Starting Grant call (the closing date of the call was October 2012). One of these two grants was ANTIVIRNA "Structural and mechanistic studies of RNA-guided and RNA-targeting antiviral defence pathways", by Dr Martin Jinek, who was the first author on the 2012 Science paper with Emmanuelle Charpentier and Jennifer Doudna.

A.3.3. Addressing specific stakeholder needs

The ERC was set up in 2007 following a long campaign by the European scientific community for a simple science driven funding mechanism at EU level[27]. The European scientific community has subsequently been a consistent and vocal supporter of the ERC.

The Scientific Council has also consistently taken the lead on the key issues affecting European science such as open access[28], gender balance[29], widening participation to the ERC's calls[30] and research integrity[31]. For example, in December 2006 the ERC Scientific Council issued its first statement on open access long before any grant was awarded. This statement was followed a year later by specific guidelines stating that all peer-reviewed publications from ERC funded projects should be made openly accessible shortly after their publication. In October 2012, the ERC issued the first strategy on scientific misconduct at the European level[32].

A prerequisite for achieving the aims of the ERC to fund the best frontier research was to establish a pan-European competition between the best researchers working in Europe. According to the Analytical Evaluation of the IDEAS Specific Programme which was carried out by Andrea Bonaccorsi as part of the ex-post evaluation of FP7[33]. *"Excellent ideas do not emerge from a vacuum, but from epistemic communities that engage themselves in the search for solutions, compare systematically their results, and compete for discoveries and recognition. In particular, good ideas emerge from a scientific environment in which selection rules are clear, are maintained in the long run, and enforce competition. Competition is an essential element of the scientific life, inextricably linked to cooperation and openness."*

Achieving this could by no means be taken for granted. When the ERC was created in 2007, it entered a relatively complex research funding landscape, consisting of a web of institutions which support research at the international, European, national and regional levels. It can be assumed that leading researchers were already familiar with and were able to get funding from those existing institutions. However already in 2009 an independent Review of the European Research Council's Structures and Mechanisms found that *"…overall, that ERC has succeeded beyond expectations in attracting outstanding scientists across Europe and abroad to serve on its panels and received thousands of applications which were all well reviewed despite the difficulties inherent in setting up such a complex endeavour in such a short time."*[34] The competition for ERC grants has been intense. The success rate in ERC competitions averages 11.8% and ERC

[27] *The European Research Council—A European Renaissance, May 2004*
http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.0020161
[28] *Open Access Guidelines for research results funded by the ERC*
https://erc.europa.eu/sites/default/files/document/file/ERC_Open_Access_Guidelines-revised_feb_2016.pdf
[29] *ERC Scientific Council Gender equality plan 2014-2020*
https://erc.europa.eu/sites/default/files/content/pages/pdf/ERC_ScC_Gender_Equality_Plan_2014-2020.pdf
[30] *ERC sets guidelines for national and regional fellowships to visit ERC projects*
https://erc.europa.eu/sites/default/files/press_release/files/ERC_Highlight_Fellowship_Viiting_Guidelines.pdf
[31] *ERC Scientific Misconduct Strategy, October 2012*
https://erc.europa.eu/sites/default/files/document/file/ERC_Scientific_misconduct_strategy.pdf
[32] http://www.nature.com/naturejobs/science/articles/10.1038/nj7421-573b
[33] http://ec.europa.eu/research/evaluations/pdf/archive/fp7-ex-post_evaluation/ideas_final.pdf#view=fit&pagemode=none
[34] https://erc.europa.eu/sites/default/files/content/pages/pdf/final_report_230709.pdf

success rates are well below those of other comparable funding organisations[35] despite significant steps taken by the ERC Scientific Council to manage demand.

The Scientific Council continues to monitor the ERC's activities closely and believes that there is a strong demand for a simple, bottom-up instrument to support collaboration between Europe's top scientists and will therefore reintroduce in 2018 the Synergy Grant which was piloted in 2012 and 2013. The results of the 2015 assessment of the Synergy Grant pilot were that the Synergy grant scheme would be a valuable addition to the current ERC frontier schemes by supporting highly ambitious research goals that cannot be achieved by a single PI. The projects funded during the pilot phase showed a much closer level of collaboration than under a regular EU framework programme collaborative project. Some achieved high international recognition putting European research on the global map, often in a leading position and showed signs of creating new fields.

Evidence for the continued support of stakeholders can be seen in the responses to the public consultation for the Horizon 2020 interim evaluation.

"In recent years, the European Research Council (ERC) has become a European "brand name" for excellence in basic and pioneering research. ERC grants are the European yardstick for global scientific excellence and tangibly promote regional competition in Europe – thereby strengthening Europe's competitiveness as a whole. This makes the ERC irreplaceable and justifies the demand to preserve its future funding at the very least at current levels. " Resolution on the development of EU research and innovation funding on the occasion of the interim evaluation of Horizon 2020 and other EU funding programmes - German Rectors' Conference (HRK), December 2016.

"The creation of the European Research Council (ERC) has attracted global attention and is held in high esteem. The ERC is and should remain a cornerstone of the European Research and Innovation Framework programme." Interim Evaluation of Horizon 2020 - LERU, October 2016.

"In Horizon 2020 and its successor programmes, EU actions should play a role that cannot be played at national level. Examples of clear European added value include the European Research Council's (ERC) role in fostering Europe-wide competition… Science Europe strongly supports the ERC and its role in strengthening competition in research at European level while also helping to achieve and sustain research excellence. As shown by the analysis carried out by the ERC Executive Agency, the funding of curiosity-driven 'High-Risk High-Gain' research delivers significantly above-average scientific impact. It also provides benefits to society, development of policies and the economy." The Framework Programme that Europe Needs – Science Europe, October 2016.

"We should further promote European added-value of R&I programmes, which is achieved by promoting collaborative instruments in balance with other instruments. Single participant instruments such as the ERC and the SME Instrument have become larger than ever under Horizon2020 … the European excellence labelling by ERC is well

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[35] *For example, NSF receives approximately 40 000 proposals each year for research, education and training projects, of which approximately 11 000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships.* https://www.nsf.gov/funding/aboutfunding.jsp

recognised and clearly adds value as great EU benchmark ...". First Thinking Forward for FP9 - EARTO, September 2016.

The common interest of the newly created Guild of European Research Universities, according to University of Vienna Rector Heinz Engl, is the continuation of EU research programmes, especially the ERC[36].

A.3.4. Lessons learnt/Areas for improvement

The ERC's independent Scientific Council has been able to set up from scratch a respected peer review system, to adapt the programme flexibly as the need arises including the introduction of measures to manage demand and has also consistently taken the lead on key issues affecting European science such as open access, gender balance, widening participation to the ERC's calls and research integrity. The European scientific community which first campaigned for a simple science driven funding mechanism at EU level has been a consistent and vocal supporter of the ERC and remains so as can be seen in the responses to the public consultation for the Horizon 2020 interim evaluation.

In policy terms there is now a broad consensus that government needs to support the knowledge infrastructure of universities and research institutions that are central to innovation systems.

The EU's public sector research system is large and diverse and remains the largest producer of knowledge in the world but indicators related to the excellence and frontier nature of research still show significant weaknesses and on average each public sector researcher in the EU has fewer resources, produces fewer publications, and produces less well cited publications than their US counterparts. Given the rapidly evolving nature of the global research system and the remaining weaknesses in the European research system compared to other major research systems the ERC's original rationale and objectives remain valid.

ERC aims to become a key part of Europe's innovation eco-system which is the foundation for strengthening Europe's competitiveness and to stimulate investment for the purpose of job creation. Strengthening Europe's science base is therefore a precondition for achieving many of the EU's key policy objectives.

The bottom-up nature of ERC funding has also already allowed to channel funds into new and highly promising research areas as it was designed to do.

A.4. EFFECTIVENESS

A.4.1. Short-term outputs from the programme

In the completed calls so far under Horizon 2020 the ERC has evaluated 19 906 applications. Considering FP7 and Horizon 2020 together, there have been over 60 000 applications from 44 175 distinct PIs (28% have applied more than once) equivalent to less than 5% of EU public sector researchers[37]. The ERC Scientific Council introduced measures to manage demand in both 2009 and 2014 (see section *A.5.2 Programme's attractiveness* below). In Horizon 2020 ERC has awarded 2 555 frontier research grants

[36] http://science.apa.at/rubrik/bildung/Forschungsintensive_Unis_in_Europa_vernetzen_sich/SCI_20161117_SCI833059066

[37] *In 2014 there were nearly 900 000 non-business sector researchers in the EU28 (OECD Main S&T Indicators).*

to PIs in its main calls with another 4 354 awarded in FP7. Therefore since 2007 the ERC has awarded grants to considerably less than 1% of the EU's public sector researchers.

When assessing the effectiveness of the ERC it is important to state from the outset that the large majority of all the ERC grants awarded since 2007 are still running (around 5 400 are still running out of nearly 7 000 awarded) and it will be many years before the results and final impact of these projects are known.

However, the ERC has set up several systems for continuously monitoring the outputs and outcomes of the projects and a considerable body of evidence has already emerged on the output and effectiveness of the projects which is summarised below.

One feature of the ERC is that, given its bottom-up nature and the essential continuity of its funding practices since 2007, there is no substantive distinction between the projects funded between 2007-2013 (FP7) and those funded since 2014 (Horizon 2020) and therefore outputs and outcomes of the former provide valid insights on the impact of the ERC under Horizon 2020.

The ERC will also continue to monitor the outputs and outcomes of the projects in the long-term such as impacts on careers or citations to publications, even after particular projects have been completed in order to fully capture the impact of frontier research.

The direct output of the ERC is the frontier science that it funds. The publication of the results of research is an essential part of the scientific method. Scientific publications report the findings of original experimental and theoretical work in appropriate scientific journals. The dissemination of results is therefore an integral part of the scientific endeavour.

The ERC uses complementary sources to carefully track the publications produced by its funded projects. Firstly the ERC records the publications reported by the Principal Investigators during the scientific reporting of their projects. It can also track publications from institutional repositories via OpenAire[38] and publications which acknowledge its funding or which can be linked to its projects from the large commercial bibliographic databases including Web of Science and Scopus. Taken together these sources can be used to produce reliable datasets of publications funded by the ERC. Knowing the individual PIs that it funds is essential for the ERC to be able to accurately carry out this tracking process.

Based on just reported publications, nearly 95 000 papers from ERC projects have been published in international, peer reviewed journals as of November 2016. All of these projects were funded under FP7.

As mentioned earlier, the vast majority of the ERC grants are still on-going, however if one takes only the 314 completed ERC projects from the earliest calls for proposals (187 projects from StG2007 and 127 projects from AdG2008), they have reported 10 796 publications[39]. This gives an overall average of 34 publications per project but with marked differences between fields and projects. Projects in Life Sciences have on

[38] https://www.openaire.eu/
[39] *Only those publications which were validated by a digital object identifier (DOI) and identified in the Scopus database are counted. This represents about 80% of all publications which have been reported. The Scopus database maintained by Elsevier covers around 51 million records from 22 000 peer-reviewed journals "in the fields of science, technology, medicine, social sciences, and arts and humanities" going back to 1995.*

average 23 publications, Physical Sciences and Engineering 48, and Social Sciences and Humanities 18.

If this average were to be maintained, then the roughly 14 000 PIs expected to be funded by the ERC under FP7 and Horizon 2020 combined will eventually produce around 475 000 publications altogether. These publications would be produced over many years from 2007 to 2025 and beyond. To give a rough indication of the scale of this output it is about the same as the publications of all the researchers in China in 2014 (480 782 in Scopus) and is higher than the output of every EU country bar France, Germany, Italy, Spain and UK over the period 2000-2011 (full counting Scopus[40]).

The number of publications by itself does not guarantee quality or impact but empirically there is a very strong correlation between scientific productivity and impact. For example in the period 2000-2010, 98% of the authors in the Scopus database that were in the top 10% for the number of highly cited publications produced were also in the top 10% for the overall number of publications produced[41]. And for high-impact scientists, productivity increases almost threefold during their career, whereas the increase is modest for low-impact scientists[42]. The productivity of ERC grantees is therefore a positive sign of potential future impact.

Tracking the output of social sciences and humanities projects in certain disciplines can be more difficult than for other disciplines where publications are the main method of disseminating results. However the ERC has conducted an initial analysis of the books reported by ERC grantees with an ISBN number (64% of them were reported by SH, 26% by PE and 10% by LS projects). This showed that Scopus indexes only a small proportion of the books and book chapters that ERC grantees report. For the first 617 completed projects only 115 reported books/chapters were found in Scopus, while another 740 were not in Scopus. Another 4 500 books/book chapters were reported with no ID and these will have to be checked manually.

A.4.2. Expected longer-term results from the programme

A.4.2.1. Bibliometric assessment of ERC funded research

Counting the number of times a publication is cited by other publications is widely considered to be a useful proxy for quickly assessing the potential significance or impact of a particular publication or body of publications. The ERC carries out a number of bibliometric analyses of ERC publications. In particular the ERC monitors the ERC performance indicator specified in the Horizon 2020 legislation which is the number of ERC publications among the top 1% highly cited by field, year of publication and type of publication divided by the total number of ERC publications. As of June 2016, the value of this indicator was: 7% (for the entire pool of ERC publications from all sources – reported, acknowledging ERC, OpenAire; Scopus 2016); 8% (for the publications currently reported by all ERC projects; Scopus 2016); 8% (for the publications reported by 617 completed ERC projects; Scopus 2015); and 7% (for the first 35 000 publications acknowledging ERC funding; WoS 2014). One third of all ERC grantees have already published an article that ranks in the top 1% most highly cited worldwide. These are

[40] *Country and Regional Scientific Production Profiles, Science Metrix for DG RTD 2013.*
[41] "Publishing and perishing – bibliometric profiles of individual authors worldwide" *from Science Research and Innovation performance of the EU, 2016.*
[42] "Quantifying the evolution of individual scientific impact", *Science 2016* *http://science.sciencemag.org/content/354/6312/aaf5239.full*

striking numbers given that by definition only 1% of all publications are in the top 1% most highly cited publications, 2.3% of publications with a US author are in the top 1% most highly cited in the world and 1.5% of publications with an EU author are in the top 1% most highly cited in the world.

Another proxy for quality is when publications are published in the most prestigious journals. Over 1 900 articles acknowledging ERC funding have appeared in Nature, Science and the Proceedings of the National Academy of Sciences alone. In 2014, 6.3% of all papers published in Nature and Science and 20% of the Nature and Science papers that have authors based in the EU and the Associated Countries were ERC funded publications.

A.4.2.2. Qualitative assessments of ERC funded research

In addition to quantitative measures and tracking highlights and prizes, the ERC has also undertaken qualitative assessments of the impact of ERC funded research.

The ERC has conducted an analysis of the results and outcomes of ERC research funding following a qualitative approach with a particular focus on the frontier nature of the research, and of any potential research breakthroughs and discoveries. In this evaluation, which served as a pilot exercise for the future evaluation of completed ERC-funded projects, the qualitative evaluation of 199 completed ERC-funded projects from the first two calls was undertaken by independent high-level scientists who were selected by the ERC Scientific Council[43]. Table 7 below shows the results of this evaluation. The results and the approach taken were also reported in Nature[44]. A similar type of assessment will be repeated in future for each cohort of finalised ERC projects.

Table 7 - Results of qualitative evaluation by independent experts of 199 completed ERC projects from StG2007 and AdG2008 (FP7)

A scientific breakthrough	**A**	**21%**
A major scientific advance	B	50%
An incremental scientific contribution	C	25%
No appreciable scientific contribution	D	4%

Source: ERC qualitative evaluation of projects (SAP).

A peer review evaluation of ERC funded work was also carried out as part of a wider study funded by the ERC. An initial sample of 100 ERC-funded papers was drawn from the top 1% of highly cited papers in their respective fields. Reviews were obtained from 95 experts, covering 56 of these papers. Reviewers considered 21% of the papers reviewed to have made a landmark contribution to their field, including the identification of new entities or phenomena, methodological advances in the study of a topic and the elaboration of theoretical principles. The majority of papers (61%) were considered to have made a significant contribution to science or major addition to knowledge[45].

[43] https://erc.europa.eu/sites/default/files/document/file/Qualitative_Evaluation_of_completed_projects_funded_by_the_ERC.pdf

[44] ***Europe's premier funding agency measures its impact,*** *European Research Council embarks on an unusual evaluation that could inspire others,* http://www.nature.com/news/europe-s-premier-funding-agency-measures-its-impact-1.20328

[45] https://erc.europa.eu/sites/default/files/document/file/ERC_Qual_Paper.pdf

A.4.2.3. Funding scientific breakthroughs and major advances

The ERC systematically collects information about ERC funded results which represent major advances in their respective research communities.

For example, Physics World's publishes annually the 'Top Scientific Breakthroughs'. Those are discoveries which are chosen based on the criteria of: fundamental importance of the research; significant advance in knowledge; strong connection between theory and experiment; and its general interest to all physicists. In the last 10 years, 65 discoveries have been highlighted and European researchers had contributed to 40 of them. Of this 40, ERC funding contributed to 15 of them, which represents 23% of all the highlighted discoveries and 37% of the discoveries co-authored by European researchers.

Since 2008 the list of breakthroughs by ERC grantees is in Table 8 below.

Table 8 - Physics World top scientific breakthroughs by ERC grantees

Loophole-free Bell inequality violation using electron spins separated by 1.3 kilometres	**Ronald Hanson**	**Delft University**
Evidence for a spectroscopic direct detection of reflected light from 51 Pegasi b	Jorge Martins	University of Porto
Observation of J/psi p Resonances Consistent with Pentaquark States in Lambda(0)(b) -> J/psi K(-)p Decays	-	LHCb Collaboration
Conventional superconductivity at 203 kelvin at high pressures in the sulfur hydride system	Mikhail Eremets	Max Planck Institute for Chemistry
Turbulent amplification of magnetic fields in laboratory laser-produced shock waves	Gianluca Gregori	Oxford University
Cloning of Dirac fermions in graphene superlattices	Andre Geim	University of Manchester
Signatures of Majorana Fermions in Hybrid Superconductor-Semiconductor Nanowire Devices	Leo Kouwenhoven	Delft University
Non-invasive imaging through opaque scattering layers	Allard Mosk	University of Twente
Quantum Entanglement of High Angular Momenta	Anton Zeilinger	University of Vienna
Observation of the dynamical Casimir effect in a superconducting circuit	Per Delsing	Chalmers University of Technology
Indication of Electron Neutrino Appearance from an Accelerator-produced Off-axis Muon Neutrino Beam	-	T2K Collaboration
Control of Graphene's Properties by Reversible Hydrogenation: Evidence for Graphane	Konstantin Novoselov	University of Manchester

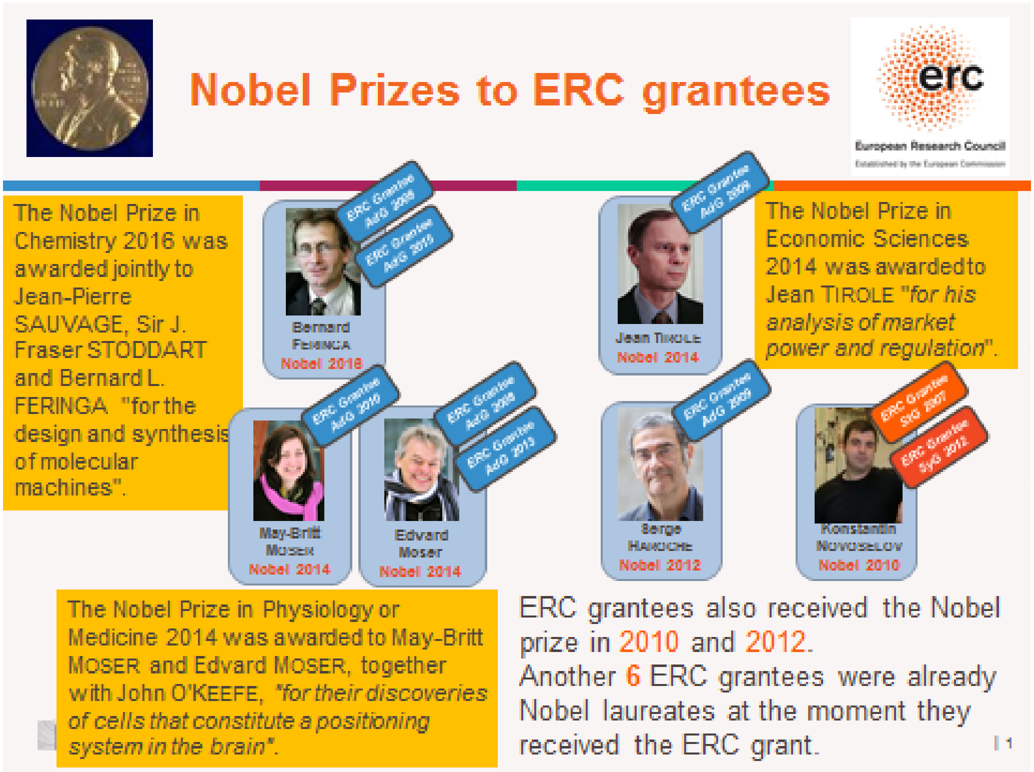
Source: ERCEA and Physics World.

The journals Nature and Science also highlight important noteworthy results from the scientific literature. They are called 'Editor's Choices' in Science and 'Research Highlights' in Nature. Out of the highlights published between 2010 and 2015 about 4% refer to papers which acknowledge ERC funding.

So far, the ERC has collected over 600 fully documented, independently selected highlights based on outstanding scientific merit from multiple authoritative sources. This approach goes beyond the approach of selecting “success stories” based on self-reporting by projects or of media coverage alone (media interest in science projects often arises because the research or researcher are local to the media source or because the science is of interest to the public regardless of its overall scientific merits). For example, the work of Kouwenhoven not only proved the existence of the “Majorana fermion” a particle theorised about since the 1930s, but thanks to the properties of these particles they could prove useful as stable “quantum bits” of information that could make quantum computers a reality.[46]

The ERC also systematically monitors the announcement of important scientific prizes to see if ERC grantees have been honoured. Six ERC grantees have been awarded the Nobel Prize and four ERC grantees have been awarded the Fields Medal after being funded by the ERC. Altogether he ERC has funded twelve Nobel laureates, five Fields Medallists and the winners of many more internationally recognised prizes. As of December 2016, 407 ERC grantees had been the recipients of 526 major prizes, awards and other forms of recognition which are recorded in the ERC Statistical Database. They are taken mainly from reporting by ERC grantees but also from public records.

Figure 6 - Nobel Prizes to ERC grantees 2007-2016 (FP7 and Horizon 2020)



Source: ERCEA based on public records.

[46] https://erc.europa.eu/sites/default/files/publication/files/erc_annual_report_2015.pdf

An analysis in 2014 of over 7 000 leading researchers in Europe found that 30% had applied to the ERC's calls and around one in six were ERC grant holders – see Figure 7.

Figure 7 - Percentage of ERC grantees in selected lists of leading researchers

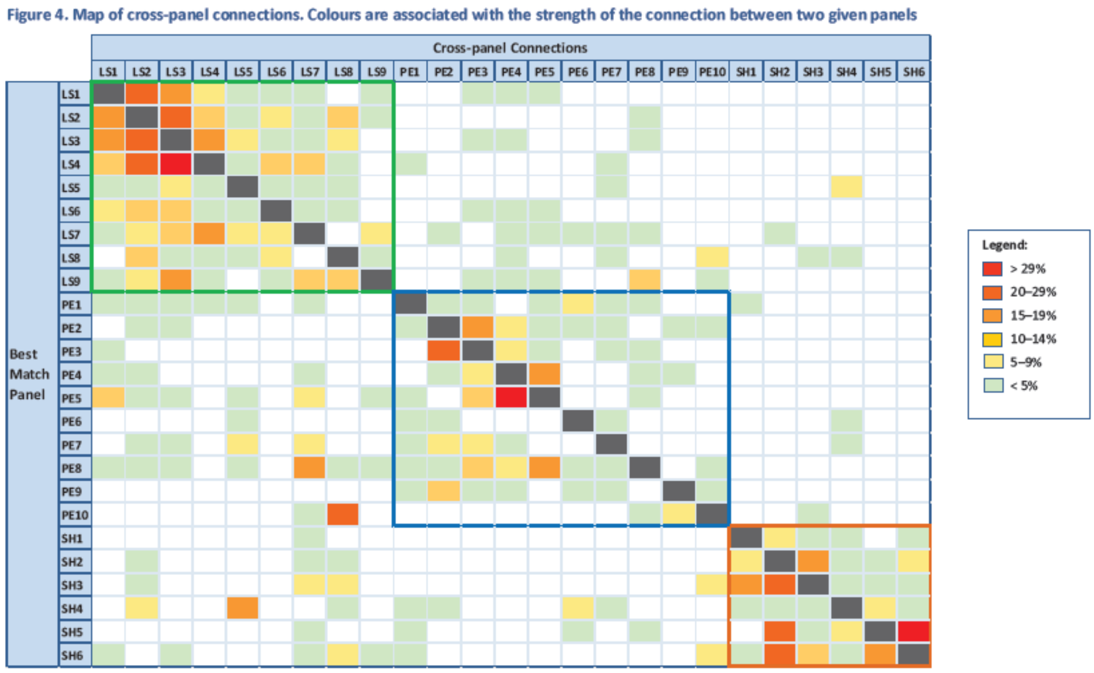
Selected lists of leading researchers	Total number of leading researchers worldwide (a)	Number of EU/AC-based leading researchers (b)	Number of EU/AC-based leading researchers that applied for an ERC grant (c)	EU/AC-based leading researchers that applied for an ERC grant % (c/b)*100	Number of EU/AC-based leading researchers that were funded by the ERC (d)	EU/AC-based leading researchers that applied to and were funded by the ERC % (d/c)*100	EU/AC-based leading researchers funded by the ERC % (d/b)*100
A) Bibliographic metrics							
Highly Cited Thompson Reuters	3 215	980	269	27%	148	55%	**15%**
B) Formal recognition by scientific community / peers in forms of prizes or awards							
US NAS Foreign Associates	424	228	53	23%	34	64%	**15%**
National Prizes	180	180	68	38%	45	66%	**25%**
Howard Hughes Scholar	25	12	7	58%	5	71%	**42%**
EMBO members	1 558	1 558	465	30%	260	56%	**17%**
C) Informal / Reputation-based recognition							
Gordon Conference Chairs	2 174	507	173	34%	70	40%	**14%**
Grand totals	**7 576**	**3 465**	**1 035**	**30%**	**562**	**54%**	**16%**

Source: ERCEA based on public records.

A.4.2.4. Fostering interdisciplinarity and new ways of working

A portfolio analysis by ERCEA of all the projects funded under FP7 (Science behind the projects[47]) showed that a significant proportion of the projects funded by the ERC cover areas of research beyond those that are within the remit of each individual evaluation panel. On average, 42% of the projects funded by any of the panels have a connection to another panel within the same or a different domain. This figure varies across the three domains: the LS domain has the highest share of funded projects with a cross-panel component (54%) and the PE domain the lowest share (31%), while the SH domain is in the middle (45%). Most of the cross-panel connections are between panels within the same domain.

Figure 8 - Cross-panel connections between ERC projects



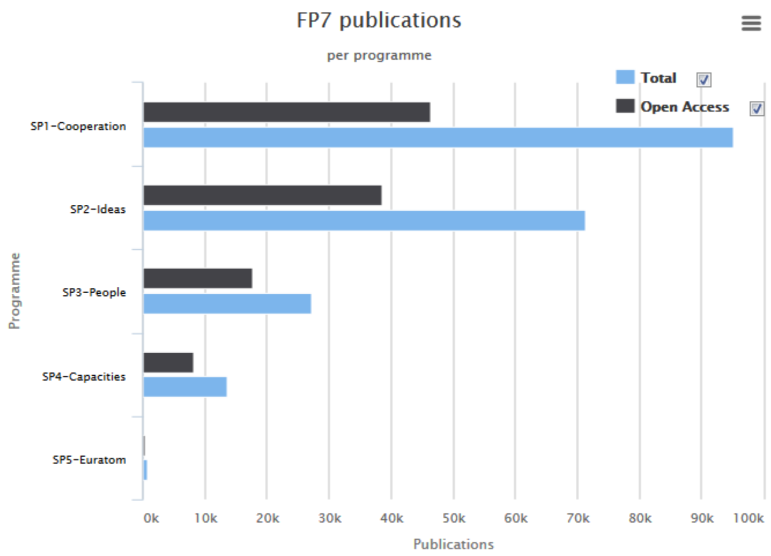
Source: ERC Science Behind the Projects, 2013.

A.4.2.5. Supporting open science

According to data from OpenAire retrieved on 28 November 2016, 38 535 out of 71 398 publications from the FP7 Ideas Programme (ERC) were open access (54%). This compared to 46 338 out of 95 136 in Cooperation (49%), 17 668 out of 27 148 for People (65%) and 8 191 out of 13 620 for Capacities (60%).

[47] https://erc.europa.eu/sites/default/files/publication/files/ERC_Science_behind_the_projects_FP7-2007-2013.pdf

Figure 9 - Share of FP7 publications in open access



Source: OpenAire, November 2016.

A.4.2.6. Supporting social sciences and humanities

The ERC funds individual researchers to carry out ambitious, long-term projects of their own choosing in any field, including the social sciences and humanities, on the sole basis of the scientific quality of the project.

For the main calls an indicative budget is allocated to each panel in proportion to the budgetary demand of its assigned proposals. In Horizon 2020 so far around 20% of the budget has gone to social sciences and humanities projects (around EUR 900 million or the equivalent of EUR 2 600 million over the course of Horizon 2020) which means that the ERC is now the main funder of social sciences and humanities at EU level.

As an illustration of the depth of the ERC portfolio, Figure 10 is a cluster diagram showing the main key words from 248 ERC projects where the term "archaeology" appears in the title, abstract or text. The details of each of the individual projects can be read along with any associated publications, highlights and awards.

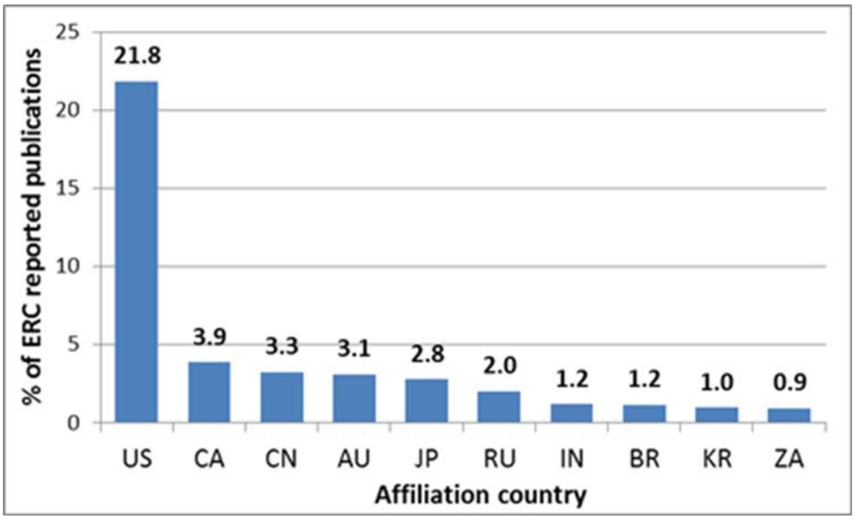
Figure 10 - Cluster diagram for ERC projects addressing archaeology 2007 – 2016 (FP7 and Horizon 2020)

Source: ERC Research Information System December 2016.

A.4.2.7. International collaboration

The share of ERC publications with international co-authorship (i.e. publications with authors from at least two institutions from different countries (EU, AC and third country) is 56%. 34% of all ERC reported publications have at least one author affiliated to an institution based in a non-ERA country. For the ERC top 1% highly-cited publications this rate is 46%. The collaboration with third countries is most intense with US-based authors: 22% of all ERC reported publications have at least one US-based author or 64% of ERC reported publications written in a non-ERA collaboration (75% if only top 1% papers are considered). This shows the highly global and collaborative nature science at the very highest level.

Figure 11 - Share of ERC reported publications with author in selected countries



Source: ERC Statistical Database, December 2016.

A.4.2.8. Impact on the careers of ERC grantees

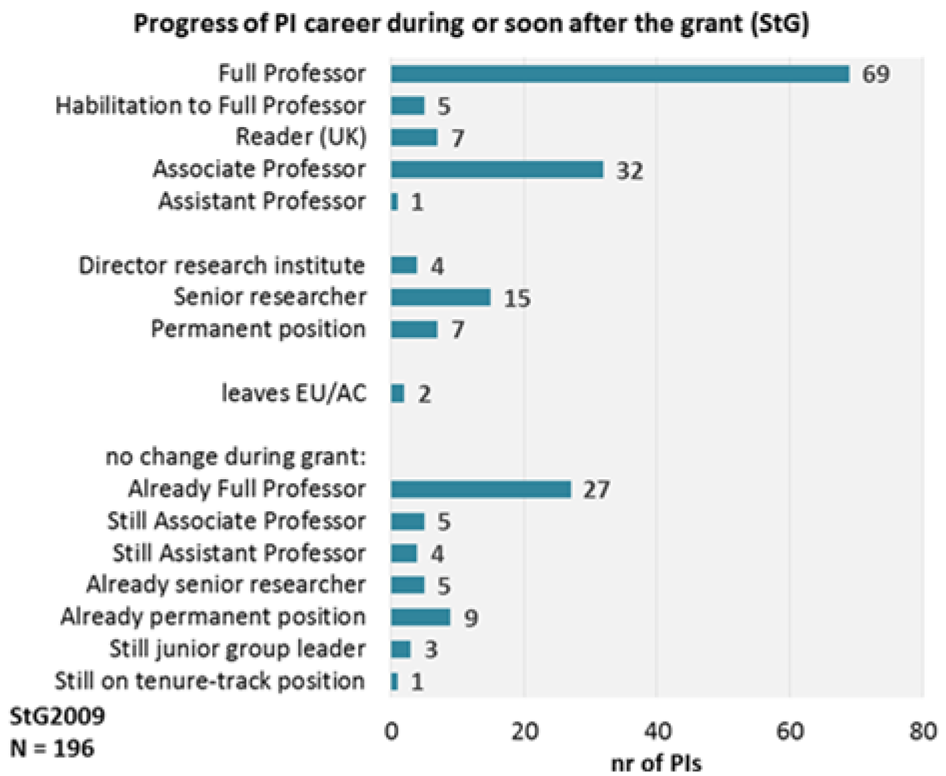
The Ex-Post Evaluation of the Seventh Framework Programme (FP7) contained evidence for the effect on researchers' careers including from a number of studies and surveys funded by the ERC.

It is only now that the first completed projects are starting to deliver their final reports.

ERC Starting grantees are outstanding researchers at the early stage of their careers on the verge of establishing an independent research career and their own research team. An analysis of 196 StG2009 projects for which the final scientific reports have been received indicated that overall 71% of the ERC Starting grantees made progress on their career path or improved their academic status as a result of the ERC project. For 29% of the Starting grantees there was no important change in the academic position during the grant, but half of them were already in a top academic position.

In terms of career path almost half of the Starting Grantees (88 PIs) obtained the positon of full professor or senior researcher during or soon after the grant. Considering that 16% of the PIs were already full professor or senior researcher at the beginning of the grant, it means that altogether 61% of the StG2009 grantees are now top academics. Over a quarter of the Starting grantees also progressed on their career path by becoming Readers and Associated professors or obtaining a permanent research position.

Figure 12 - Career changes reported by ERC Starting Grant 2009 holders

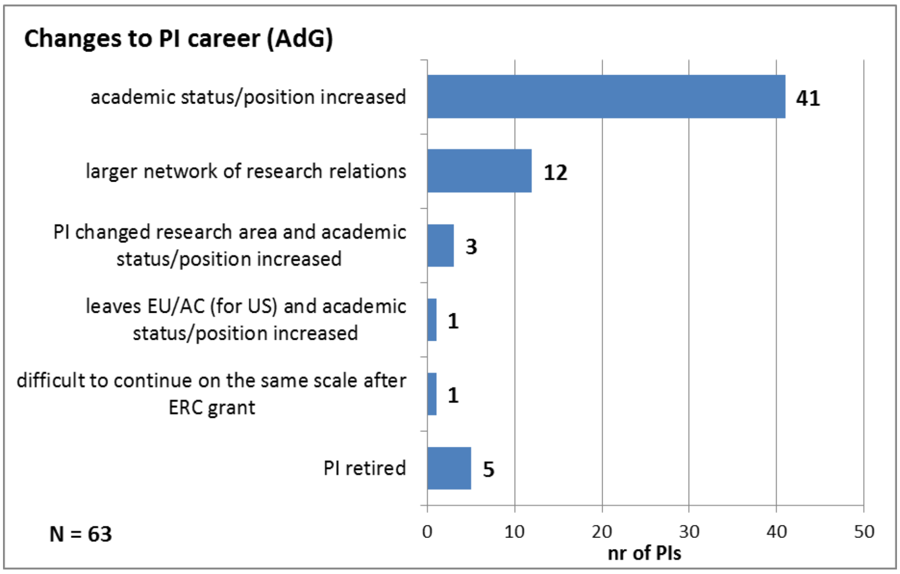


Source: ERC Statistical Database.

ERC Advanced grantees are established researches in their field that must have shown a strong scientific record in the past 10 years. Even so, an analysis of all the 236 AdG2008 projects for which the final scientific reports have been received again showed signs of impact to the career of the Principal Investigator.

45 Advanced grantees (i.e. 19%) reported an increase of their academic status or position as a result of the ERC project and other 12 grantees (5%) reported an enlargement of their research collaboration network due to the grant.

Figure 13 - Career changes reported by ERC Advanced Grant 2008 holders



Source: ERC Statistical Database.

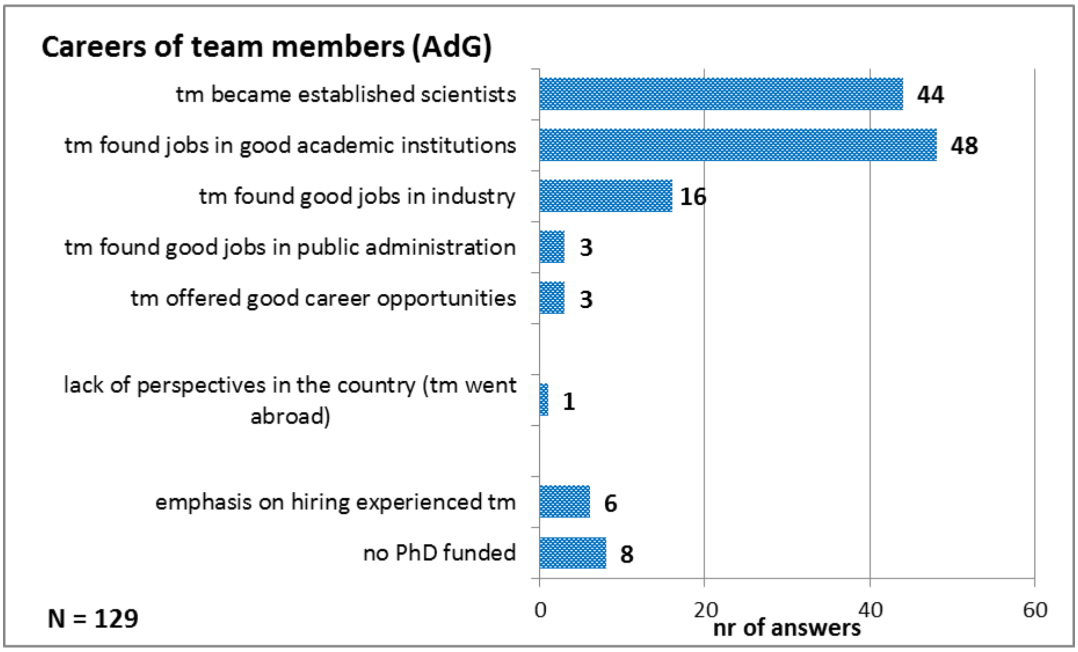
A.4.2.9. Training a new generation of researchers

In 2014 a sample of 1 901 ERC projects reported 14 218 staff in total (7.5 team members on average) of which 3 134 were PhDs (23%) and 4 650 were Postdocs (35%). From this one can extrapolate that over the course of the nearly 7 000 currently running ERC projects more than 30 000 PhDs and postdocs will be part of the teams.

Normally a significant majority of PhDs will go onto have a career outside of science[48] and this is positive for society and the economy. Indeed many studies conclude that the recruitment of skilled graduates represents the most important channel by which firms derive benefit from frontier or basic research[49]. However ERC grantees are typically exceptional scientists and the team members of ERC grantees are therefore also likely to be an exceptional population.

There is some evidence that team members on ERC projects are more likely to remain in science from the analysis of the 236 AdG2008 and 196 StG2009 projects for which the final scientific reports have been received. About half of these reports contained information about the career of the team members. In about 34% (AdG2008) / 44% (StG2009) of the projects providing this information the team members continued in science as established scientists (this refers to researchers employed on permanent or tenure-tracked positions in research institutions). In about 37% (AdG2008) / 63% (StG2009) of the projects the team members found jobs in good academic institutions either on temporary contracts, e.g. as post-doctoral researchers, or in an unspecified type of job. In about 12% (AdG2008) / 23% (StG2009) of the projects the team members found good jobs in industry after the project.

Figure 14 - Career changes by team members reported by ERC Advanced Grant 2008 holders



Source: ERC Statistical Database.

[48] *Royal Society The Scientific Century, 2010.* https://royalsociety.org/topics-policy/publications/2010/scientific-century/

[49] *The economic effects of basic research: evidence for embodied knowledge transfer via scientists' migration, Zellner, 2003.* http://www.sciencedirect.com/science/article/pii/S0048733303000805

A.4.2.10. Global visibility and prestige

By conferring status and visibility on the best research leaders working in Europe and offering attractive funding conditions the ERC aims to attract and retain outstanding researchers to the ERA. The ERC actions are open to researchers of any nationality who intend to conduct their research activity in any Member State or Associated Country.

The proportion of ERC grantees with non-ERA nationality in Horizon 2020 is about 9% (compared to 7% in FP7). However many of these were already based in Europe at the time of application. Altogether since 2007, the proportion of ERC grantees that were resident outside ERA at time of application is about 2.7% (most being ERA nationals in US at the time of application). This is not particularly surprising as while researchers tend to be very mobile early in their careers they are less likely to move at the stage when they have received tenure from their host institution which is a stage of many researchers in the ERC target population.

On the other hand, around 23% of the PhDs and post-docs in ERC teams were from outside Europe, the largest number being from China, the USA and India. This shows the potential of ERC PIs to attract talented early-stage researchers to Europe from around the world.

Another indication that ERC is viewed very positively on the global stage is that since 2012 a series of "Implementing Arrangements" have been negotiated with peer funding organisations around the world. These provide opportunities for early-career scientists supported by non-European funding agencies to temporarily join a research team run by an ERC grantee in Europe. New arrangements are being considered with more expected to be signed in 2017.

- National Science Foundation (NSF), USA (2012)
- Ministry of Science, ICT and Future Planning, Republic of Korea (2013)
- Ministry of Science, Technology and Productive Innovation, Argentina (2015)
- National Natural Science Foundation (NSFC), China (2015)
- Society for the Promotion of Science (JSPS), Japan (2015)
- National Research Foundation (NRF), South Africa (2015)
- Mexican National Council of Science and Technology (Conacyt), Mexico (2015)
- Brazilian National Council of State Funding Agencies (CONFAP), Brazil (2016)
- Canadian Tri-Agency Institutional Programmes Secretariat (TIPS), Canada (2016)

The ERC takes part alongside the Commission in the annual meetings of the Global Research Council since its inception in 2012.

The visibility of the ERC can also be traced in terms of media coverage. In 2015, the ERC was mentioned in over 7 000 articles of which over 1 500 were published in print media. In the last period monitored from 1 July 2016 to 30 September 2016 there were 2 199 media items relating to the ERC. The ERC website with more than 500 000 visitors yearly is a key communication tool. Social media are playing a growing role in the communication activities used by the ERC. More than 15 000 people and institutions follow the ERC on Facebook and close to 30 000 on Twitter. The results of each call are regularly reported in hundreds of articles across Europe and indeed the world. These often but not exclusively cover grants awarded to "local" applicants and articles frequently contrast the number of ERC grants in the country or region to the number in other countries and regions.

A.4.3. Progress towards attaining the specific objectives

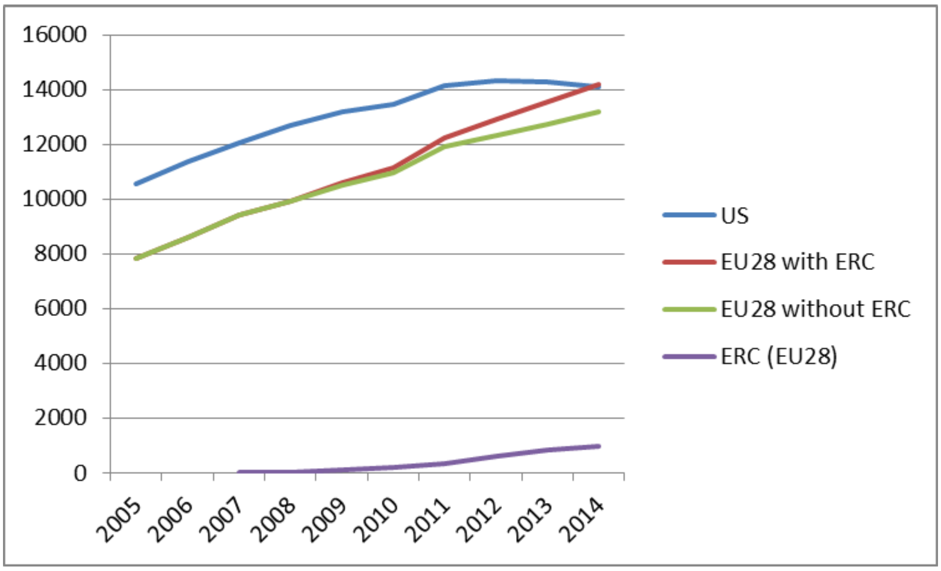
A.4.3.1. Reinforcing the excellence, dynamism and creativity of European research

Since 2007 the ERC has been able to award grants to considerably less than 1% of the EU's public sector researchers. Given this, has the ERC been able to make a measurable impact so far at the European scale? One way to measure "the excellence, dynamism and creativity of European research" is by looking at publications and the citations they attract.

During the period 2005-2014 the number of publications which are in the top 1% most highly cited in the world has grown from around 21 000 to around 35 000 of which 8 000 (38%) in 2005 and 14 000 (40%) in 2014 had an EU based author. Top 1% publications with authors based in US have also increased but not by as much and in 2014, for the first time authors based in the EU appeared on more top 1% cited publications (14 172) than authors based in US (14 093) in absolute numbers[50].

The first reported ERC publications began to appear in 2007 and since then publications acknowledging ERC funding have gone from contributing less than 0.1% of EU top 1% publications in 2007 (2) to nearly 7% in 2014 (973). The growth in the number of ERC publications in the top 1% most highly cited in the world compared to the overall number in the US and EU is shown in Figure 15 below. This shows that the scientific impact of ERC PIs is visible in the top 1% most highly cited publications even at the global level.

Figure 15 - Evolution of number of top 1% most highly cited publications 2005-2014



Source: ERC Statistical Database and Scopus.

[50] *It should be noted however that a lot higher proportion of publications with US authors are in the top 1% most highly cited (2.3% of publications with a US author as against 1.7% of publications with an EU author). Finally, it should also be noted that many top 1% publications have authors from both EU and US showing the extensive cooperation between the top scientists at world level.*

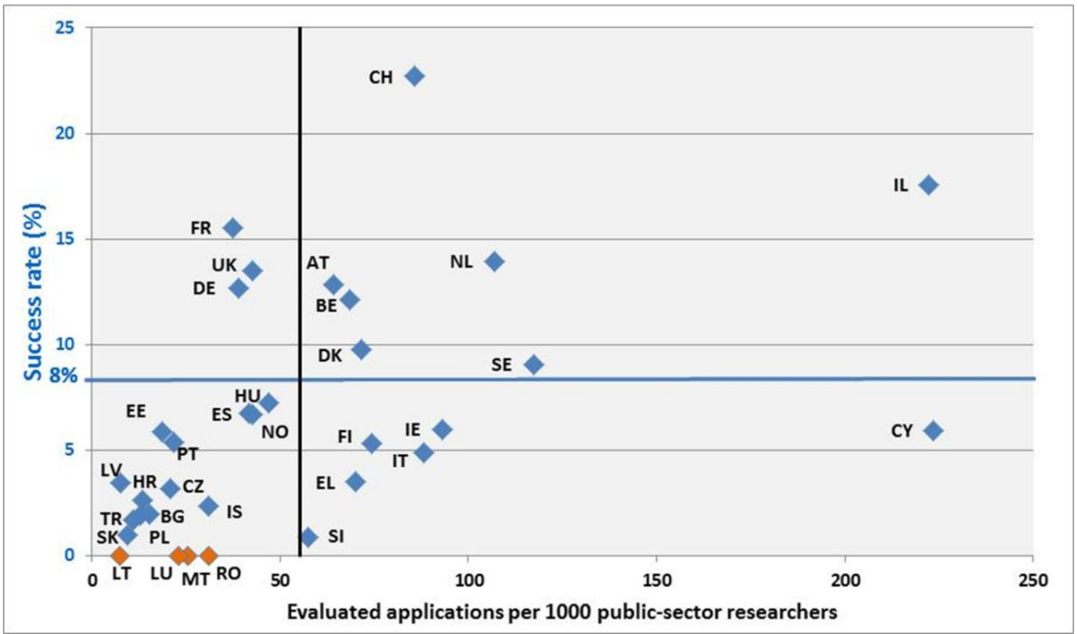
A.4.3.2. ERC benchmarking effect

One of the main ways in which the ERC makes an impact is by providing feedback for national policymakers.

For example, there are significant differences between the application patterns of researchers based in different countries – see Figure 16 below. The application rate during FP7 per 1 000 public sector researchers is over 200 in some countries and below 10 in others. This provides important feedback to decision makers at national and institutional level.

The discrepancy could be down to a wide range of factors such as the availability of national funding, the availability of competitive funding, and the levels of support and awareness for applications at national level. Of course initial low success rates will also tend to discourage applications.

Figure 16 - ERC success rate versus applications 2007-2013 (FP7)



Source: ERCEA based on ERC Statistical Database and Eurostat data.

For those considered the best researchers at national level there is an element of reputational risk in applying to a pan-European competition with low success rates. It could be for example that the best researchers from some of the traditionally strong countries are sufficiently funded at the national level and therefore apply less. Ironically, given the debate over widening participation, the massive provision of regional funding for research and innovation over the periods 2007-2013[51] and since 2014 may also have resulted in the best researchers in some of the traditionally weaker countries being sufficiently funded at the national level leading to fewer applications[52].

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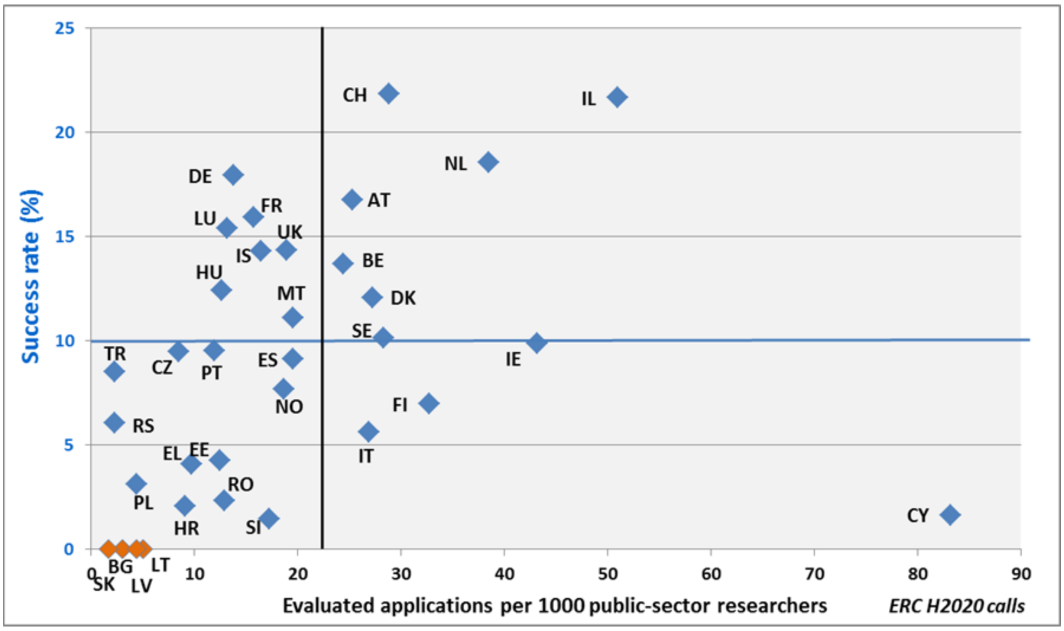
[51] *For 2007-2013 there was around EUR 86 billion available for "innovation" from EU regional funding out of a total of EUR 347 billion = 25% (http://ec.europa.eu/regional_policy/index_en.cfm). In other words, during 2007-2013 there were 11 euros allocated to the least research intensive regions for every one euro allocated by the ERC. For 2014-2020 there will be around EUR 100 billion available for "investing in growth" from EU regional funding out of a total of EUR 325 billion.*

[52] *Structural Funds financing RTDI projects represent a very significant part of public support to RTDI in many Member States. In some, in particular in EU-13 Member States, Structural Funds for RTDI are of the same order of*

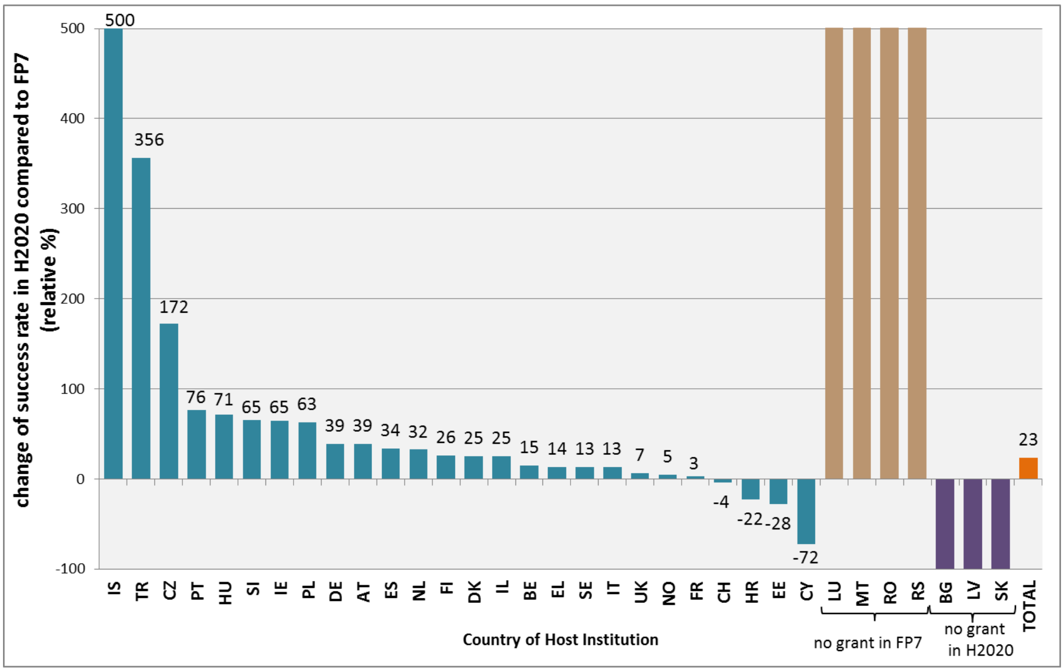
There are already signs that the research authorities and scientific communities can react to this feedback. Researchers based in Iceland, Turkey and the Czech Republic have seen large increases to their success rates between FP7 and Horizon 2020. Researchers based in Portugal, Hungary, Slovenia, Ireland and Poland have also seen their success rates increase by more than 50%.

Figure 17 - ERC success rate versus applications 2014-2016 (Horizon 2020)



Source: ERCEA based on ERC Statistical Database and Eurostat data.

Figure 18 - Change in success rate in ERC calls between FP7 and Horizon 2020



Source: ERC Statistical Database.

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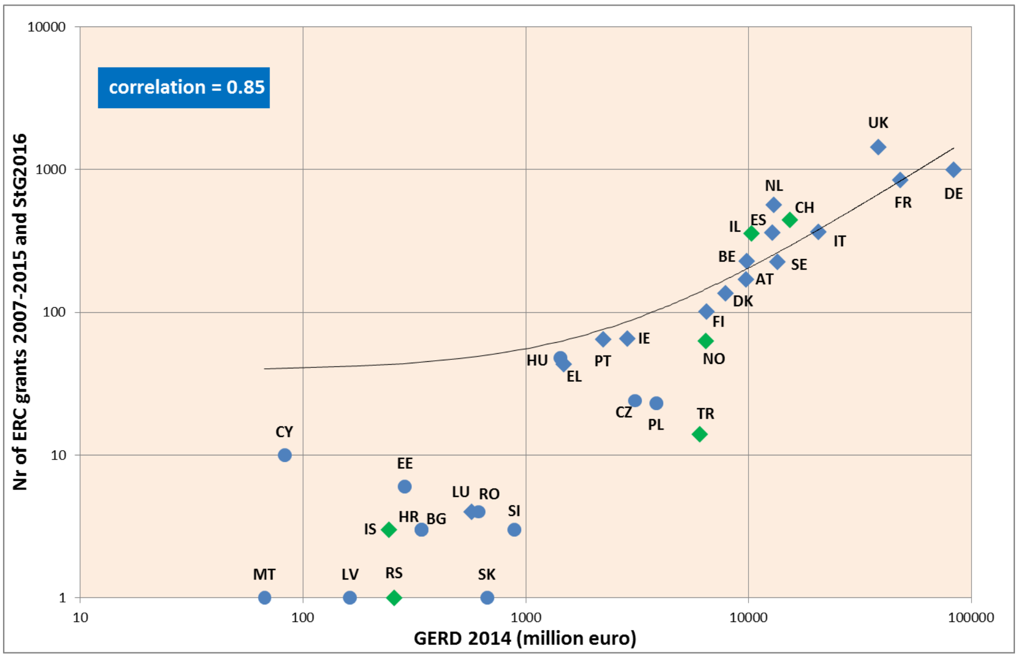
magnitude as the national budget for civil R&D, so that Structural Funds roughly double (or more than triple in the case of Latvia) the volume of government funding to R&D in the country. In EU-15 Member States, Structural Funds for RTDI are more modest compared to the national civil R&D budget (1% to 5%) but still substantial, in particular in Portugal, Spain and Italy. http://ec.europa.eu/research/innovation-union/pdf/competitiveness_report_2013.pdf

The distribution of ERC grants also offers important lessons for policymakers. World class frontier research rarely happens on its own. It requires the right framework and resources. In general there is a strong correlation between the absolute size of a country's gross domestic expenditure on R&D (GERD) and the number of ERC grants to nationals of that country or based at institutions of that country. This trend applies both to "old" and "new" Member States.

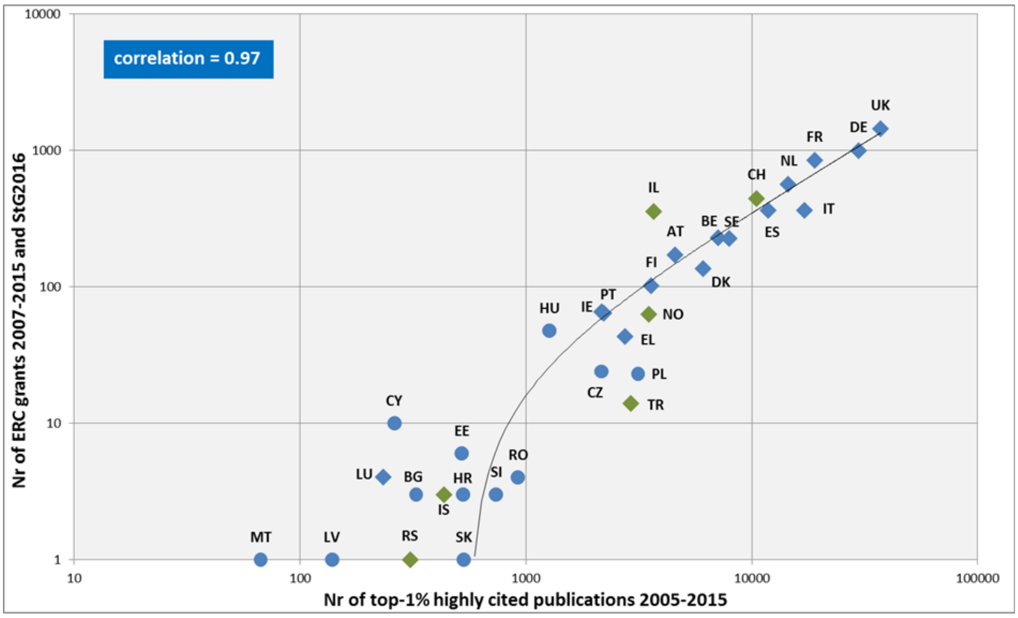
Figure 19 - ERC grants to Gross expenditure on R&D (GERD) at national level



Source: ERCEA based on ERC Statistical Database and Eurostat data.

However there are important qualitative differences between national research systems which go beyond the resources available and the number of ERC grants hosted in any particular country is most closely correlated with the number of top publications produced by authors from that country.

Figure 20 - ERC grants to top 1% publications



Source: ERCEA based on ERC Statistical Database and Scopus.

A.4.3.3. *Impact on national research systems*

The Ex-Post Evaluation of the Seventh Framework Programme (FP7) showed the transformative role of the ERC for national policies. Some Member States are already explicitly reforming their policies and practices in line with ERC practices.

The Analytical Evaluation of the IDEAS Specific Programme which was carried out by Andrea Bonaccorsi as part of the ex-post evaluation of FP7[53] in 2015 offered the following conclusions about the systemic effect of the ERC: *"The IDEAS programme has been, overall, highly successful. It has produced remarkable scientific results in a relatively short time frame. It has used the resources available effectively and efficiently. It should be continued and possibly expanded. The European Research Area has long been in need of this institution. By and large, the superiority of the US research system with respect to the European one, in the last two or three decades, can be explained as follows: in the US there has been half a century of systematic, comprehensive, tough ex-ante competitive selection process, largely based on peer review, at federal level. The large size of the competition has forced all researchers, with no exception, to fight for quality of research and, where possible, for excellence. Several decades of this institutional design have shaped the research system deeply and irreversibly. In Europe, on the contrary, the ex-ante selection process has been based in most cases on panel-based ministerial decisions, inevitably associated to considerations other than peer review. The size of the pool has been traditionally small, the intensity of competition rather limited. In the initial decades the European research policy, due to limitations in the legal framework, has been largely based on networks and coalitions of institutions and teams. While this policy orientation has been extremely valuable in capability building and networking, it has not created the intensity of competition experienced in the USA. The ERC has been the first step in changing this state of affairs. The initial results are remarkably positive and reinforce the rationale from which it has been created."*

Under Horizon 2020, there are clear indications that the ERC continues to be a source of encouragement and inspiration for investments in research and in research capacity. In particular, the ERC continues to provide a benchmark, and the prestige of hosting ERC grant-holders and the accompanying 'stamp of excellence' are also intensifying competition between Europe's universities and other research organisations to offer the most attractive conditions for top researchers and to increase investment in research capacity and excellence.

For example, the 2016 review[54] of Sweden's innovation policy by the OECD states: *"Another widely used indicator of top-level researcher performance is success in obtaining European Research Council (ERC) grants. Relative to the national researcher population or the number of applicants, Sweden's performance is solid, but not outstanding. [...] Sweden's returns from the ERC relative to the national R&D effort input are about what could be expected, but no better."*

[53] http://ec.europa.eu/research/evaluations/pdf/archive/fp7-ex-post_evaluation/ideas_final.pdf#view=fit&pagemode=none

[54] *According to the OECD website, "*OECD Reviews of Innovation Policy *offer a comprehensive assessment of the innovation system of individual OECD member and partner countries, focusing on the role of government. They provide concrete recommendations on how to improve policies which impact on innovation performance, including R&D policies. Each review identifies good practices from which other countries can learn." Source:* https://www.oecd.org/sti/inno/oecdreviewsofinnovationpolicy.htm

Öquist and Benner (2012) argue that unlike Denmark, the Netherlands and above all Switzerland, which contribute more strongly to the most-cited small percentage of scientific articles, Sweden fails to focus on top-class science or nurture top talent. In other words, funding is insufficiently skewed to allow excellent research groups to emerge and accumulate enough resources to build strong positions in international research competition."[55]

The 2016 Peer Review of the Hungarian research and innovation system performed as part of the Horizon 2020 Policy Support Facility notes that Hungary is the most successful of all Central and Eastern European countries in ERC competitions[56]. The Peer Review states: *"In recent years, the Hungarian R&I system has undergone major changes and reforms. More competition and transparency are matched with a progressively increased focus on scientific excellence and a higher concentration of resources on relevant areas. This generated the country's first successes in the EU's European Research Council, and in attracting more high-tech businesses and leading researchers. However, much more needs to be done. The Peer Review panel identified deficiencies and worrying trends. Public R&I policy needs to improve in its design, implementation and evaluation. Hungary's human capital must be nurtured. Pockets of excellence should be supported and broadened."*[57]

To underscore the ERC's role as catalyst for additional national investment in research capacity, the report goes on to recommend "*that Hungary continues its financial support for projects based on proposals submitted to the Horizon 2020's European Research Council (ERC) that have been positively screened by international peer reviewers but are finally not funded by the ERC.*"[58]

National governments also make direct use of ERC grants data in order to benchmark their own policies. For example, in 2015 the European Research Area and Innovation Committee (ERAC) – a permanent EU advisory body on research and innovation policy composed of national government representatives – was asked by the Competitiveness Council of the European Union to "*propose a set of core indicators [...] to monitor the implementation of the ERA [European Research Area] Roadmap*", a strategic policy document developed by ERAC[59]. The indicators were independently chosen by ERAC and developed with the technical support of the Commission's Joint Research Centre. For the ERA priority "Effective national research systems", ERAC chose a composite indicator that uses as a component "ERC grants (numerator: Value of ERC grants, denominator: GOVERD+HERD)"[60].

The competition for ERC grants encourage investment also at institutional level, where they are recognised as excellence markers by the most authoritative policy reviews. For example, in its 2016 Review of Luxembourg's Innovation Policy, the OECD makes recommendations on the strategy of the University of Luxembourg, one of the country's

[55] *OECD (2016),* OECD Reviews of Innovation Policy: Sweden 2016, *OECD Publishing, Paris, p. 72.*
[56] *Ferguson, M. et al. (2016),* Peer Review of the Hungarian Research and Innovation system – Horizon 2020 Policy Support Facility, *Publications Office of the European Union, Luxembourg, p. 31.*
[57] *Ferguson, M. et al. (2016),* Peer Review of the Hungarian Research and Innovation system – Horizon 2020 Policy Support Facility, *Publications Office of the European Union, Luxembourg, p. 11.*
[58] *Ferguson, M. et al. (2016),* Peer Review of the Hungarian Research and Innovation system – Horizon 2020 Policy Support Facility, *Publications Office of the European Union, Luxembourg, p. 13.*
[59] *See Council document ERAC 1213/15 of 4 December 2015, "ERAC Opinion on the ERA Roadmap – Core high level indicators for monitoring progress".*
[60] *ERAC 1213/15 of 4 December 2015, "ERAC Opinion on the ERA Roadmap – Core high level indicators for monitoring progress", p. 6.*

main innovation actors. The OECD recommends that the University defines "*the meanings, relevance and implications of research excellence; delineate a fair reward system for research excellence and relevance among faculty research units and interdisciplinary centres*"[61]. To provide examples of successful strategies, the OECD makes the examples of Switzerland's École Polytechnique Fédérale de Lausanne (EPFL) and Universitat Pompeu Fabra (UPF)[62]. In both cases, the capacity to attract ERC grants is considered an important marker of success for budget and strategy decisions.

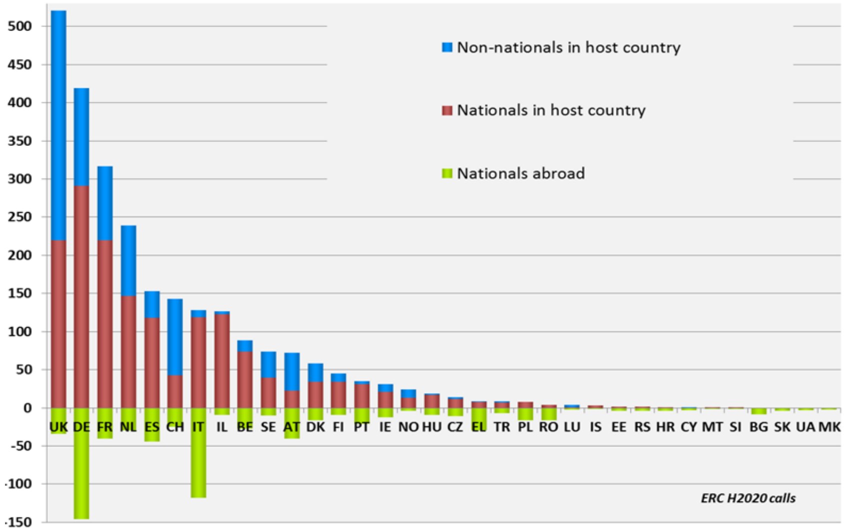
The example of the ERC has also been influential beyond the European Research Area. In October 2016 the American Society for Cell Biology called for the establishment of an ERC-like system in the US to focus on funding for young scientists.[63]

These examples show how, within the short life span of Horizon 2020, the ERC continues to exert clear and significant influence on research policy by acting as a benchmark. Thanks to the high quality peer review process implemented to select ERC grantees, ERC outcomes confer status not only to individual researchers, but also to research institutions and whole countries. When outcomes are more disappointing than expected, policy makers are regularly advised to increase investments in the science base.

A.4.3.4. Contribution to the achievement and functioning of the European Research Area

The results of the ERC calls clearly show that to a considerable extent there is already a European Research Area at the top level of science. In several countries a substantial proportion of the ERC grantees are non-nationals. Nearly half of the ERC grantees in the UK are non-nationals and the majority of ERC grantees in Austria and Switzerland are non-nationals. Conversely for many countries there are more nationals with ERC grants based outside of the country than in it. This is once again an important benchmarking and policy learning effect of the ERC showing the relative attractiveness of each country's research system.

Figure 21 - ERC grantees: nationals at home and abroad 2014-2016 (Horizon 2020)



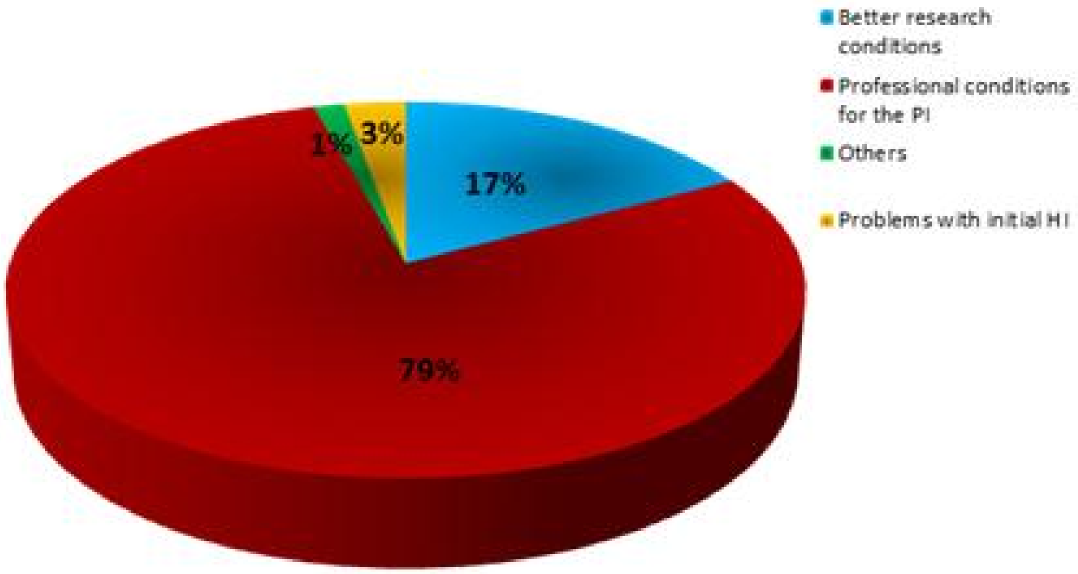
Source: ERC Statistical Database.

[61] *OECD (2016), OECD Reviews of Innovation Policy: Luxembourg 2016, OECD Publishing, Paris, p. 87.*
[62] *OECD (2016), OECD Reviews of Innovation Policy: Luxembourg 2016, OECD Publishing, Paris, p. 87.*
[63] http://hymanlab.mpi-cbg.de/hyman_lab/wp-content/uploads/2016/11/OCT-NL-2016PresidentsColumn.pdf

One of the specificities of the ERC grants is that the Principal Investigator is the principal actor of the ERC grant, as the funding is conferred to empower individual researchers and provide the best settings to foster their creativity. Projects are meant to be carried out by an individual team headed by the PI[64]. For this reason the Principal Investigator may request the transfer of the ERC grant to a new beneficiary, provided that the objectives of the action remain achievable.

Between 2007 and 2015, 5.75% of ERC PIs requested portability before grant signature and a further 6.21% of ERC PIs requested portability after grant signature. For portability after grant signature the main reasons are summarised in the chart below. 58% of portability cases involved a move to another institution within the same country. Informally beneficiaries have stated that often moving countries results in loss of academic credits and loss of social security and pension rights, showing that there is still some way to go in fully realising the ERA.

Figure 22 - ERC grantees main reasons for portability 2007-2015 (FP7 and Horizon 2020)

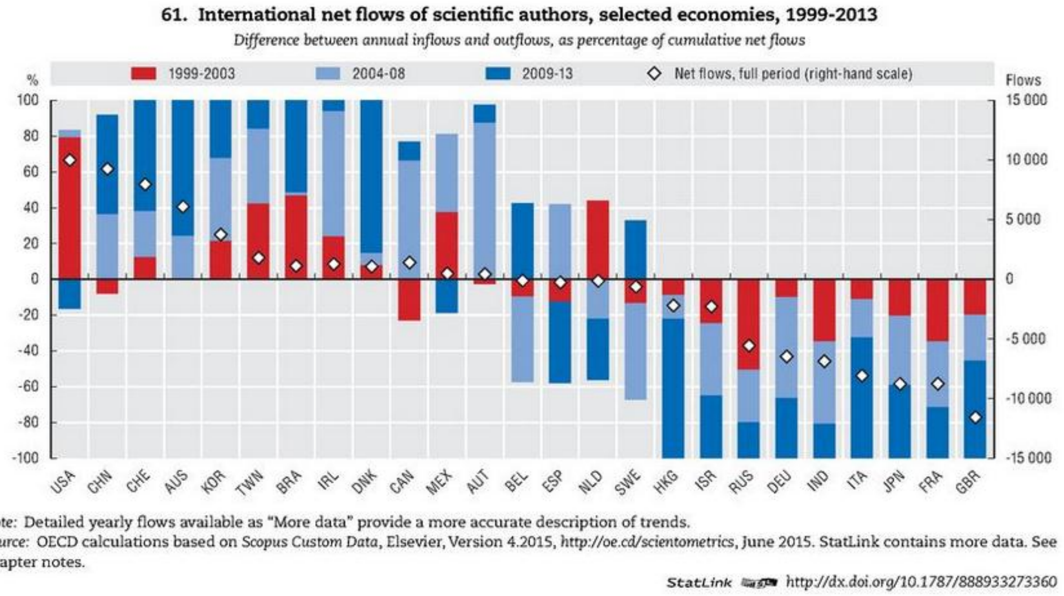


Source: EREA Grant Management Department.

However focussing only on the internal situation in Europe gives a partial view. Looking at net international flows of scientific authors between 1999-2013 shows for example that UK has seen the highest outflow in that period (mainly to US, Canada and Australia) with France, Italy and Germany also seeing significant outflows. This shows that there is still a strong need to increase the attractiveness of the ERA to top researchers at the global level which is one of the objectives of the ERC. This data also shows that, even though US has seen the largest inflows during this period as a whole, in more recent years (2009-2013) this has turned into an outflow, and that China is now seeing a considerable inflow of researchers from abroad.

[64] *For ERC grants there is a particular set-up between the Host Institution (HI), the Principal Investigator (PI) and the ERCEA. Whilst the legal beneficiary of the grant is the HI, a compulsory Supplementary Agreement links the HI and the PI guaranteeing certain rights to the PI, the ERCEA not being party to this agreement.*

Figure 23 - International net flows of scientific authors 1999-2013



Source: OECD Science, Industry and Technology Scoreboard 2015.

A.4.4. Progress towards the overall Horizon 2020 objectives

A.4.4.1. Fostering excellent science in scientific and technological research

This is the main objective of the ERC and its achievements against it are detailed above.

A.4.4.2. Boosting innovation, industrial leadership, growth, competitiveness and job creation

Frontier research increases the stock of useful knowledge, both codified (e.g. in terms of publications) and tacit (skills, knowhow and experience), trains skilled graduates and researchers in solving complex problems, produces new scientific instruments and methodologies, creates international peer networks for transmitting the latest knowledge and can even raise new questions about societal values and choices[65].

A strong science base allows countries to be at the forefront of knowledge creation because, without this knowledge, individuals, firms or countries lack the absorption capacity to identify and assimilate potentially exploitable knowledge created elsewhere.

Frontier research is therefore central to innovation systems and funding such research is in itself is the main contribution of the ERC to boosting innovation, industrial leadership, growth, competitiveness and job creation.

Nonetheless frontier research can also generate new opportunities for commercial or societal application in the short term. The ERC Scientific Council explicitly recognised this in 2011 by creating the Proof of Concept Grant (PoC) to explore the commercial and social potential of ideas arising from ERC grants. Already there have been around 590

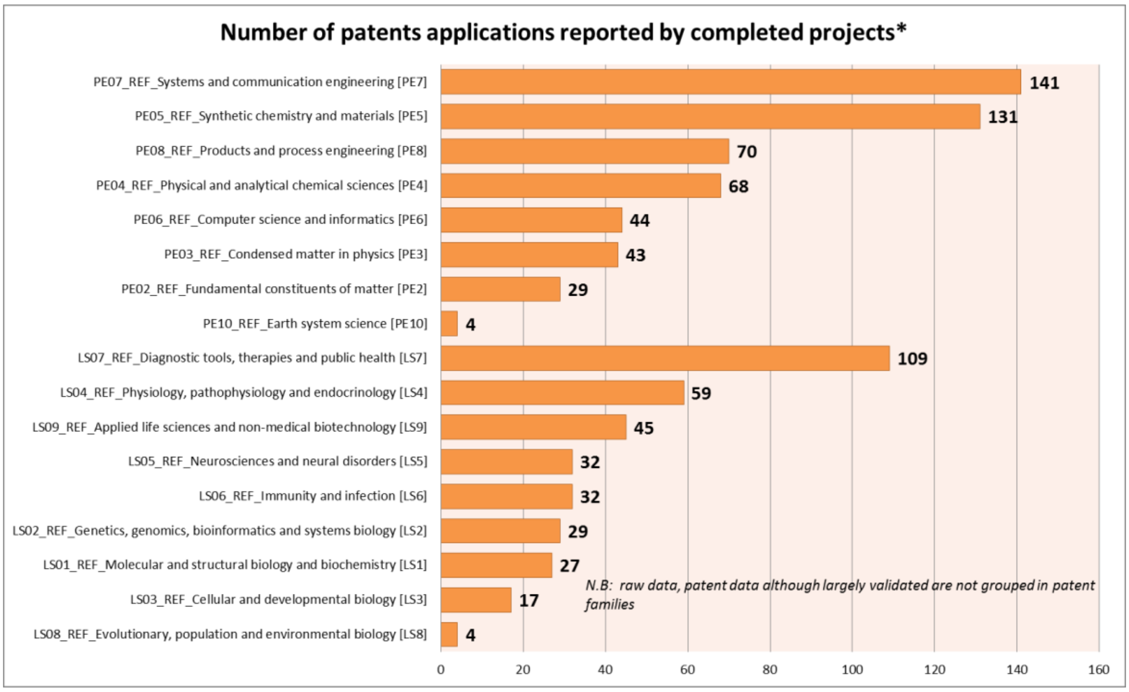
[65] *The benefits from publicly funded research, Martin and Tang, June 2007* https://www.sussex.ac.uk/webteam/gateway/file.php?name=sewp161.pdf&site=25

projects supported and around 300. Of the first 140 projects around 20% of them spun-out a new venture.

In November 2015 the European Business Angels Network (EBAN) awarded its first-ever prize for "Innovation in Science Venture Finance" to the ERC as recognition of its efforts to bring frontier research closer to the market[66].

One-fifth of completed projects by ERC Principal Investigators working in the Physical Sciences and Engineering (PE) and Life Sciences (LS) domains have reported at least one patent arising from their project. And those projects that do patent report on average more than one patent.

Figure 24 - Patents reported by completed ERC AdG2008 projects (by panel)



Source: ERC Statistical Database.

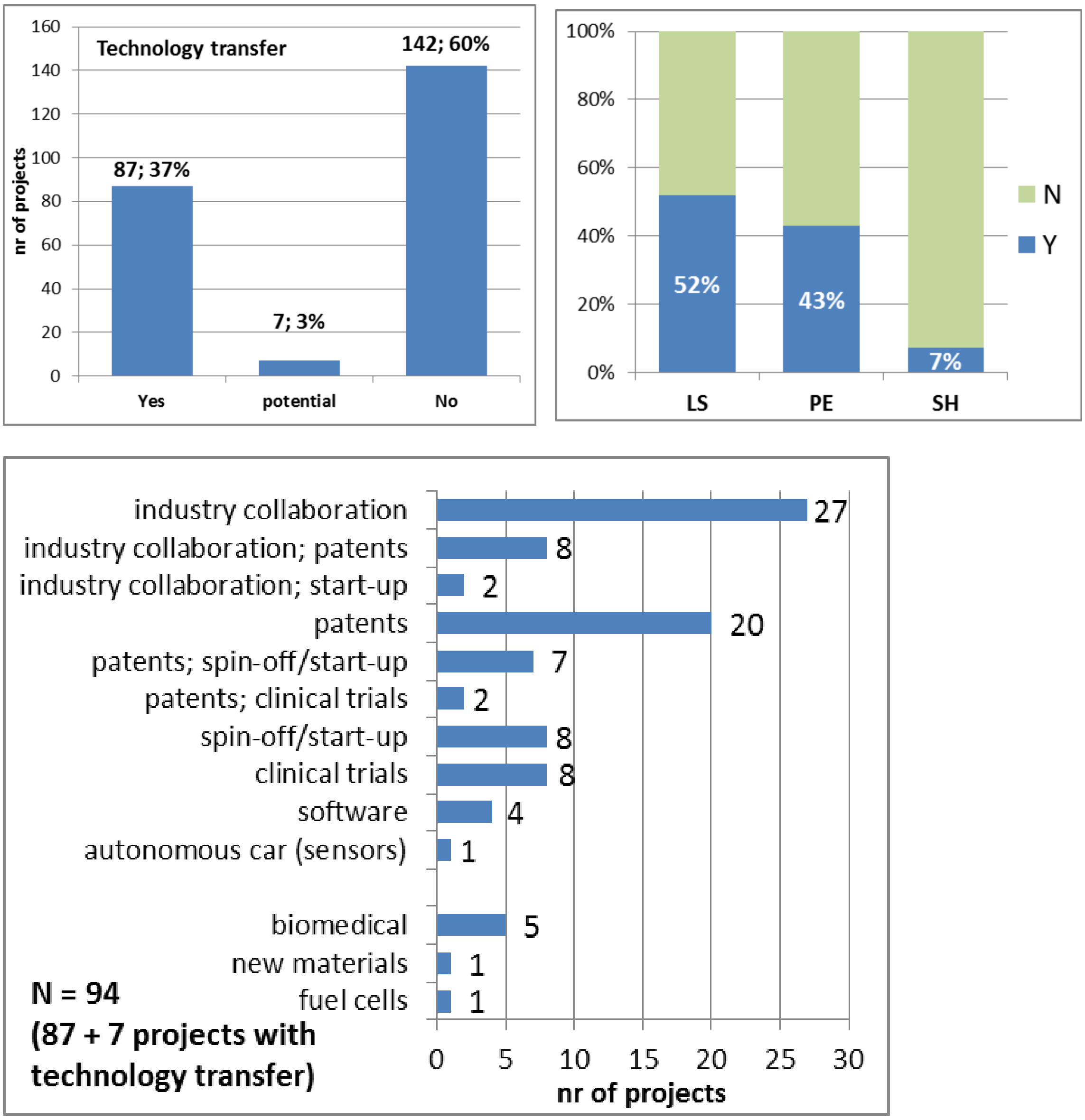
An analysis of all the 236 AdG2008 projects for which the final scientific reports have been received showed that 87 (i.e. 37%) indicated that technology transfer occurred during the project, while another seven projects indicated potential technology transfer soon after the end of the project, but without being specific about the form of this transfer. Most cases of technology transfer took place via collaborations with industry, patenting and establishment of spin-off or start-up companies. One project reported 25 patent applications.

Sometimes the collaborations with industry resulted in industrial PhD projects funded by the companies further investigating the scientific results of the grant or in team members from the ERC project being employed by companies.

By domain 52% of the LS projects, 43% of the PE projects and 7% of the SH projects indicated technology transfer (this includes the projects with potential technology transfer).

[66] http://www.eban.org/eban-winter-university-2015-in-copenhagen-highlights

Figure 25 - Technology transfer reported by completed ERC AdG2008 projects (by domain)



Source: ERC Statistical Database.

Half of the grantees that indicated technology transfer on their projects submitted at least one application for Proof of Concept between 2011 and 2015. Out of 43 grantees applying for PoC, 21 were successful (49%). One grantee had two PoC proposals funded.

At the same time 13% of the grantees that did not indicate technology transfer on their projects submitted one or two Proof of Concept proposals. Out of 19 grantees applying for PoC, 8 were successful (42%). Overall 236 AdG2008 projects generated 97 PoC proposals, of which 30 were funded.

Besides technology transfer, the collaboration of ERC-funded researchers with the private sector could be an important way for new knowledge to flow into the economy and contribute to science-based innovation. In the period 2007-2014, 1.52% of ERC projects (70 out of 4 606 projects) reported at least one co-publication with the private sector[67]. ERC grantees have collaborated with several multinationals including Novartis, IBM, Microsoft and Thales.

A.4.4.3. Addressing the major societal challenges

The ERC project portfolio not only serves to build up frontier research capacity in Europe and contribute to economic growth but also helps to generate societal benefits. Analysis of the ERC project portfolio shows that its funding strategy has resulted in a broad portfolio of projects mixing projects designed around fundamental research questions and those designed around well-defined technological and societal challenges.

The ERC undertook a comprehensive analysis of the portfolio of research it funded over the course of FP7 (Science Behind the Projects[68]) and Figure 27 gives two examples of how ERC funding addresses societal challenges and enabling and industrial technologies.

Another analysis showed that from 2007-15 in the area of health and medical research ERC funded 1 621 grants (82% in LS domain, 7% in PE domain, 11% in SH domain), with a total value of grants of almost 3 billion EUR[69] in the following broad areas: Biomedical Research (962); Clinical Medicine (646); Psychology and Cognitive Sciences (229); and Public Health and Health Services (68).

The ERC has put considerable resources into being able to analyse its portfolio of grants and has developed the ERC Research Information System (ERIS). This portfolio analysis can now be performed automatically by ERC panel, classification, topic or cluster and is now starting to be used to inform priorities for the rest of the framework programme.

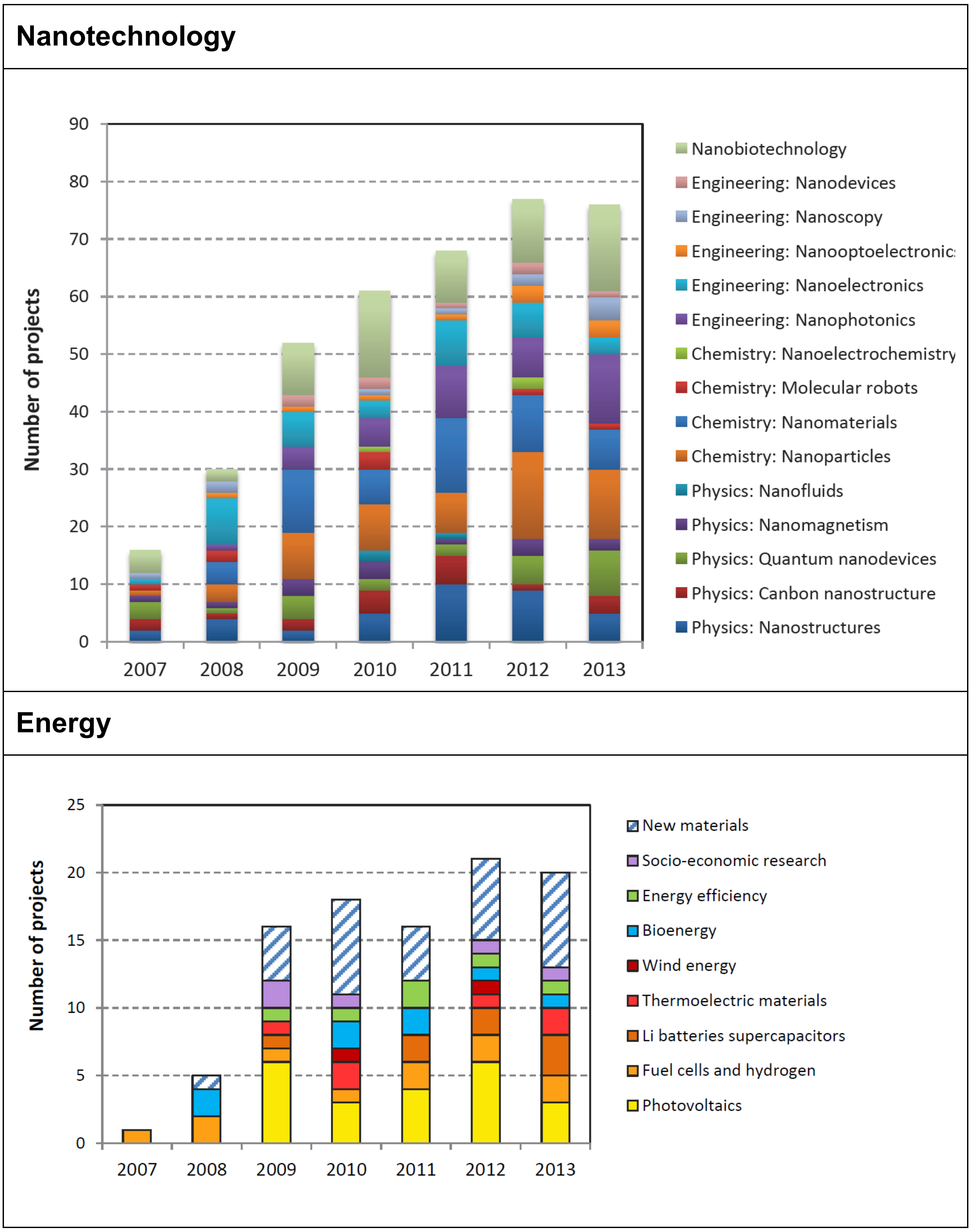
For example, Figure 26 is a cluster diagram showing the main key words from 157 ERC projects where the term "climate change" appears in the title or abstract. The details of each of the individual projects can be read along with any associated publications, highlights and awards.

Figure 26 - Cluster diagram for ERC projects addressing climate change 2007-2016 (FP7 and Horizon 2020)

Source ERC Research Information System (ERIS), December 2016.

[67] *The average for all EU publications is around 1.7% - Science Research and Innovation performance of the EU, 2016.*
[68] *https://erc.europa.eu/sites/default/files/publication/files/ERC_Science_behind_the_projects_FP7-2007-2013.pdf*
[69] *Based on all ERC Starting, Consolidator and Advanced grants 2007-2015 without AdG2015.*

Figure 27 - ERC projects addressing a selected societal challenge and enabling and industrial technology 2007-2013 (FP7)



Source: ERC Science Behind the Projects, 2013.

Another example of the relevance of ERC funded research to climate change is that 128 publications from 48 ERC funded projects were cited by the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report published in 2013-14. In other words one-third of all the ERC projects on climate change at the time (150) were cited in this authoritative report. The ERC project ATMNUCLE (Atmospheric nucleation: from molecular to global scale) carried out by Markku Kulmala at Helsinki University has over 20 publications cited in the report. Another ERC project, WATERWORLDS (Natural environmental disasters and social resilience in anthropological perspective) by Kirsten Hastrup at Copenhagen University has more than 10 publications cited in the report.

There are 198 projects for the topic “energy supply” based on the following key words: “energy, solar, conversion, fuel, efficiency, production, hydrogen, efficient, generation”, and a further 50 projects for the topic “energy storage” based on the following key words: “battery, storage, energy, electrode, traffic, ion, density, lib, capacity”.

A.4.4.4. Spreading excellence and widening participation

The ERC does not have the specific objective of spreading excellence and widening participation. However, the Scientific Council has set up a Working Group on Widening European Participation with a mission to *capitalize on the full potential for frontier research in Europe without departing from the ERC's principle of excellence.* The Working Group aims to contribute to a truly inclusive European culture of competitiveness in science by way of strengthening the participation of researchers in ERC calls from Europe less research-performing regions.

A survey of ERC grantees based at host institutions in countries with a lower than average success rate in the ERC calls conducted by the ERC in 2014 at the behest of the working group identified the following bottlenecks for stronger participation in ERC calls common to EU-13 countries.

- Low international profile of research: lack of international dynamics and mobility.

- Unattractiveness of research environment: scientific isolation, missing culture of scientific excellence, lack of open and merit based reward system.

- Poor career prospective: lack of science career building programmes and long-term research career prospective, non-merit based recruitment practices.

- Low levels of research investment: low salaries for top scientists, lack of additional and sustainable funding: ERC top-up, ERC runners-up, ERC exit programmes.

- Inadequate research funding systems: not appropriate for pursuing ambitious projects.

- Lack of institutional support to ERC applicants and grantees provided locally: administration of HI, NCPs, colleagues and peers, personal coaching.

As seen above, one of the main issues for countries and regions looking to improve their knowledge base is whether they can offer attractive conditions for excellent researchers in terms of the research environment, career progression and salaries. Having an open system offering attractive conditions is also vital to attracting talented researchers from other parts of Europe and the world. Institutions need the autonomy to recruit, promote and set the salaries of researchers (unlike the case in some Member States where researchers are included in fixed civil service recruitment procedures and salary scales).

Measures have subsequently been taken to enhance the awareness of the ERC grants schemes in countries which have been relatively unsuccessful in hosting ERC Principal Investigators. The ERC also published in January 2016 guidelines for national or regional authorities and other organisations that wish to set up fellowship programmes to fund short-term visits of potential ERC applicants to current ERC grantees’ teams. Five countries - Czech Republic, Estonia, Hungary, Poland and Slovenia - as well as the

Belgian region of Flanders, have set up such fellowship programmes. On 1 September 2016 the ERC informed some 2 800 of its grantees about a call for expression of interest regarding the new fellowship programmes, encouraging them to host visitors.

In addition research funded by the ERC is setting a clear and inspirational target for frontier research across Europe and raising the ambitions of Europe's leading researchers and institutions. ERC success is unanimously seen as a new quality marker for research organisations across Europe. Increasing competition between European countries and institutions to host ERC grantees is leading to major reforms in the way research funding is allocated and to more attractive conditions for the best researchers.

A.4.4.5. Science with and for society

As shown above there are fewer applications from female than male researchers for ERC grants. Female applicants represent 32% of all applicants under the StG and the CoG schemes, and as few as 15% of all applicants under the AdG scheme.

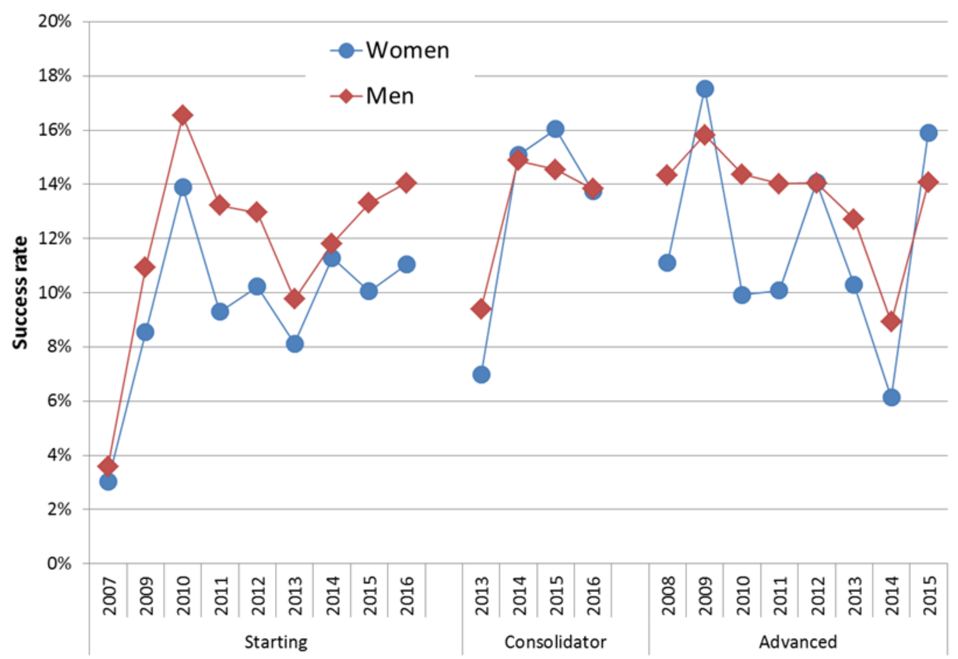
However this reflects the fact that the academic career of women remains markedly characterised by strong vertical segregation. In 2013 women represented only 45% of grade C academic staff in Europe, 37% of grade B and 21% of grade A. The under representation of women in academic careers is even more striking in the fields of science and engineering.

The ERC has developed two Gender Equality Plans since 2008 with the main objectives to:

- Raise awareness about the ERC gender policy;
- Identify and remove gender bias in evaluation;
- Improve gender balance in ERC calls (PIs and teams);
- Monitor differences in gender specific careers;
- Keep gender awareness in ERC processes;
- Strive for gender balance among the ERC peer reviewers.

Overall the success rate of women to the ERC calls under Horizon 2020 is now only 1% lower than men and women are now more successful as men in some calls and domains (see Figure 28 below).

Figure 28 - Comparative success rate of men and women in ERC calls 2007-2016 (FP7 and Horizon 2020)



Source: ERC Statistical Database.

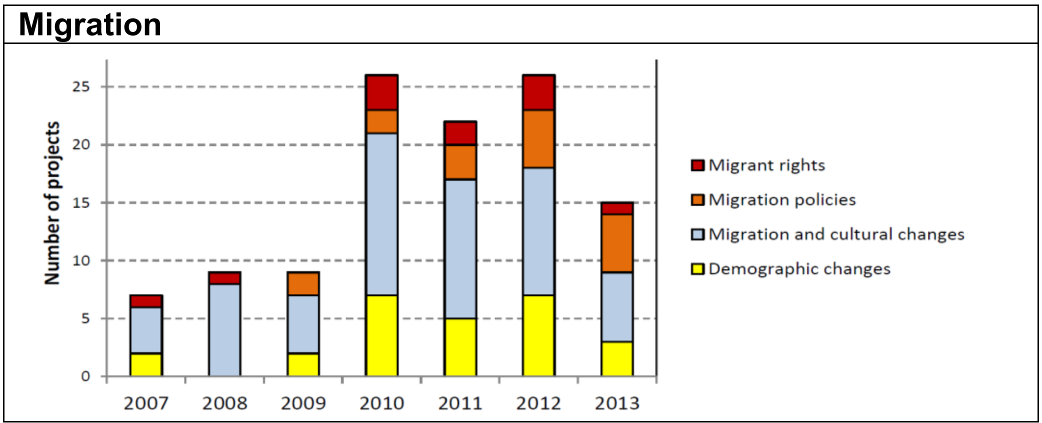
A.4.4.6. Science for policy

The ERC's broad portfolio of grants including in the social sciences and humanities mean that many projects are delivering results which are policy relevant.

One obvious example is that the ERC has supported some of the world's leading economists including the Nobel Prize winners Jean Tirole, Christopher Pissarides and James Heckman as well as Thomas Piketty and Helene Rey.

As part of a comprehensive analysis of the portfolio of research it funded over the course of FP7 (Science Behind the Projects[70]), ERC found many examples of how ERC funding addresses topics related to the policy priorities of European Union including for example on migration (see Figure 29 below).

Figure 29 - ERC projects addressing migration 2013-2017 (FP7)



Source: ERC Science Behind the Projects, 2013.

[70] https://erc.europa.eu/sites/default/files/publication/files/ERC_Science_behind_the_projects_FP7-2007-2013.pdf

This portfolio analysis can now be performed automatically by ERC panel, classification, topic or cluster and is now starting to be used to inform priorities for the rest of the framework programme. For example, Figure 30 is a cluster diagram showing the main key words from 170 ERC projects where the term "financial crisis" appears in the title or abstract.

Figure 30 - Cluster diagram for ERC projects addressing financial crisis 2007-2016 (FP7 and Horizon 2020)

Source ERC Research Information System (ERIS), December 2016.

There are 198 projects for the topic "public policy" based on the following key words: "political, policy, democracy, institution, institutional, public, country, party, government". There are 279 projects under the topic "European Union" based on the following key words: "european, europe, national, legal, political, research, law, comparative, public".

A.4.5. Lessons learnt/Areas for improvement

The majority of the projects currently funded by the ERC including those funded under FP7 have yet to be completed. But already ERC grantees have demonstrated that they are producing exceptional numbers of very high quality scientific publications. Based on just reported publications, nearly 95 000 papers from ERC projects have already been published in international, peer reviewed journals. 7% of ERC publications are among the top 1% highly cited in the world by field, year of publication and type of publication compared with 1.5% of publications with an EU author. In 2014, 20% of the Nature and Science papers that have authors based in the EU and the Associated Countries were ERC funded publications.

Furthermore qualitative analysis of ERC funded work has confirmed the breakthrough nature of the work carried out so far. As reported in Nature, the ERC has conducted a qualitative evaluation of 199 completed ERC-funded projects from the first two calls by independent high-level scientists who were selected by the ERC Scientific Council. 71% of projects were considered to have made a scientific breakthrough or major scientific advance. A different peer review evaluation of a sample of 100 ERC-funded papers considered 21% of the papers reviewed to have made a landmark contribution to their field, including the identification of new entities or phenomena, methodological advances in the study of a topic and the elaboration of theoretical principles.

The ERC has so far collected over 600 fully documented, independently selected highlights based on outstanding scientific merit from multiple authoritative sources. Six ERC grantees have been awarded the Nobel Prize and four ERC grantees have been awarded the Fields Medal after being funded by the ERC. As of December 2016, ERC grantees had been the recipients of 526 major prizes, awards and other forms of recognition which are recorded in the ERC Statistical Database.

Taken together, this evidence offers an indication that the ERC attracts and funds excellent researchers through its calls and ERC projects are producing a substantial number of the most significant and high impact research findings worldwide in emerging areas leading to breakthroughs and major advances. The work of ERC grantees is also highly interdisciplinary and ERC grantees collaborate internationally and publish their results openly across all fields of research including the social sciences and humanities.

There is also already evidence of the longer term impacts of ERC grants on careers, on training highly skilled postdocs and PhDs, on raising the global visibility and prestige of European research and on national research systems through its strong benchmarking effect. The ERC has funded a broad portfolio of research activities and can show that it is contributing to many of the wider goals of Horizon 2020 in terms of the societal challenges and enabling and industrial technologies. These impacts can only be expected to grow in future as the ERC projects are finally completed.

A.5. EFFICIENCY

A.5.1. Budgetary resources

A.5.1.1. Economies of scale and low coordination costs

A major study commissioned by DG Budget[71] to make proposals on the main areas of policy in which expenditure from the EU Budget should be concentrated in future years concluded that: *"The programme Ideas establishes a European Research Council (ERC). The ERC should fund projects proposed by researchers, similar to the National Science Foundation in the United States. Formally, the objective of this programme is "supporting 'investigator-driven' research carried out across all fields by individual national or transnational teams in competition at the European level". Only one legal entity is required for funding.*

The scope for economies of scale is large in this programme. By deciding centrally which proposals receive funding, the risk of duplication of research is limited; and it is less costly to employ the experts needed for high-quality assessment of project proposals. Centralisation also avoids the negative effects of trans-national externalities and limited systems competition: the nationality and country of residence of the researchers submitting a proposal becomes less relevant for the chances of obtaining a grant. In a decentralised system, an Austrian working in Italy is unlikely to get a German grant. In addition, the risk of 'personalism' can be reduced if the experts evaluating a proposal come from another country than the persons submitting it. The 'second-best' argument, that centralisation promotes competition and diffusion of knowledge, also applies to this programme…

[71] *A Study on EU funding, June 2008*
http://agriregionieuropa.univpm.it/sites/are.econ.univpm.it/files/FinestraPAC/Editoriale_12/study_EUspending_en.pdf

The overall conclusion is that the role of the EU in providing funding for R&D is appropriate. In many cases, there are economies of scale in centralising R&D funding, such as EURATOM, JRC, Cooperation, Ideas and Capacities regarding infrastructure. In addition, the programmes Cooperation, Ideas, and People internalise spillovers. Of course these benefits of centralisation have to be weighed against the diversity argument. However, as long as the Member States themselves have substantial R&D budgets, these country-specifics can be addressed. Given the economies of scale and externalities involved, it could even be argued in favour of shifting a part of the national R&D budget to the EU level for these specific categories."

The current European research and innovation system is often characterised as "fragmented" and the solution is seen as more trans-national coordination, often looking to build critical mass around a mission-orientated approach, either to address societal challenges or establish industrial leadership in key technologies. However, the coordination costs of agreeing priorities for, setting up and managing major, transnational public-public or public-private joint ventures, joint programmes, cooperation platforms, networks or consortia can be large (though the benefits may still outweigh the costs). By operating a bottom-up competition (soliciting investigator-driven projects on any topic) evaluated on the sole criterion of excellence the ERC's coordination costs are very low in comparison. It is unlikely that any alternate delivery mechanism such as an intergovernmental approach or system of bilateral or multilateral agreements could achieve the same objectives with the same degree of efficiency, if in fact agreement could be reached on such an approach at all.

A.5.1.2. Geographical distribution of ERC funding

Some observers have criticised the geographical distribution of ERC funding on the grounds that the ERC is reinforcing areas that already have a strong frontier research capability and not helping sufficiently to build capacity in weaker regions. However this criticism would appear to be misplaced given the ERC's intervention logic and the analysis of Europe's position in the global research system upon which this logic is based.

Because of the size and diversity of the European research system the ERC was set up with a distinct target group. It was not intended to be the basic research funder for the whole of Europe or directly to build capacity in the weaker countries. The ERC is meant to channel resources in a simple and flexible way to the most promising researchers, support the best new ideas, confer status and visibility on the best research leaders working in Europe, offer attractive funding conditions to attract and retain outstanding researchers, provide benchmarks for individual research institutions, and ultimately creating economic and societal benefits.

The original analysis[72] was that Europe consists essentially of a large number of national research communities and that the relatively small scale of many of these poses constraints on the strategies that research institutions (and indeed funding agencies) can pursue. It was hoped that the ERC would provide more of a single research space, where universities would have opportunities to pursue more differentiated strategies, enabling them to make best use of their capabilities. The creation of the ERC would encourage research-intensive universities in this direction, with the expectation that the best will

[72] *ERC High Level Expert Group, February 2005: http://erc.europa.eu/publication/frontier-research-european-challenge-high-level-expert-group-report-0*

then be in a far stronger position to establish themselves as effective global players. For those universities already taking up this challenge, the ERC would provide much-needed support, acting as an incentive and providing an indicator of success as well as a source of funds. The ERC was therefore set up to have a direct impact at the top level of European research.

Traditionally the Framework Programme has focussed on building up critical mass by supporting "virtual centres" and networks. However, it has been suggested that *"... all these efforts for greater European coordination in research have at best led to what I would call 'research saupoudrage' [sprinkling]: allocating an albeit limited amount of research funds over a very broad scattered field of research institutions."*[73]

The ERC, by providing generous funding to research teams in situ and by making this funding portable, reinforces existing centres of excellence and allows ambitious new centres to quickly scale up the research profiles in which they are particularly strong. The reinforcement of existing centres of excellence is an integral component of the ERC's mission given the increasing importance of innovation clusters and "brain hubs" built around public research centres, for driving innovation and productivity[74]. For example, *"Massachusetts, and more specifically the Boston–Cambridge region, has created a dense life-science ecosystem. Research at universities and teaching hospitals has spun out into start-ups and fast-growing mid-sized firms, and the combination has lured pharmaceutical giants to the state, creating jobs and bringing in tax revenues. The life-sciences sector has grown out of decades of federal investment in basic research and more recent state efforts to boost the science-driven economy... The Boston area is home to a rich collection of research universities, including Harvard University, Massachusetts Institute of Technology, the University of Massachusetts, Boston University and Worcester Polytechnic Institute, that have long pulled in substantial amounts of federal research funding."*[75]

The indirect structural impacts of the ERC need also to be recognised. One of the explicit aims of the ERC is to act as a benchmark for researchers, institutions and national policy makers. In this way the ERC complements national funding schemes. Through its own high standards, it aims to set a clear and inspirational target for frontier research throughout Europe. It seeks to increase the international visibility of European research in general, including for countries and institutions that host limited numbers of grantees. Ambitious individuals, institutions, regions and countries can seize the initiative and scale up the research profiles in which they are particularly strong.

Furthermore, the ERC is just one part of the overall support for R&I in the EU. The ERC has 17% of the Horizon 2020 budget which itself constitutes a small fraction of the total research expenditure in Europe.. In addition within Horizon 2020, specific and targeted measures exist to help spread excellence and widen participation.

Finally, many of the results of frontier research constitute a public good with extensive trans-national spillovers and non-linear impact. Economic growth at the national level is not solely dependent upon research and innovation at the national level. Rather global innovation leads to national growth, and national innovation leads to global growth[76].

[73] https://www.bvekennis.nl/Bibliotheek/05-0888_UKpresidency_Soete-final.pdf
[74] http://joeg.oxfordjournals.org/content/early/2013/06/19/jeg.lbt016
[75] http://www.nature.com/nature/journal/v537/n7618_supp/full/537S18a.html
[76] *"The charge of technology", Nature, October 2008*
http://www.nature.com/nature/journal/v455/n7216/full/4551030a.html

The ERC is therefore contributing to the provision of this public good which could lead to economic growth far both in space and time from where the research was carried out.

A.5.2. Programme's attractiveness

The ability of the ERC to establish a pan-European competition between the best researchers working in Europe was an indispensable prerequisite for achieving the aims of the ERC. Competition for ERC grants has been intense, but the success rate by itself however does not by itself say anything about the quality of the applications.

However, the quality of the ERC's peer review was very quickly acknowledged by the research community as reported by a panel of independent experts in 2009.[77] And the interim evaluation of FP7 in 2010 concluded that, *"Despite being a new, and thus untried, instrument, the European Research Council (ERC) has manifestly succeeded in attracting and funding world-class research and is playing an important role in anchoring research talent."*[78] An extensive study of the bibliometric profiles of ERC applicants and grantees in 2015 also concluded that *"the data clearly indicates that the ERC competitions do attract high profile researchers"*[79].

In 2014, to analyse whether leading researchers in Europe have applied for ERC funding schemes, the ERC identified over 7 000 individuals from six selected groups including highly-cited scientists, elected European foreign associates of US National Academies, laureates of selected prestigious national research prizes and chairs at Gordon Conferences, and then the subset of these researchers affiliated with a European institution (see Figure 7 above). These were then matched with a database of all ERC applicants since 2007. This analysis showed that around 30% of these "leading" researchers had applied for ERC funding schemes with around half of these being funded (some after multiple applications) meaning that 16% of the identified leading researchers had been funded by the ERC (562 out of 3 465).

The ERC has also been able to keep attracting new participants. 162 new Host Institutions signed or were invited to sign grant agreements with ERC in Horizon 2020 compared to FP7 (or 30% of all Horizon 2020 grant signatories). At the same time 87% of the 2 555 Principal Investigators that have received ERC grants in Horizon 2020, were not ERC grantees in FP7. Overall 70% of the Principal Investigators applying to ERC in Horizon 2020 did not apply to ERC during FP7.

Despite the increase to the ERC budget in 2014-2020 it is still forced to turn away many excellent proposals. In the first five calls of Horizon 2020 there were nearly 1 000 proposals worth EUR1.8 billion which the ERC's panels awarded the top "A" score but did not have sufficient funds to support. This means that the ERC's average success rate is still very low.

Given this evidence and the fact that over FP7 and Horizon 2020 together, the equivalent to less than 5% of EU public sector researchers have applied to the ERC is a strong indication that a high level of self-selection is taking place amongst applicants to the ERC.

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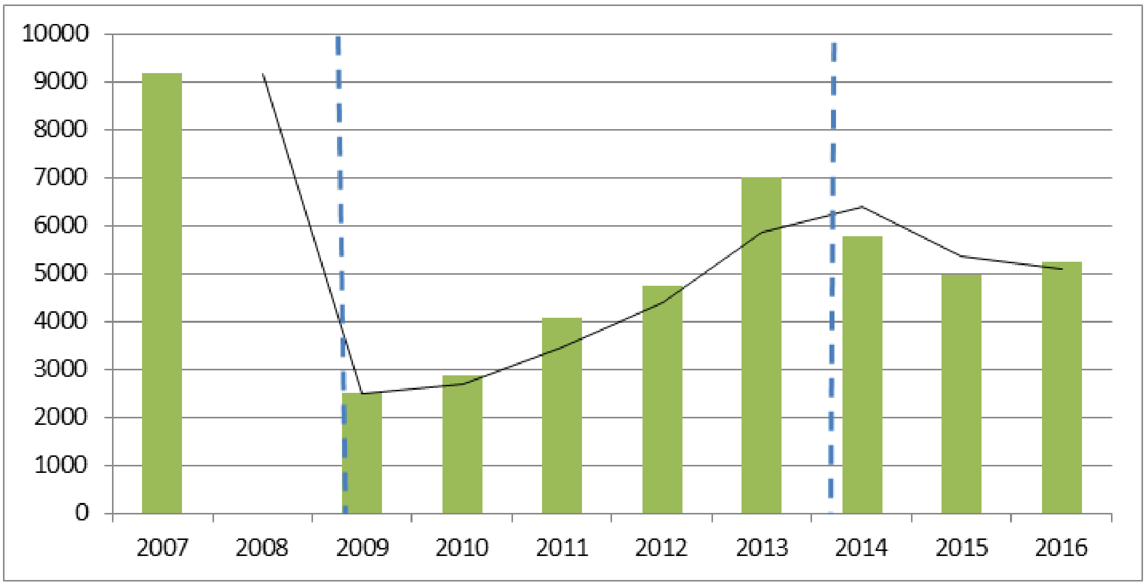
[77] Review of the European Research Council's Structures and Mechanisms *(July 2009).*

[78] *http://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/fp7_interim_evaluation_expert_group_report.pdf#view=fit&pagemode=none*

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

The ex-post evaluation of FP7 stated that: *"The share of high quality proposals was ... lowest in FP7-IDEAS ..."*. However this statement represented a serious misunderstanding by the expert group as pointed out in a statement by the ERC Scientific Council at the time[80]. Unlike other parts of the framework programme the ERC has a two-step evaluation process, bases 50% of the evaluation on the track record of the Principal Investigator and since 2009 has taken steps to manage demand in order to maintain the quality and integrity of the evaluation process. A tightening of the 2009 restrictions was announced ahead of the 2014 calls, and since the 2015 calls (based on the results of the 2014 calls) applicants can be restricted from submitting proposals to future ERC calls for up to two years based on the score given to their proposals. These restrictions are designed to allow unsuccessful PIs the time necessary to develop a stronger proposal.

Figure 31 - Number of applications to the Starting and Consolidator Grant calls 2007-2016 (showing the two year moving average and the announcement of restrictions on submissions by the Scientific Council in 2009 and 2014)



Source: ERC Statistical Database.

A.5.3. Cost-Benefit Analysis

The current structure of the ERC was established under FP7. It was the subject of dedicated reviews in 2009 and 2011[81]. In addition, both the Interim evaluation of FP7 in 2010 and the recent ex post evaluation of FP7 assessed the performance of the ERC within the context of the FP7 IDEAS Specific Programme.

A.5.3.1. ERC evaluation procedure

The quality of the ERC's evaluation is critical to its success. Proposals are evaluated by peer review panels composed of renowned scientists and scholars selected from all over the world by the ERC Scientific Council. For despite criticism of peer review over the years it is still considered the gold standard for the evaluation of research proposals[82].

[80] https://erc.europa.eu/sites/default/files/press_release/files/ERC_ScC_Comments_FP7_report.pdf
[81] https://erc.europa.eu/about-erc/reviews-and-development-erc
[82] *Big names or big ideas: Do peer-review panels select the best science proposals? Li and Agha, 2015* http://science.sciencemag.org/content/348/6233/434.full

There are 25 panels per call covering all areas. Each panel has around 10-15 members plus a chair person. Around 350 panel members are involved per call. In addition around 2 000 remote referees are involved in each call. These provide specialised reviews of individual proposals in their field. Each evaluates only a small number of proposals.

Recruiting these panel members and remote referees involves a very significant effort on the part of the Scientific Council and the ERCEA. For example, the positive response rate of remote referees is around 30%. Therefore for each call over 7 000 potential remote referees need to be identified and contacted.

In order to ensure transparency, the names of the panel chairs are published on the ERC website before the deadline of a call. Similarly, the names of panel members are published after the evaluation process is concluded.

The ERC offers a large scope for economies of scale. By deciding centrally which proposals receive funding, the risk of duplication of research is limited and it is less costly to employ the experts needed for high-quality assessment of project proposals. The scarcity of excellent peer reviewers in particular is a major factor for all research funding bodies.

A.5.3.2. Simple and flexible procedures

From the start the Scientific Council wished to ensure that the ERC used procedures that maintained the focus on excellence, encouraged initiative and combined simplicity and flexibility with accountability (offering for example the freedom to the Principal Investigators to transfer resources within the grant).

ERC grants would cover up to 100% of the total eligible direct costs of the research plus a contribution towards indirect cost (this flat-rate model introduced by the Scientific Council in FP7 has subsequently been extended to cover the whole of Horizon 2020). Host institutions would sign a supplementary agreement with the Principal Investigator to provide appropriate conditions for the PI to independently direct the research and manage its funding.

In addition ERC grants were to be portable, meaning that the Principal Investigator could request to transfer the entire grant or part of it to a new beneficiary, under specific conditions.

Under Horizon 2020, the Commission has committed itself to signing grant agreements within a period of eight months (245 days) for actions other than ERC actions. The ERC has a different, specific, "two-step" evaluation procedure, including interviews with applicants in Step2 for Starting Grant and Consolidator Grant calls. The ERC actions may therefore exceed the Time-to-Grant benchmark, as established in the Horizon 2020 Rules for Participation and Dissemination.

A.5.3.3. Dedicated implementation structure

As part of its overall autonomy, the ERC has in addition to an independent Scientific Council, a dedicated implementation structure to support its evaluation processes and grant awards. Since 2009 the ERC's dedicated implementation structure has been the ERC Executive Agency (ERCEA).

The Review of ERC's Structures and Mechanisms in July 2009 confirmed that the executive agency structure was working, with some recommendations for changes, including a further review. This review was conducted by the ERC Task Force in July 2011 and made recommendations for changes to be brought in under the Horizon 2020 legislation, including the creation of a full time President based in Brussels.

The FP7 legislation unusually contained specific provisions on the administrative efficiency of the ERC: *"The administrative and staffing costs for the ERC relating to the Scientific Council and dedicated implementation structure will be consistent with lean and cost-effective management; administrative expenditure will be kept to a minimum and will not exceed 5% of the total financial allocation for the ERC, consistent with ensuring the resources necessary for high quality implementation, in order to maximise funding for frontier research." 1982/2006/EC*

There are a detailed set of key objectives and performance indicators for the implementation of tasks entrusted to the ERCEA. The ERCEA reports on its performance against these targets on a regular basis in a series of monthly, quarterly and annual reports to the parent DG.

The ERCEA has low administrative overheads (just over 2% against a legal requirement of less than 5%). In comparison the "internal operations" at the US National Science Foundation, including salaries and expenses for about 1 500 permanent staff , account for approximately 6% of its overall budget.[83]

In 2016 the latest three yearly independent Evaluation of the Operation of ERCEA (2012-2015) was published[84]. The survey of ERCEA's beneficiaries indicated a very high level of satisfaction with its performance. 93% of beneficiaries were very satisfied or satisfied with the services provided by the Agency. The evaluation also observed the trend of slightly increasing satisfaction over time. Also, about 95% of "independent experts" (the ERC's panel members and remote referees) were satisfied with the Agency's performance. The ERCEA was very efficient in managing the delegated programmes and achieved good results in terms of key performance indicators. Overall, the retrospective CBA shows that due to the lower staff costs and savings in overheads the executive agency scenario remained considerably more cost-effective than the in-house scenario, generating substantial savings to the EU budget.

The report concluded that: *"The evaluation also revealed that the delegation of operational tasks to the ERCEA has been very successful. The Agency performed in an effective, highly efficient and cost-effective way in implementing the tasks delegated to the Agency during the period 2012-2015… First, the Agency achieved its objectives and produced the planned outputs during the reference period. Second, its performance was highly efficient during the reference period in terms of the ratio between the administrative and operational budget and budget 'per head'. Third, the executive agency scenario allowed achieving substantial cost savings to the EU budget."*

Having said this, one lesson learnt over the course of FP7 and the early years of Horizon 2020 is that the current way of allocating administrative resources to the ERC Executive Agency is inflexible. The staff allocation of the Executive Agency is determined for seven years at the start of the period based on the existing workload and schemes and this severely hampers the flexibility of the agency to respond to new initiatives by the Scientific Council. The ERC would be able to better use its autonomy if ERC could also

[83] https://www.nsf.gov/news/news_summ.jsp?cntn_id=100595
[84] https://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/ercea_executive_summary.pdf

argue for more operational flexibility e.g. the administrative budget and staff allocation could be set as ceilings (for example, 3% max for admin budget) and not a fixed amount per year.

The ERC Scientific Council has on occasion expressed frustration concerning ERC autonomy and independence related to efforts to harmonise policy and procedures across the framework programme.

A.5.4. Lessons learnt/Areas for improvement

The ERC has large scope for economies of scale and low coordination costs. By deciding centrally which proposals receive funding it is less costly to employ the experts needed for high-quality assessment of project proposals. Centralisation also avoids the negative effects of trans-national externalities and limited systems competition.

The geographic distribution of ERC funding appears appropriate given the ERC's intervention logic and the analysis of Europe's position in the global research system upon which this logic is based. The reinforcement of existing centres of excellence is an integral component of the ERC's mission given the increasing importance of innovation clusters and "brain hubs" built around public research centres, for driving innovation and productivity. Furthermore, the ERC is just one part of the overall support for R&I, in the EU a significant proportion of which is already allocated to capacity building in the weaker regions and countries.

The ERC was able to establish quickly a credible pan-European competition between the best researchers working in Europe which is an indispensable prerequisite for achieving its aims. The ERC's calls have demonstrably managed to attract leading researchers and have been able to keep attracting new participants. The ERC has been able to pioneer simple and flexible procedures some of which have been taken up by the rest of the programme in Horizon 2020.

A number of independent reviews and metrics have shown the ERCEA to be a lean organisation with effective delivery and low costs. However the pre-allocation of resources to the agency for a seven year period limits the flexibility of the organisation to respond to new initiatives by the Scientific Council. And too much harmonisation of procedures and policies across the framework programme can also interfere with the Scientific Council's ability to act independently.

A.6. COHERENCE

A.6.1. Internal coherence

A.6.1.1. Internal coherence of the actions implemented by the ERC

The Scientific Council has been able to monitor the ERC's operations and modify and tailor these through the ERC's annual Work Programme in order to adapt to changing circumstances.

Since 2007, the ERC followed a demand-driven approach to allocating funding between panels within domains whose allocation was set by the Scientific Council. But since the calls under the 2015 Work Programme there has been no allocation by domain and therefore funding is distributed to panels entirely by demand in full alignment with the ERC's bottom-up approach. This allows ERC to channel funds dynamically into new and highly promising research areas.

The age distribution between the grantees also shows that the division between the main grants schemes is well founded.

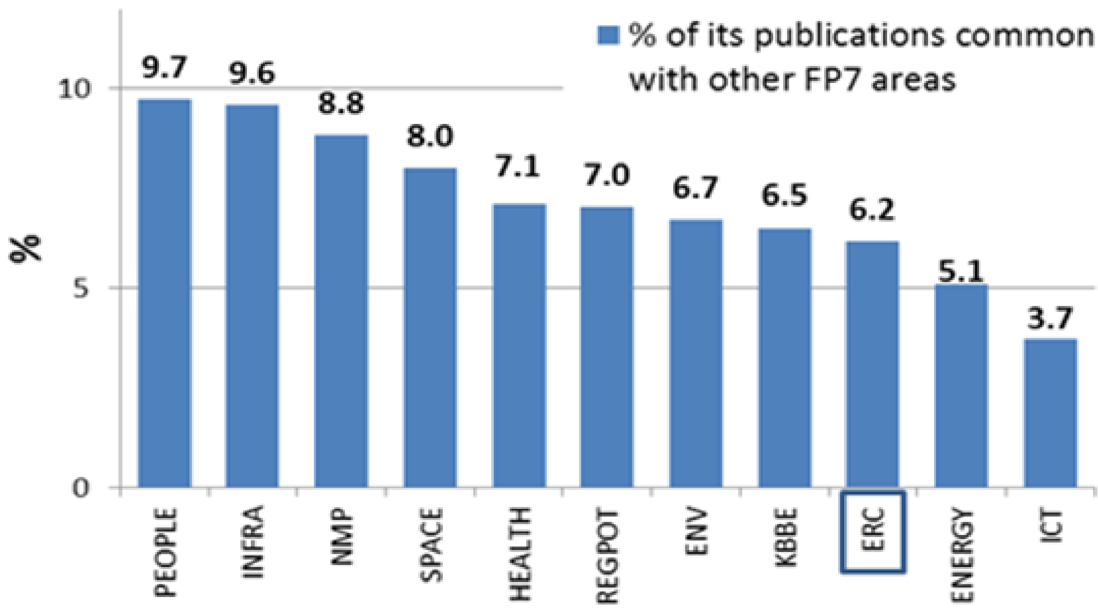
A.6.1.2. Internal coherence with other Horizon 2020 intervention areas

The Horizon 2020 structure built around the three pillars of excellent science, industrial leadership and societal challenges has been recognised as a coherent and logical structure for supporting the full range of R&I at European level. It is widely recognised that such support should offer a balance between different forms. *"Basic research is particularly important, as it gives rise to significantly larger knowledge spillovers than applied research while making applied research much more productive (Akcigit, Hanley and Serrano-Velarde, 2014). The history of science shows that many of the great breakthroughs resulting from scientific research were regarded as significant only in hindsight (Kirshner, 2013). They were not the result of a focused effort to achieve a specific impact, but instead reflected serendipity. Ensuring a balance between basic research, driven by excellence, and more focused, mission-oriented research is therefore an important challenge for public funding."*[85]

And as shown above, the ERC is funding a broad portfolio of projects which have a high degree of complementarity with the themes and challenges of the rest of Horizon 2020.

Another way to measure coherence between various framework programme components is to look at common publications. In Figure 32 below common publications means either co-authored publications or publications of the same individual acknowledging (or reported under) more than one FP7 component.

Figure 32 - Share of FP7 component publications linked to at least one other FP7 component



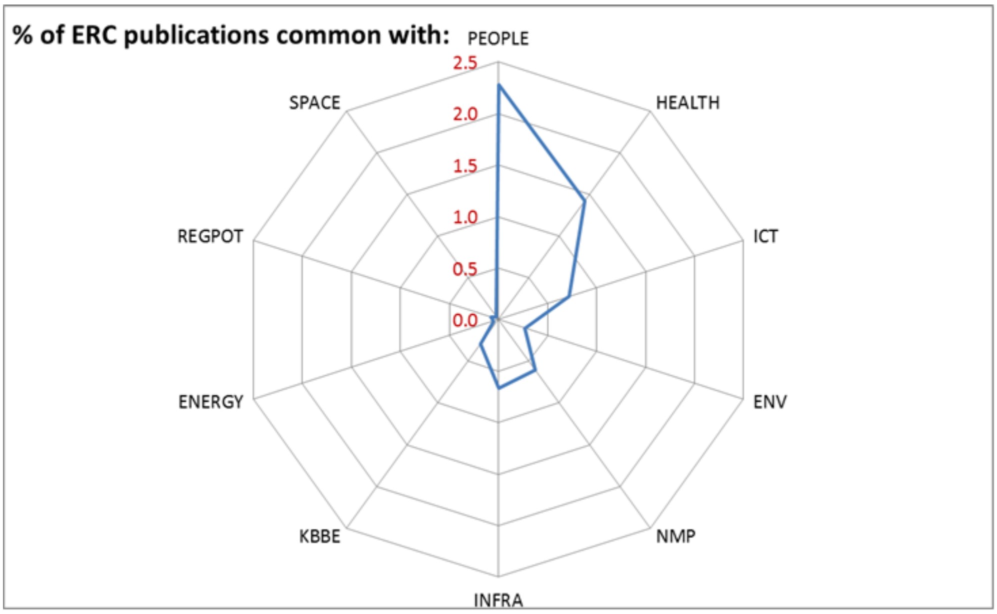
Source: ERC Statistical Database.

6.2% of the ERC publications are linked to other FP7 components. 40% of them are common to ERC and PEOPLE. Significant numbers are also linked to HEALTH, ICT, INFRA and NMP. These figures show that there is only a small level of overlap between

[85] *Chapter 5, The OECD Innovation Strategy - 2015 revision* http://www.oecd.org/sti/innovation-imperative.htm

the work funded by the ERC and the other parts of the framework programme showing that they are complementary.

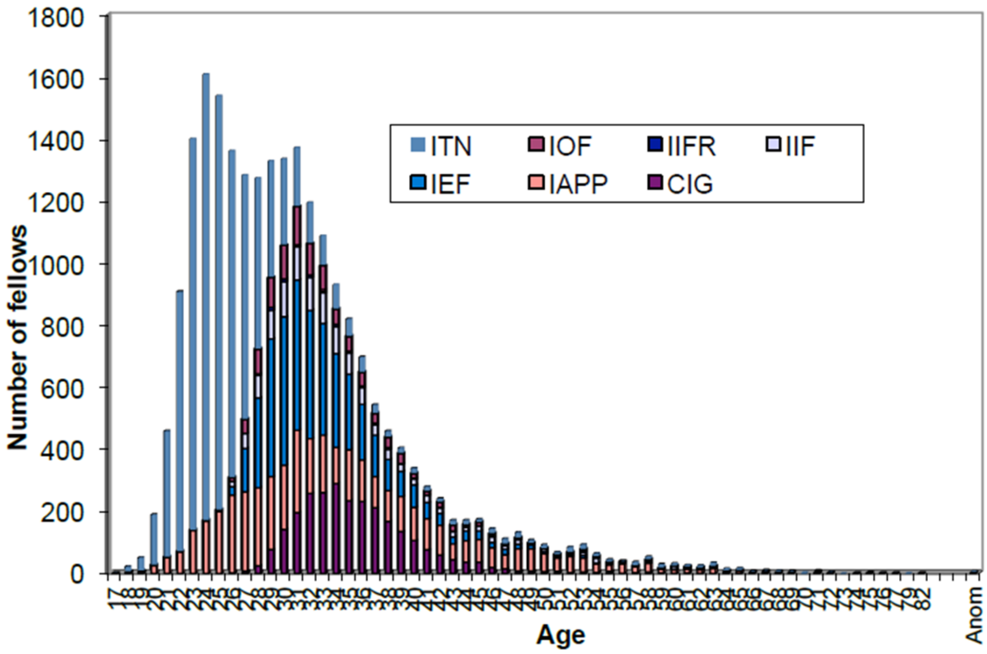
Figure 33 - Share of ERC component publications in common with other FP7 component



Source: ERC Statistical Database.

The age profile of the MSCA fellows is very complementary to ERC grantees (i.e. they tend to be younger).

Figure 34 - Distribution of MSCA fellows by age 2007-2013 (FP7)



Source: FP7 ex-post evaluation People Specific Programme – Statistical Annex[86].

[86] https://ec.europa.eu/research/evaluations/pdf/archive/fp7-ex-post_evaluation/people_annex_1_final.pdf#view=fit&pagemode=none

Many of the responses to the public consultation for the Horizon 2020 interim evaluation have expressed a high demand for funding for collaborative projects with low TRLs. This is a demand which the ERC is looking to address with the reintroduction of the Synergy Grant calls although this will divert funding from the other calls.

A.6.2. External coherence

A.6.2.1. Coherence with other EU funding programmes

In principle there is a strong coherence between the ERC which acts to reinforce the more research intensive actors and to provide a benchmark for others in the European research system and the European Structural and Investments Funds which reinforce capacity in less research intensive regions. However, there are inherent tensions and contradictions between these different EU objectives. .

A.6.2.2. Coherence with other public support initiatives at regional, national and international level

Given that research is a shared competence between the EU and the Member States coherence with actions at the regional, national and international levels is critical to the success of any EU intervention in this area and this aspect is covered above.

A.6.3. Lessons learnt/Areas for improvement

The Scientific Council has been able to monitor the ERC's operations and modify and tailor these through the ERC's annual Work Programme in order to adapt to changing circumstances.

The ERC has developed a suite of consistent grant schemes and provides clear complementarities with the rest of the Framework Programme as well as with actions at the regional, national and international levels. It is widely recognised that a balanced programme of support for R&I should ensure support for curiosity driven frontier research alongside other forms of support. The ERC is funding a broad portfolio of projects which have a high degree of complementarity with the themes and challenges of the rest of Horizon 2020.

There is only a small level of overlap between the work funded by the ERC and the other parts of the framework programme showing that they are complementary.In particular the age profile of the MSCA fellows is very complementary to ERC grantees (i.e. they are younger).

A.7. EU ADDED VALUE

A.7.1. EU Added Value

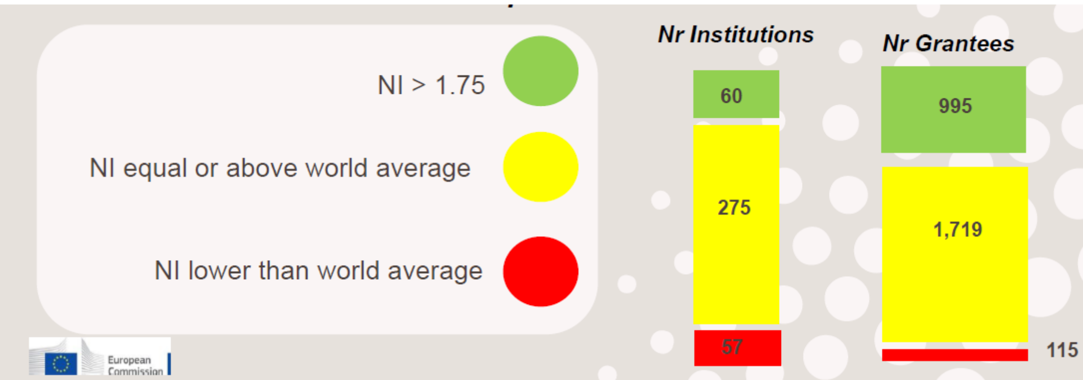
The case for public funding of basic or frontier research is well established. As this case is based on knowledge externalities or "spillovers" and these externalities are recognised as trans-national externalities this case is even stronger at EU level.

By setting up a truly pan-European competition the ERC is able to draw on a wider pool of talents and ideas than would be possible for any national scheme. In this way the best researchers with the best ideas can receive funding irrespective of local bottlenecks or the availability of national funding.

Such a competition can also create significant structural impact. ERC funded projects and researchers should set a clear and inspirational target for frontier research in Europe, raise its profile and make it more attractive for the best researchers at global level. And by acting as a benchmark the ERC allows individual researchers and research institutions as well as national and regional authorities to assess their relative strengths and weaknesses and reform their policies and practices accordingly.

An open competition like ERC makes it possible to find and fund researchers from relatively small institutions whose ideas are seen as more promising by review panels. A good measure of this is the number of grantees which go to organisations which rank relatively low in various benchmark exercises. Here the SCIMAGO rating is used to detect the "pockets of excellence", that is grantees hosted by institutions which do not commend leading positions in various institutional rankings.

Figure 35 - Number of ERC host institutions and grantees by Normalised Impact



Source: ERC Statistical Database and SCIMAGO.

The ERC provides for the first time a European-wide competitive funding structure based on the sole criterion of excellence. In economic terms this transnational competition avoids the negative effects of trans-national externalities and limited systems competition. This has far-reaching consequences:

- Resources are allocated more efficiently, the best researchers with the best ideas receive funding regardless of their nationality and the availability of national funding;
- ERC peer review and funded research acts as a gold standard allowing Member States and individual research institutions to benchmark the relative strengths of their systems and policies leading to important reform of national policies and institutional practices.

A.7.2. Lessons learnt/Areas for improvement

The case for public funding of basic or frontier research is well established. As this case is based on knowledge externalities or "spillovers" and these externalities are recognised as trans-national externalities this case is even stronger at EU level.

By setting up a truly pan-European competition the ERC is able to draw on a wider pool of talents and ideas than would be possible for any national scheme and such a competition can also create significant structural impact. In other words scarce resources are allocated more efficiently and the feedback provided to national policymakers, institutions and individuals irrespective of whether they receive resources directly allows them to understand what they need to do to improve their relative performance.

A.8. SUCCESS STORIES FROM PREVIOUS FRAMEWORK PROGRAMMES

ERC funded result amongst top ten physics discoveries of the last decade

ERC grantee Leo Kouwenhoven recently proved the existence of the "Majorana fermion", a particle theorised in the 1930s. Detecting Majorana's particles is not only exciting for particle physicists; thanks to their properties they could prove useful as stable "quantum bits" of information that could make quantum computers a reality.

In October 2015, the result of Prof. Kouwenhoven's team was listed among the top 10 physics discoveries of the last 10 years by *Nature Physics*. The properties of the Majorana fermions could bring us one step closer to the much-talked-about high-speed quantum computers. In theory, the nature of the particles that can simultaneously be their own opposite could become a building block for quantum information processing and transmission.

Leo Kouwenhoven received an ERC Synergy Grant in 2012 together with Lieven Vandersypen and Carlo Beenakker to further work on bridging the gap between science and engineering in the field of quantum computing[87].

Microsoft has recently hired four leaders in the field of quantum computing, including Leo Kouwenhoven, who will now build a Microsoft lab on the Delft campus[88].

ERC funded research is shattering existing science paradigms in the area of solar cells

ERC funded researchers Michael Gratzel from the Swiss Federal Institute of Technology Lausanne and Henry Snaith at the University of Oxford have been instrumental in the development of a highly promising alternative to conventional solar cells, perovskite solar cells (PSCs). The first perovskite solar cells were made in 2009. They converted 3.8% of the light falling on them into electricity. Now, the best hoover up around 20%. This rate of conversion is similar to the performance of commercial silicon cells, and researchers are confident they can push it to 25% in the next few years.

Moreover, unlike silicon, perovskites are cheap to turn into cells. To make a silicon cell, you have to slice a 200-micron-thick wafer from a solid block of the element. A perovskite cell can be made by mixing some chemical solutions and pouring the result onto a suitable backing, or by vaporising precursor molecules and letting them condense onto such a backing. If these processes can be commercialised, silicon solar cells will have a serious rival.

With the help of the 2012 ERC Proof of Concept grant NEM, the project research team of Henry Snaith has been able to enhance the stability of PSCs. A number of new patents have been filed during the course of the PoC project associated with both enhanced stability and performance of the perovskite solar cells, further improvements required for

[87] http://www.tnw.tudelft.nl/fileadmin/Faculteit/TNW/Actueel/Nieuws/Archief_2013/07_juli_2013/Mourik_Zuo_copy_ENG.pdf
[88] http://www.nature.com/news/quantum-computers-ready-to-leap-out-of-the-lab-in-2017-1.21239

a commercial technology are being pursued through the Oxford spin-out, Oxford PV Ltd[89].

Nobel Laureate in Physics (2010) to ERC grantee

Professor Konstantin Novoselov, was awarded the Nobel Prize in Physics in 2010 for ground-breaking experiments on the two-dimensional super material graphene. Prior to that, in 2007, he received an ERC Grant to study the properties of the same material. One of the world leaders in graphene research, Novoselov is now leading the Hetero2D Synergy project, funded by the ERC. By combining one-atom thick materials such as graphene, the team aims to develop a new class of materials which could offer a wide range of industrial applications and devices, such as photodetectors, solar cells, transistors and other optical, photonic and electronic components.

ERC funded research is new landmark in epigenetics

While women inherit two X chromosomes, the expressions of one of them is shut down during embryonic development. Professor Edith Heard was awarded ERC grants to understand the intricate processes behind the phenomenon, with unexpected results that changed the way gene regulation is now looked at.

Her team was able to investigate the way that DNA was folded within the X-inactivation centre, the master regulator of initiation of X inactivation. This provided unique insights into the regulatory potential and organisation of the X-inactivation centre, as well as chromosome folding in general, as it led to the discovery of a new level of folding of the genome into Topologically Associating Domains (TADs) and how TAD organisation of the genome is linked to biological function.

During the term of her grant, Prof Heard was elected Professor of the College de France (2012) and Fellow of the Royal Society (2013). With a second ERC Advanced Grant, awarded in 2015, she will use cutting edge approaches including CRISPR/Cas9 to decipher the molecular mechanisms behind X inactivation at the level of genes[90].

ERC funded researcher is the "*economist to watch in 2016*"

The research of Professor Hélène Rey of the London Business School has focused on the functioning of the International Monetary System, capital flows and the behaviour of the financial sector has raised interest from academics, central banks and policy-makers. Recently named *"the economist to watch in 2016"* by the *Economist*[91]. She returned to Europe from the US with her ERC Grant for the project IFA Dynamics[92].

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[89] http://www.economist.com/news/science-and-technology/21651166-perovskites-may-give-silicon-solar-cells-run-their-money-crystal-clear
[90] https://erc.europa.eu/sites/default/files/publication/files/erc_annual_report_2015.pdf
[91] http://www.theworldin.com/article/10633/edition2016next-piketty
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A.9. LESSONS LEARNT/CONCLUSIONS

A.9.1. Relevance

- Given the rapidly evolving nature of the global research system and the remaining weaknesses in the European research system compared to other major research systems the ERC's original rationale and objectives remain valid.
- The ERC's funding for frontier research makes it central to the Europe's innovation eco-system which can provide future jobs and growth.

A.9.2. Effectiveness

- The ERC can already show a clear range of direct and indirect impacts across a number of important dimensions. Most clearly the ERC is already funding breakthroughs and major advances and having a visible impact on the European research system, while contributing to many of the wider goals of Horizon 2020. Its strong benchmarking function also provides a structuring effect to the European Research Area and national and regional research policies.
- The current size of the ERC limits its impact compared to the scale of the European research system.

A.9.3. Efficiency

- The ERC's calls have demonstrably managed to attract leading researchers and so the ERC has been able to realise its large scope for economies of scale and low coordination costs and avoids the negative effects of trans-national externalities and limited systems competition.
- However, the ERC is just one part of the overall support for R&I in the EU and it cannot be expected to address all of the issues facing EU research.
- The Agency has performed in an effective, highly efficient and cost-effective way, however the current way of allocating administrative resources to the ERC Executive Agency is inflexible and attempts to harmonise policy and procedures across the framework programme also have the potential to limit the Scientific Council's autonomy.

A.9.4. Coherence

- There is little overlap between the research funded by the ERC and that of the rest of the framework programme showing that the ERC is complementary.

A.9.5. EU Added Value

- The case for public funding of basic or frontier research is well established and because of the existence of trans-national spillovers this case is strengthened at EU level.

The ERC has demonstrated the EU-added value based on pan-European competition.