Ex-post Evaluation
of the Seventh Framework Programme

Support paper to the High Level Expert Group

IDEAS Specific Programme Analytical Evaluation

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Introduction

This paper is aimed at supporting the Report of the High Level Expert Group in charge of the Ex-post evaluation of the Seventh Framework Programme. It is devoted to the analysis and assessment of the IDEAS Specific Programme implemented by the European Research Council.

The paper is based on the analysis of existing documentation provided by the European Commission and the ERC, and of available studies. The paper does *not* reproduce the basic information on the activities of ERC, which are accessible in the official documentation. No additional references have been used at this stage. In some points, the analysis is integrated by our own original work, with some external collaboration.

The structure of the paper follows the main issues illustrated in the Terms of Reference.

1. Rationale

From an evaluative perspective, it is important to assess whether the objectives against which the ERC must be assessed have been formulated in a clear way, and whether these objectives are adequately designed to address EU needs and societal challenges.

The main goals of the ERC were formulated around the key notions of excellence, dynamism, creativity, and attractiveness of European research. These goals are the result of a clear policy rationale. This rationale was predicated on a number of well-grounded assumptions, based on the empirical evidence and a large consensus in the scientific community. It is important to ask whether the rationale is still valid, an issue that will be discussed below.

First, it was felt[1] that European science was losing ground with respect to US science (and in perspective, with the Asian competitors) not in the average scientific performance, but in the scientific leadership. By scientific leadership it is meant the ability to introduce new ideas, often radically new ideas, and to develop them over time until a point where they become accepted by the scientific community and orient the future of scientific investigation. Scientific leadership orients and shapes the research activity of communities all over the world. In fact, once these ideas are accepted, they become enormously attractive worldwide. One important reason is that junior researchers, who must orient their interests and career over many decades, perceive them as an opportunity. Academically-minded PhD students, post doc researchers and junior faculty migrate around the world in search of places where new ideas are created and nurtured. In other words, international attractiveness is a by-product of scientific leadership. This is a difficult challenge, because good ideas are not enough in science, what is needed is the result.

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[1] In the following discussion we refer mainly to the so called Mayor Report, promoted by the Council of Ministers (Competitiveness) (*The European Research Council. A Cornerstone in the European Research Area*. Report from an expert group. Ministry of Science, Technology and Innovation. Copenhagen. December 15 2003) and to the Report promoted by the European Commission (*Frontier Research. The European challenge*. High-Level Expert Group Report. European Commission, 2005). The Commission Decision establishing the European Research Council - (2007/134/EC), available at http://eur lex.europa.eu/LexUriServ/ LexUriServ.do? uri=OJ:L:2007:057:0014:0019:EN:PDF is largely built upon the conclusions of these Reports.

For this reason, second, in these documents it was correctly argued that ground-breaking scientific ideas emerge from the interaction of researchers who can pursue their ideas in autonomy. Researchers need to procure enough funding to plan the project, staff the human resources, procure the technical resources, develop it towards the goal. All this process requires a long term view and the ability to control the critical resources. It requires the creation of a team, under the direction of a principal investigator who takes responsibility towards the funding agency. It was considered that in the European context this autonomy was difficult to achieve, due to the fragmentation of the funding landscape in national agencies, the small scale of the funds available, the short time span of most national programmes. It was considered that new ideas were significantly slowered by the need for researchers to create a patchwork of several funding sources over time, with multiple difficulties in ensuring the timing of funding, recruiting junior people, maintaining the autonomy. In particular, young researchers had a difficult life because for them the autonomy in managing the funds was typically postponed at later stages of career, which often means after their most creative period.

Third, good ideas require not only autonomy, but competition. 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. This notion has nothing to do with the kind of competition experienced in the market. In science competition tends to be “friendly”, because scientists need each other in building their recognition and prestige. This explains why in science the recognition of scientific merit, as it happens for discoveries, is rarely accompanied by resentment of colleagues excluded from the same prestige. In addition in the economic competition companies may benefit from the exclusion of rivals (due to increase in profits), while in science competitors always bring benefit to other researchers.

For the reasons discussed above, it was argued that the European research policy, which had been otherwise successful in other dimensions, was missing the goal of leadership and attractiveness due to the lack of an open, large and competitive funding instrument. Excellent individual researchers might address national agencies, but then the scope of competition was too small to systematically ensure excellence. Or they might address EU Framework Programmes, but then they had to create consortia with other countries, somewhat diluting the original ideas and making organizational compromises. There was a clear and distinctive need for a new instrument. The new instrument should allow for competitive funding (no just retour criteria), target individual investigators and teams (no consortia), be open to excellent projects in any scientific area (no top down priority setting), and provide additional resources with respect to national funding (no crowding out).

Under this respect, the first evaluative question (whether the objectives of the ERC were clear) has a strong positive answer. This is remarkable with respect to other EU policy instruments, for which some ambiguity in the formulation of goals has been eventually damaging (see for example the Network of Excellence, whose goal was formulated in terms of rationalization/critical mass/concentration of efforts, for which the instrument was clearly inadequate, ultimately leading to the cancelation of the instrument itself).

The second evaluative question (whether the objectives were designed to address EU needs and societal challenges) has a qualified answer. The rationale was clearly stated in terms of contribution to the attractiveness of European science in the global context. It might be asked whether this objective is still valid or must be redefined. From this perspective the EU need is still valid and the original rationale is strongly confirmed. The recent evidence shows that European research still suffers from a relative weakness in the upper tail of scientific impact. Among many other studies, the ASPI Report[2] estimates that the APQI-10 indicator (Average Publication Quantity and Impact-top 10%) per researcher is at 2.35 in the USA and 0.81 in Europe. There still is a distinguished need for a European-level instrument for funding excellent research. The degree to which this instrument is also conducive to the resolution of societal challenges is an intriguing question, which will be addressed below.

A related evaluative issue is whether the allocation of activities and budgets is adequate with respect to the fulfillment of the objectives. There are two main allocation decisions: among schemes and among disciplines.

The grants awarded by the ERC are of five types:

- Advanced
- Starting
- Consolidator
- Synergy
- Proof of concept

The differences among the schemes are clearly articulated among three criteria: (a) scientific experience and seniority (i.e. distance from the PhD date); (b) amount of money; (c) individual researcher or team. Thus Advanced grants are allocated to teams, with a principal investigator in his scientific maturity and a large budget; Starting and Consolidator are allocated to individuals, in their early career, with a medium-size budget that allows to pursue their original ideas, while Synergy grants have been conceived for a small group of principal investigators each of which may include her own team, in order to manage large projects in promising areas. Finally, Proof of concept grants are targeted to researchers who have already experienced one of the former schemes and need further support for the downstream stages of the research. Overall, the design of the schemes addresses adequately the needs.

There is also some flexibility in the allocation of the budget among the grants, which must be evaluated positively. Initially the Advanced scheme absorbed the largest share of the budget, approximately 2/3 of the total. During PF7, the shares of Starting and Consolidator schemes were instead increased significantly. According to the ASPI study (p. 6) “the initial idea was that the Advanced Grants would receive two-thirds of the ERC budget. However over the course of FP7 the Scientific Council successively reinforced the Starting and Consolidator Grants due to rising demand with the aim by the end of FP7 that two-thirds of the ERC budget would go to these schemes”.

[2] European Research Council, *Analysis of Specific Programme- IDEAS (ASPI)*. Report to the European Commission, 2014.

In addition, the Synergy and Proof of concept schemes were added afterwards, in response to a need to develop the scientific ideas into a subsequent stage of validation of the concept.

With respect to the allocation among disciplines, the ERC follows a rule of pre-allocation of resources, which is however adjusted and modified ex post, according to the distribution of proposals that pass the first step of selection. Again, this flexibility is welcome.

Summary

- The rationale underlying the IDEAS Specific programme is clearly articulated
- The objectives defined for the IDEAS Specific programme at its creation are still valid and deserve to be pursued for many years in line
- The allocation of the budget among the types of grant is consistent with the overall objectives and benefits from a certain flexibility

2. Implementation

2.1 Participation patterns

From an evaluative perspective it is important to examine the patterns of participation, asking whether there is a correspondence between the intended population of participants (by country, thematic area, and type of institution) and the realized one. In particular, it is important to examine whether the best research institutions and the most innovative firms actually participated to the funding scheme.

2.1.1 Participation patterns by country

With respect to the breakdown by country, it is important to recall that there is no expected a priori distribution. Excellent frontier research may arise from any country. At the same time, since the threshold of quality defined by the ERC is set at high levels, it is likely that researchers self-select themselves, submitting proposals to the ERC only if they believe they have a strong case. Thus the number of proposals is expected to follow, on the one hand, the number of active researchers at national level, on the other hand, the proportion of researchers who are prepared to compete at international level for funding.

Another influencing factor is the richness of the national funding environment. Other things being equal, in countries with a large scientific pool but with shrinking national budget for research, it is more likely to find applicants at European level. This is even more so with respect to the reduction in public research expenditure in countries under fiscal constraints after the financial crisis started in 2008.

In addition, the pattern of participation at country level must take into account the difference between country of origin of researchers and country of the host institution. The analysis of these two distributions makes it possible to identify the following patterns:

- large (Germany, France, UK) and medium-sized countries (Netherlands, Switzerland, Sweden, Denmark) with well developed scientific systems and no fiscal constraints are at the same time the source and the destination of a large share of grants;
- among large countries, UK is the most attractive one; among medium-sized counties, Switzerland and Netherlands are also remarkable;
- large countries with a well developed scientific systems but significant areas of weakness (Italy, Spain) are the source of large number of applicants but the destination of a much lower share; this effect is magnified by the reduction in public spending to the fiscal compact;
- cohesion countries, both in Eastern Europe and Southern Europe, exhibit a more problematic picture, being at the same time the source and the destination of a relatively small share of grants.

Success rates are largely different by country: they are in the range 1-3% in Eastern European countries, 5-10% in countries that are moderate innovators, and 12-16% in Belgium, Germany, Austria, Netherlands, UK and France.[3] The ASPI Report has modelled the expected success rates per country as a function of population, GDP, GERD and number of top publications. In this model four countries have a largely better performance with respect to the expected level of success (Israel, Cyprus, Switzerland and Netherlands) and other four have a better performance (United Kingdom, Belgium, Sweden, Austria). Among large countries, France performs in proportion to the independent variables, while Spain, Germany and Italy have a lower performance than expected. All Eastern European countries have a lower performance.

We advance a general explanation for these findings. These patterns have a long term or structural component and a short term component. The structural pattern can be explained by two main factors: the size of the research system and its internal differentiation. Size is a precondition for excellent research, because it emerges from a selection process over a pool of ideas. It is very difficult to sustain excellent research if the pool is too small. On the other hand, it is also important to observe that countries differ by the degree to which their internal research system is vertically differentiated, that is, has institutionally embedded layers of research quality. Under this respect, some large countries, such as Germany, France, Italy and Spain, generate a large number of applicants, but are not particularly attractive for foreign researchers. In the case of Germany and France there are two well developed and well-funded research systems, largely untouched by the fiscal crisis, with a large role played by Public Research Organisations (PROs). Universities play a relatively minor role, with only a few exceptions. In these countries there is not an institutional tradition of vertical differentiation or stratification of universities. The distribution of funding for research is not concentrated but spread evenly. The same tradition can be found in Italy and Spain, where, in addition, the funding trend has been negative. Overall, in these countries the average research quality is

[3] See European Research Council, *Annual Report on the ERC activities and achievements in 2014*. European Commission, 2015. Our elaboration from Figure 3.3

good or very good, but excellent research is spread across many universities, so that there are few universities able to compete globally on the basis of top scientific performance.

On the contrary, in countries such as United Kingdom, Netherlands, Switzerland, and to a certain extent Belgium and Sweden, not to mention Israel, it can be shown that universities have been forced to differentiate their offering profiles, so that eventually those that wanted to excel in research were placed in the condition to pursue excellence across several disciplines. This has led to a relatively larger number, both in absolute terms and relative to the size of the country, of global players.

This interpretation is supported by the analysis of the number of institutions that receive at least 20 grants in the period. While this threshold is arbitrary, it is useful to discriminate the situations. In France there are six institutions, all of which are PROs (CNRS, with 217 grants; INSERM 58; CEA 48; INRIA 33; Pasteur Institute 25; Curie Institute 29). In Germany there are four institutions: a large PRO (Max Planck, 110 grants) and three universities (Munich, Technical University of Munich, Heidelberg). By aggregating several institutes that are counted separately by the ERC it seems that also Helmholtz is to be included (23 grants). In these two countries there is a certain effect of crowding out between PROs and universities: not only very few of them equal 20 grants, but also there are almost no French universities and a few German ones in the range between 10 and 20 grants received from the ERC. Taking the other two large Continental European countries, in Spain there is only one institution with at least 20 grants (CSIC, with 40 grants) and in Italy none (the largest PRO, the National Research Council, is at 17).[4]

At the same time, there are 12 UK institutions with at least 20 grants. In addition, in relatively small countries the number of institutions with at least 20 grants is more favorable than in the large continental countries: they are as many as 9 in the Netherlands, 5 in Switzerland, 4 in Sweden and Israel, 3 in Belgium, 2 in Denmark.

With respect to Eastern European countries it must be taken into account that the restructuring of the research system is still in place. In addition, in these countries (as well as in Southern European countries) there is probably a crowding-out effect from the research funds of Structural Funds.

Summing up, the distribution by country shows that those that receive the largest share of grants are: (a) large and well funded but non differentiated systems; (b) large or medium-sized highly differentiated systems. Those that receive the least are: (c) large, relatively poorly funded and non differentiated systems; (d) relatively less developed systems.

These patterns are not likely to be changed easily. The short term pattern, on the contrary, may be changed in the next few years if the fiscal consolidation of countries such as Spain and Italy is successful and if Eastern European countries are in the position to invest in R&D.

Summing up, the pattern of country participation is the direct and clear consequence of the underlying distribution of excellent research. It may be asked whether the ERC contributes to reinforcing these patterns or should instead act in order to counterbalance them. In principle, it is not the mission of a funding agency to compensate for the weaknesses of national systems. Its mission is to keep the scientific competition open and transparent and to offer full justification of the decisions made. Faced with the evidence of large differences in country

[4] Data kindly provided by the European Research Council, Monitoring and Evaluation team.

performance, it is the duty of national governments to take measures to strengthen excellence internally. Thus the contribution of the ERC to reach a more balanced distribution of grants is to offer the service of evidence, and generate reactions at various levels. It will be seen below that this process is actually going to happen.

Summary

- The pattern of participation by country reflects the strengths and weaknesses of national scientific systems of Member States, with respect to the size of the pool of researchers, the level of public funding, and the trend of funding in recent years
- The pattern of participation by country also reflects the institutional history of Member States. Countries in which the institutional structure and the funding patterns have supported the emergence of global players among universities (defined as universities which exhibit excellent research at world level across many disciplines) benefit more than others
- In France and Germany the ERC grants are strongly concentrated in PROs, while universities are relatively less represented. In UK, Switzerland, Sweden, Denmark, Belgium, as well as in Israel, there is instead a core of universities able to receive at least 20 grants. In Italy and Spain the PROs are relatively weaker and there are no universities beyond the threshold of 20 grants

2.1.2 Participation patterns by thematic area

With respect to the breakdown by thematic area, it is important to recall the approach followed by the ERC. Following the initial rationale, the ERC is committed to fund excellent frontier research from any thematic area. This follows a clear departure from a traditional science policy approach in which thematic priorities are defined ex-ante and with a top down procedure. In addition, funding research in any thematic area implies there is not mission-oriented research. This orientation is extremely important to differentiate the ERC from other funding instruments.

This means that from an evaluative point of view there is no reference point into a mission statement. We suggest two reference points to be used in the evaluation: the distribution of the academic staff and of scientific publications. Both data refer only to Higher Education Institutions (HEIs), for which the effort of collecting disaggregated data is far more advanced than for PROs. Data disaggregated by thematic area are not available for all countries. For academic staff the aggregation in thematic areas has been carried out on the basis of the Fields of Education (FoE) standard classification; for publications it is based on the Subject Category classification. Table 1 offers a preliminary assessment of the problem. In reading the table please take into account that Human and Social Sciences are heavily underrepresented in the distribution of journal publications, since the coverage of bibliometric databases is poor for journals in national languages and for books and chapters. In addition, the large field of Biochemistry and Biology is included in Life Sciences in publications, but in Natural Sciences in the count of academic staff. Therefore in the analysis of staff, Natural Sciences and Engineering are overestimated. With this *caveat* in mind, it is shown that Life Sciences absorb approximately 23% of academic staff against 41.7% of Natural sciences and Engineering. This distance is somewhat eliminated in the case of publications, where the two shares are almost equivalent in the European case, while at world level Natural Sciences maintain a distance of almost ten percentage points. Human and Social Sciences are found somewhere in the middle between a few percentage points and one third of the total.

Compare these data with the ERC breakdown. According to the ERC Report 2014, "over FP7 in the three main funding schemes (Starting, Consolidator and Advanced Grant), the Physical and Engineering domain received 41.2% of the budget (€3.2 billion in commitments), the Life Sciences domain 36.2% (€2.8 billion in commitments), and the Social Sciences and Humanities domain 15.4% (€1.2 billion in commitments). Finally 3.3% of the total ERC budget (€256 million in commitments) was allocated to "interdisciplinary" projects (ID), while the remaining 3.9% (€301 million in commitments) corresponds to the Synergy Grant and Proof of funding schemes, and to support actions".

This breakdown is reasonable. Human and social sciences receive a share half-way between their weight in headcount and their share of publications. Considering that the cost of research in these fields is significantly lower than in the other two areas, this seems a remarkable share of funding. For the other two areas, we see that Physical and Engineering domain is at the top with 41.2%, or 15% more than Life Sciences. This delta is smaller than the one we find in academic staff, but larger than the one we find in publications in Europe. Thus the overall distribution is correct.

Table 1: Estimates of the distribution of the research potential by thematic area

	Life Sciences	Engineering and Physics	Human and social sciences	Life Sciences (%)	Engineering and Physics (%)	Human and social sciences (%)
Number of publications*	3,481,298	4,167,945	172,348	44.5	53.3	2.2
Number of publications (Europe)**	1,289,715	1,328,055	51,683	48.3	49.8	1.9
Number of academic staff***	123,334.7	224,537.3	190,785.1	22.9	41.7	35.4

(*) Total number of publications in the period 2007-2010 in a global census of HEIs. Source: our elaboration on Global Research Benchmarking System (GRBS) data based on Scopus. Data refer to occurrences in Subject Categories; articles may appear in more than one Subject Category.

(**) Total number of publications in the period 2007-2010 in European HEIs. Source: as above.
(***) Academic staff in European HEIs. Sum of full time equivalent (UK) and headcount (all other countries) data. Source: EUMIDA for AT, BE, DK, FI, IT (data refer to 2008); HESA for UK (data refer to 2011) and ETER for CH, DE, ES, NO, SE (data refer to 2012-2013), our elaboration.

From an evaluative perspective, there are several issues to be examined. First of all, we have to avoid the grade inflation problem. By this term, well known in the literature on evaluation, it is meant the process by which referees may attribute larger scores to projects in the attempt to secure more funds for their own discipline. If the breakdown by thematic area and discipline is not fixed in advance, then the distribution of funds must follow the overall ranking. If this is the case, "inflating" projects in one's own discipline may help to fund more projects and to strengthen its profile. This may happen even if referees are highly professional and are not fully aware of the cognitive distortion induced by the evaluation procedure. On the contrary, if the allocation by thematic area is fixed, then there is no point in inflating the grades, because there will be no benefit in the overall allocation.

With respect to the grade inflation issue, the ERC follows an appropriate procedure. In fact, it announces to referees that an overall allocation across thematic areas has been fixed, neutralizing the risk of grade inflation. However, it retains the right to adjust the final allocation at the margin at the end of the process, if the realized distribution of scores is such that the allocation eliminates a significantly larger share of excellent projects in one area with respect to others. This flexible adjustment is not mandatory, in order to prevent the expectations that lead to grade inflation. Thus the allocative scheme at the same time allows for the recognition of excellence from any area, but mitigates the distortions that may arise.

It remains to be seen whether this dynamic equilibrium can be maintained once the expectations of referees are stabilized.

This leads to a second evaluative issue. In a multi-disciplinary funding environment, the consistency of peer review criteria across areas cannot be taken for granted. It is always possible that the same abstract criteria of excellence and quality are operationalized in different ways. In some areas there might be large, even universal, agreement on the operationalization, so that criteria are commonly applied and understood and exhibit significant stability over time. In these areas it may be safely assumed that selecting referees randomly delivers quite consistent results over time. Overall, this seems to be the case for Physics and Engineering, and for Life Sciences, that is, for all scientific and technological areas.

However, in other areas there are many more quality criteria and there might be disagreement on the importance of these criteria and on the weighting schemes. This is somewhat the case of Humanities and Social Sciences. In the latter field there are important exceptions in economics and in some traditions in psychology, sociology and political science.

Thus there are differences in the number and type of research quality criteria, the operationalization adopted, the level of agreement on criteria and operationalizations. This creates a challenge to a multi-disciplinary funding agency, insofar as it requires that the same level of selectivity is maintained across areas.

We investigated in-depth the procedures followed by the ERC in the Ex-ante selection of projects. They are based on a two-step process. This is welcome, because it helps to separate acceptability criteria, which refer mostly to formal aspects of scholarly proposal writing, from criteria that go deeply into the epistemic content of proposals. Once proposals reach the second step, they are subject to an intense scrutiny, which combines external referees with consensus procedures in the panel. We find the overall procedure highly professional and adequate to the goal.

At the same time, even the most professional peer review system is subject to limitations. While there is no such thing as an optimal peer review procedure, there is room for continuous improvement. Self-reflection on the peer review process is the best way to ensure such improvement.

We would recommend to start a programme of evaluation studies aimed at investigating the quality of peer review. Several directions of evaluation may be identified. First, an inter-panel agreement approach might be followed. A sample of projects might be subject to the evaluation of different sub-panels in the same panel (or assigned to external referees in separate groups) following a controlled design. The degree of inter-rater, or inter-panel agreement might be used as a measure of robustness and stability of quality criteria. Second, a focus on discarded projects might help to examine the extent to which the selection process creates false negatives. By changing the group of referees in a controlled way it might be possible to examine the extent to which false negatives are found and to reflect deeply on the criteria adopted. Third, cases with a minority opinion in the panel might be investigated in depth.

While data on the ex-post performance of funded projects are routinely available in the information system, it might be important to reconstruct the performance of: (a) admissible but not funded projects; (b) discarded projects. The relation between the ex-post performance and the pattern of ex-ante evaluation might be investigated in depth.

Summary

- With respect to thematic areas the breakdown approximately reflects the distribution of academic staff of European higher education institutions (HEIs) per discipline and the distribution of publications
- The allocation of the budget per thematic areas follows a pre-allocation rule. This arrangement is positive since it prevents the distortion that might be created by grade inflation. At the same time, the system allows some ex-post flexibility in order to adjust for large variations in the rates of success.

2.1.3 Participation patterns by institution

With respect to the breakdown by institution, it is important to recall that excellent frontier research can be done, in principle, in any institution. The ERC selects individuals and teams, not institutions. From this perspective, what is crucial is to assess whether there are obstacles to participation. At the same time, excellent research itself is most likely to result from a process of continuous exploration and selection. Good ideas grow better in research environments in which they are subject to tough scrutiny from a community of engaged and high level researchers. From this angle, it is reasonable to expect that most projects come from institutions that benefit from this tradition and have recruitment procedures aimed at ensuring uncompromised high quality staff at any time.

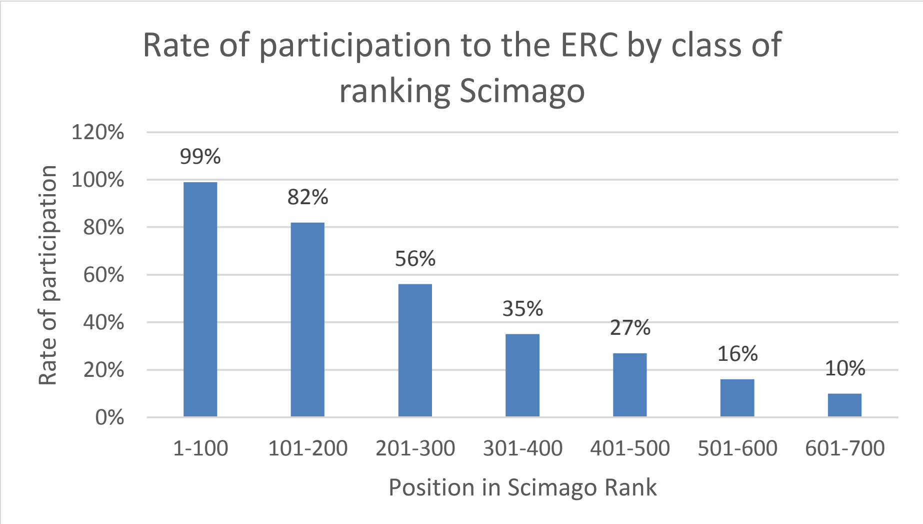
We obtained data from the ERC on 584 institutions, receiving 4532 grants since 2009 (extraction August 2014). The concentration of grants is significant, with the top 5% institutions accounting for approximately 40% of the total budget.

From an evaluative perspective it is important to distinguish whether the concentration of grants in excellent institutions is the result of an adequate ex-ante selection process, or follows an indirect (and unintended) reputational effect. This might happen if the referees assign significantly larger scores to proposals coming from excellent institutions, with respect to similar projects coming from non-excellent institutions. This is called "halo effect" in the literature. The referee may attribute to the project at hand some features of scientific quality that are attributed to the overall institution, not controlling for the unit of analysis. This is methodologically flawed, because there is a mismatch of attribution between the container (the excellent institution) and the content (the individual project). While there might be a positive relation between the two, at aggregate level, this relation cannot be presupposed in the ex-ante evaluation process.

This problem may be particularly serious in the European landscape, because it is known that only a few institutions have a consistently high level of research quality across all thematic areas. In most cases, within the same institutional umbrella there is large variability of research quality, not only across areas, but also within the same thematic area, or department. This follows from the institutional history of European higher education, in which excellence is scattered (or "fragmented") in many institutions.

Therefore from an evaluative perspective, we would be interested in seeing both concentration of grants in excellent institutions *and* a certain share of grants allocated to institutions that lag behind. What account for excellence of institutions is, however, a non-obvious issue. There are several possible definitions and rankings. We investigated this issue by adopting a largely used ranking of institutions (Scimago), which is only based on bibliometric information. We examine separately the case of Higher Education Institutions (HEIs) and Public Research Organisations (PROs), using two separate rankings. Given that the list of host institutions has been extracted in 2014, we use the 2013 edition of the ranking (SIR Global Ranking-Output). For universities, we match the names in the ERC list with Scimago, merge the Western Europe, Eastern Europe and Middle East rankings based on the total output, and re-rank accordingly. For PROs, on the contrary, it is impossible to match the Scimago ranking with the classification of ERC, because the latter includes PROs at different level of aggregation (e.g. under the same umbrella at CNRS and Max Planck, under the name of the institute for Hemholtz and Leibniz). We then use the published Scimago rank 2013 as it stands, including both HEIs and PROs. We are interested in the overall pattern, rather than the position of individual cases.

Figure 1: Rate of participation to the ERC by class of ranking Scimago (2013)



Let us examine universities first. The first evaluative question is whether excellent universities have been involved in the ERC. In order to address this issue we calculated the number of participants across the classes of the Scimago ranking of universities in 2013 (HEIs only). Figure 1 shows that as almost all universities in the range 1-100 received ERC grants and a large majority (82%) of those in the 101-200 range. The rate of participation declines monotonically with the class of ranking: only 56 institutions in the range 201-300, 35 in the range 301-400 and 27 in the range 401-500 participate to the ERC.

Table 2: Number of ERC grants per classes of modified ranking Scimago- HEIs only

Rank Scimago	Number of participants	Number of grants	Average number of grants
1-100	99	2038	20,6
101-200	82	676	8,2
201-300	56	235	4,2
301-400	35	73	2,1
401-500	27	59	2,2
501-600	16	25	1,6
601-700	10	43	4,3

Table 3: Relationship between the total number of ERC grants and the position of HEIs in Scimago ranking

	Number of grants	Modified rank
University of Oxford	134	2
University of Cambridge	125	4
University College London	92	1
Swiss Federal Institute of Technology Lausanne (EPFL)	91	46
Swiss Federal Institute of Technology Zurich (ETH Zurich)	86	9
Weizmann Institute	86	172
Hebrew University of Jerusalem	74	67
Imperial College	66	5
University of Leuven	46	7
University of Edinburgh	43	15
University of Bristol	41	33
University of Munich (LMU)	36	10
Leiden University	36	30
University of Amsterdam	35	12
Technion - Israel Institute of Technology	35	75
University of Zurich	34	53
University of Copenhagen	33	16
Free University and Medical Center Amsterdam (VU-VUmc)	33	25
King's College London	32	20
Karolinska Institute	32	22
University of Geneva	32	106
Utrecht University	30	8
Tel Aviv University	30	24
Delft University of Technology	30	31
University of Helsinki	30	34
Technical University of Munich	28	13
University of Manchester	27	6
University of Groningen	27	29
Lund University	27	37
Uppsala University	27	50
University of Warwick	26	94
Ghent University	25	18
Aarhus University	25	32
Eindhoven University of Technology	25	93
University of Vienna	25	105
University of Exeter	25	149
University of Sheffield	24	41
University of Leeds	24	47
University of Oslo	22	44
Royal Institute of Technology (KTH)	22	74
University of Basel	21	167
University of Heidelberg	20	14
University of Twente	20	122

Not only universities that are ranked higher participate more, but they also receive on average more grants. Table 2 shows that those in the 1-101 range receive on average more than 20 grants, ten times the number of universities below the 300th position (the average number of the few below 600th position is influenced by two special cases). This means that universities in the range 1-100 are able to submit excellent research proposals in all thematic areas and across a wide range of topics.

A related evaluative question is whether the institutions that receive more grants are excellent institutions. In order to address the issue we tabulated the number of total ERC grants of HEIs and selected those that received more than 20 grants (Table 3). It is interesting to note that almost all institutions with more than 20 grants are included in the top 100 by the Scimago ranking.

A remarkable exception is the Weizmann Institute in Israel, ranked 172th but receiving no less than 86 grants. Only five universities in this list are ranked below the 100th position.

Table 4: Distribution of ERC grants at Public Research Organisations

Host Institution- PROs	ERC grants	Scimago output	Scimago ranking
National Centre for Scientific Research (CNRS)	217	215261	1
Max Planck Society	110	54202	3
National Institute of Health and Medical Research (INSERM)	58	43602	5
French Alternative Energies and Atomic Energy Commission	48	27309	14
Spanish National Research Council (CSIC)	40	49873	4
National Institute for Research in Computer Science and Automatic Control (INRIA)	33	14855	62
Pasteur Institute	25	4763	261
Flanders Institute for Biotechnology (VIB)	22	1698	577
Curie Institute	21	2841	387
European Molecular Biology Laboratory (EMBL)	19	1327	681
National Research Council (CNR) – Italy	17	39874	6
Medical Research Council UK	17	6252	207
Institute of Science and Technology Austria	14	1373	666
Institute of Photonics Science	14	1038	794
Cancer Research UK	13	5135	242
Centre for Genomic Regulation	12	779	919
Royal Netherlands Academy of Arts and Sciences	12	3721	323
Helmholtz Center Munich- German Research Center for Environmental Health	11	4278	289
Institute of Genetics and Molecular and Cellular Biology - Strasbourg	11	1124	763
Netherlands Cancer Institute	11	2659	409

Source: our elaboration from ERC data and Scimago website

With respect to the PROs, the situation is more complicated (Table 4). Overall, 1415 grants have been allocated to 235 PROs (our own classification from ERC data). This represents a realistic share of the total, one third of the total, with two thirds being represented by HEIs.

All large PROs are represented at the top (CNRS at 217, Max Planck at 110, INSERM at 58, CEA at 48, CSIC at 40). Less represented is the Italian CNR, at 17. With respect to the German institutional landscape, there are several other PROs involved, which however are classified by the ERC not under the same umbrella, but with the name of individual institutes, at Helmholtz and Leibniz foundations. They do not appear in the top list. Among the large European PROs with more than 10.000 publications (Scimago output) only the French INRA and the Italian INFN are relatively less represented in the top list. After the large PROs we then see a list of medium-sized institutes, mostly in the range 1000-5000 publications. While we report their Scimago ranking, it is important to note that it is not particularly informative, since it is based on the total output, which is clearly influenced by the level of aggregation. Furthermore, the ranking used here includes both HEIs and PROs.

As it happens for universities, there is then a long tail of PROs with one or a few grants.

2.2 International participation

The ERC has been created to foster mobility of researchers and attracting to Europe talented researchers from abroad.

We know from the literature on scientific mobility that long term mobility, and particularly changes in the affiliation, take place early in the researchers career. After researchers have settled down in a place with a family, it become increasingly more difficult to attract them in another country.

With this qualification in mind, the fact that 17% of PhD involved in ERC grants come from outside Europe is a remarkable result. There are 2,700 Phd students in total who come mainly from China, USA and India, and spend their doctoral studies collaborating with a ERC-funded project.

Another evidence in support of the international attractiveness has been provided in the ASPI Report. The ERC has identified approximately 14,000 leading researchers based in Europe, combining data on highly cited scientists (ISI), members of US national academies, who are elected as foreign affiliates, selected prestigious national research prizes, and Gordon Conferences. Among this pool of talent, approximately ¼ applied to the ERC, of which 43% were funded. Overall, 1,647 leading researchers have been funded, or 12% of the total identified pool.

2.3 Industry participation

The participation of companies is extremely limited. We were able to identify only IBM Research GMbH, the Nestlé Institute of Health Sciences, the Robert Bosch Society for Medical Research. There are also several Foundations, some of which may be private, but whose origin, governance and funding is hard to determine without a detailed examination.

Overall, the private sector plays only a marginal role in the participation to the ERC. This is not bad, however. We believe that it is good for European research policy to target different instruments to different populations. The ERC, by mission and organization, is not suitable for heavy industry involvement.

2.4 Success rates

The success rates vary by year, scheme and thematic area but remain within certain ranges. In a forthcoming Report, the ERC provides extremely detailed data, following a common practice among funding agencies in the advanced world. [5]

According to the ASPI summary, overall the success rates of Starting grants are in the 9-15% range, of Advanced grants in the 12-16% range, of Proof of concept in the 24-50% range, and of Synergy in the 1-3% range.

The high success rate of the Proof of concept scheme is clearly influenced by the novelty of the scheme and by the fact that it is targeted to previous ERC researchers, who already have deep knowledge of the peer review process and the expectations attached to ERC proposals. It is likely that the success rate will decrease in the near future.

The extremely low success rate of Synergy has to do, on the contrary, with the fact that it provides abundant funding to large teams. The pool of potential candidates is very large indeed.

It is therefore important to focus on the success rates of the two largest schemes, Starting grants and Advanced grants. The low success rates are the joint product of a large demand on the side of researchers, the limits of the ERC budget, and the toughness of the peer review process.

It is useful to compare these success rates with the ones of the largest funding agencies in the world, the NSF and NIH in the USA. In both cases the success rates are significantly larger than for the ERC. It is true that ERC grants are larger and longer than the typical NSF grants (see last column in Table 5). But the most plausible explanation has to do with the much smaller size of the ERC budget with respect to other funding agencies (at least in USA, Japan, Germany and UK).

Interestingly, in the case of NIH Research Grants there has been a decline: they were around 30% until 2003, then declined to 20% in 2006 and stayed at this level until 2010. After 2010 the level declined further at 17-18%, a level which is considered with some concern from the US scientific community.

[5] See European Research Council, *ERC funding activities 2007 funding activities 2007-2013. Key facts, patterns and trends*. Draft report, 2015. We thank the Monitoring and evaluation team of ERC for making the Report accessible before the publication.

Table 5: Success rates at National Science Foundation (NSF) and National Institute of Health (NIH)

	Number of Proposals	Number of Awards	Funding rate/ Success rate (*)	Average Decision Time (months)	Mean Award Duration (years)
NSF 2014	48.074	10.981	23%	5.75	2.59
NSF 2013	49.013	10.844	22%	5.77	2.62
NIH 2014 (Grand Total)	68.285	14.372	21%	n.a.	n.a.
NIH 2013 (only Research grants)	49.581	8.310	17%	n.a.	n.a.

(*) Funding rates are usually larger than success rates since they include resubmission of rejected proposals.

Sources: NSF: http://dellweb.bfa.nsf.gov/awdfr3/default.asp; accessed March 21, 2015; funding rates. NIH: http://report.nih.gov/success_rates/ (Table # 205A) for 2014; http://report.nih.gov/nihdatabook/index.aspx for 2013; accessed March 21, 2015; success rates.

What we can learn from this comparison is that the quality standards followed by the ERC with respect to the ex-ante selection process are indeed at world level. At the same time, there is clearly a problem of relative size of the funding agency with respect to the size of the pool of potential applicants. In the European context it seems that there is room for enlarging further the ERC budget and still maintain high levels of selectivity and quality. Even assuming the recent level of success or funding rates of NSF and NIH at 20% as a benchmark, it seems that the ERC might increase significantly the number of projects awarded and still maintain high standards of quality.

3. Direct achievements

3.1 Direct impact on scientific production

The impact of ERC funding on scientific production may be evaluated with respect to the current production and to the production of completed projects.

The ongoing volume of publications in Web of Science including a recognition for ERC is approximately 30,000, of which 650 in *Nature* or *Science* (data refer to August-September 2014). This amounts to 6.7 papers per grant. However, the 314 projects already completed (187 Starting grants and 127 Advanced grants started in 2007-2008) have produced 10,796 papers, or an average of 23 per grant in Life sciences, 48 in Physical and Engineering sciences, 18 in Human and social sciences.

With respect to the quality of publications, those that originate from completed projects are found in the top quantile with much larger probability than average. Out of 10,796 publications, 7,003 are indexed in Scopus and 1,996 in ISI. In Scopus the proportion of top 1% is 20.6% in Life sciences, 9.2% in Human and social sciences, and 7.9% in Physical and Engineering sciences. These are larger numbers that the average Europe share (1.4%) and US share (2.2%). In ISI the share of top 1% from ERC funding is 12% on average. Coming to the top 10% quantile, it exceeds 30% in all areas in both Scopus and ISI. These numbers tell that the ERC is funding top quality research.

According to the ASPI Report, among the most cited publications that recognize the ERC funding, some refer to discoveries that are commonly considered breakthroughs. Among these, the synthetization of graphane, on which several ERC grantees are currently working, the dye-sensitized solar cell, Higgs boson, the large scale structure of the universe, storage energy in cells, Diabetes Type-2 and biological image analysis.

Coming to a crude estimate of the cost per unit of output, we can compare the ongoing production with the one coming from completed projects. While an average productivity of 6.7 papers per grant corresponds to a cost per paper in the order of 250k euro, the indicators of completed projects suggest a cost per paper in the order of 60-70k euro, which is a realistically low level. While it would not be correct to project the production of completed projects unto the overall activity (it may be possible that some projects actually fail), there is evidence that the scientific production is not only effective, but also efficient.

Finally, the ERACEP study[6] has found that several ERC grants have been awarded in scientific areas characterized by accelerated dynamics. This means addressing existing research clusters with exceptional growth, or the creation of completely new clusters, or the shift of existing clusters into new topics.

[6] European Research Council. *Emerging Research Areas and their Coverage by ERC-supported Projects (ERACEP).* Final report. April 2013.

Summary

- The participation to ERC has allowed a number of breakthrough discoveries just in the few years following the implementation of the scheme
- Several outstanding scientific Prizes have been awarded to researchers who benefited from ERC grants: only in 2014 three grantees received the Nobel prize and two grantees received the Fields Medals. Overall, there are 11 Nobel prizes and 5 Fields medalists among the grantees.[7]
- The publication record of researchers who have received a grant from the ERC is remarkable, particularly in the top 1% and top 10%
- The cost efficiency of scientific production of completed projects is very high. The administrative costs are kept under 3% of the operational budget of the ERC. Duplication is limited due to the European scale of operations. There is an intensive use of scarce resources of referee skills and time.

3.2 Direct impact on innovation

One of the concepts upon which the ERC has been created is the concept of frontier research. This concept had the ambition to overcome the traditional distinction between basic or fundamental research and applied research. In the original formulation, in fact, it was argued that most discoveries in the last part of XX century opened the way to a range of potential applications, particularly in the fields of materials and nanoscience, life science, and information science. In these fields several new experimental techniques (a clear example of Grilichesian innovation) make it possible at the same time the observation and the manipulation of matter. The distinction between discovery and invention becomes blurred. There is an increasing need of multidisciplinary teams in which scientists work together with engineers and challenge each other interactively.

While this formulation is in itself an achievement in research policy, its practical realization is not easy and may take time. As a matter of fact, research is organized by discipline and multidisciplinary efforts require a clear vision and rationale and strong discipline, something that is not obviously found in most academic environments. Furthermore, the ability to develop applications requires systematic interaction between laboratory engineers and design/manufacturing engineers. It may not be enough to develop concepts or even prototypes in a laboratory setting. Considering the complexity of the migration of knowledge from the lab to the application, the ERC introduced a new funding scheme, called Proof of concept.

In its Report, the ERC provides data on the PoC scheme and add information about the patenting activities of grantees. The PoC scheme is too young to be evaluated in a rigorous

[7] European Research Council. Annual Report on the ERC activities and achievements in 2014. Brussels, 2015. Available at

way. With respect to patents, it is shown that out of 107 completed projects in Life Sciences, 19 had at least one patent, with a total number of patents at 30, while out of 156 completed projects in Physical and Engineering sciences, 34 had at least one patent, totalling 68 patents. Overall, 53 projects had at least one patent, or 20.2% of the total.

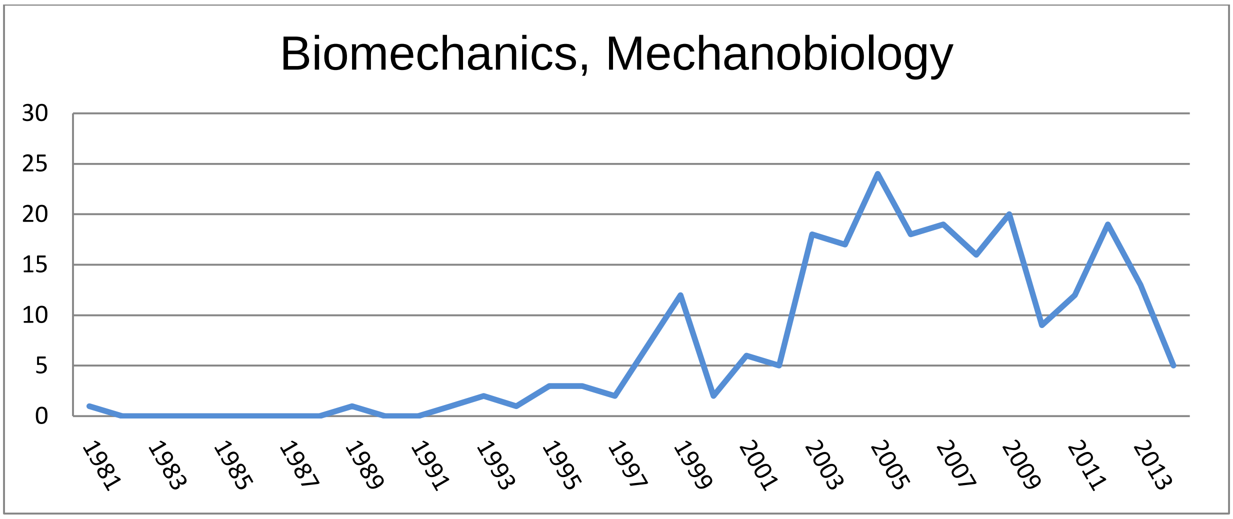
These data provide an interesting but limited snapshot on the potential of ERC research for applications. In fact, there is no need to assume that those who produce the original knowledge are themselves those who may want to exploit it via patenting activity. This measures only the direct impact of research, and is a narrow definition of impact. There might be an indirect effect, potentially much larger, that comes from the utilization of ERC results from the technological community at world level.

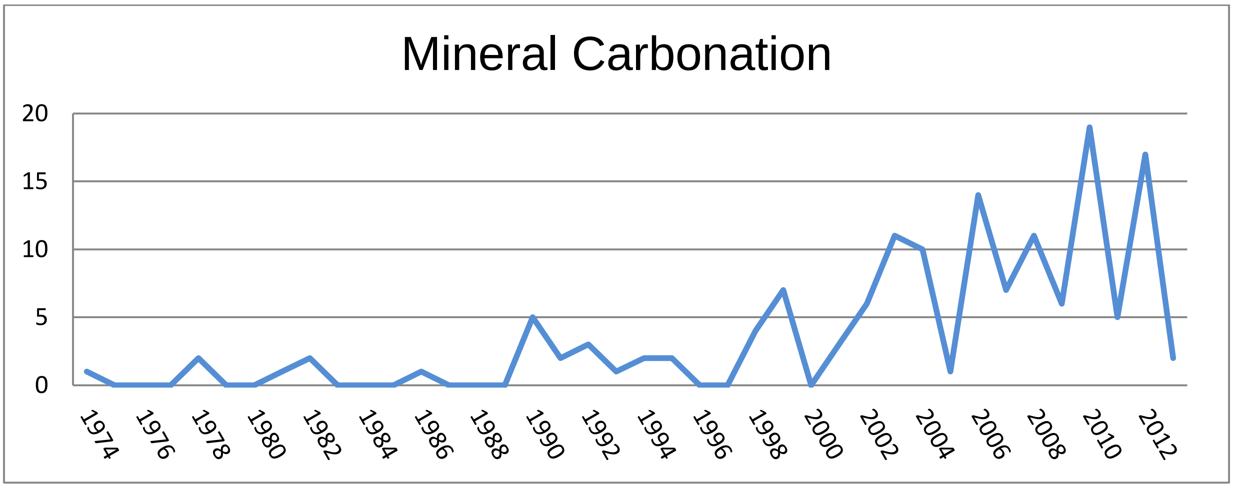
The DBF study introduced the notion of *pasteuresqueness* "in reference to the definition of Pasteur's Quadrant (Stokes 1997), which describes scientific research or methods that seek both fundamental understanding and social benefit. Guided by the Pasteur Quadrant, the indicator pasteuresqueness serves as a proxy for the applicability of expected results of each proposal. It is based on patent counts and journal classification (ratio of applied vs. theoretical) of applicant publications". Using the results of the peer review process, the study concludes that this dimension is not significantly used for the selection or projects.

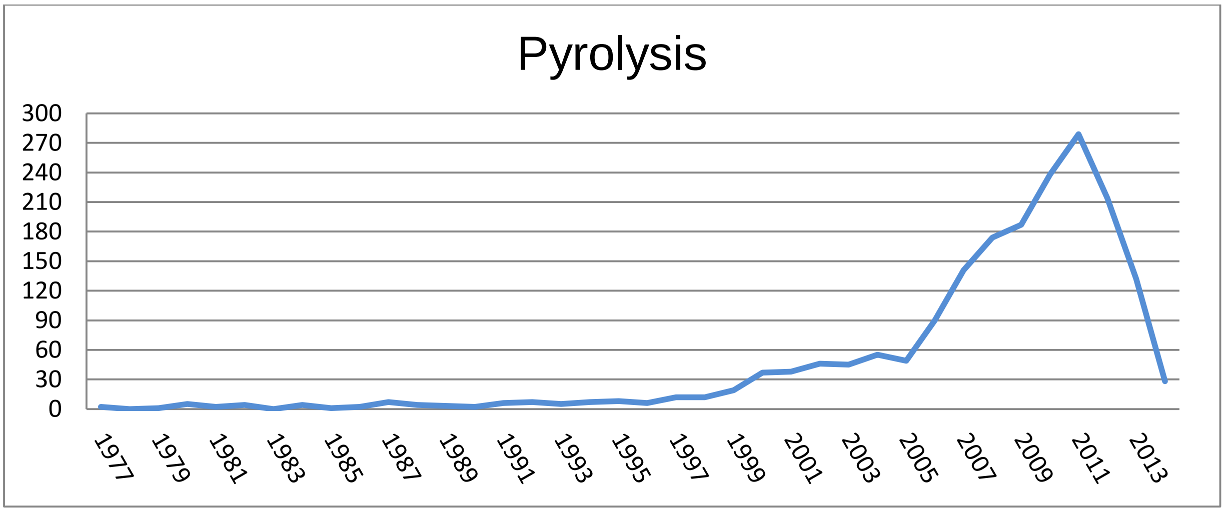
In order to collect evidence on this issue, we tested a methodology based on queries on patents. The methodology is based on the search for the keywords included in the ERC grants in an integrated patent database, going back to the '60s, and covering USPTO, EPO, JP (Japan) and PCT patents. The queries are carried out in titles, abstract and claims of patents (the text of queries and the underlying methodology are not reported here). The methodology requires dedicated work to identify the novelty of keywords, isolating those words that appeared only recently in the documentation, and controlling for the relation between roots and words, particularly in the case of generic words. The list of keywords was provided by the ERC, while for the processing of data we obtained a *pro bono* collaboration from Erre Quadro, a spinoff company of the University of Pisa specialised in technology intelligence. The main goal of the analysis was to identify some patterns in the way in which the areas of research of ERC grantees are also of interest of the larger technological community. In other words we want to examine whether there is a large number of patents using the keyword(s) before, during and after the period of submission of the ERC proposal. In order to interpret the data, please consider that the last years (2013 and 2014) are incomplete due to the late publication of patent data and should not be taken at face value. Therefore the graphs should be read by "truncating" the last two years, which are reported only by completeness. In addition, yearly data are often volatile, so that a more appropriate format should be based on moving averages. Finally, we show a small sample of results without any implication whatsoever for the validity of the projects which used the keywords. An accurate case-by-case analysis would be required in order to conclude for individual projects.

From an extensive analysis we isolated a few stylized case studies, from which we draw lessons for the evaluation. The first pattern is visible in Figure 2. We label it "matching of technological interest", meaning that ERC proponents are working on scientific areas in which there is an initial accumulation of patents, in all cases starting approximately in year 2000, which accelerated during the period of ERC grant. In the latter case (Pyrolysis) we observe a sharp increase of technological interest in the last part of the decade, with a peak shortly after the ERC start in 2009. This interest is still alive, with several patents per year (not considering the final years, as stated above, due to the delay in records of data). This means that ERC grantees were in a good position to benefit from a technological community that takes an interest in their research and might exploit it. In these cases the ex-ante selection process at ERC has been able to identify promising and growing areas of technological interest.

Figure 2: Pattern of matching of technological interest





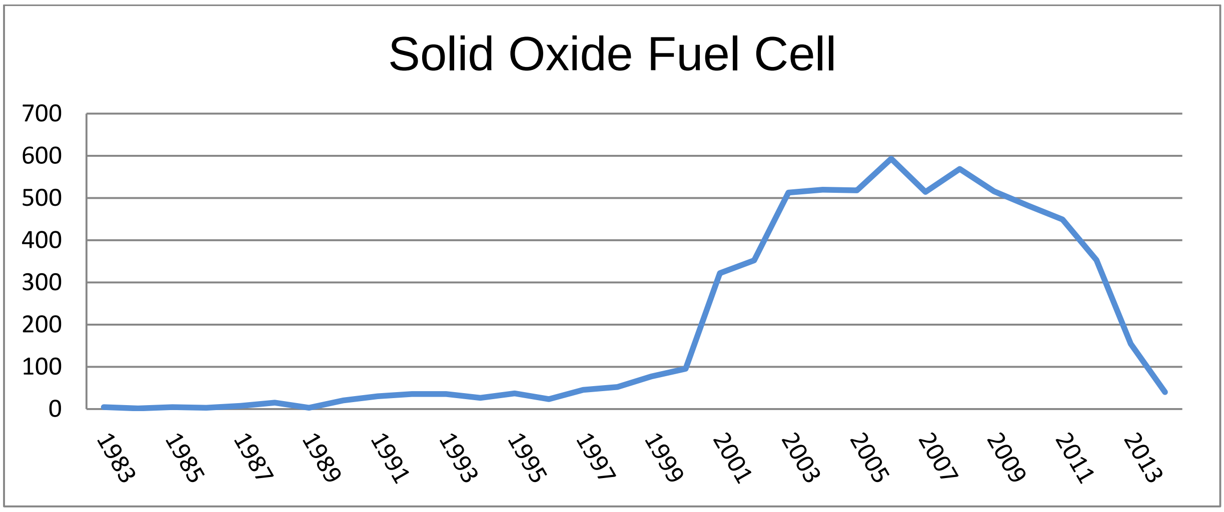


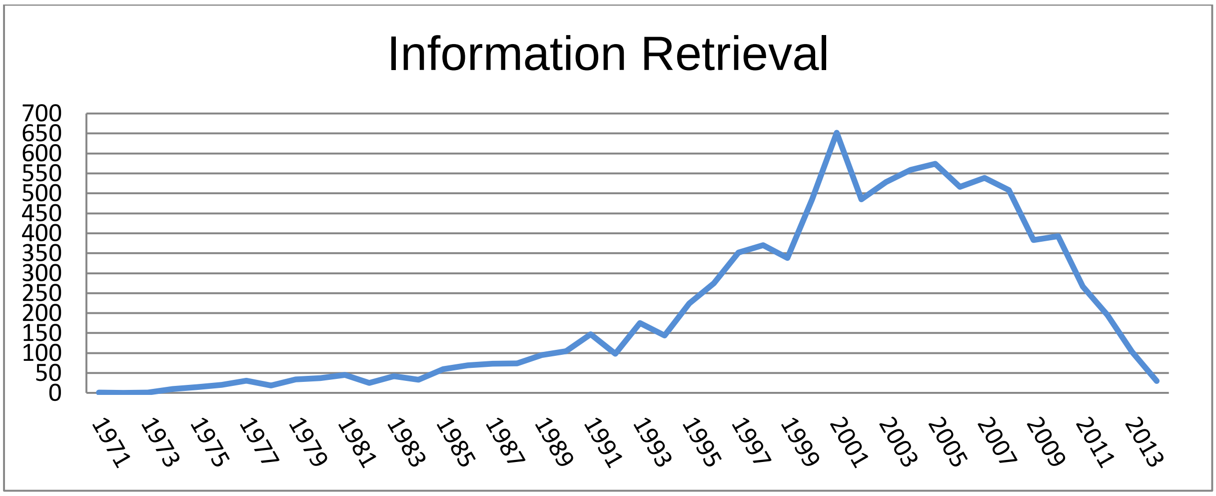
Source: courtesy of Erre Quadro srl.

In these cases if the proponents made the claim that their research could have an impact on innovation, this claim is confirmed by data in the following years. Although patents are not all a sufficient condition for innovation, they are often a good predictor.

At the same time, however, we need to issue a warning against the request that frontier research must demonstrate its impact at a very early stage. By its very nature, frontier research is working at the edge of knowledge, where new knowledge is generated on a continuous basis and there is huge uncertainty. Researchers shed light in the dark. It may happen, as it is witnessed in Figure 3, that the technological interest which is lively at the time of the proposal, declines afterwards. By time of the proposal we mean year 2009, the first year of the collection of keywords used in the analysis. The decline may be sharp. The reasons behind this decline should be investigated in detail - perhaps the technology has become obsolete due to a superior technology, or it has been abandoned due to unsolved puzzles, or on the contrary it has reached maturity - a steady state in which there is no longer room for inventions and patents but only for exploitation and manufacturing.

Figure 3: Pattern of decline of technological interest *after* submission





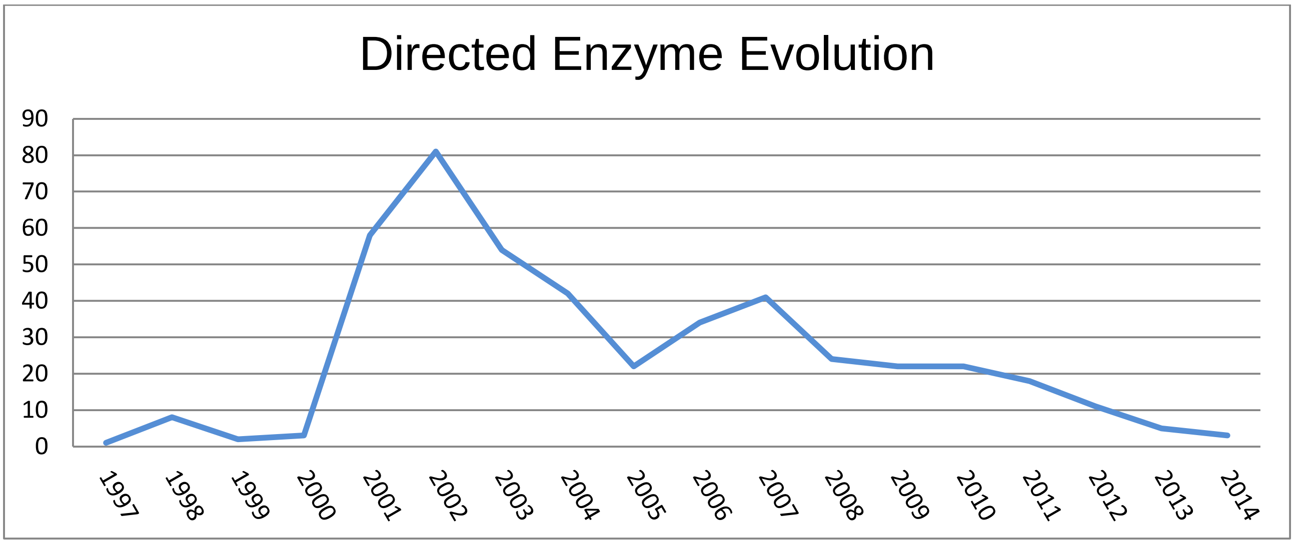
Source: see Figure 2

The fact that the number of patents per year declines is not, per se, an indicator of the loss of potential for innovation. Companies may exploit old patents. It may also be that most technological puzzles have been solved, opening the way to a wave of innovations that exploit a stable technological configuration.

If this is the case, then it would be appropriate for the ERC grantees to move to the exploitation stage.

Yet another case is a decline in technological interest which takes place before the submission of the ERC grant. As it is visible in Figure 4, in some cases there is a peak of interest in a technology (in this example, in 2002), after which there is a continuous decline which takes place before 2009. This is a case which might be identified in the ex-ante selection of projects.

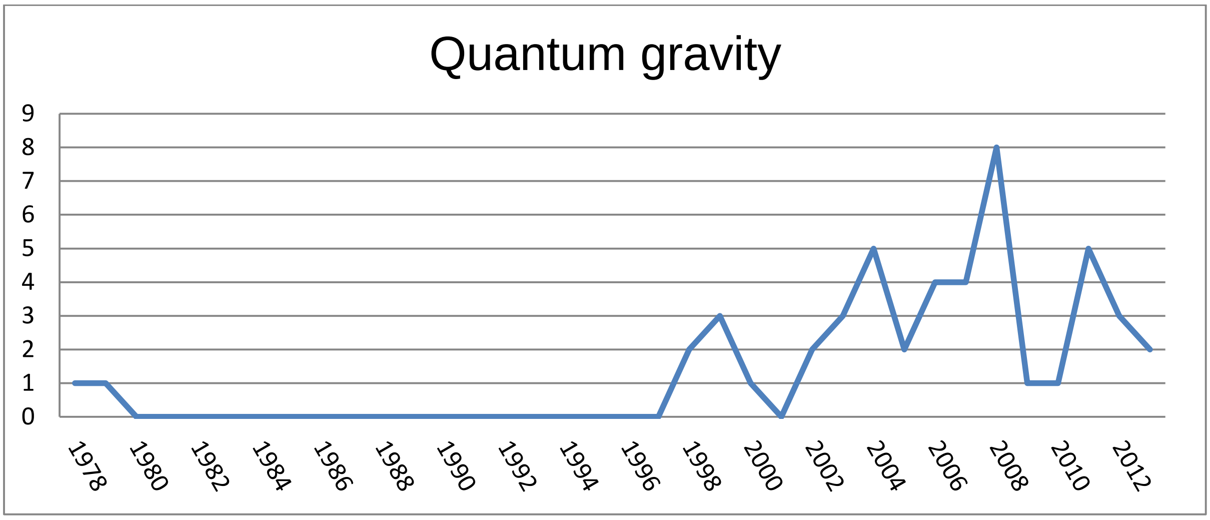
Figure 4: Pattern of decline of technological interest before submission



Source: see Figure 2

Finally, there are also cases in which the research carried out by the ERC grantees does not appear to have any interest to the technological community. An obvious case is fundamental research in physics, as witnessed by Figure 5, in which the number of patents is negligible (and the inspection of them shows that the inclusion of the keyword is somewhat questionable). Here it would be meaningless to look for an impact on innovation, at least in the time framework of an assessment. This kind of knowledge should be left free from any pressure to demonstrate an impact.

Figure 5: Pattern of limited technological interest



Source: see Figure 2

The impact of the ERC on innovation should receive more attention. A promising line of activity is the cross-referencing of publications and patents, supported by new generation tools of data mining and analysis.

The patterns identified in this brief case study might be studied in depth across a large set of projects and technologies. The observation of the technological evolution *after* the time of the proposal would offer interesting lessons to be learnt.

Overall, it seems that the issue of "closing the gap" between discovery, invention, and commercial exploitation (if possible) is not yet addressed systematically. In addition to new funding schemes, such as the Proof of concept, it would be important to experiment with new solutions for making the results of ERC research available, understandable and exploitable, to technological communities across Europe.

- The impact of ERC on innovation is difficult to estimate
- The topics covered in ERC projects are new from a technological point of view. Their keywords do not exist at all before the '80s and grow significantly only in the 2000s. This confirms that ERC researchers are, in general, working on frontier research
- Their potential for innovation could be examined by monitoring on a yearly basis the patent pool at world level using the same keywords or combination thereof. The analysis of the size, country of origin, type of institution, and content of the patent pool might offer insights on the evolution of the technology
- The analysis of the patent pool might also suggest promising avenues for exploitation (e.g. targeting interested companies)
- While in some cases the ex-ante selection of ERC has clearly been able to "pick the winner", this is not always the case. In some cases there was the possibility to identify non-promising areas, although in most cases it would not be possible to predict the future evolution of technology
- There is large room for learning on the innovation potential of the ERC on the basis of the first period of operations.

4. Longer term impacts

4.1 Impact on the research system and on national policies

The EURECIA study has identified a number of sources of impact on national research systems. They include benefits in terms of reputation/prestige, novelty and originality of research; the overall size of funding; the peer review process, and the network of international collaborations.

Countries with no funding agencies adopted the ERC model at institutional level. According to the EURECIA study, there are 10 countries which now have a separate funding agency (or equivalent) with respect to the situation before the start of the ERC. The institutional model of the Research Council, as opposed to the model of ministerial priority setting, has become the reference point. This is a major achievement.

The ERC has also changed the traditional EU support by adopting an investigator-driven approach, which leaves the definition of the research agenda to scientific communities.

According to this study, when coming to individual organisations the most important impact is felt at the middle-level of the research system. In fact, top research organisations receive from the ERC a confirmation of their pre-existing excellence, and do not change internal procedures or recruitment rules due to the success in receiving ERC grants. At the other extreme, weak research organisations only receive one or a few grants from ERC. This may create high visibility and offer incentives for many other researchers and teams to submit proposals - almost invariably with subsequent failures. On the contrary, those in the middle may use the ERC quality mark and prestige to accelerate internal restructuring, placing internal units (laboratories, departments) into competition and offering special recruitment opportunities for grantees.

Summary

- The ERC has produced significant impact on the organization of national research institutions, particularly on the design and implementation of funding agencies, providing a model role of peer-review based, independent, investigator-oriented funding institution
- The quality mark attributed by the ERC is considered an element which gives prestige to the host institution
- The impact of the ERC has been quite limited, on the contrary, on the career pattern in Member States. Only rarely have ERC grantees received special treatment in the national organization of careers. When government provisions have been done for reserving tenured positions for ERC grantees, these have been blocked at university level by local constituencies
- The most likely impact of the ERC on careers will take place via the slow adaptation of recruitment systems, placing increasingly higher weight to scientific excellence, as opposed to criteria of relational proximity, or in-breeding

4.2 Impact on the career and research productivity of grantees

The MERCI study has examined the overall satisfaction of researchers for the ERC funding, comparing in a controlled way the opinions of accepted versus rejected people. We classified the responses for which the satisfaction of approved researchers is larger than for rejected, in four groups, in descending order of importance.

First of all, the most important benefit is *Autonomy* (Academic autonomy; Opportunities for external collaboration). The ERC allows talented researchers to reach autonomy in their research much before and better than the ordinary academic life in the national context.

Second, there is a clear advantage in *Status* (Status within academic community; Status at institution). The ERC grant is a mark of excellent quality.

Third, there is an advantage in *Resources* (Access to research equipment; Access to qualified research staff), which is complementary to autonomy.

It is interesting to note that almost all items that refer to the *Career*, on the contrary, show only marginal advantages with respect to researchers not funded by the ERC (Job security;

Long-term career perspectives; Remuneration; Overall workload; Work-life balance). This is perhaps the most critical aspect of the impact of ERC - the structure of careers at European universities and PROs is still rigid and did not adjust at all to the novelty created by the ERC.

Overall, being funded by the ERC allows a time budget which is more oriented to research with respect to rejected researchers (41.8% of time budget vs 29.8%), less active in teaching (11.3% vs 15.8%) and less obliged to pay service to various administrative activities (4.5% vs 10.3%).

The EURECIA survey on grantees and a control sample has examined in depth the impact on careers. It shows that in academic systems based on lecturers (UK, Netherlands) the ERC grant has helped to get promotions in the same university. On the contrary, in academic systems based on chairs (Germany, Austria, Switzerland) it is not possible to be promoted from untenured positions to professorship in the same university. Fixed term positions cannot be turned to permanent position. Mobility is required, which is however often problematic. It can be considered that in systems based on national habilitation (France, Italy, Spain) the problems for grantees are even greater.

The impact on mobility has been on the contrary quite limited. According to the APSI study, portability has taken place during granting in 6% of cases, after granting in 5.6% of cases. It must be underlined, however, that the impact on researcher mobility should be evaluated over a longer time horizon.

An interesting future study might be based on the automatic tracking of names of ERC grantees over their entire career, supported by the ORCID number, in order to identify the mobility patterns (affiliation) and the collaboration patterns (co-authorship). The set of grantees should then be compared with a control sample with comparable features.

Summary

- The ERC has produced large benefits in terms of Autonomy, Status and Resources to grantees
- It has had a lower impact on the structure and dynamics of research careers. The career and recruitment systems of Member States are found to be more inertial and conservative than anticipated at the creation of the ERC
- Also the impact of portability, a cornerstone of the funding arrangement, has been limited in practice (6% during granting, 5.6% after granting)

5. European value added

There are several dimensions of European value added to be considered.

In order to examine the various dimensions of the European value added, the Commission asked a group of experts to explore the socio-economic benefits of the European Research

Area. The report fails to deliver a quantitative estimate of the value added, but rather offers a number of rationales. According to this report: “At the heart of the analysis lies the argument that a larger pool for selection of researchers and research projects will increase the quality of research. A selection process that takes place from a larger pool is more likely to pick up the best opportunities. A larger set increases competition and this, in turn, leads to a higher overall quality of research.” It is not only competition, however, that may deliver value added at European level, there is also specialization: “Increased competition in a larger selection pool creates a pressure towards specialization. The larger is the size of the selection pool, the stronger is the pressure towards specialization. Specialization implies a finer division of labour, both internally within universities or research organizations, and through networks, joint specialisations by establishing durable and strategic relations with other actors”. The report argues that talented scientists are disproportionally more productive than average, create more spillover when teaching postgraduate students and early researchers, are able to organize the research infrastructure, and enjoy more social visibility. All these dimensions can be found in the ERC experience. We may assume this analysis as the starting point to examine whether the IDEAS Specific Programme has generated added value at the European level.

First of all, the selectivity of the ERC has created a benchmark that nobody can ignore. After the first years, in which the novelty of the funding scheme and, arguably, the need to compensate for budget cuts in several Member States, generated a rush of proposals, there is now a steady flow of proposals. These proposals tend to be the result of a conscious strategy of candidates and of a certain period of preparation. Improvisation is not rewarded. Given the large number of proposals examined in the first years of operations, most researchers across European countries are currently aware of the threshold required in terms of research quality and professionalism, innovativeness, and ambition. In submitting proposals, researchers from various European countries know they must compete with the best colleagues in all other countries. It is not enough to be among the best in any given country, what is need is to be among the best at European level. This creates a self-selection effect (i.e. only good researchers submit their projects, and only good projects are submitted from them).

This is a clear example of the positive impact of the “larger selection pool” illustrated in the Report on the socio-economic benefits of the ERA. This impact could not be obtained at national level. What is observed is a process of diffusion of standards of quality *towards the top*. In a funding landscape in which each Member State had its own funding arrangement for research, the standards of quality might be defined at many possible levels, depending on the institutional history, the patterns of specialization, and the openness to international competition. Therefore standards of quality were largely variable across scientific fields. For example, countries in which a large community of researchers had the opportunity to study abroad in leading scientific countries and then returned home, tend to have higher standards in these communities than in others. In a fragmented funding landscape we observe large heterogeneity in quality standards, within and across countries.

The ERC has created a large pan-European selection pool in *all* fields. All researchers are challenged to meet not their own national standard of quality, but the one defined by the best country, or international community of scholars, in that field. This process of upgrading of quality standards is replicated in all fields. We believe this is the most important European value added.

Second, the institutional centrality of the peer review process has created a common understanding among Member States. According to the ASPI Report (p.31) based on the results of the EURECIA study "before the creation of the ERC, 12 of the current EU countries had national research or scientific councils involved as decision making bodies in the governance of competitive funding of basic research in 2014 all but five EU countries had such bodies".

In addition, Member States now share policies for excellence, given that their researchers have a benchmark at European level. There is increased awareness of the importance of focusing on high quality research. Ex-ante peer review is considered the state of the art in policy making. There is increasing recognition of the need to make it professional and permanent. This is in clear opposition to the past tendency of Ministries of Research to keep ex-ante selection under their discretionality, or to appoint panels on a temporary basis only. Independence of peer review requires a strong and well organized professional organization, coupled with a turnover among the referees. Here the European value added comes from a policy learning effect, following a pressure for institutional isomorphism. This de facto harmonization of research policies takes place at the level of scientific communities, not governments. There is no priority setting involved in this process, that is, a process that is by nature highly contentious and problematic.

Third, there are clear benefits from visibility of European science. Not only due to the award of Nobel prizes and Fields Medals to ERC grantees, but more generally due to the public interest for the novelty and ambition of many of the funded projects, there is a positive impact on the public opinion. Also, there is some impact at the level of international relations. It is not certainly appropriate to state that the US now have only one telephone number, as Henry Kissinger famously advocated, but some effects of visibility and attractiveness at diplomatic level are now visible. The attractiveness with respect to researchers is visible at the level of PhD students and junior researchers; it is instead less prominent for senior researchers. Summing up, the visibility created by the ERC is starting to produce results at European level which could not be achieved at the level of Member States.

Fourth, the coordination costs have been lower at the ERC with respect to other FP Specific programmes. According to the ASPI Report (p.19) the administrative expenditures have been kept below 3% of the operational budget, well below the limit defined by the legislation of FP7 at 5%. In addition the error rate on cost claims is below 2%. This means that the European value added generated largely outweighs the cost of organizing the activity.

6. Conclusions and recommendations

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.

There are areas for improvement, however.

First, the peer review process should be the object of intense scrutiny, supported by external evaluation studies. The ability of referees to identify frontier research, to avoid conformism, to support risky research, should be subject to systematic scientific examination, with appropriate design of the analytical and assessment studies.

Second, the ability of the ex-ante selection to identify the potential for innovation should be strengthened. New organisational solutions to make the ERC research results not only available, but also understandable and exploitable by European technological communities could be designed. Bibliometric and patent data sources should be combined appropriately. Lessons from past failures should be drawn and absorbed in the organization.

Third, the overall ex-ante cycle should be streamlined and shortened.

Finally, the impact of ERC grants on academic careers and recruitment systems should be examined in detail over many years.