European Commission

Comparative scientometric assessment of the results of ERC funded projects

Patent analysis report (D6)

European Research Council
Established by the European Commission

EUR [number] EN

Research and Innovation

EUROPEAN COMMISSION

Directorate-General for Research and Innovation
ERC EA – The European Research Council Executive Agency
Unit A1 — Support to the Scientific Council

E-mail: erc-info@ec.europa.eu

European Commission, ERC Executive Agency
B-1049 Brussels

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Cataloguing data can be found at the end of this publication.

Luxembourg: Publications Office of the European Union, 2015.

ISBN [number]
doi:[number]

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Patent Analysis Report (D6)

Pascal Lemelin, Vincent Larivière, Alexandra Pollitt, Salil Gunashekar, Jean-Pierre Robitaille

Prepared for EUROPEAN COMMISSION, RESEARCH & INNOVATION DIRECTORATE-GENERAL
Unit A1 – Support to the Scientific Council

ERCEA/A1/2014/20
Under the Framework Contract: 'Provision of Services in the Fields of Research Evaluation and Research Policy Analysis' [No 2010/S 172-262618]
Lot 2: Data collection and performance indicators to monitor European research policy

RR-1217-ERC
July 2015

RAND EUROPE

Observatoire des sciences et des technologies

Preface

This document, prepared by Observatoire des sciences et des technologies (OST) and RAND Europe serves as the Final Patent Analysis Report (deliverable: D6) for the study “Comparative technometric assessment of the results of ERC funded projects” for the European Research Council Executive Agency (ERCEA).

In addition to this report, other analysis and findings from this study are reported in:

- D3: Field classification report
- D4: Data coverage report
- D5: Bibliometric assessment report
- D7: Alternative metrics report
- D8: Peer-review evaluation of highly ranked publications from scientometric assessment
- D11: Final synthesis report

The authors would like to acknowledge the support of ERCEA, in particular Boris Kragelj, members of the ERC Scientific Council and other ERC staff members who have provided useful feedback, data and advice throughout the study. We would also like to thank our quality assurance reviewers, Yves Gingras, Susan Guthrie and David Kryl, for their constructive comments and timely review.

This document has been peer reviewed in accordance with RAND Europe’s quality assurance standards.

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1. Introduction and aims

This document serves as the Final Report (deliverable: D6) for the study “Comparative scientometric assessment of the results of ERC funded projects” for the European Research Council Executive Agency (ERCEA). Observatoire des sciences et des technologies (OST) has been working with RAND Europe to deliver high quality research, incorporating state of the art and innovative scientometric techniques, including bibliometrics, patent analysis and alternative metric analysis.

This report presents a technometric evaluation of the European Research Council’s funding programme. Based on patent analysis, this report will first present an evaluation of the quality of the research proposals’ selection process. Second, the effect of funding on the inventive productivity of funded researchers will be analysed and finally, an assessment of the productivity of ERC-funded researchers against that of researchers funded through other large international funding agencies will be presented.

As stated, this assessment of researchers’ inventive activities will be measured by using utility patent applications as the unit for the computation of the indicators. Given their obvious connection to inventive activities, patents have long been used as indicators of technological development. The reliability of patent data for the analysis of inventive activities has been demonstrated by many studies (Archibugi 1991; Narin et *al* 1987; Grupp and Schwitalla 1989; Schmoch 2008). Their main advantages reside in the fact that, for administrative and legal reasons, they have been indexed in databases for many years, they contain numerous fields of information and the quality of this information is quite good, all of which greatly facilitates their identification and treatment in number for the production of statistics.

More precisely, the scope of the current assessment can be summarised in the three following evaluation questions:

1. Is the ERC peer review process successful in selecting the best candidates among those who submit a proposal?

We compare ERC-funded researchers against researchers who applied for ERC grants but were refused. More precisely, we evaluate the inventive production of researchers prior to their applications to ERC granting competitions. We compare researchers’ performance over time by using competition year cohorts and the data is presented according to the researchers’ funding status, ERC evaluation committee’s scientific domain and panel, and by researchers’ level of seniority.

2. Does the funding provided by ERC help the grantees improve their scientific output?

We compare ERC-funded researchers’ inventive activities before and after receiving the grant. More precisely, we evaluate the inventive production of researchers prior to and after the start year of their ERC financing. We compare researchers’ performance over time by using competition year cohorts and the data is presented according to ERC evaluation committee’s scientific domain and panel, and by researchers’ level of seniority.

3. Do ERC grantees perform better than researchers sponsored by other European and American funding agencies?

We assess post-funding inventive activity of ERC-funded researchers against that of researchers funded by different European and American funding agencies. We compare researchers' performance by funding agency, scientific domain and level of seniority.

Chapter 2 details the methods used for the calculation of the different indicators: the samples of researchers, the data sources, the description of the indicators and their calculation methodology. Chapter 3 presents the findings according to the three aforementioned evaluation questions, before we conclude in Chapter 4 by recalling key findings and discussing the significance of these findings.

2. Methods

2.1. Studied Population of ERC Researchers and Benchmark Samples

The studied population includes 2,556 researchers selected for funding by the ERC between 2007 and 2011. The researchers are distributed across three large domains (Life Sciences (LS), Physical Science and Engineering (PE), and Social Sciences and Humanities (SH)) and 25 disciplinary panels, each including two categories of grants or "call schemas": starting grants (StG) awarded to young scientists and advanced grants (AdG) intended for senior researchers. Table 2-1 below shows their distribution.

Table 2-1. ERC-funded researchers by panel and project type

Panel		1_StG	3_AdG	Total
LS01	Molecular and Structural Biology and Biochemistry	60	42	102
LS02	Genetics, Genomics, Bioinformatics and Systems Biology	67	44	111
LS03	Cellular and Developmental Biology	64	40	104
LS04	Physiology, Pathophysiology and Endocrinology	55	43	98
LS05	Neurosciences and neural disorders	70	55	125
LS06	Immunity and infection	51	44	95
LS07	Diagnostic tools, therapies and public health	53	58	111
LS08	Evolutionary, population and environmental biology	54	46	100
LS09	Applied life sciences and biotechnology	40	27	67
PE01	Mathematics	86	71	157
PE02	Fundamental constituents of matter	80	62	142
PE03	Condensed matter physics	74	53	127
PE04	Physical and Analytical Chemical sciences	69	45	114
PE05	Materials and Synthesis	84	63	147
PE06	Computer science and informatics	77	43	120
PE07	Systems and communication engineering	42	35	77
PE08	Products and process engineering	54	47	101
PE09	Universe sciences	48	35	83
PE10	Earth system science	50	45	95
SH01	Individuals, institutions and markets	51	40	91
SH02	Institutions, values, beliefs and behaviour	67	35	102
SH03	Environment, space and population	24	14	38
SH04	The Human Mind and its complexity	70	44	114
SH05	Cultures and cultural production	28	22	50
SH06	The study of the human past	41	44	85
Grand Total		**1 459**	**1 097**	**2 556**

Source: European Research Council, List of applicants provided in September 2014, compiled by OST.

The following samples were used for the benchmarking of funded researchers' performance:

- 2,556 ERC non-funded applicants;
- 1,000 EU FP7 collaborative projects/cooperation funded researchers;
- 1,000 US National Science Foundation (NSF) funded researchers;
- 400 US National Institutes of Health (NIH) funded researchers;
- 100 Howard Hughes Medical Institutes (HHMI) funded researchers;
- 237 US National Endowment for Humanities (NEH) funded researchers.

ERC non-funded applicants

As requested by the study's Steering Committee, the ERC non-funded applicants sample has the same structure as the group of funded applicants (distribution across panels and call schemas) but it also includes:

- 1,304 applicants rejected at step 1;
- 1,252 applicants rejected at step 2, of whom 175 were rejected just below the threshold for funding.

A sample representative of the balance between step 1 and step 2 in the population of rejected applicants (88.4% vs 11.6%) was drawn from these two sub-samples. It comprises 1,304 step 1 and 172 step 2 researchers to give a total of 1,476 non-funded researchers. From the population of funded researchers and the sample of non-funded applicants, another subgroup of 350 researchers was selected for a pair-wise analysis. It comprises 175 applicants rejected at step 2 with the highest scores below the funding threshold of each panel, competition year and call schema. The other 175 researchers are the funded applicants who obtained the lowest scores from the same panels, competition years and call schema. By comparing each of those funded researchers with their counterpart from the group of non-funded, we will seek to analyse the effect of funding on their scientific production. Indeed, assuming that at the time of the application, these two groups comprise researchers of (almost) equal quality, we can postulate that the differences of scientific output between them will be the effect of ERC funding.

EU FP7 funded researchers

The European Union's Seventh Framework Programme (EU FP7) is divided into ten" level 1 project programme descriptions" related to broad research areas in the natural sciences and engineering, 68 "level 2 project programme descriptions" and, within those, 1,254 specific "themas". As requested by ERCEA representatives, the sample of 1,000 EU FP7 collaborative projects includes, for each of the ten level 1 project programme descriptions, 100 researchers, each one being the most funded in their respective thema. Given that (1) we had to select 100 researchers per level 1 project programme description, (2) we had to cover the maximum number of themas within each level 1 project programme description, and (3) some level 1 programme project descriptions comprise fewer than 100 themas, the sample covers the highest possible number of themas, which is 878. For the level 1 project programme descriptions comprising fewer than 100 themas, we also selected as needed the second, third and fourth most funded researchers until 100 funded researchers were included in the sample. Given this selection process, the average amount of funding of selected researchers is more than twice that of the whole population of funded researchers, at €833,000 compared with €411,000. Hence, this is not a sample representative of the whole population of EU FP7 collaborative projects, but a sample made up of the most funded projects in each thema. It should be noted that no distinction is made in this sample between junior and senior researchers, since the information was not available for the population.

US comparison groups

For the NSF, NIH and HHMI samples of funded researchers, the Steering Committee also requested a profile of senior and junior researchers similar to the ERC (at 3/5 compared with 2/5). Thus, the group of NSF-funded junior researchers comprises a random sample of 570 scientists who received a CAREER grant between 2007 and 2011, and the senior group comprises a random sample of 430 researchers who were funded between 2007 and 2011 and who also received at least one CAREER grant between 1992 and 2002.

The group of NIH junior researchers is made up of 217 scientists who received at least one DP2 grant between 2007 and 2011, while the group of senior researchers comprises 183 researchers who received at least one R01 grant during the same period. For HHMI, the group of juniors is comprised of 57 researchers randomly selected from HHMI early career scientists, international early career scientists and Janella Junior Fellows, while the group of seniors is randomly drawn from all other HHMI researchers.

A last sample of 237 researchers funded by NEH was also selected for the benchmarking of the three ERC panels devoted to the humanities, namely SH02, SH05 and SH06.

Table 2-2 summarises the composition of the studied groups of researchers.

Table 2-2. Number of Researchers by Agency and Large Disciplinary Domain

Agency	Life Sciences	Phys. Sc. & Engineering	Soc. Sc. & Humanities	TOTAL
ERC Funded	913	1,163	480	**2,556**
ERC Non-Funded	913	1,163	480	**2,556**
European Union's FP7 (EU FP7)	100	800	100	**1,000**
US National Sciences Foundation (NSF)	87	837	76	**1,000**
US National Institutes of Health (NIH)	400			**400**
Howard Hughes Medical Institute (HHMI)	100			**100**
US National Endowment for the Humanities (NEH)			237	**237**
TOTAL	**2,513**	**3,963**	**1,373**	**7,849**

2.2. Author Disambiguation

All bibliometric data sources require cleaning in order to be reliable. Author and institution names come in many different forms, including first names and initials, abbreviations and department names; they may include spelling errors or change over time (synonymy problem). On the other hand, the same name might refer to more than one person or department (homonymy problem). Disambiguation and the cleaning of author names and institutions is fundamental to computing meaningful technometric and bibliometric indicators for use in research evaluation.

We consider that a researcher has contributed to an invention when his or her name is explicitly mentioned in the “inventor” field of the database.

This disambiguation process was done through a two-step method:

- First, we performed an automatic matching of researchers’ names contained in the list of ERC-funded researchers and all control groups with authors’ names contained in the bibliometric database.
- Second, to avoid overestimates as a result of the (numerous) namesakes, a manual review and validation of each individual patent file was performed. It should be noted that this manual validation is also the stage at which we can check the patent files that remain empty after the automatic matching. This can be due to that fact that those researchers actually patented nothing or to an error in the list of researchers’ names. For a variety of reasons, the names of several researchers in the lists of funding agencies are not recorded identically in the patent databases. In such cases, only a manual search allows us to identify and correct the issue.

2.3. Data Sources

The patent data used for the production of statistics for this evaluation is from the European Patent Office's Worldwide Statistical Patent Database (PATSTAT – spring 2014 edition). This database, developed in 2005, contains patent information from over 80 countries, including EPO and USPTO, as well as PCT applications. The database contains the bibliographic information from published patent applications and granted patents; such as, patent office, applicants, inventors, technological classification, processing dates.

2.4. Indicators

Average annual number of distinct inventions and average annual number of applications per distinct invention.

Firstly, the statistics presented in this evaluation are based on patent applications. Since patenting is a long process that, from the first application to the granting of a patent, may take several years, applications are much closer in time to the inventive activities leading up to them, therefore greatly improving the timeliness of the indicator. Even so, since for the main national offices there is an 18-month delay between the filing of an application and the publishing of the application, the data shows a sharp decrease in the number of applications for the last available years (see Appendix A). Therefore, we adjusted the study's various time periods accordingly to minimise this problem, but the effect still persists, affecting mainly the results we obtained for the second question of the evaluation that examines the effect of funding on researchers' scientific production. Details on the measured periods are presented for each indicator in the results section.

Secondly, we counted patent applications for utility patents filed at the national level: we did not take into account PCT applications since they are still in an international phase, although utility patent applications emanating from PCT applications that are in their national phase are counted in. This evaluation also does not take into account copyrights, design patents, plant patent, utility models, etc.

Thirdly, the time period for which patent applications were attributed to their respective researchers ranges from 2002 to 2013 for funded ERC researchers and from 2007 to 2013 for the benchmark groups of researchers (NSF, HHMI, NEH, ERC non-funded researchers and EU FP7 funded researchers).

PATSTAT has a unique feature that links applications filed for the same invention in different national offices. Indeed, EPO has performed the matching of related patent applications across national offices, thus allowing for the computation of two different indicators: the first is the number of distinct inventions (a single invention filed in different countries will only be counted once at the earliest filing year) while the second is a ratio between the number of applications (a single invention filed in different countries will be counted as many times as the number of national offices it has been filed at) and distinct inventions. While the first indicator reflects the intensity of researchers' inventive activity, the latter acts as a measure of the perceived commercial value of the invention by the applicant, the rational being that since the cost involved in patenting an invention in multiple countries is high, the projected value of a patent will vary accordingly. Therefore, this second indicator will act as a proxy of the "quality" of a given invention. Obviously, this indicator is entirely dependent on the quality of the linking work between patent applications done by EPO.

These indicators are presented as average annual numbers, meaning that they are divided by the length of the period for which they are measured and then averaged by the number of projects in the level under study. Concretely, the average annual number of distinct inventions is calculated by dividing the total number of distinct inventions from a given group of researchers in a given period by the number of years of said period and the number of researchers in the group. Along the same lines, the average annual number of patent applications per distinct invention is calculated by dividing the ratio of patent applications per distinct invention from a given group of researchers in a given period by the number of years of said period and the number of researchers in the group.

The computed indicators are broken down at different levels depending on the three questions of this evaluation. For the first question on the quality of the selection process, statistics are presented by competition year cohort, researchers' funding status, ERC evaluation committee's scientific domain and panel, and level of seniority. For the second question on the evaluation of the effect of ERC funding, data are broken down by competition year, evaluation committee's scientific domain and panel, and by researchers' level of seniority. For the third question, data for the assessment of ERC–funded researchers' performance against that of researchers funded by other major funding agencies is presented by funding agency, evaluation committee's scientific domain and level of seniority.

3. Results

3.1. Selection of ERC-Funded Researchers

Is the ERC peer review process successful in selecting the best candidates among those who submit a proposal?

To answer this question, this section presents a comparison between ERC-funded researchers and researchers who applied for ERC grants but were refused. More precisely, we evaluate the inventive production of researchers prior to their applications to ERC granting competitions. As stated in Section 2.1, a group of researchers whose proposals were refused at the second step of the evaluation (step 2 researchers) is compared against the group of funded and non-funded researchers. It is important to mention that step 2 researchers represent 11.6% of the non-funded researchers' group as a whole. This group was created to further assess the quality of the selection process according to the hypothesis that researchers whose applications were rejected later in the process will have a better performance than the researchers whose applications were rejected earlier during the process.

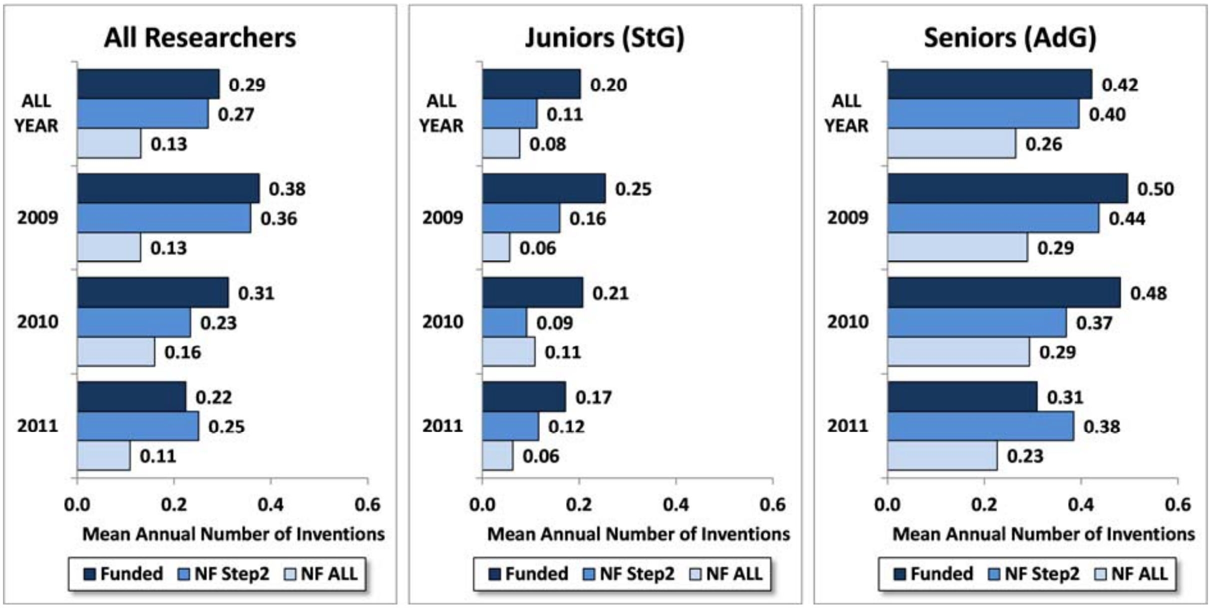
Since ERC non-funded researchers' patent files were constructed from 2007 onward, the annual cohorts are based on the years of competition 2009, 2010 and 2011. The period of inclusion ranges from three years prior to the year of competition for researchers applying for a Starting Grant (StG), to the complete available period prior to competition year for researchers applying for an Advanced Grant (AdG). Since it is unlikely that researchers applying for a StG Grant (junior researchers) would present a patent file going back several years before the year of competition (unlike the seniors (AgG)), we limited the observation window to the three years preceding the competition year. As an example, for competition year 2011, patents filed between 2008 and 2010 are included for the StG researchers group while patents filed between 2007 and 2010 are included for the AdG researchers group.

The presented data is broken down according to annual cohorts, the three ERC funding domains and included panels (Social Sciences and Humanities (SH), Life Sciences (LS) and Physical Sciences and Engineering (PE)) and funding status.

The number of distinct inventions and the number of applications per distinct invention for the aforementioned periods is divided by the number of years comprised in the period to obtain an annual value. This annual value is then averaged for the number of projects comprised in the level under scrutiny (annual cohort, funding status, and domain/panel) to obtain the indicators presented below.

Overall, Figure 3-1 shows that the inventiveness of funded researchers is higher than that of step 2 researchers, and that the latter's inventive activities are greater than those of non-funded researchers. It is also worth noting that senior researchers show an inventiveness representing at least double the inventiveness of junior researchers.

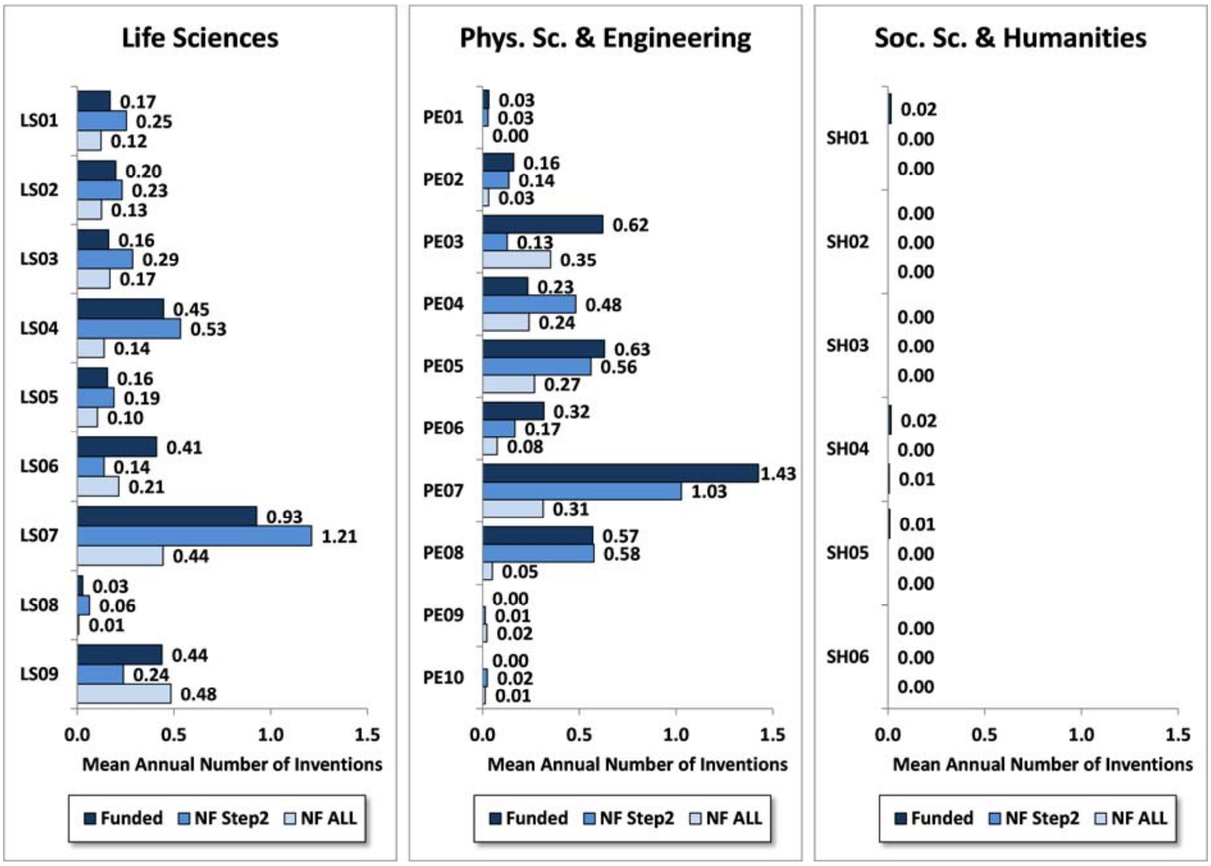
Figure 3-1. Mean Annual Number of Inventions per ERC Applicant Prior to Competition Year by Seniority, Competition Year and Funding Status



Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition. European Research Council, list of applicants provided in September 2014, compiled by OST

Figure 3-2 shows that for most panels of Life Sciences, funded researchers' inventiveness is lower than that of step 2 researchers, while for the Physical Sciences and Engineering domain, funded researchers' inventiveness is higher than that of the other groups for the majority of panels (except for PE04, PE08, PE09 and PE10). In Social Sciences and Humanities, the numbers are too low to draw any conclusions.

Figure 3-2. Mean Annual Number of Inventions per ERC Applicant Prior to Competition Year by Domain, Panel and Funding Status

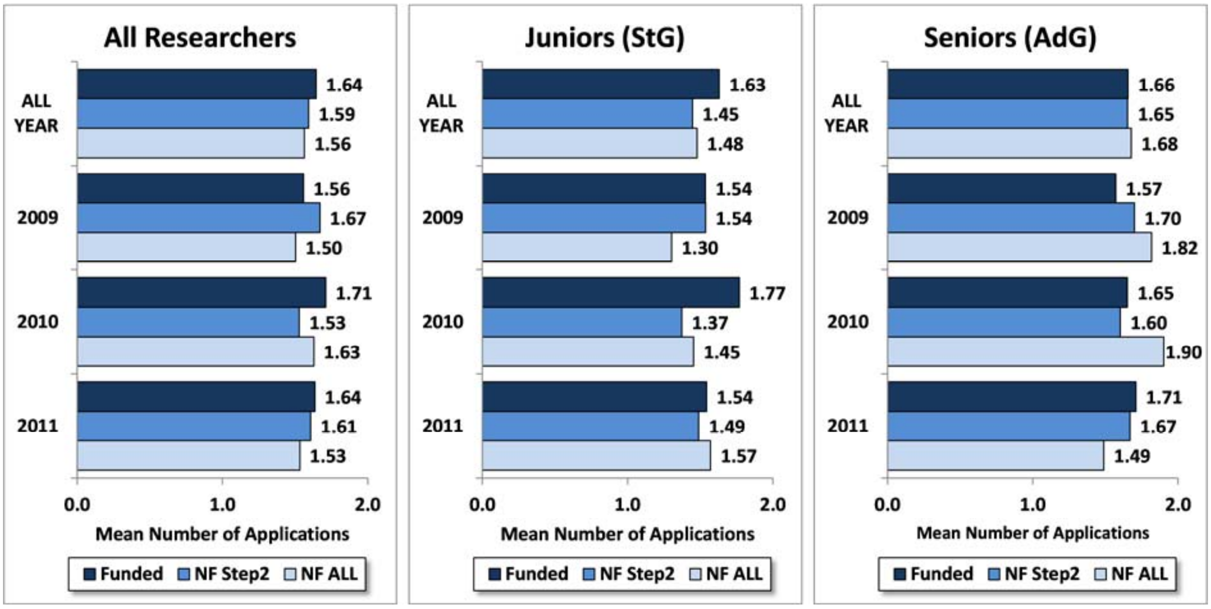


Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition. European Research Council, list of applicants provided in September 2014, compiled by OST

Figure 3-3 shows that the gap between funded and non-funded researchers narrows considerably when we consider the average annual number of applications per invention in comparison to the number of distinct inventions (Figure 3-1). Globally, funded researchers still present a higher inventiveness than step 2 or non-funded researchers but by a much smaller margin.

For junior researchers, if funded researchers are ahead globally and throughout most of the period (except for 2011), non-funded researchers tend to present a greater inventiveness than step 2 researchers. For senior researchers, funded researchers show a similar value to that of the non-funded group (1.66 and 1.68).

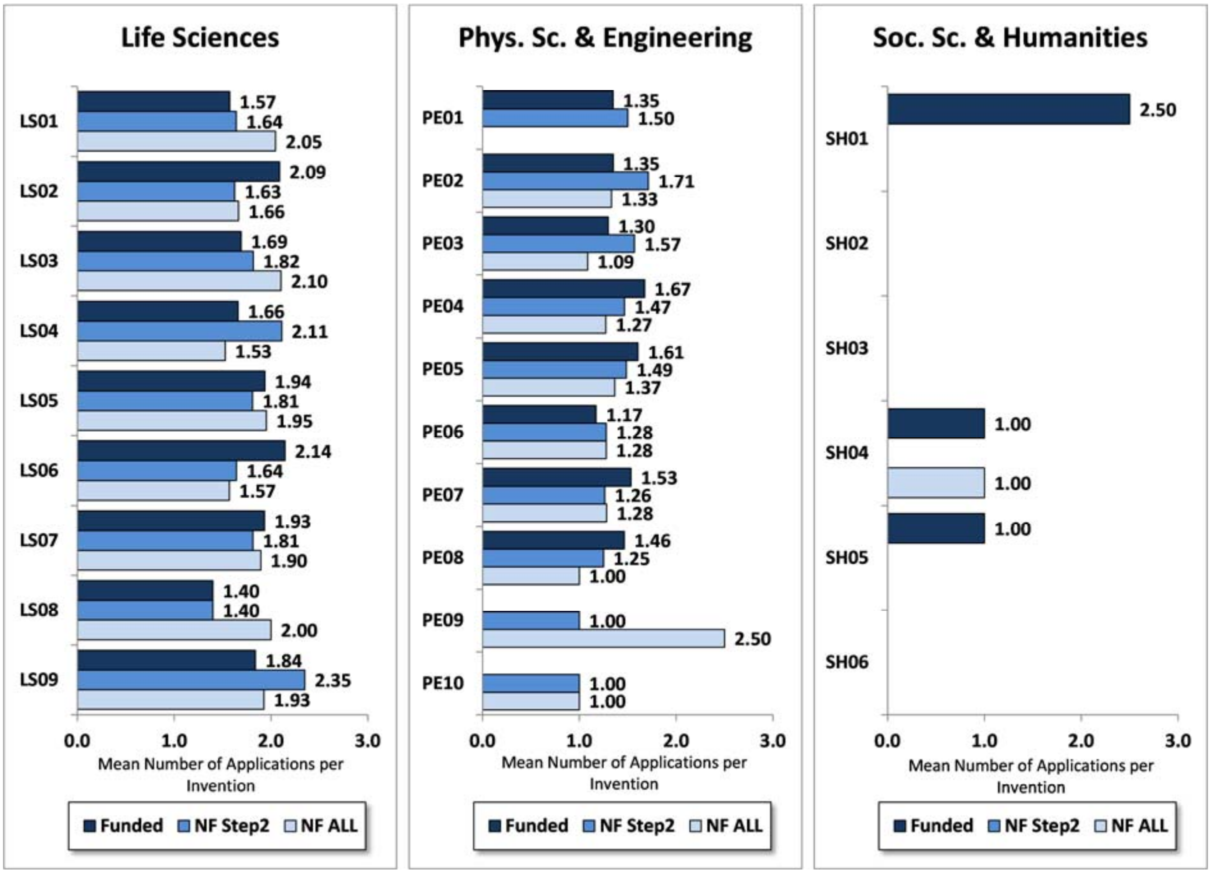
Figure 3-3. Mean Annual Number of Applications per Invention for ERC Applicants Prior to Competition Year by Seniority, Competition Year and Funding Status



Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition. European Research Council, list of applicants provided in September 2014, compiled by OST

For the Life Sciences panels (Figure 3-4), funded researchers show a higher applications per invention ratio than both non-funded groups for less than half the panels (LS02, LS06 and LS07). The same can be said for the Physical Sciences and Engineering domain, where funded researchers score higher than both non-funded groups for less than half of the panels (PE04, PE05, PE07 and PE08).

Figure 3-4. Mean Annual Number of Applications per Invention for ERC Applicants Prior to Competition Year by Domain, Panel and Funding Status



Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition. European Research Council, list of applicants provided in September 2014, compiled by OST

To answer our first evaluation question, we can say that, overall, the ERC peer review process is indeed successful in selecting the best candidates among those who submit a proposal and that this observation is confirmed for both levels of seniority. However, this tendency is less clear when we look at the panel level, where for most Life Sciences panels, funded researchers' inventiveness is lower than that of step 2 researchers.

3.2. Effect of Funding

Does the funding provided by ERC help the grantees improve their scientific output?

This section presents an evaluation of ERC-funded researchers' inventive activities before and after receiving the grant. More precisely, we evaluate the inventive production of researchers prior to and after the start year of their ERC funding.

The annual cohorts are based on the year of the competition (from 2009 to 2011) and the period of evaluation is calculated as follows:

- For the period prior to the start of the funding

  - For researchers who applied for a Starting Grant (StG): 3 years prior to the year that the funding started[1]
  - For researchers who applied for an Advanced Grant (AdG): the complete available period prior to the year that the funding started
- For the period following the start of the funding
  - For researchers who applied for a Starting Grant (StG): from the funding's starting year (starting year included) to 2011
  - For researchers who applied for an Advanced Grant (AdG): from the funding's starting year (starting year included) to 2011

It is important to note that the latest filing year considered for the calculation of the indicators for the period following the start of the funding is 2011 in order to minimise the effect caused by the 18-month delay between application filing and publication discussed in section 2.4, which causes a sharp decrease in the number of applications in the later years of the period. The figure in Appendix A indicates that the annual number of applications peaked in 2007 and has been declining ever since. It remains difficult to evaluate the extent of this effect when one takes into account other factors that can affect the rate of patent production.

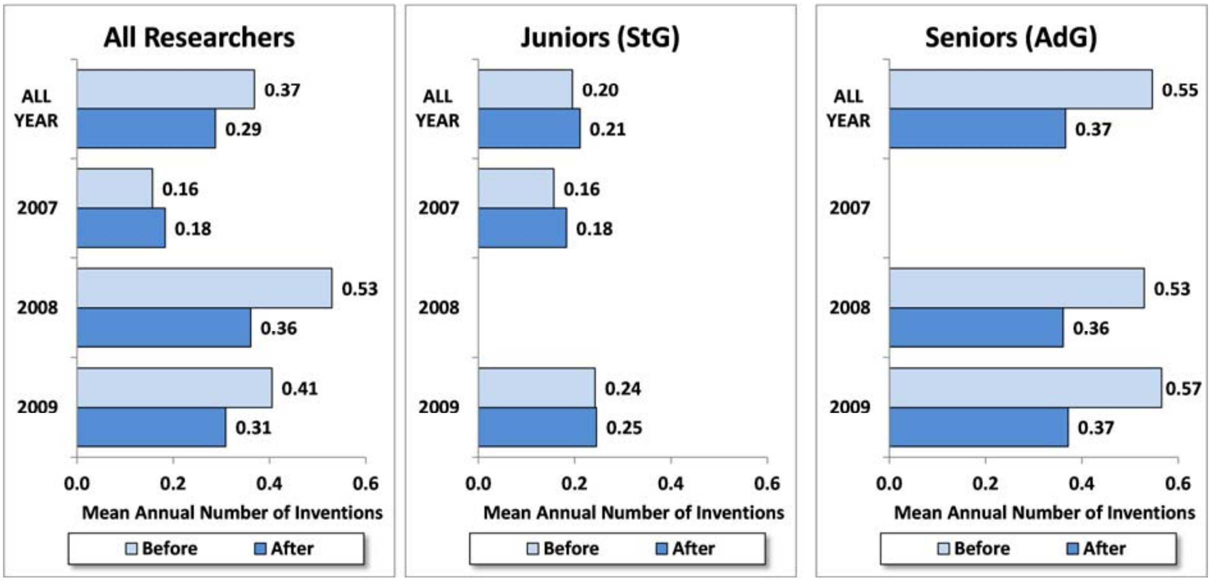
The data presented is broken down according to competition year cohorts, the researchers' level of seniority and the three ERC funding domains and associated panels: Social Sciences and Humanities (SH), Life Sciences (LS), and Physical Sciences and Engineering (PE).

The number of distinct inventions and the number of applications per distinct invention for the aforementioned periods are divided by the number of years in the period to obtain an annual value. This annual value is then averaged for the number of projects included in the level under scrutiny (annual cohorts and domain/panel) to obtain the indicators presented below.

Overall, researchers' inventive activities seem to decline after receiving funding (Figure 3-5) and our hypothesis is that even if we controlled the length of the "After" period to account for the decline of patent applications near the end of the period, these results would tend to indicate that this effect is still present. This would tend to be confirmed by the fact that, for all researchers combined, the productivity after receiving the grant was higher in 2007 but then lower for 2008 and 2009. However, junior researchers' inventiveness is slightly higher after receiving the grant than before, while that of senior researchers is much lower.

[1] Here again, since it is unlikely that researchers applying for a Starting Grant (junior researchers) present a patent file going back several years before the year of competition (unlike the seniors (AdG)), we limited the observation window to the three years preceding the competition year.

Figure 3-5. Mean Annual Number of Inventions per ERC-Funded Researcher Before and After the Grant Start Year by Seniority and Competition Year[2]

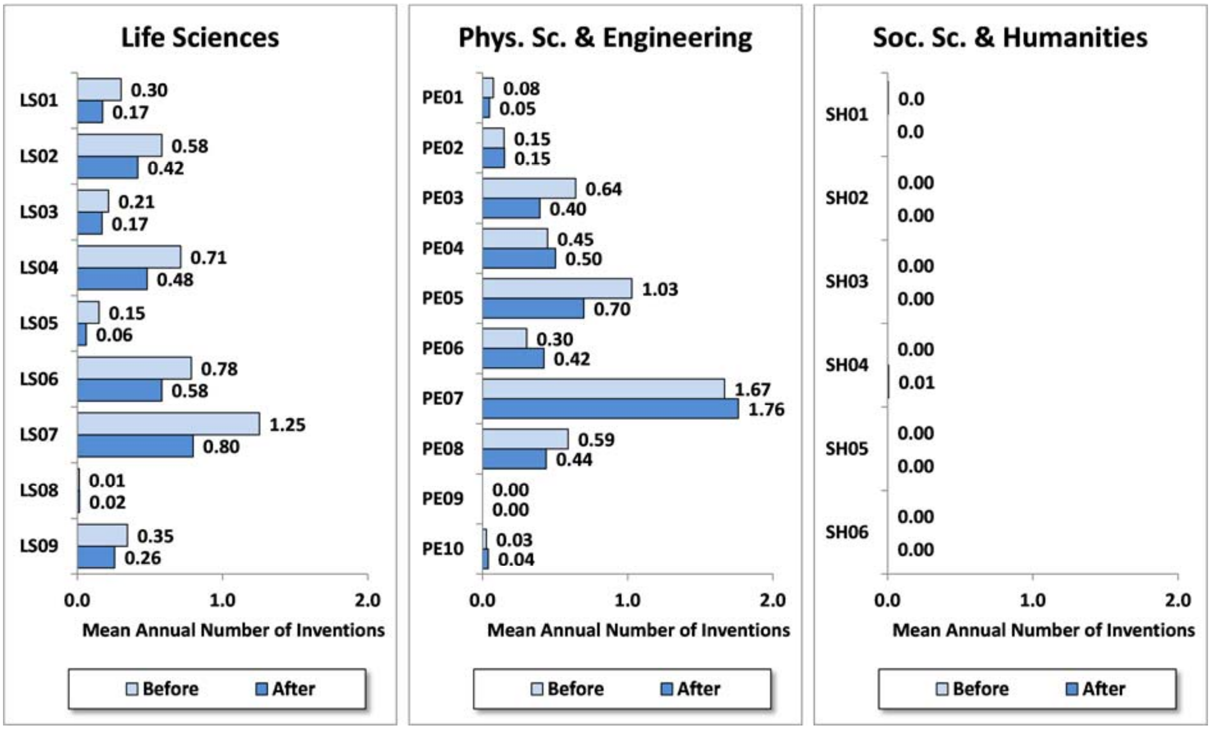


Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition. European Research Council, list of applicants provided in September 2014, compiled by OST

Figure 3-6 shows that for Life Sciences, researchers' inventiveness is always higher before receiving the grant than after (with the exception of the LS08 panel which shows very low values). The same can be said for the Physical Sciences and Engineering domain, where only the funded researchers from the PE04, PE06, PE07 and PE10 panels present a higher value after receiving the grant.

[2] There were no competitions for junior researchers in 2008 and for senior researchers in 2007.

Figure 3-6. Mean Annual Number of Inventions per ERC-Funded Researcher Before and After the Grant Start Year by Domain and Panel

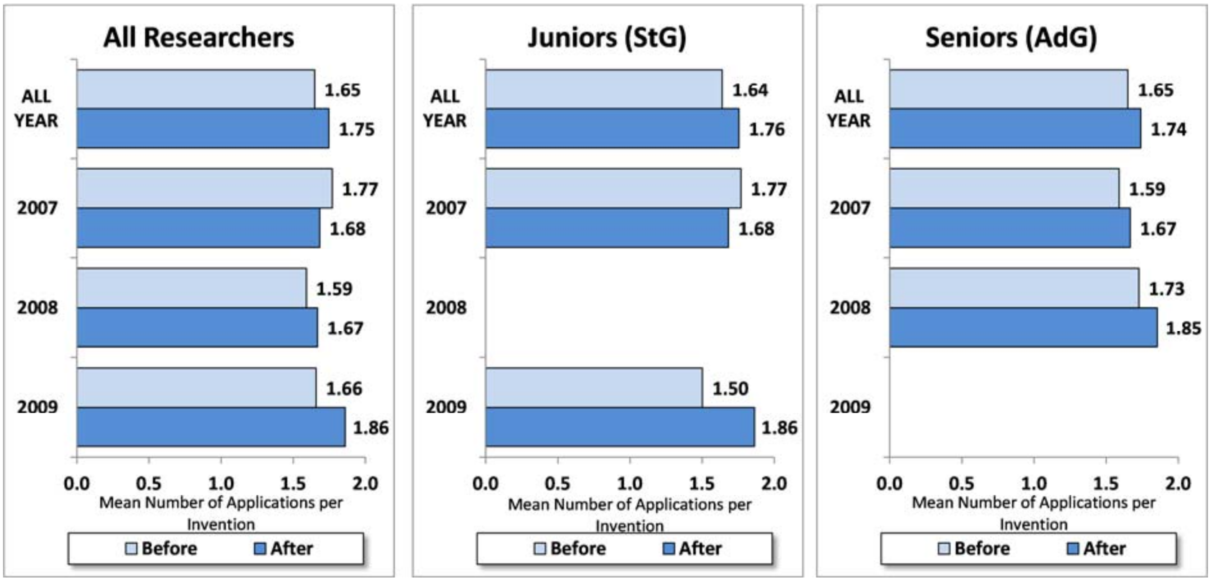


Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition. European Research Council, list of applicants provided in September 2014, compiled by OST

Figure 3-7 reveals that unlike in Figure 3-5, the overall numbers of applications per distinct invention of researchers improve after receiving the grant.

Also contrary to what we see in Figure 3-5, senior researchers perform better after receiving the grant, which would tend to indicate that they produce fewer distinct inventions but that they keep seeking intellectual property rights for those they already have by continuing to file new applications.

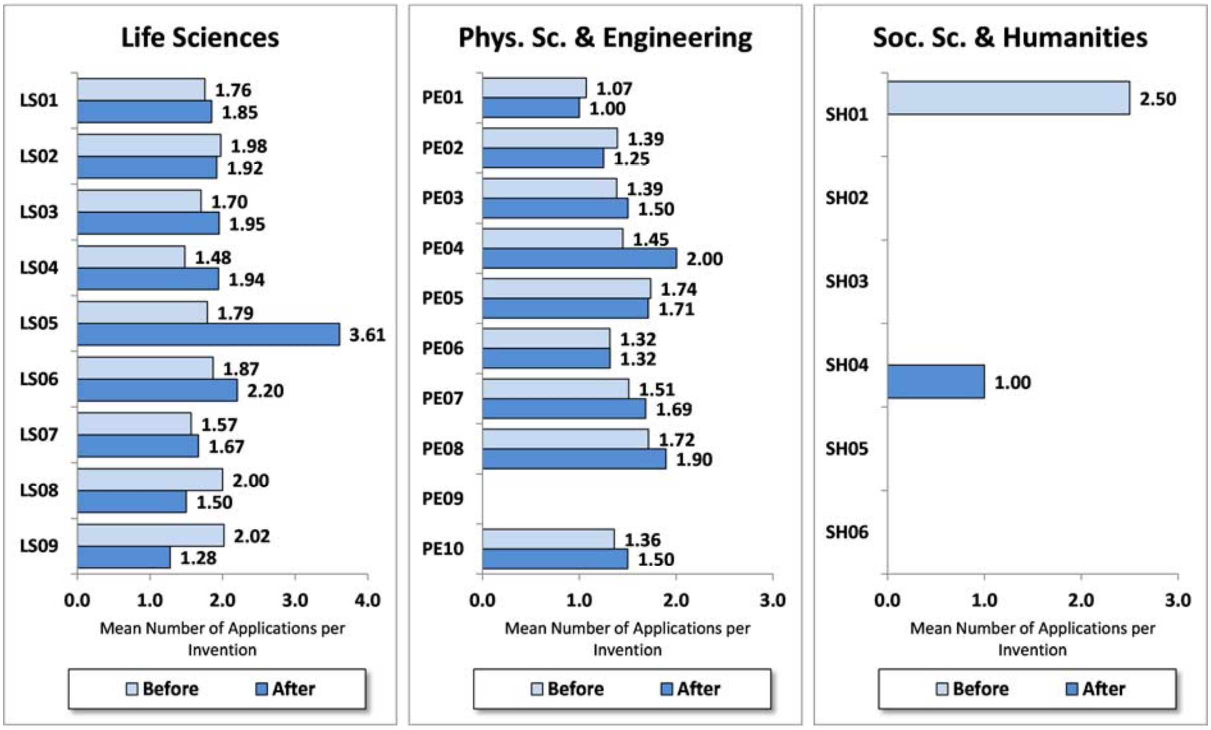
Figure 3-7. Mean Annual Number of Applications per Invention for ERC-Funded researchers Before and After the Grant Start Year by Seniority and Competition Year



Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition. European Research Council, list of applicants provided in September 2014, compiled by OST

The mean annual number of applications per invention of ERC-funded researchers is higher after funding for the LS01, LS03, LS04, LS05, LS06 and LS07 panels in Life Sciences and for the PE03, PE04, PE07, PE08 and PE10 panels in Physical Sciences and Engineering (Figure 3-8). Here again, numbers for Social Sciences and Humanities are too low and uneven to allow for any analysis.

Figure 3-8. Mean Annual Number of Applications per Invention for ERC-Funded Researchers Before and After the Grant Start Year by Domain and Panel



Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition. European Research Council, list of applicants provided in September 2014, compiled by OST

To answer our second question, we cannot definitively conclude that funding has a positive impact on researchers' inventiveness, mainly because of the measured decrease in patent application numbers near the end of the period. However, the different patterns observed when we compare junior to senior researchers would tend to indicate that the funding has a slight positive effect for junior researchers, while it does not improve the productivity of senior researchers. A possible explanation for this is that senior researchers already may be at the top of their productivity and that one cannot expect it to rise continuously, as there are diminishing returns in any economic activity, including research. Moreover, from a methodological point of view, this would lead us to believe that the decrease in patent applications near the end of the period may not affect the results that much after all and that, perhaps, for all researchers combined, the grant has no positive effect on inventiveness.

3.3. International Benchmarking

Do ERC grantees perform better than researchers sponsored by other European and American funding agencies?

This section compares the post-funding inventive activity of ERC-funded researchers against that of researchers funded by different agencies: NIH, HHMI, NSF, NEH and EU FP7.

The measured periods are based on the funding's start year (from 2007 to 2011) and the length of the observation window is calculated from the funding's start year to 2011. As before, this is to circumvent the number of patent applications' decline near the end of the period caused by the 18-months delay between application filing and publication.

The presented data is broken down according to funding agency, funding domain, funding status and the researchers' level of seniority. Note that we were not able to attribute a level of seniority to EU FP7 researchers.

The number of distinct inventions and the number of applications per distinct invention for the aforementioned periods is divided by the number of years comprised in the period to obtain an annual value. This annual value is then averaged for the number of projects comprised in the level under scrutiny (funding agency, level of seniority and domain) to obtain the indicators presented below.

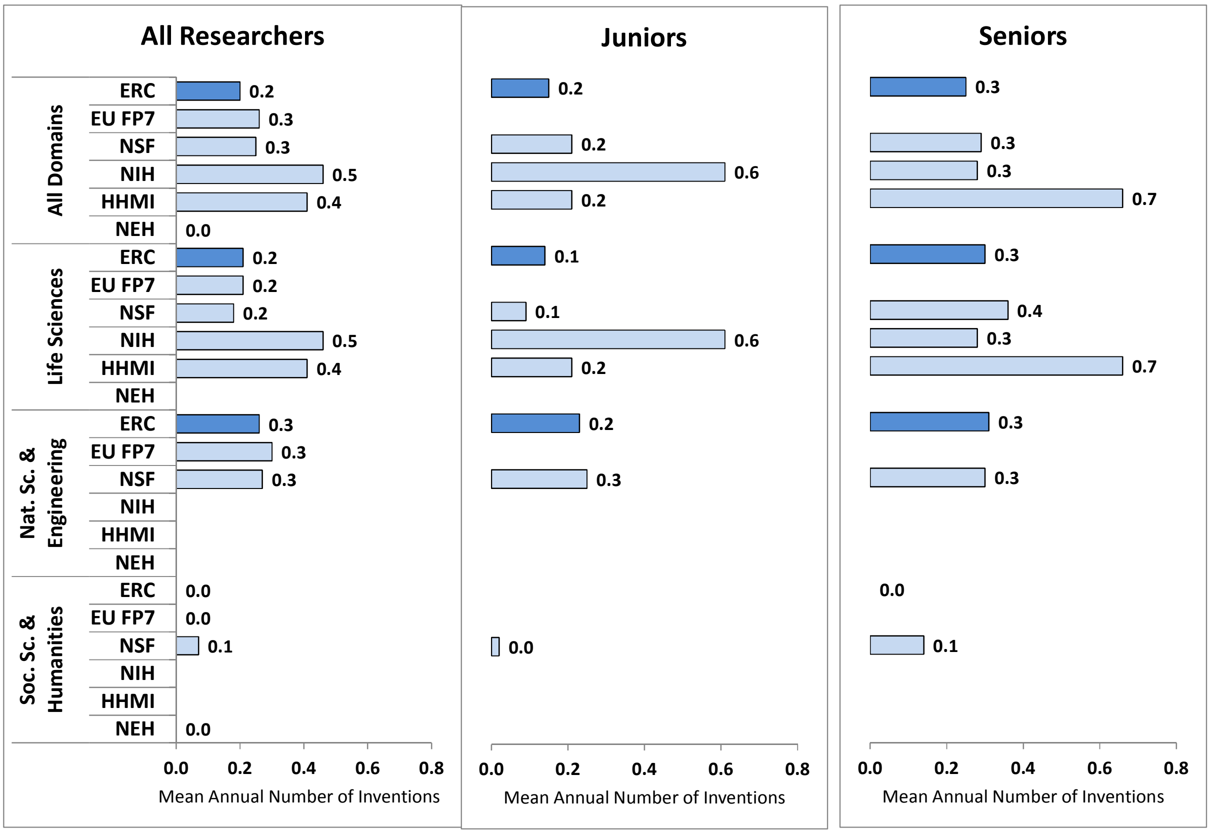
Concerning Figure 3-9, it should first be mentioned that NEH-funded researchers have no patents, which is to be expected given their fields of research.

For all researchers:

- For all domains taken together, and in Life Sciences separately, NIH and HHMI-funded researchers show the highest annual numbers of distinct inventions, while ERC researchers score lower.
- For Physical Sciences and Engineering, ERC, EU FP7 and NSF all present a similar score of 0.3.
- For Social Sciences and Humanities, the numbers are very low: NSF-funded researchers obtain a score of 0.1, while that of ERC and EU-funded researchers is near 0.

For junior researchers, the trends remain the same as those previously described but the gap between the score of NIH-funded researchers and the other groups is greater. For senior researchers, HHMI-funded researchers show the highest score for 'all domains' and in Life Sciences.

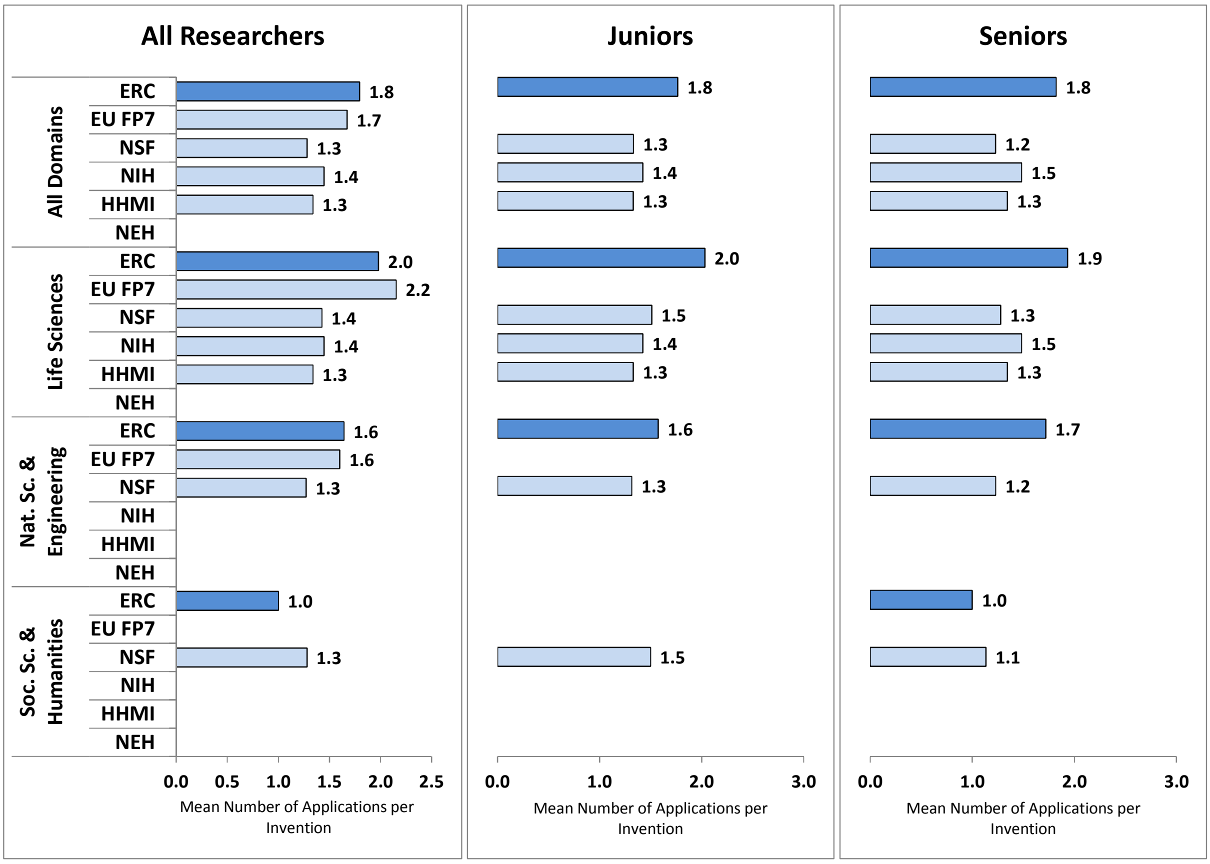
Figure 3-9. Mean Annual Number of Inventions per Funded Researcher After the Grant Start Year by Seniority, Domain and Agency



Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition, NSF, NIH, HHMI, NEH, European Research Council, list of applicants provided in September 2014, compiled by OST

Globally, Figure 3-10 shows that the mean annual number of applications per invention is higher for European researchers (ERC and EU FP7) than for researchers funded by North American agencies. This is confirmed throughout domains and levels of seniority, except for Social Sciences and Humanities, where NSF-funded researchers scored better than ERC-funded researchers.

Figure 3-10. Mean Annual Number of Applications per Invention for Funded Researchers After the Grant Start Year by Seniority, Domain and Agency



Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition, NSF, NIH, HHMI, NEH, European Research Council, list of applicants provided in September 2014, compiled by OST

Table 3-1 shows that for all agencies except NSF, at least half of patent applications are classified in Chemistry, followed by Electrical Engineering and Instruments. Interestingly, for HHMI-funded researchers, almost all patent applications are classified in Chemistry. For NSF researchers, Electrical Engineering represents half of all attributed patent applications while Chemistry and Instruments each represents about one third.

The ratio of applications per distinct invention shows that for all agencies except NSF, Chemistry is the technological domain where the number of applications filed at many national IP offices for the same invention is the greatest. The NSF still displays a particular behaviour since Chemistry, Instruments and Mechanical Engineering show similar ratios (1.34, 1.33 and 1.37, respectively).

Table 3-1. Number of Distinct Inventions, Number of Applications and Number of Applications per Distinct Inventions by Technological Domain and Agency

Technological Domains	Distinct Inventions					Applications					Applications / Distinct Inventions				
	ERC	EU	HHMI	NIH	NSF	ERC	EU	HHMI	NIH	NSF	ERC	EU	HHMI	NIH	NSF
All Domains	**3,727**	**1,814**	**237**	**1,086**	**1,488**	**6,182**	**2,656**	**319**	**1,463**	**1,913**	**1.66**	**1.46**	**1.35**	**1.35**	**1.29**
Chemistry	2,142	900	227	671	524	3,937	1,466	302	979	704	1.84	1.63	1.33	1.46	1.34
Electrical engineering	1,046	576	10	158	745	1,476	769	12	200	896	1.41	1.34	1.20	1.27	1.20
Instruments	1,166	355	61	441	415	1,810	516	82	509	550	1.55	1.45	1.34	1.15	1.33
Mechanical engineering	175	328	17	42	139	282	424	20	50	190	1.61	1.29	1.18	1.19	1.37
Other fields	32	44	4	3	26	47	54	4	5	30	1.47	1.23	1.00	1.67	1.15
Not Classified	106	98		7	2	166	114	1	13	13	1.57	1.16		1.86	6.50

Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition, NSF, NIH, HHMI, NEH, European Research Council, list of applicants provided in September 2014, World Intellectual Property Organisation technological domains classification (2008), compiled by OST

To answer our third and final question, we can say that ERC-funded researchers show a lower inventive activity than researchers funded by North American agencies but that they file for more patents from a single invention than the other groups of researchers. This is probably due to the fact that even though Europe is constituted of many countries with as many national IP offices, it represents in reality a single large commercial market, forcing inventors to file for patents in many national offices to ensure protection across Europe. On the other hand, the United States represents, for many inventors and companies, a sufficiently viable economic market to ensure the commercial success of an invention, therefore lowering the propensity to patent in multiple countries.

4. Conclusion

The current assessment was conducted to evaluate inventive activities in the ERC funding programme by answering three evaluation questions:

1. Is the ERC peer review process successful in selecting the best candidates among those who submit a proposal?

Overall, the ERC peer review process is indeed successful in selecting the best candidates among those who submit a proposal. However, this tendency is less clear when we look at the panel level, where for most Life Sciences panels, funded researchers' inventiveness is lower than that of non-funded step 2 researchers.

2. Does the funding provided by ERC help the grantees improve their scientific output?

We cannot draw definitive conclusions about the impact of funding on researchers' inventiveness, mainly due to the measured decrease in patent application numbers near the end of the period. However, the different patterns observed when we compare junior to senior researchers would tend to indicate that the funding has a slight positive effect for junior researchers while it does not improve the productivity of senior researchers.

3. Do ERC grantees perform better than researchers sponsored by other European and American funding agencies?

We can say that ERC-funded researchers show a lower inventive activity than researchers funded by North American agencies but that they file for more patents from a single invention than the other groups of researchers, most likely due to a conjuncture of geographic and economic reasons.

However, in interpreting these results it is important to keep in mind the limitations of patent indicators and the effects of external factors on the actual patenting activities. These can affect both comparisons between researchers in the same group and comparisons between groups of researchers from different countries. Some factors include, but are not limited to, institutional and national policies on intellectual property, internal operations of said offices, propensity to patent across fields, industrial fabrics supporting development and commercialisation of inventions, entrepreneurial spirit of individuals, contact network and business opportunities.

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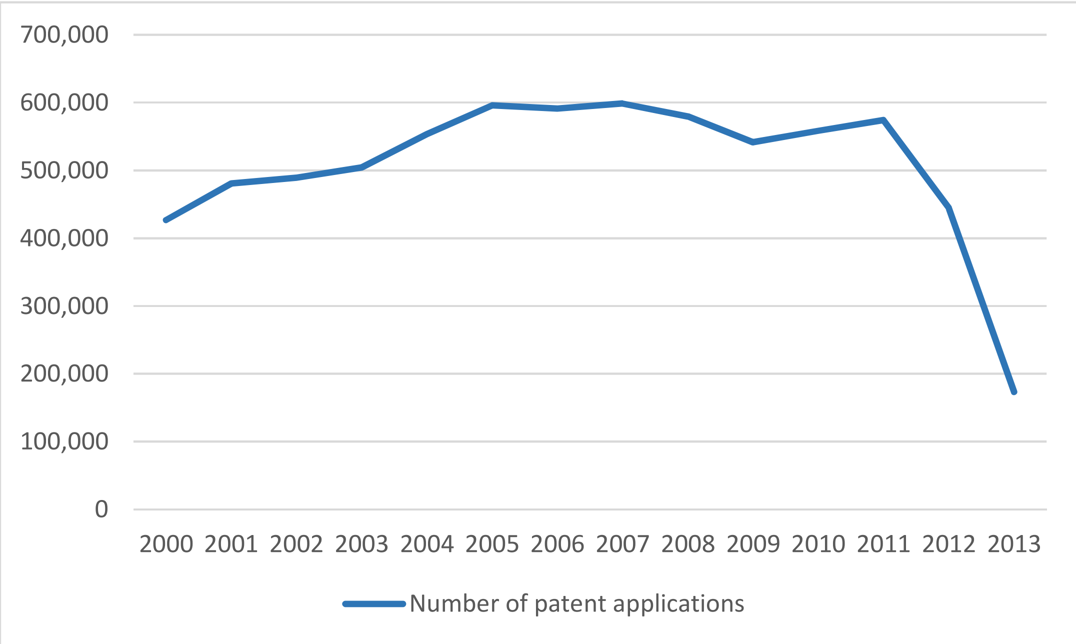
Appendix A

Figure A-1. Number of applications by filing year for the national offices of Canada, Finland, France, Great Britain and the United States, 2000-2013



Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition

Table A-1. Number of Distinct Inventions, Number of Applications and Number of Applications per Distinct Invention by Technological Domain, Agency and Domain.

Distinct Inventions

Agency / Domain	Chemistry	Electrical engineering	Instruments	Mechanical engineering	Other fields	Not Classified	All Sectors
All Agencies	**4,257**	**2,475**	**2,383**	**696**	**109**	**209**	**8,083**
LS	2,350	270	1,020	111	8	76	**3,075**
PE	1,982	2,220	1,415	586	101	136	**5,112**
SH	5	24	5				**33**
ERC NSE	**2,141**	**1,037**	**1,164**	**175**	**32**	**106**	**3,716**
LS	1,277	89	462	39		64	**1,552**
PE	886	960	734	136	32	43	**2,211**
ERC SSH	**1**	**9**	**2**				**11**
SH	1	9	2				**11**
EU	**900**	**576**	**355**	**328**	**44**	**98**	**1,814**
LS	191	4	43	11		5	**206**
PE	711	573	312	317	44	93	**1,610**
HHMI	**227**	**10**	**61**	**17**	**4**		**237**
LS	227	10	61	17	4		**237**
NIH	**671**	**158**	**441**	**42**	**3**	**7**	**1,086**
LS	671	158	441	42	3	7	**1,086**
NSF	**524**	**745**	**415**	**139**	**26**	**2**	**1,488**
LS	71	11	19	2	1		**86**
PE	449	719	393	137	25	2	**1,380**
SH	4	15	3				**22**

Applications

Agency / Domain	Chemistry	Electrical engineering	Instruments	Mechanical engineering	Other fields	Not Classified	All Sectors
All Agencies	**7,036**	**3,260**	**3,377**	**958**	**140**	**298**	**12,092**
LS	4,121	361	1,454	174	11	123	5,087
PE	3,026	2,913	1,996	786	129	178	7,152
SH	5	30	5			1	40
ERC NSE	**3,936**	**1,463**	**1,808**	**282**	**47**	**166**	**6,167**
LS	2,501	129	793	87	1	100	2,926
PE	1,466	1,348	1,054	195	46	67	3,301
ERC SSH	**1**	**13**	**2**				**15**
SH	1	13	2				15
EU	**1,466**	**769**	**516**	**424**	**54**	**114**	**2,656**
LS	403	7	62	16		12	435
PE	1,066	765	454	408	54	102	2,225
HHMI	**302**	**12**	**82**	**20**	**4**	**1**	**319**
LS	302	12	82	20	4	1	319
NIH	**979**	**200**	**509**	**50**	**5**	**13**	**1,463**
LS	979	200	509	50	5	13	1,463
NSF	**704**	**896**	**550**	**190**	**30**	**13**	**1,913**
LS	90	16	24	2	1		110
PE	610	863	523	188	29	12	1,778
SH	4	17	3			1	25

Applications / Distinct Inventions

Agency / Domain	Chemistry	Electrical engineering	Instruments	Mechanical engineering	Other fields	Not Classified	All Sectors
All Agencies	**1.65**	**1.32**	**1.42**	**1.38**	**1.28**	**1.43**	**1.50**
LS	1.75	1.34	1.43	1.57	1.38	1.62	1.65
PE	1.53	1.31	1.41	1.34	1.28	1.31	1.40
SH	1.00	1.25	1.00				1.21
ERC NSE	**1.84**	**1.41**	**1.55**	**1.61**	**1.47**	**1.57**	**1.66**
LS	1.96	1.45	1.72	2.23		1.56	1.89
PE	1.65	1.40	1.44	1.43	1.44	1.56	1.49
ERC SSH	**1.00**	**1.44**	**1.00**				**1.36**
SH	1.00	1.44	1.00				1.36
EU	**1.63**	**1.34**	**1.45**	**1.29**	**1.23**	**1.16**	**1.46**
LS	2.11	1.75	1.44	1.45		2.40	2.11
PE	1.50	1.34	1.46	1.29	1.23	1.10	1.38
HHMI	**1.33**	**1.20**	**1.34**	**1.18**	**1.00**		**1.35**
LS	1.33	1.20	1.34	1.18	1.00		1.35
NIH	**1.46**	**1.27**	**1.15**	**1.19**	**1.67**	**1.86**	**1.35**
LS	1.46	1.27	1.15	1.19	1.67	1.86	1.35
NSF	**1.34**	**1.20**	**1.33**	**1.37**	**1.15**	**6.50**	**1.29**
LS	1.27	1.45	1.26	1.00	1.00		1.28
PE	1.36	1.20	1.33	1.37	1.16	6.00	1.29
SH	1.00	1.13	1.00				1.14

Source: Worldwide Statistical Patent Database (PATSTAT), spring 2014 edition, NSF, NIH, HHMI, NEH, European Research Council, list of applicants provided in September 2014, World Intellectual Property Organisation technological domains classification (2008), compiled by OST

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The European Research Council Executive Agency (ERCEA) asked RAND Europe and the Observatoire des sciences et des technologies (OST) to use innovative scientometric techniques, including bibliometrics, patent analysis and alternative metric analysis, in carrying out a comparative assessment of European Research Council funded projects. The four interrelated objectives of the study were: (i) to provide a systematic overview and assessment of results stemming from ERC-funded projects; (ii) benchmark results of ERC-funded research and researchers against European and US control groups; (iii) conduct a qualitative peer-review assessment to explore the kinds of contributions made by ERC-funded research; and (iv) provide a scientometric framework and consolidated database for future assessment of ERC funded research.

This document is the patent analysis report for the study.

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