A comparative analysis of the publication behaviour of MSCA fellows

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2018

document version
Publisher's PDF, also known as Version of record

European Commission

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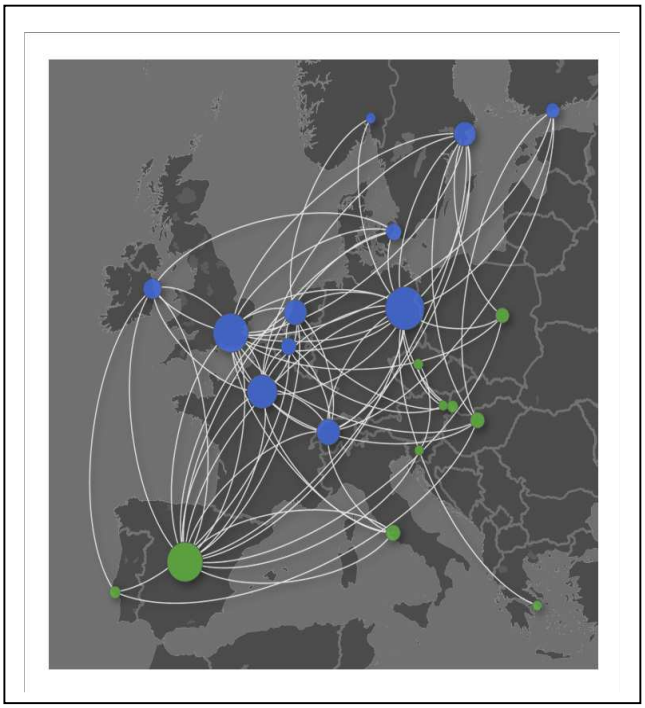

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2018

Joint Research Centre

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JRC Science Hub
https://ec.europa.eu/jrc

JRC109688

Brussels: European Commission, 2018

How to cite this report: Jonkers, K., Fako, P., Isella, L., Zacharewicz, T., Del Rio, JC, Sandström, U., Van den Besselaar, P., 2018., A comparative analysis of the publication behaviour of MSCA fellows, Brussels: European Commission

Title A comparative analysis of the publication behaviour of MSCA fellows

Abstract
MSCA applicants from South and Eastern European countries underperform researchers from North Western Europe before receiving the grant. However, the median difference disappears by the time of the grant and in the period after this. Due to a higher number of outliers (top performers) among the researchers from North Western Europe, the mean impact scores do remain significantly higher.

Contents

Foreword

This report is drafted by the Joint Research Centre (JRC), the European Commission's science and knowledge service. It aims to provide evidence-based insights into the performance of successful applicants in the Marie Sklodowska Curie Action (MSCA) fellowship scheme in order to support policymaking in the European Research Area. The scientific output expressed does not imply a policy position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of this publication.

Acknowledgements

We would like to thank colleagues from DG EAC, Przemyslaw Jankowski, Peter Whitten, Julie Sainz and Bodo Richter who gave us a comprehensive explanation of the structure and operation of the MSCA fellowship, organised a presentation of the report at DG EAC which yielded useful feedback and provided detailed comments on the final draft. Colleagues from the Research Executive Agency Ilse De Waele, Brito Ferreira, Olsson Hector Fredrik, provided access to crucially important data. Further feedback was received from colleagues at the ERCEA and from academics at two international conferences: the STI/ENID conference in Paris and the Atlanta Science and Innovation Policy Conference. Dániel Vértesy and Giacomo Damioli (DG JRC Ispra) as well as Martin Muehleck (DG JRC A3 now DG EAC) and colleagues in the Knowledge for Finance, Innovation and Growth Unit provided useful comments during this project. While thanking these people for their time and expertise, the responsibility for the analysis and any errors therein remain those of the authors.

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Executive summary

The Marie Sklodowska Curie Action (MSCA) fellowship scheme aims, as a part of the European framework programmes, to promote scientific excellence, mobility and research collaboration in the European Research Area. As most elements on the EU Framework Programmes, it also aims to widen capacity development throughout the EU in Member States with different levels of scientific development. This report analyses the mobility, publication and international co-publication behaviour of a group of European researchers that have taken part in the Marie Sklodowska Curie Action (MSCA) Fellowship schemes. It compares researchers that received their PhD from organisations in two groups of countries before and after being granted the fellowship.

The first group of countries (from North-Western Europe: FPIC receives a relatively large share of their research funding budget from the European Framework Programmes and a relatively low share from the European Structural and Investment Funds. The second group of countries (from South and Eastern European: ESIFIC) presents a lower Framework Programme funding intensity but the Funding intensity of the European Structural and Investment Funds is higher. The funding intensity levels associated with these broad programmes are taken as an indication of the level of scientific development. It strongly correlates with the average impact of the publications made by researchers in these countries. Also relevant to this analysis is that the first group of countries tend to host more MSCA fellows than they send whereas the reverse holds for the second group group.

The analysis measures performance as the sum of the citation impact of a researchers publications. Before the grant one observes a difference between the performance of applicants from South and Eastern Europe (ESIFIC) on the one hand and those from North Western Europe (FPIC) on the other. Over time the median performance gap disappears: there is convergence in the median performance of researchers from the two country groups. However due to a larger number of outliers (top performers) in North Western European countries there remains a difference in the average performance.

When comparing MSCA applicants with other grant schemes, one finds that the MSCA applicants perform well before and after the grant - though as expected below the performance of researchers funded by the highly selective ERC junior grant which tend to be more senior. The MSCA applicants show a marked improvement after the grant in comparison to before. This in contrast to a similar national individual fellowship in an EU MS.

Post grant performance is mainly correlated to pre-grant performance. One does not find a significant correlation with the quality of the research environment (as proxied by citation impact of the host organisation). This is surprising because the quality of the host environment is an explicit selection criterium.

Post grant international collaboration behaviour is mainly correlated to pre-grant international collaboration: it appears as if the well connected remain well connected also after being funded. What we did find was that after the grant a considerable share of the increase in co-authored high impact papers are co-published with researchers from North Western Europe: this suggests the MSCA mobility experience leads to productive research links.

The potential for robust evaluations, either in the form of counterfactual analyses or randomised controlled experiments should be taken into account at the planning and implementation phase of the Framework Programmes.

The JRC is carrying out a number of other analyses on the framework programme. It carries out micro-economic assessments of different instruments, including *assessments of the effect of different FP instrument on the growth and innovation capacity of participating firms. The* JRC *is* also *involved in a number of analyses of the differential use and impact of ESIF and FP funding in different European countries and regions.*

This report first provides the policy context and embeds the work in the broader scientific literature on scientific mobility, collaboration and research performance. It proceeds by outlining the methodological approach taken to address the research questions. The results section discusses the outcome of the author level analyses. In the discussion the identified performance increase of MSCA fellows is compared with the pre- and post-grant performance of grantees in other individual based grant schemes, including the ERC junior investigator grants and the Dutch VENI programme. The concluding section summarizes the findings and discusses potential policy implications.

Recent JRC work on mobility include a recent report by Sanchez Barrioluengo & Flisi (2018). This report focuses on student mobility at tertiary level in the EU between 2011 and 2014 describing the main destinations of mobile students, and inward mobility across and within countries with a particular focus on institutions and regions. Using the European Tertiary Education Registry, it compares institutional vs. regional factors in attracting degree and credit mobile students. A second report is an inquiry into the return mobility of scientific researchers in Europe (Cañibano, Vértesy & Vezzulli, 2018). The aim of this report is "to take stock of conceptual and measurement issues related to the return mobility of researchers, and see how they relate to research excellence". Wagner and Jonkers (2017, 2018) recently explored the relation between mobility, collaboration and the scientific impact of leading science producers. Forthcoming work in the field Higher Education and universities include a mapping of existing collaborative partnerships between Higher Education Institutions to inform policy on the support of "European University Networks". Other recent work included the development of an assessment framework for the regional innovation impact of universities (Jonkers, Tijssen, Karvounaraki, Goenaga, 2018). The latter report will form the basis for further work on the innovation impact of universities in the coming year.

1 Introduction and Literature Review

1.1 MSCA, history, studies, evaluations

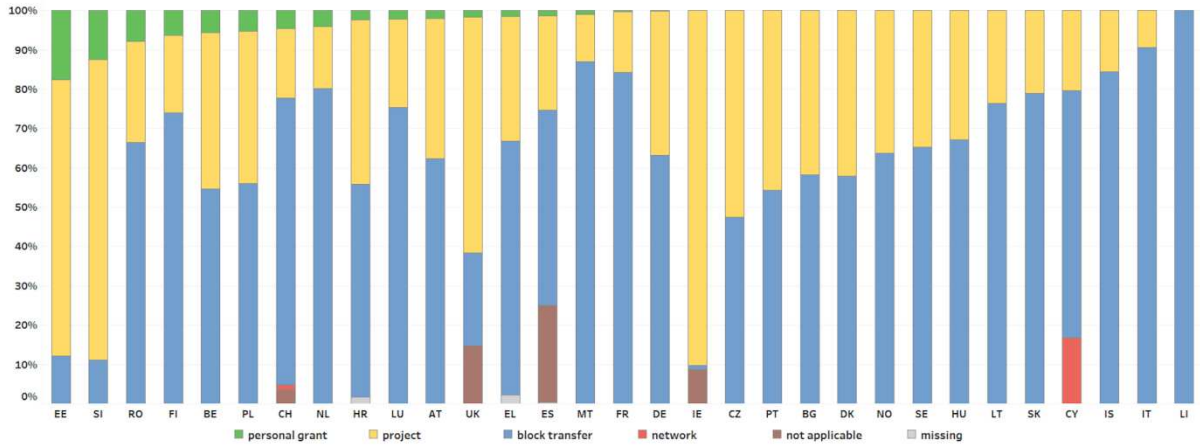
A commitment to the development of a pool of researchers is one of the four pillars of European research policy (cooperation, ideas, people, capacities)[1]. The EU has addressed this task primarily through the European Framework programmes for research and technological development. This programme is the financial tool for implementing the EU´s research policy and currently represents around 7% of total public research funding in Europe. While this share seems relatively low, its true potential for influencing the direction of European research becomes clearer when one considers that the share of FP in total EU project funding is considerably higher. Figure 1 provides information on project and person bound grants: a rough estimate based on PREF[2] and EU Framework Programme figures suggests that the share of EU funding of total European project funding lies at around 14%. EU framework programme funding can thus leverage investments made through both project and institutional funding in the Member States. This impact is different by country. These differences are important as it shows that in some countries the pressure to obtain EC funding may be (much) larger than in others.

The MSCA fellowships are a kind of personal grants and are thus different from the regular project funding which is dominant in the portfolio of most national research funders. Figure 1 shows that a number of European Member States have also set up such personal grant schemes which in some cases take up a considerable share of the national research funding budget. Examples of such programmes include the Veni programme in the Netherlands, the mid-career fellowship in UK or the Academy of Finland grants for research projects. The MSCA fellowship programme is different in nature to these national schemes as it includes an element of geographical, cross border, mobility. Nonetheless, in countries where well-funded person bound grants are offered by national funders, the pressure to apply for MSCA funding may be lower.

[1] https://ec.europa.eu/research/fp7/index_en.cfm?pg=capacities

[2] PREF is a study which the EC contracted out to a consortium led by CNR which engaged in a "data collection exercise of GBARD data by mode of allocation (competitive vs institutional) and themes".

Figure 1 GBARD by mode of allocation



Source: Reale (2017): reference year 2014.

Note. Countries with reduced data collection not included. Reference year is 2013 for AT, ES, LT, UK and 2015 for FR.

Another source of EU funding for research and innovation has become increasingly important, especially in the Central and Eastern European (CEE) and Southern European (SE) Member States. A considerable share of the EU Structural Investment Funds (ESIF) for regional development can be spent on reinforcing regional research and innovation systems. The conditions for receiving research funding from structural funds are considerably different from the very competitive selection process that characterises different EU Framework Programmes. For example the success rate of the MSCA programme (FP7 2007-2013) was 22%, for the collaboration project (FP7 2007-2013) it was 20% and for the ERC starting grants (period 2007-2013) 9%. Some analysts and EU policy makers are concerned that without adequate inducement mechanisms, researchers in CEE and SE MS will frequently decide not to apply for the more selective FP funding in light of the more easily accessible structural funds. To put this concern into context, Figure 2 shows that the share of FP funding (taking FP6 as a baseline) taken up by EU13 countries[3] is decreasing with time, while it remains roughly stable for EU15 countries.

One should, however, avoid seeing this in terms of 'higher quality' and 'lower quality' grants: the aims are very different. The ERC and MSCA grants focus on the career development of a next generation of leading scientists and (together with other FP funded research) at the movement of the knowledge and technology frontier. The ESIF, on the other hand, aims primarily at the creation of a local knowledge infrastructure which aim is less the knowledge frontier and more capacity building in order to adopt new science and technologies for economic innovation and societal problem solving. A longer term aim of ESIF is to make systems become more competitive in excellent science. However, whether this latter goal is

[3]EU13 refers to countries that joined the EU in 2004, 2007 and 2013 – namely: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia
EU15 refers to countries that were EU MS before 2004 – namely: Austria, Belgium, Denmark, Finland, France, Luxembourg, Germany, Greece, Ireland, Italy, Spain, Portugal, Sweden, The Netherlands, United Kingdom

realistic, and to what extent, is an important question. Excellence in science and technology is scarce, and often geographically concentrated. Creating a pool of researchers may be stimulated by FP and ESIF equally, but creating a European pool of excellent researchers may result in brain drain and further geographic concentration in the most developed European research systems. The latter is not uncommon, and we see the same in e.g. the US.

Figure 2 EU FP/H2020 trends of budget share from FP6 to H2020 (FP6=100%)[4]

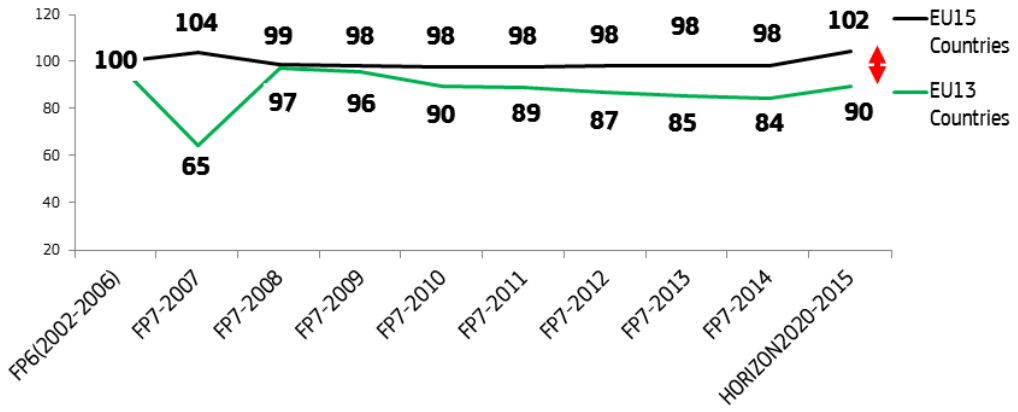


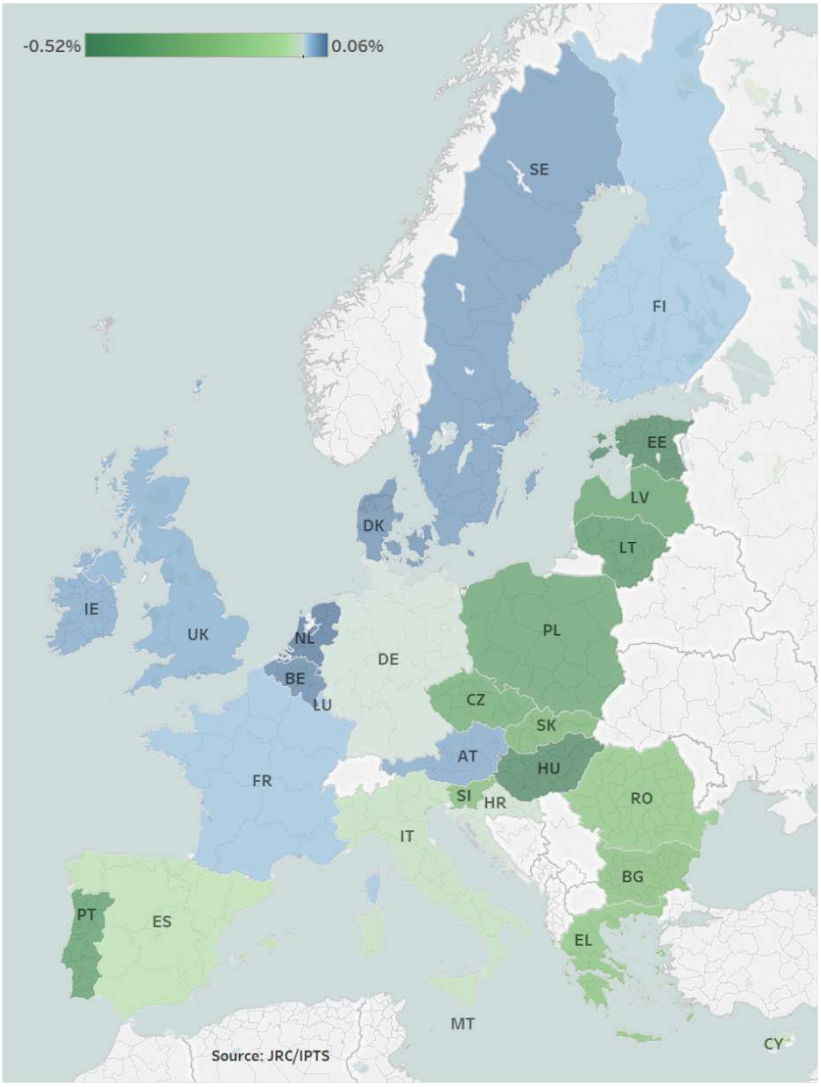
Figure 2 shows the innovation divide between EU 15 and EU 13 countries from an FP/H2020 perspective. It shows that the share of the FP7 budget going to EU13 countries has decreased in comparison to FP6. In H2020 the gap has so far stabilised, but the gap between the two groups of countries remains significant.

Figure 3.1 shows that Structural Funding Based R&D intensity is higher in the Central and Eastern European and Southern European regions, whereas in North Western European the FP funding intensity is higher. In this report we will make a distinction between countries which experience a high ESIF intensity (ESIFIC) and those which experience a high FP funding intensity (FPIC) as follows:

ESIFIC	Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovak Republic, Hungary, Slovenia, Croatia, Romania, Bulgaria, Serbia, Montenegro, Italy, Portugal, Greece, Spain, Cyprus, Malta
FPIC	United Kingdom, Ireland, Belgium, The Netherlands, Luxemburg, Germany, Denmark, Switzerland, Austria, France, Finland, Norway, Sweden, Iceland

[4] Figures 2 and the data for figure 3 were provided by courtesy of the Stairway to Excellence project, JRC-Seville

Figure 3 FP based R&D intensity Minus SF based R&D intensity



This country grouping in ESIFIC (South and Eastern Europe) and FPIC (North Western Europe) could have been based on different criteria. More specific to the MSCA scheme, ESIFIC countries tend to send out more researchers than they host, while the reverse is true for most of the FPIC countries. If one considers the average citation impact of ESIFIC and FPIC countries one observes that the latter group tends to have a considerably higher Field Normalised Citation Score than the first group.

There are considerable differences between research organisations in both the ESIFIC countries, where pockets of local excellence exist, as well as the FPIC countries where lower impact (e.g. organisations focused more on applied research or teaching) co-exist alongside research organisations that operate at the forefront of research. For this reason this study will also take into account the level of individual research organisations in our analyses.

Among the stated objectives in Horizon 2020 (the 8th Framework programme) are (i) the improvement of excellence of European science and (ii) the widening of research capabilities. One of the approaches to

adhere to both objectives simultaneously would be to strengthen participation of researchers in the ESIFIC regions in the Framework programmes, without reducing selection standards. The JRC promotes this process through its Stairways to Excellence project. It is, as argued above, considered to be not just a question of capabilities but also of preparedness to invest in the risky, as very selective, FP application process when other funding is available. But, as also said above, S&T research has become a very heterogeneous phenomenon, from basic science working at the boundaries of knowledge to applied research to solve pressing problems in innovation and society. This implies that widening research capabilities is not necessarily the same as widening the (geographical) sphere of excellent frontier research. And going for ESIF instead of going for FP grants is not necessarily going for the easier way – it could simply fit the situation in ESIFIC countries better.

As part of its funding programme the European Community supports a number of fellowship schemes which are collectively known under the brand name of 'Marie Sklodowska Curie Fellowships'. A distinguishing feature of the Marie S. Curie Scheme is the requirement of international mobility: to meet the eligibility requirements a fellow must be prepared to move to a research institution in another European country. In addition to providing targeted training, promoting international mobility and career development, this programme aims to promote excellent research. Another aim of the MSCA scheme is to foster international research collaboration. Previous studies have shown that international mobility does indeed have a significant effect on both the intensity and direction of international research collaboration (Jonkers & Tijssen, 2008; Jonkers & Cruz-Castro, 2013). In order to foster scientific collaboration between European Member States, the promotion of international mobility between them can thus be a useful instrument.

In terms of thematic focus, the Marie Skłodowska-Curie Action (MSCA) provides individual bound fellowships following a bottom up call for proposals. Its selection criteria include measures of research excellence; an assessment of the quality of the research proposal, the quality of the supervisor and the quality of the host institution are also given considerable weight in the selection process.[5]

In MSCA there are four actions: host based action to provide research, training and career development for early stage researchers (usually PhDs), individual fellowships for experienced researchers (post-docs), RISE – research and innovation staff exchange scheme and COFUND – supporting regional, national or international research programmes. This

[5] WP 2018-20 – see p68 http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-msca_en.pdf

project focuses on MSCA individual fellowships (MSCA IF) in FP7, more specifically the:[6]

- **IEF** Marie Curie Intra-European Fellowships for Career Development: provided support for researchers moving inside Europe
- **IOF** Marie Curie International Outgoing Fellowships: provided support for researchers moving away from Europe

The fellowships considered in this report are at post-doctoral level. Within FP7 the applicants are grouped into several different categories according to scientific field. In this report we limit our analyses to fellows in the Environment (ENV), Chemistry (CHE) and Life Science (LIF) fields.

DG Research and Innovation and its predecessors have commissioned a number of evaluations of the MSCA programmes in 2005 and 2010 (Van de Sande et al, 2005;Watson et al, 2010) and DG EAC which is currently responsible for the implementation of the MSCA has commissioned an evaluation for 2017 (Franke et al, 2017). Although the twofold objectives of EU policy are to develop a single market for research and to boost excellence, the issue of excellence has remained relatively unaddressed in analyses of the impact of FP funding. At national level, a study indicated that FP funded research in climate change research in Sweden had a higher average impact than all other funders (including internationally co-authored papers). In the Netherlands FP funded climate change research had an about equal impact as internationally co-authored papers, but the impact of this research was also higher than publications funded through other sources (Van den Besselaar & Sandström 2013). In both cases, the EC funded research on average thus outperformed the research funded by the national councils. A Danish evaluation of the impact of FP funding on scientific output found that international collaboration could explain the differential impact scores for FP6 funded research, but that FP7 funding had a marked additional impact that could not be explained by international co-authoring alone.[7] Secondly, the study highlighted that research funded by the ERC and Marie Curie accounted for most of the effect of FP funding on impact in comparison to national grants (DASTI, 2015). Assessing the impact of FP projects/programs in a more systematic way could help analysts and policy makers understand the factors underlying this higher impact and thus help inform the design of national and future European funding instruments. Such an assessment would consist of at least three related questions:

- What is the impact of EC funding on performance in terms of research productivity and scholarly impact?

[6] See also: European Commission: Marie Curie Actions – A pocket guide:http://ec.europa.eu/assets/eac/msca/ documents/documentation/publications/mariecurie-pocketbook2010-101130.pdf

[7] Even if the effect would be largely because of international collaboration, this does not make the conclusion less important. It still shows that requiring international collaboration is important to increase impact.

- Is the scholarly impact of EC funded research (on average) higher than the impact of research funded by other research funding institutions?
- Is the selection process robust: are the best researchers selected?

The answers to these questions are not trivial and very relevant[8] as one needs answers to both questions in order to optimize the return on FP-investment.

Given that an ongoing evaluation of the MSCA scheme commissioned by DG EAC (Franke et al, 2017) evolved into an exercise that analyses the impact of the MSCA scheme on the output and the citation impact of publications from MSCA funded researchers compared to other – non-funded - researchers, this report will not aim to give an alternative assessment of the MSCA scheme as a whole. Instead it aims to address alternative research questions that aim to place the MSCA scheme in the context of the broader European R&I funding landscape. According to Ackers (2008), the Marie S. Curie Fellowship Scheme explicitly seeks to reconcile the potentially conflicting objectives of promoting excellence and equality of opportunity at an individual level with balanced growth: i.e. the aforementioned twin objectives of promoting excellence and "widening". The aim of this report will be to analyse to which extent successful applicants from the ESIFIC countries, differ from funded applicants from FPIC countries in terms of:

- The mobility pattern (location and "quality" - in terms of field weighted citation impact - of the home and host institution)
- The change in their publication behaviour over time
- The change in impact of these publications over time
- The change in collaboration network

'Over time' refers here to a comparison of publications and impact in the period before they have received the grant (2003-2007) and the period after they have been funded (2009-2013).

The answers to these questions will show whether the combination of widening and excellence results in:

- Different (implicit) criteria for selecting researchers from ESIFIC and FPIC countries.
- A difference in the returns on investment between the groups: does scientific excellence develop differently between the groups

These findings will also help explore whether the environment (host country and host institution) influences the returns on investment in the three groups.

[8] see e.g., studies on the Dutch council NWO (Van den Besselaar & Leydesforff 2009; Bornmann et al 2010; Van den Besselaar & Sandström 2016)

1.2 Literature review

Over the past decades the international mobility of scientists has received considerable attention from policy makers and academics. Whereas mobility between Europe and the US, or between developing/emerging countries and the "west" is often couched in terms of competition and "brain drain", this is less the case for intra-EU mobility. Though also here in recent years, analysts speak of a "brain drain" from CEE and SEE countries to the research systems in North Western Europe and North America. Traditionally and from a policy perspective however, the intra-European mobility of scientists in Europe is seen as an instrument to foster collaboration, competition and capacity building[9] in the emerging European Research Area. Scientific mobility, rather than a zero-sum game between winning "host" and loosing "home countries" is seen as a continuous and often temporary process in which mobile scientists will often end up returning to their home country after acquiring skills, knowledge and contacts during a stay of a few years in another European research system. This chimes with the results of analyses of the OECD's CDH survey which indicates that the share of doctorate holders planning to move abroad on a temporary basis is high relative to the share which plans to do so permanently (Auriol, 2015). Overall mobility within the EU is seen as a mean to improve knowledge circulation and to strengthen scientific competitiveness of the union as a whole as well as individual member states (Ackers 2008; Flanagan, 2015).

The European Commission and the EU member States have made a number of attempts to foster the development of a pan-European labour market for researchers. According to Musselin (2004) this did not yet exist in 2004 due to linguistic and institutional differences between the EU Member States. She argued rather that the academic labour market followed a two-tier system consisting of an international labour market for elite scholars and promising young researchers on the one hand and national academic labour markets on the other. Progress towards the ERA is not likely to have led to a fully integrated European labour market yet: think e.g. of the need for an academic pension system that was only recently launched. While promising young scientists, including our MSCA cohort, will continue to be the most mobile contingent, possibilities for mobility within Europe have increased at all levels since the time that Musselin wrote her analysis. One more thing needs to be taken into account. As science has become increasingly heterogeneous - different types of research exists, even a pan-European labour market for researchers may in the end be a very segmented labour market, not in terms of countries, but of types of research and related types of researchers. The intensity of international mobility can be different in the different segments. By looking at the MSCA fellowship this report only discusses the segment of researchers involved in frontier research. This is

[9] For discussion of the role of mobility as an instrument for capacity building see e.g.: Ackers 2005; Edler et al. 2011; Jonkers and Cruz-Castro 2013, Jonkers, 2010

the segment of researchers which are expected to show the highest levels of mobility.

One of the main purposes of the MSCA is to support mobility as a mean to increase international collaboration and a higher quantity and quality of research output. As the MSCA grant leads to a long stay (2+ years) in another country, it may also lead to a sustained high-level collaboration between researchers.

The next sections present an overview of the concept of international scientific mobility, of its relation with patterns of collaboration and of what is known about the relation between mobility, collaboration and impact.

In the literature international mobility is conceptualised in several ways. Some analysts already consider temporary mobility of several weeks and more as a form of international mobility (Cañibano, 2011; Van den Besselaar et al, 2012). The OECD considers doctorate holders to be internationally mobile once they have spent more than 3 months in a foreign country (Auriol, 2016). What already becomes clear from the above variation is that analysing scientific mobility is a hard task in part because the target population is difficult to define and count (Ackers, 2008, Flanagan, 2015). The movement of scientists within the framework of the Marie Sklodowska-Curie Scheme provides some insight into the processes of scientific mobility in the context of European integration.

Since mobility in the MSCA program is understood as not being an aim in itself but a mean to impact the level of collaboration and the creation of a single scientific labour market, it is useful to distinguish different forms of mobility as these may have different impact in terms of the objectives.

- Temporary job at an institution abroad – with the perspective to return to the home country (MSCA). See also Ackers (2005, 2013) and Flanagan (2015): "mobility within positions" or "non-job mobility".
- Permanent mobility to a position at an institution abroad (with or without the intention to return at some moment). See also Ackers (2013) and Flanagan (2015) "moves for positions".
- Research visits to organizations in other countries, within the context of the position in the home institution. How long should it be to count as mobility; and needs it to be a continuous visit or would we call repeated short visits also as mobility.

The MSCA individual fellowship programme mainly targets the first type of mobility, though it may subsequently result in one of the latter two types of mobility as well.[10].

OECD CDH data reveal that "on average, 14 % of national citizens with a doctorate degree have had at least one experience of international mobility of 3 months or longer over the previous 10 years." This could be a relatively low estimate since the data are based on declarations of

[10] It is worth noting that other actions such as RISE promote the exchange of R&I staff

returnees, while not including those who remain abroad. The data reported by the OECD also does not reflect the fact that researchers can spend a longer time abroad in many short stays.[11]

For individual scientists the motivations for engaging in international mobility are diverse. As for all highly skilled migrants employment opportunities, professional advancement and higher salaries are likely to be motivations. Some analysts argue that access to resources (funding, but also materials, samples etc), research infrastructures and equipment, collaborators and favourable working environments (including the: research environment, professional reward structure, and presence of competitive funding programmes), trump salary considerations for most scientists (Flanagan, 2015). Given the relatively generous conditions of the MSCA grants, the latter motivation should not be ignored altogether. Also Leyman et al. (2009) and Edler et al. (2011) indicate that scientists see international mobility primarily as a strategy to increase their knowledge, skills and access to collaborators. An analysis of OECD CDH survey data also suggests academic reasons to be the prime motivation for international mobility (Auriol, 2015) and this is reinforced by the outcomes of the Globsci survey (Franzoni et al, 2015). Others argue that the aforementioned considerations could also be seen in the light of the future career opportunities and potentially salaries which this development may bring (Enders and Musselin 2008; Flanagan 2015).[12] In both cases researchers in general seek to engage in international mobility as a way to improve their career as a researcher.[13] Potentially as a consequence of the above considerations most researchers, given the choice, are expected to opt to move towards research organisations that offer most potential for the development of research skills, knowledge and collaborators as well as those that offer attractive employment possibilities and career development opportunities (Fernandez-Zubieta, Geuna, Lawson, 2015). As Acker's argues, international mobility can also be driven by necessity rather than by choice (Ackers and Gill, 2011). Naturally she does not refer here to forced mobility, but to mobility choices motivated by the lack of employment possibilities in the home system. This appears less relevant a consideration in the case of the MSCA applicants as this is a highly

[11] This can be captured through the CDH survey microdata (see: Cruz-Castro et al, 2015)

[12] There are also studies which indicate that international mobility experience in some countries can have a negative effect on career advancement due to the specific institutional set up of these systems Sanz-Menéndez et al. 2013). This might be specific to the Spanish context, though it may be a more general phenomenon as in its green paper with new perspectives on the European Research Area which advocates for greater scientific mobility, the EC (2007) recognised that "Mobility across borders [. .still ..] tends to be penalised rather than rewarded"

[13] In individual cases, other considerations may of course be in play including personal factors related to e.g. following the partner or returning temporarily to countries with which the researcher has a cultural / personal tie. Anecdotal evidence suggests it may be important not to ignore such factors altogether and e.g. Kannankutty and Burrelli (2007 in Flanagan, 2015) found that family considerations were among the primary reasons which immigrant scientists and engineers gave for moving to the USA. Also Ackers and Gill (2008) indicate that personal and family considerations played an important role in either limiting intra-EU mobility by generating resistance to international mobility or in the case of pre-existing links facilitating mobility between EU countries.

competitive scheme which might suggest that successful applicants engage in international mobility as a positive choice.[14]

Cruz Castro et al (2016) previously analysed for Spain the relationship between a range of individual characteristics (gender, age, employment status, salary, field of study, the applied or fundamental nature of their research work, the time it took researchers to complete their doctorate, the way their doctoral studies were financed, prior mobility experiences; etc) and the likelihood to engage in international mobility. The observation that those PhD holders involved in applied research are less likely to engage in international mobility than those involved in basic research ties into the aforementioned argument on the emergence of a segmented European labour force of PhD holders, in which especially the segment involved in basic research is highly mobile. Cruz Castro et al´s (2016) study builds on quantitative and qualitative studies, which highlighted the importance of several of these factors in other countries (e.g. Auriol, 2015; Ackers and Gill 2008; Canibano et al. 2011, Vandevelde, 2011, and IDEA Consult, 2010).

Leyman et al. 2009 and Edler and colleagues (2011) indicated that one of the motivations for scientists to engage in international mobility is to increase their access to collaborators. Empirical research has shown this expected positive relationship between international mobility and international research collaboration (Franzoni et al, 2014; Furukawa et al., 2011; Jonkers and Tijssen, 2008; Ynalvez and Shrum, 2011; Jonkers and Cruz Castro, 2013). Not only do researchers that have spent time abroad collaborate more with foreign based researchers, they are also more prone to collaborate with researchers in their former host region after they have left this region (Jonkers and Tijssen, 2008; Jonkers and Cruz Castro, 2013).

Most (of the scarce) empirical work argues that there is a clear positive relationship between international mobility, research productivity and publication impact (Jonkers and Cruz Castro, 2013; Baruffaldi and Landoni 2012; Defazio et al. 2009). This argument is also made by Edler et al. (2011). Yet other studies found small or even negative short term effects of international mobility on the productivity researchers (Cruz-Castro and Sanz-Menendez, 2010; Fernandez-Zubieta, Geuna, Lawson, 2015). The successful MSCA applicants are not only internationally mobile, they also receive a prestigious research grant which allows them to spend time at a different research organisation selected because of the favourable environment it offers for furthering the applicants research agenda. This, in combination with the increase in seniority of the applicants, suggests it is a reasonable expectation that both the productivity and the average impact of the publications of a successful MSCA applicant will increase in the period after he/she has received funding.

[14] On the other hand the high share of researchers from Spain and to a lesser extent Italy in our sample does suggest that the lack of career opportunities in these research systems may have resulted in some degree of mobility out of necessity.

Finally, there is the question of the effects of grants on careers. One can distinguish between indirect effects of grants on careers and direct effects. Traditionally, grants are seen as inputs to research and may lead to better performance. If better performance then leads to a faster/better career, one may see this as an indirect effect of grants. However, getting a prestigious grant as such is increasingly seen itself as performance (Van Arensbergen et al 2014), and then grants may have a direct effect on careers. In science policy studies and in economics, scientific careers have been studied in relation to various independent variables (e.g., Pezzoni et al. 2012). However, evidence of the effects of grants on careers is rather scarce (Bloch et al 2014). Pion (2011) showed a positive effect of pre-doctoral grants on careers, such as getting a tenure track position, and getting a job at a top-ranked academic institution. In a study of Danish grant applicants, it was found that "the probability of obtaining a full professorship for grant recipients is almost double that for rejected applicants, 16 percent compared to 9 percent. The probability for career advancement in general is about 9 percentage points higher for grant recipients" (Boch et al 2014).

In another study, the effect of the Netherlands' eary career grant (VENI) on academic careers was studied, using a regression discontinuity approach.[15] Gerritsen et al (2013) find in a study of the Dutch Veni scheme that "the receipt of an IRI-grant enhances the probability of a successful career in science. In particular, grant recipients are more likely to stay in academia, to become a full professor and to receive follow-up grants. However, grant recipients do not seem to benefit in terms of higher wages and have a lower probability to be employed on a permanent contract" A second analysis of the Netherlands' VENI funding scheme showed that getting a VENI grant had a substantial effect on the career of the grantee: of those that received a grant, 37% had become full professor, whereas another 35% were promoted to associate professor. For the non-grantees, these figures were 15 % and 26% (Van den Besselaar & Sandström 2015). Interestingly, this effect was found after controlling for academic performance in terms of productivity and impact – suggesting the abovementioned direct effect of grants on careers. Furthermore, the effect of grants is stronger for female researchers than for their male counterparts (Van den Besselaar & Sandström 2016).

[15] The advantage of focusing on early career grants is that for the population that are eligible for such a grant do hardly have other possibilities to get a grant. However, the methodology is based on the assumption that those that score just above the threshold to get a grant and those that just scored below that score are similar in most releant variables, and only differ in having received a grant or not. This assumption, however, may be too strong considering the uncertain nature of panel review and panel selection

2 Methodology

2.1 Methodological approach

The broad aim of this study was to explore the effect of the MSCA grant on scientific excellence and international collaboration[16]. After considering various options[17] to do this, the following approach was taken: the comparison of two different groups of successful MSCA applicants. The first group has received his/her PhD from an organisation in the countries most heavily reliant on structural funds (ESIFIC), the other group received his/her PhD from countries which especially rely on FP funding (FPIC) and to a lesser extent on Structural Funds for research and innovation.[18]

The first part of this analysis aims to assess whether there are statistically significant differences between the publication profiles of the two groups of researchers. Several interesting issues can be investigated through this method. (i) Do the grantees from ESIFIC dependent countries have a different past performance than those from FPIC countries? If it is correct that the research environment is important for scholarly performance, there may or may not be a difference. The evaluation procedure focuses on scientific excellence, i.e. the potential of the applicant and the quality of the research proposal.[19] Assessments of the potential of the applicant could consider the creativity, talent and potential of the applicants in other ways than solely looking at past performance as measured by citation impact.[20] Given the relatively early stage of the applicants careers

[16] Many previous studies have indicated that international co-authorship has a strong positive effect on the scientific impact of publications (Katz and Hicks 1997; Martín-Sempere et al., 2002; Lee and Bozeman, 2005, DASTI, 2015). In order to study the effect of the MSCA programme on the impact / excellence of its grantees we may therefore want to control for the effect of international collaboration as was done in for example DASTI, (2015). This would allow us to assess whether the impact of the MSCA on excellence is mediated fully through its positive effect on international co-publication or whether there is an effect beyond that.

[17] The regular approach to analysing the impact of the Marie Skłodowska Curie Action (MSCA) funding on scientific excellence and international research collaboration would be to do a counterfactual analysis. Due to data protection regulations and the provisions indicated in the call for applications in the framework programme, the EC Data Protection Officer decided against the use of non-successful applicant data. As alternative control groups that would allow for assessing the effect of participating in the MSCA programme on individual performance several options were considered. The first was to compare the performance of successful MSCA applicants with those of another individual grant funding scheme: the ERC starting grant. Comparing funded applicants from both schemes would allow for filtering out e.g. age effects which work on both sets of applicants equally. The fact that the nature of the grants, including e.g. the relative amount of funding and the level of experience/potential of the two groups at the outset is different could then be taken into account in the interpretation of the findings. In the end we opted for an alternative comparison of two groups of successful applicant data: those from ESIFIC and those from FPIC countries. The advantage that this approach has over a comparison of different funding instruments is that we compare two groups of treated researchers which should in principle have similar characteristics as they underwent the same selection process. In a follow up study one could, apart from comparisons with ERC start grantees, consider a comparison with successful applicants in national schemes. For example, the Netherlands' early career grant is highly competitive, but unlike in the case of the ERC starting grant the academic age of the applicants is comparable to those of the MSCA applicants: slightly under 3 years. In section 3.4 we will introduce a first step in this comparisons between MSCA, ERC and Veni. A limitation is that for VENI we only have data for social science researchers: mainly economics and psychology. However, through field normalization, the samples may be comparable.

[18] It is important to note that some of the applicants may have worked after their PhD in other countries than that of their PhD awarding institution, including the host country. The grouping by country of origin thus mainly says something about the location in which the applicant has received his/her PhD training.

[19] It is possible that the stated evaluation procedure and the actual implementation of this procedure diverge, for a recent analysis see (Van Den Besselaar et al, 2018)

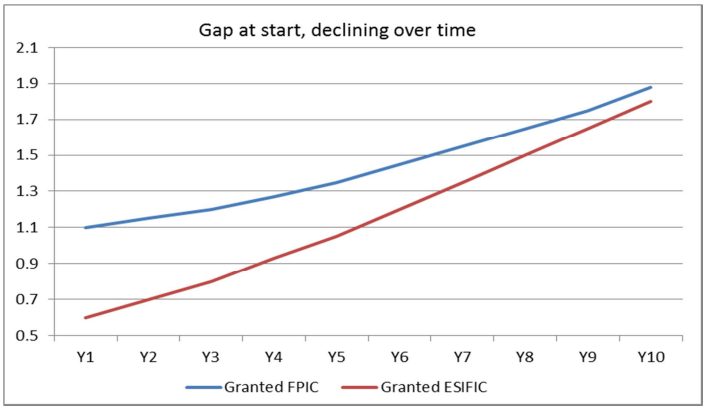
[20] They might also read and assess the publications applicants have made.

reviewers may be more prone to look beyond the publication record than is often the case for grants for more senior applicants. Differences in the past performance scores of successful applicants from ESIFIC and FPIC countries therefore do not necessarily have to imply preferential treatment of one group over the other. To ascertain this it would be interesting to either a) interview evaluators or b) analyse potential other qualitative differences in the applications of researchers from the two groups.

ii) This is followed by an analysis of the mobility pathways: do grantees from the different parts of the EU make different mobility decisions? For example, do they tend to select other host countries and institutions, and is the change (improvement) of their research environment different? More specifically, do grantees from ESIFIC less often go to host institutions that have a (much) better reputation and/or a (much) higher ranking? Or is it the other way around? In other words, which type of applicant gets the strongest improvement in the research environment. One may expect that this is the case for the researchers from ESIFIC, as their starting point (their PhD awarding institution) is on average much lower. But it remains to be seen whether this indeed is the case.

(iii) Thirdly, to what extent does a significant difference exist between the two groups in terms of their further performance? If an initial gap exists, is this widening or narrowing? If no initial gap exists, do we find emerging gaps between the groups of grantees (ESIFIC and FPIC) after having received the grant? And if so, who 'wins'? A potential reason for expecting a relative larger gain for grantees from ESIFIC countries is that researchers from these Member States may often move to better funded research systems (and institutions), the difference between home and host system may be much smaller for researchers from FPIC. This hypothesis can be illustrated as follows (Figure 4):

Figure 4 Visualisation hypothesis 1 (hypothetical)



We formulate the following research questions:

- Is there a difference in past performance between grantees from ESIFIC countries on the one hand, and grantees from FPIC countries on the other?

- Are researchers getting MSCA grants moving to countries/institutions with a higher or a lower research impact?
- Does this differ for grantees from the different EC regions?
- Is the impact gap between researchers from ESIFIC and FPIC countries decreasing or increasing? So is the impact of the MSCA grant higher for researchers from ESIFIC countries than for researchers from FPIC countries?
- To what extent does the MSCA grant lead to a higher degree of international co-publications and is there a difference between ESIFIC and FPIC? And, is the gap (if existing at the start) increasing or decreasing. Does that remain when controlling for the field weighted impact score of the home and host institution?
- What is the effect of background variables like gender and (academic) age – or time since PhD?

Some simple analyses are used to compare the changes in performance between the two groups. In addition the report explores what factors are correlated with as dependent variables (1) post grant performance in terms of the production of research results with a high citation impact and (2) international co-publications.

2.2 Data, sample and variables

CORDA is the common research data warehouse, central repository of data of present and past Framework Programmes (FP) collected and/or derived during the course of FP implementation. It contains among others data on funded (and non-funded) applicants in the MSCA programme.

For methodological reasons, namely: sample size; the effort involved in matching described in the subsequent section; and the need for a sufficiently long measurement period after the grant was awarded, the sample was restricted to the years 2007-2008. For similar reasons the sample was limited to researchers in three fields: the Life Sciences (LIF), Environmental Sciences (ENV) and Chemistry (CHE).

For the analysis presented in this report, only individual fellowship instruments were taken into account. For the years 2007 and 2008, we have thus identified successful candidates in the IEF programme who have an evaluation score that was higher than the cut off mark. The initial sample consisted of successful applicants in the fields of CHE, LIF, ENV and PHY with a maximum possible sample size of 984 authors. Applicants in the field of physics, applicants with missing data for the period before the start of the grant, "Rest of the World" applicants (i.e. applicants from regions other than ESIFIC and FPIC) as well as applicants whose project was finally not accepted or not carried out due to various reasons were excluded. The remaining applicants were matched with their publication records. The various cleaning steps resulted in a final sample of 488 authors that will be used in the subsequent analyses and that can be structured as follows (table 1):

Table 1 Share of ESIFIC and FPIC applicants in the sample of 2007/08 MSCA IF successful applications ranked by selection scores (LIF, ENV, CHE only)

Region	Lower half	%	Upper half	%	Full sample	%
FPIC	127	62.6	169	59.3	296	60.7
ESIFIC	76	37.4	116	40.7	192	39.3
Total	**203**		**285**		**488**	

In addition to the analysis of the full sample we perfomed a comparison of two sub-groups. The first consists of those researchers which received the 50% lowest evaluation scores. The second group consists of those researchers with the 50% highest evaluation scores. Comparing these groups might shed light on a) the extent to which prior research performance plays an important role in the grant selection process and b) the extent to which the evaluators score/ranking of candidates is a good predictor of future research performance. In addition some more descriptive analysis of the two samples was performed to explore for example the geographical distribution of the candidates origin in the two groups. In the population of applicants with the lower half of selection scores (Table 1) FPIC countries are slightly more prevalent in comparison to ESIFIC. As is shown in table 2, below, the academic age (years since PhD) of the upper half of the applicants tends to be slightly higher than the one of the applicants in the lower half of application scores.

Table 2 Academic Age Structure of the Sample of 2007/08 MSCA IF applicants (LIF, ENV, CHE only)**

Years	Lower half, %	Upper half, %	Full sample, %
0*	1.0	3.2	2.3
<1	30.7	20.8	24.9
1-2	33.7	33.2	33.4
2-3	10.4	10.6	10.5
3-4	7.9	10.6	9.5
4-6	11.9	12.0	12.0
7-11	3.5	4.9	4.3
>11	1.0	4.6	3.1
Total	100.0	100.0	100.0

*: PhD obtained in 2009 or 2010

**: three applicants do not hold a PhD degree

2.3 Bibliometric data: matching and derived indicators

Most studies on the effect of funding on output rely on simple publication counts which does not allow for an analysis of the effect of funding on impact of scientific production (Defazio et al, 2009, Beaudry and Alloui, 2012, Gulbrandsen and Smeby, 2005; Van Looy, 2004, Lee and Bozeman, 2005). An exception is Azoulay et al (2012), who studied the effect of individual grant schemes (the US HHMI and NIH) on the impact of the publications of funded individuals. They found a significant effect of the HHMI grant scheme on promoting the excellence of funded researchers. Other recent analyses have also looked at the impact of publications in their assessment of the impact of national and European grant funding

schemes (e.g. Van den Besselaar & Sandström, 2013; Ryan & Schneider, 2016).

Using automatic matching software[21] the successful MSCA applicants identified in CORDA were matched with their publications contained in the Web of Science database. In order to improve precision and recall, this automatic matching step was followed by a cleaning step which aimed at identifying and removing false positives i.e. articles that were assigned to an individual but which in reality were not published by him/her. An example of why this might occur is homonymy (i.e. several authors sharing a surname and initials). Another step included the identification of false negatives: i.e. articles that were published by the author in WoS journals but which had not been identified in the automatic matching step. Examples of why the latter would occur involve the treatment of people with double surnames in the database (a frequent problem for Spanish and Portuguese authors) or female researchers who changed their surname upon marriage (a common practice in several European Member States).

The automatic matching step yielded ca. 100,000 articles for the (in the end) 488 individuals in our sample (upper: 285 and lower:203). After cleaning (removing false positives) and supplementing (adding false negatives) we arrived at a dataset of ca. 8400 articles. A next step involved the calculation of impact indicators based on the citation and address data contained in the Web of Science database for each article. Using this data we calculated the following derived indicators:

- Field weighted citation impact (NCSf): Citations per Paper CPP normalised in relation to the subfield set (average=1.00)
- "Applicant citation score" (Sum(fracP*NCSf)): impact measure in which for each year the sum of the fractionally counted[22] articles times their citation impact is taken as a measure of impact in a give year T
- "Applicant average citation score" averages the applicant citation score over a period 'before' and 'after' recieving the grant.
- Top 10% most highly cited publications: Number of papers above the 10th citation percentile. (Tijssen et al., 2002; Waltman et al., 2012)
- International co-publications: refers to publications with at least two different countries among the institutional addresses of the publishing authors.

We define two periods:

[21] The BMX program developed by Erik and Ulf Sandström

[22] We use fractionaly counted performance to correct for (between researchers and between fields) different numbers of co-authors – as is often done in bibliometric analyses in order to correct for inflationaly citations, see e.g. Persson, Glänzel & Danell (2004), Waltman & Van Eck (2015).

- "Before grant" period: time period from 2003 until the year in which the applicant receives the grant (2007 or 2008);
- "After grant" period: time period from the year in which the applicant receives the grant (2007 or 2008) until 2014;

The latter indicator is frequently used as a proxy for international collaboration (e.g.: Katz and Martin, 1997; Glänzel and Schubert, 2004) and can be specified into co-publications per country or per region (e.g. intra-EU, extra-EU co-publications or co-publications with the host country).

This article level data was transformed into author level data, so that we arrived at a database in which for each author in each year (2003-2014) data points were added that indicated:

- the number of articles the researcher had published,
- the field weighted citation impact of these publications
- the number of highly cited articles
- the number of international co-publications

In order to address our research questions a few additional author level and system level variables were added. The first was the field in which the researchers were active. The MSCA applicants are grouped into various fields of research. As we know from previous studies that both mobility patterns and publication propensity vary between fields, it was considered important to control for this variable.

Through coding the CVs of successful applicants (Sandström, 2009; Canibano and Bozeman, 2009; Jonkers & Tijssen, 2008), data was collected on the academic age (years since PhD) and the home system (country of PhD awarding institution) of the applicants. The latter step was necessary since data on the home system in the CORDA database is ambiguous, referring to the country from which an application was made or the nationality of the applicant. Knowing the PhD awarding institution also allowed us to come to a more fine grained proxy for the quality of the training environment.

Use of the Thomson Reuter's Incites platform allowed for the calculation of the average field weighted citation impact of the home[23] and host country and institutions for each of the applicants and for each year. This indicator was used as a proxy for the quality of the home research system in terms of the research training it could provide and the level of resources available for doing research.

[23] As previously indicated, home country, refers to the country in which the PhD awarding institution is based – i.e. it relates to potential differences in the PhD training received. The applicants may have moved to another country at the time of application but this is not taken into account. However the literature suggests that the place where one received the PhD is more important than the residence at the moment of application.

3 Analysis

A first step at the author level is to analyse the mobility patterns of the successful applicants. To this end a flow chart is created showing the in- and outbound flows of researchers for the different countries. This is followed by an analysis of the difference between the field weighted citation impact of the home and host country in order to test whether in general researchers tend to move to systems with a higher field weighted citation impact than their home country system (institution). Field weighted citation impact is used here as a proxy for the quality of the research training and research environment that the researcher has experienced before and after he engaged in mobility. This information is collected also for the host organisation and this step is repeated at this level as there can be substantial differences between the average impact of research organisations within a single system: it is not the same for a researcher to go to a biomedical department in a top research organisation in a given country or to one of the lower level applied research organisations in the same system.

The next step is to analyse the difference in the average annual impact of the two groups of researchers before and after receiving the grant. We expect that a) the average annual impact of both groups increases, b) that the average annual impact before the grant is similar, as researchers in both groups have been selected through the same procedure, and c) that the improvement in the average annual impact of the researchers from ESIFIC countries is greater since the improvement in their research environment is on average considerably larger than for FPIC researchers, for whom the difference in terms of the quality of the research environment before and after receiving the grant is expected to be smaller.

Statistical tests are carried out to ensure that observed differences between the four groups analysed (before and after for the two broad regions) are statistically significant. Finally simple correlation analyses are carried out to explore the relationships between variables.[24]

3.1 Mobility Patterns

The second step in the analysis was conducted on the sample of 488 researchers. Further to this a comparative analysis of the "lower" and "upper" groups of successful applicants (see section 2.2). To analyse the mobility patterns of successful applicants, the movements from the home country (before the Marie Curie Fellowship) to the host country (after the Marie Curie fellowship) were aggregated for all the researchers in the dataset. Table 3, below shows the top 5 home countries in terms of number of researchers included in the sample[25]. One observes that these 5 countries account for 70% of sample.

[24] As a caveat for the latter analysis it is important to realise that the observed relationships are not linear.
[25] Further details can be found in Annex 1.

Table 3 Main sending countries

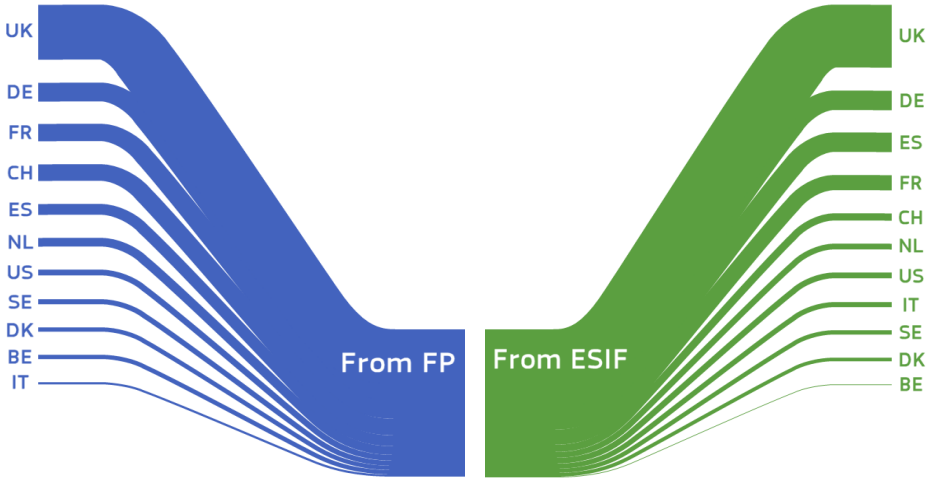
EU MS	# of researchers	% of total
Spain	104	21.3
France	90	18.4
Germany	63	12.9
United Kingdom	47	9.6
Italy	39	8.0

The relatively large number of successful MSCA applicants from Spain may be due to the large number of Spanish applicants. International experience is not necessarily correlated with faster career progression in the Spanish system (Cruz-Castro et al, 2015). However the combined effect of a considerable expansion in PhD training in Spain and the relative lack of career possibilities in Spanish academia results in relatively large numbers of Spanish researchers seeking career possibilities abroad. If anything, this phenomenon is likely to have increased in the post crisis period (Fernandez-Zubieta et al, 2017). The larger number of applicants may have resulted in a larger number of grantees. Another factor that may be important is that early research careers in the Spanish system are characterised by centralised and highly standardised application systems, not dissimilar to the MSCA applications. Spanish researchers may thus be relatively familiar with such procedures. Furthermore, there is likely to be an emulation effect: new researchers may learn from the successful applications of their national peers. What may be surprising in this respect is the relatively low number of successful Italian researchers in 2007 and 2008, since early career Italian researchers are thought to be faced with similar pressures from their domestic academic labour market. Possibly the expansion in the number of PhDs in the 2000s was less strong in Italy as it was in Spain. More generally, an explanation of the rather large differences between countries (the number of successful UK applicants is low too) requires further analysis.[26]

The flow chart in figure 5 shows that the United Kingdom, Germany, Spain, France and Switzerland appear as the host countries attracting the highest number of researchers.

[26] The uneven distribution refers to the granted applicants. The total numbers of applicants may be more balanced, which would suggest differences in success rates. If that were to be the case, some research into the decision making procedures may be worthwhile.

Figure 5 Mobility network of the researchers



One observes from figure 5 that ESIFIC researchers in general favour mainly institutions located in the same set of countries as researchers from the FPIC countries do. The same holds when comparing applicants with higher and lower evaluation scores, apart from Switzerland, France and Spain which receive somewhat more 'lower half' than 'higher half' grantees. In Germany, Denmark and the Netherlands the situation is the opposite.

Table 4 Main receiving countries for ESIFIC researchers

Country	Lower half Grantees (%)	Upper half Grantees (%)	Total 2007/08 MSCA IEF (%)
United Kingdom	39.5	37.9	38.5
Germany	10.5	12.9	12.0
Spain	13.2	11.2	12.0
France	10.5	8.6	9.4
Switzerland	5.3	3.4	4.2
Italy	3.9	2.6	3.1
Netherlands	2.6	4.3	3.6
Sweden	2.6	2.6	2.6
Denmark	1.3	2.6	2.1

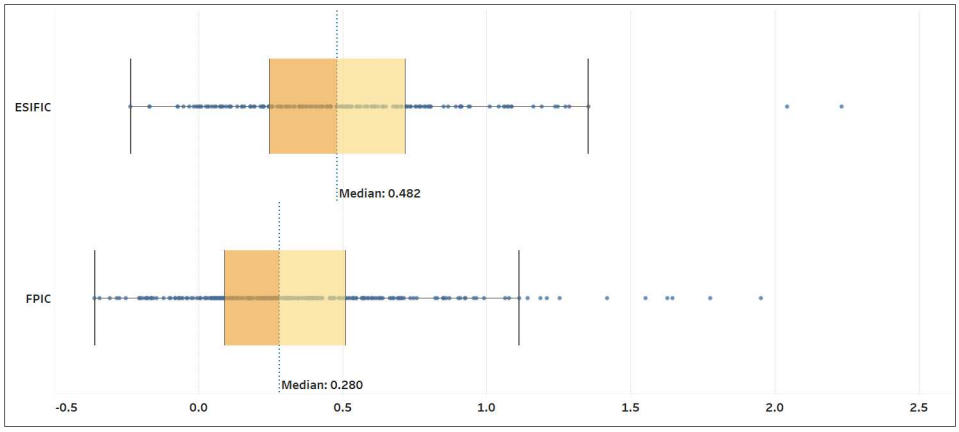
Following the identification of the mobility pattern, an analysis of the difference between the field weighted citation impact of the home and host country was performed to assess whether researchers are moving from lower to higher "quality" research systems. The "quality" of the research systems of the successful applicants' home country (and organisation) is measured as the field weighted citation impact of the national system (and organisation). For each of the applicants the difference between the quality of the home and host system (and organization) is calculated.

On average, for each of the sets of researchers, the difference is positive so the researchers moved on average to a better performing research system. Comparing the distributions of the quality increase between the

two groups, suggests that the ESIFIC group improves its position more than the FPIC group. This holds for each of the three disciplines.

Figure 6 shows a boxplot of the difference between the score of the researcher host institution and the score of his/her home institution.[27] A Kolmogorov-Smirnov test (Annex 2, Test for researchers' mobility) indicates that the distribution for researchers from ESIFIC countries is significantly different from those of researchers from FPIC countries. Visually, the median of the distribution is noticeably higher for researchers from ESIFIC countries. This is a clear indication of the tendency of ESIFIC grantees to move towards organisations with a stronger quality[28]. This conclusion is strengthened by the Wilcoxon rank-sum (indep sample mean) statistics (Annex 2, Test for mean score of applicants), which detects a highly significant shift in the median between the distributions of FPIC and ESIFIC researchers.

Figure 6 Difference between quality home and host institution



3.2 Publication impact before and after the grant

The productivity scores of FPIC and ESIFIC grantees are significantly different (Wilcoxon rank sum test for fractional counting is p = 0.000), as well as for the distribution (Mann Whitney test for fractional counting p = 0.000[29]; for full counting p = 0.000). Annex 2 gives the details. Also the impact scores are different. Figure 7 shows the distribution of the citation impact of each successful applicant broken down by the geographical origin of the applicant. We use as impact indicator the *sum* of the *fractionalized paper NCSf-scores of an applicant* over the before-grant period. The scores of FPIC and ESIFIC are significantly different (Wilcoxon rank sum test is p = 0.002). This is visible from the fact that the ESIFIC sample exhibits a lower median and lower data dispersion around the median. In other words, before the grant there are more high performing

[27] Both metrics are averaged along the years before the award of the grant.

[28] Most ESIFIC applicants move to FPIC countries. However, about 20% of ESIFIC researchers go to another ESIFIC country (in our sample 38 out of 145). The performance of these applicants does not seem to be worse than the performance of ESIFIC researchers going to FPIC countries. Though the most positive outliers are in the latter group

[29] Kolmogorov-Smirnov test yields the same p=0.000

researchers (in terms of field weighted citation impact) in the FPIC sample than in the ESIFIC sample. Statistical analysis conforms this, and the Wilcoxon rank sum test, the MW-test and the KS test are all significant at p=0.000 (see annex 2).

Figure 7 Boxplot of the applicant citation score before receiving the grant (right: detailed scale on vertical axis)

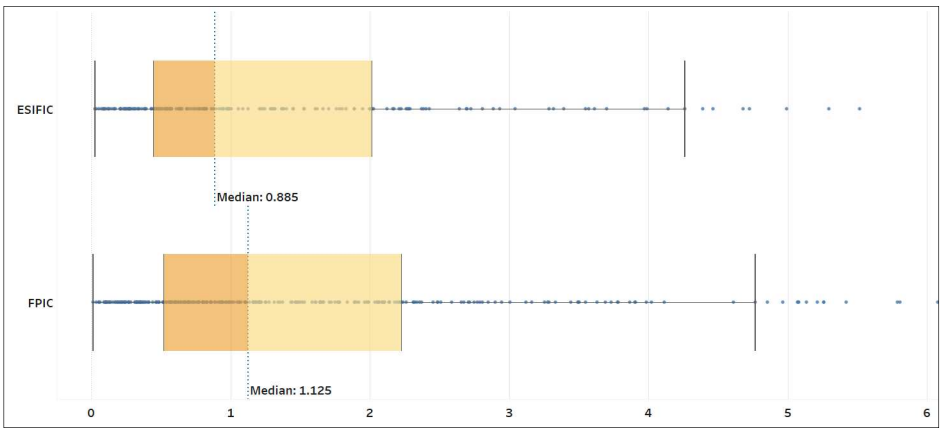
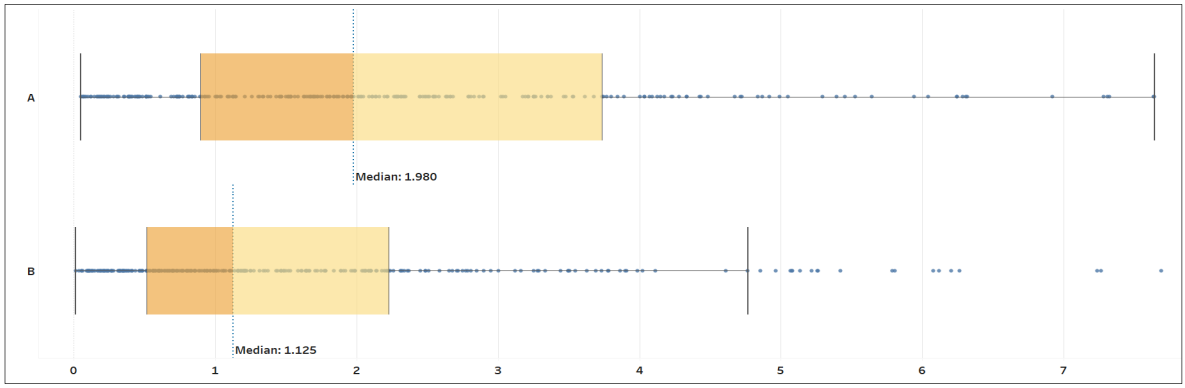


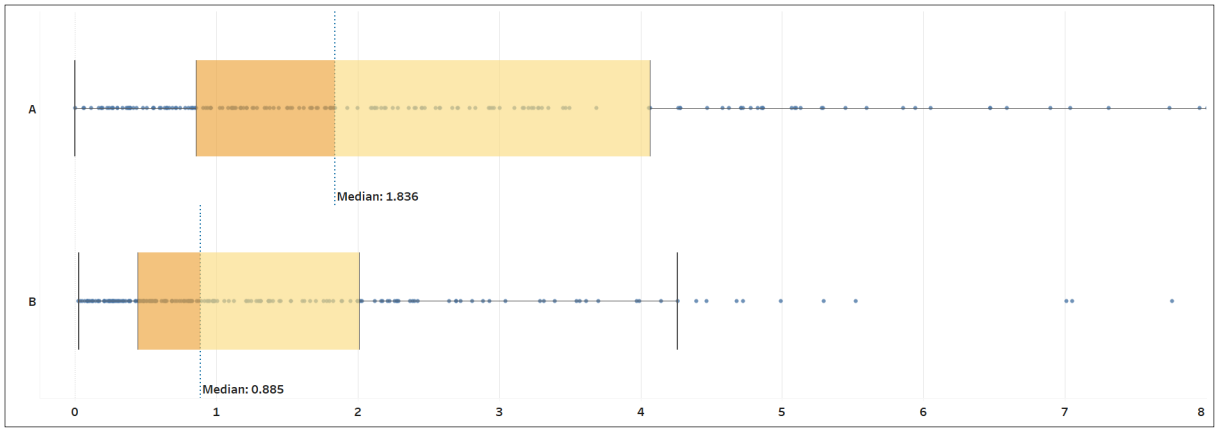
Figure 8 plot the applicants' average citation score over the period before (B) and the period after (A) receiving the grant. In other words, we use here *a time averaged* citation score. In both regions one observes an increase of the median value of the researcher's citation scores. This is also shown in the statistical tests. The Wilcoxon rank sum test, as well as the Mann Whitney test give significant differences between period B(efore) and period A(fter) in both regions (see annex 2). By the way, also productivity increases significantly over time, again for the researchers in both regions.

Figure 8. Boxplot of the applicants' average citation scores before and after the grant

FPIC:

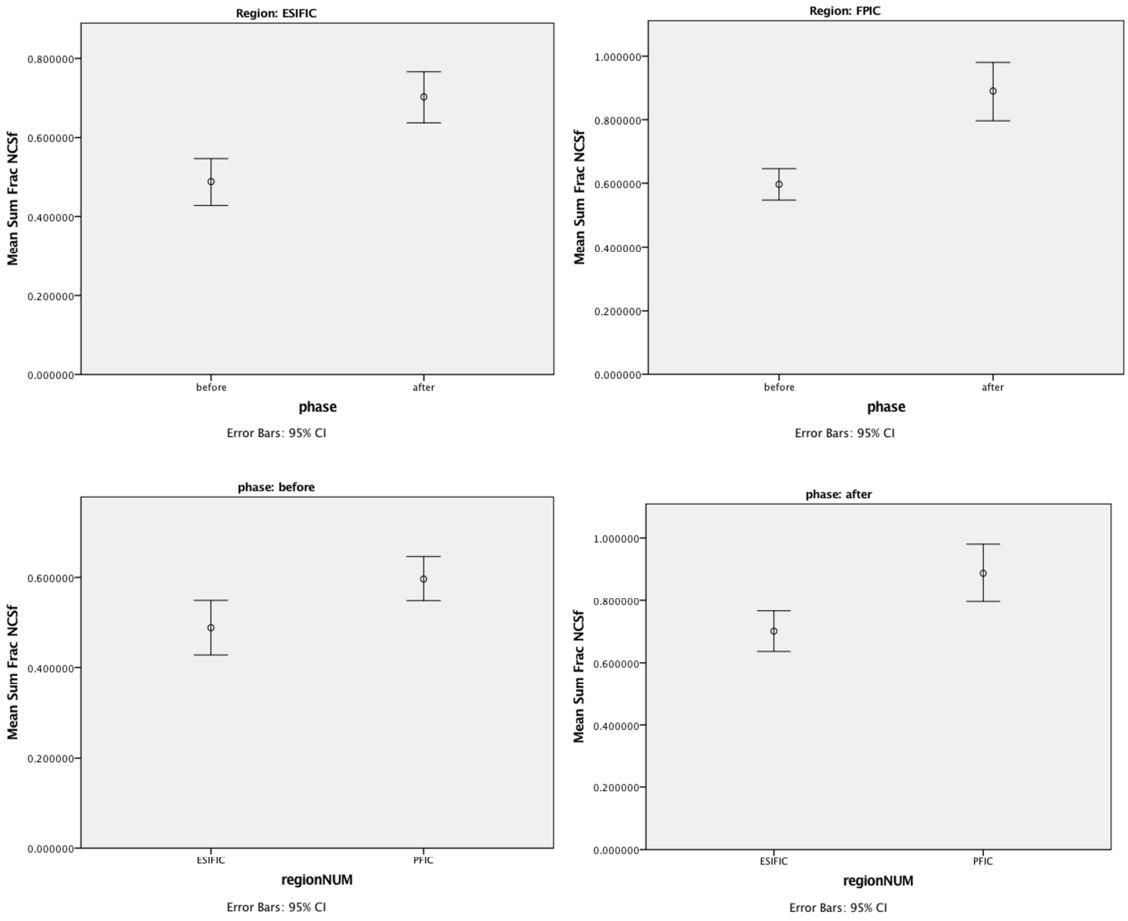


ESIFIC:



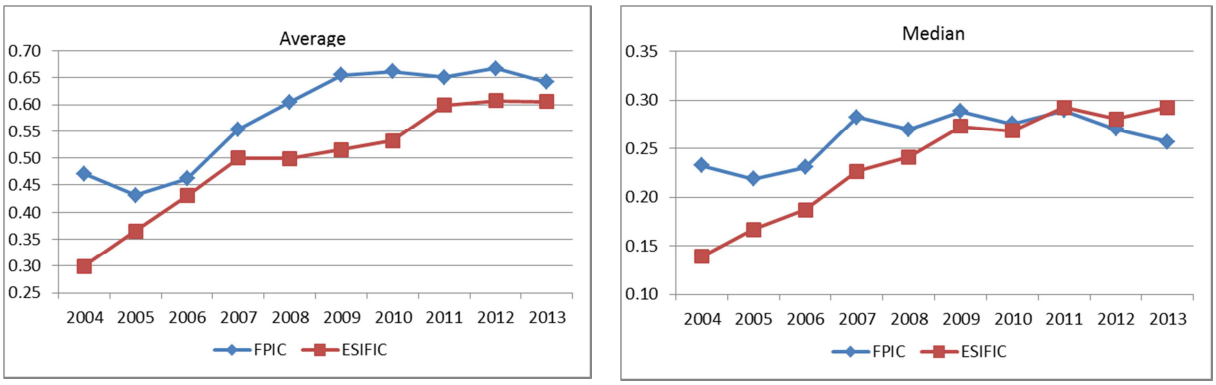
Why would the increase in impact be stronger for the ESIFIC applicants? They may have put more effort in writing the application as they know that they have to compete with applicants from stronger scientific environments. A fuller answer to this question, however, would require further research. The non-convergence of the means (Figure 9a) is due to the large influence of outliers. There are (more) top performers in the FPIC sample who have a relatively large effect on the average impact of FPIC, so that the difference with the average performance of ESIFIC researchers remains.

Figure 9 applicants' average citation scores before and after the grant



Section 2.1 discussed the hypothesis that grantees from ESIFIC countries would experience a relatively larger gain in performance, because these researchers often move to better funded research systems and institutions. To assess this, the following paragraphs discuss the difference between the two groups in terms of their performance. For this, we calculate for each the two regions the mean (Fig 10 left) and the median (Fig 10 right) of the the applicant citation scores. We use the sum of the fractionalized NCSf per paper, so the size dependent impact indicator. In the left figure we show the average of the scores of the applicants for each of the regions, the right figure shows the median for each year and both groups.

Figure 10 Performance gap between ESIFIC and FPIC researchers measured by average (left) and median (right) of NCSf (sum) – moving averages



The mean impact goes up for both groups of applicants (Fig 10 left). However, we cannot argue that the initial gap between the FPIC and ESIFIC authors disappeared, as the distance between the two curves is not decreasing unequivocally over time. The averages between the phases and the averages between the regions are significantly different as was shown in figure 9: the 95% confidence intervals are almost not overlapping. The median shows a different pattern. It goes up for both groups mainly in the "before period" but around 2009 it stabilizes for both groups (i.e. after receiving the grant). This suggests that preparing a successful application may have a positive effect on performance, more than receiving the grant. As one also expects a seniority effect (impact increases with scientific age), the conclusion could be that the grant itself does not positively affect impact. The medians not only go up, but also convergence during the "before" period, which is in line with the conclusions from Figures 8 and 9. The differences between the medians and between the distributions are statistically significant in the before phase, and marginally significant in the after phase.

Figure 11 below presents the results of a simple pairwise correlation to assess the correlation of the "After grant" applicant citation score with a number of other variables. The analysis indicates that in our sample, "After grant" applicant citation score is significantly positively correlated

mainly with pre-grant performance: the pre-grant applicant citation score as well as alternative measures of performance such as the number of top 10% most highly cited publications before the grant and pre-grant period journal score. Not surprisingly there is a strong positive correlation between "Before grant" applicant citation score and international co-publications. Gender appears to be relevant, as men have significant higher scores on most variables. However, the correlation is weak, so the gender effect is not strong. Somewhat surprisingly, the correlation between "After grant" applicant citation score and host institution and host system scores are very low and not significant.

Figure 11 Pairwise Correlation analysis with Post grant citation impactFigure

A comparative analysis was carried out of the pre- and post-grant researchers' citation score of the "lower" and "upper" groups of successful applicants. Table 5 shows the average and median FracP*NCSf of the lower and upper group before and after the grant. The mean score of the upper group is significantly higher both in the pre-grant period[30] and in the post-grant period[31]. Also the medians differ significantly[32], as do the distributions of citation scores[33]. We also tested whether the citation scores differ between the periods (within the groups), and this is also the case for the means, medians, and the citation distributions).[34]

Table 5 Pre/Post grant citation impact of lower/upper group researchers

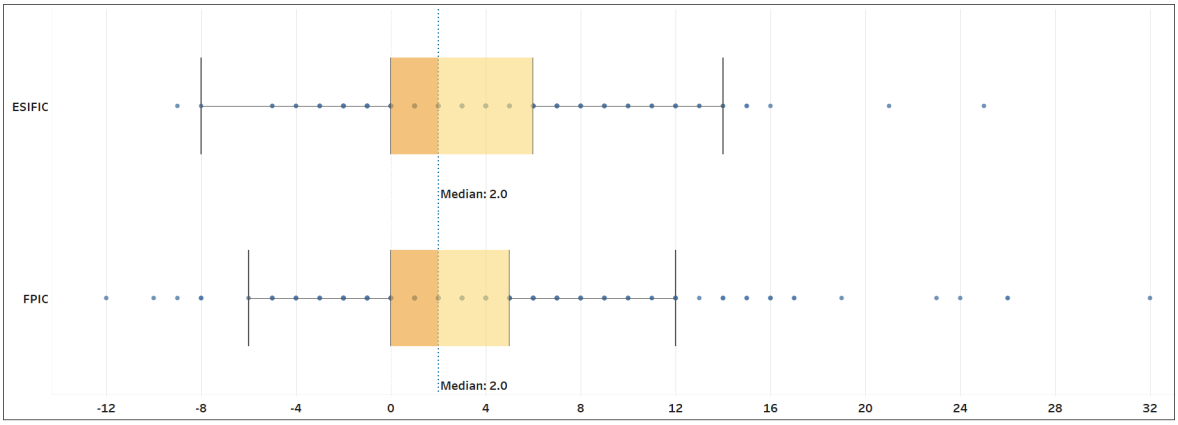
	pre-grant period	post-grant period	increase
lower group	1.358	2.675	97%
upper group	1.925	3.526	83%
difference	42%	32%	

[30] 42%; p=0.002
[31] 32%; p=0.049
[32] K-sample equality-of-medians pre: 0.005; post: 0.001
[33] Mann-Whitney, pre: 0.013; post: 0.014
[34] Lower group: compare means (ANOVA): p=0.001; compare medians (independent samples median test: p=0.000; compare distributions (Mann-Whitney): 0.000
Upper group: compare means (ANOVA): p=0.000; compare medians (independent samples median test: p=0.000; compare distributions (Mann-Whitney): 0.000

3.3 International co-publications

Another variable of interest is the number of international co-publications. The boxplot of Figure 12 indicates the quartile distribution of the before/after grant difference of the number of international co-publications co-authored by ESIFIC and FPIC researchers.

Figure 12 Difference in the number of international co-publications per author regionFigure



The statistical analyses carried out on the data in figure 12 indicates that the improvements in the performance of researchers from the ESIFIC and FPIC are both significant and of similar magnitude. The number of after grant international co-publications is thus significantly higher than before the grant.[35]

Instead of author level analyses, table 6 presents the results of an analysis at the article level. Articles are grouped in deciles according to their Field Weighted Citation impact. Comparing the shares of international co-publications in the total publications before and after the start year of the grant, one observes increases both in case of papers co-authored by ESIFIC and by FPIC applicants in each of the 10 NCSf impact categories (table 6), indicating a growth in their respective international co-authorship network.

Table 6 Deciles of international co-publications per author region before and after the MC grant

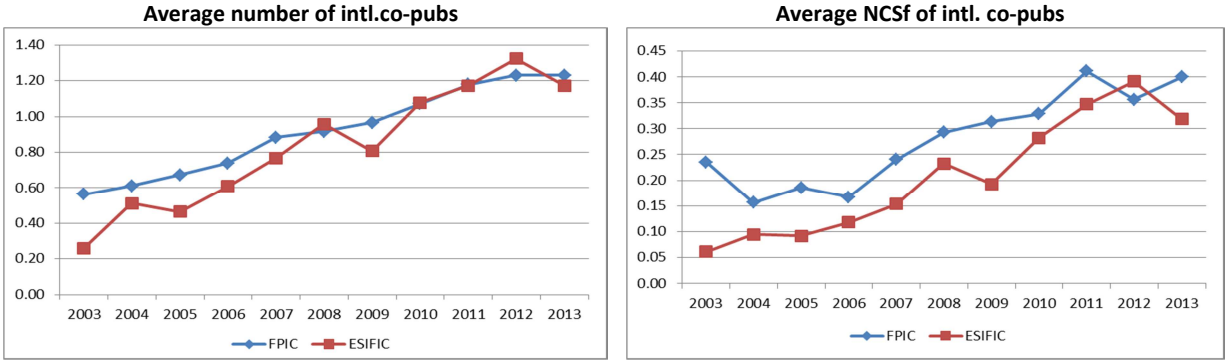
% of total publications	Overall	< D1	[D1,D2]	[D2,D3]	[D3,D4]	[D4,D5]	[D5,D6]	[D6,D7]	[D7,D8]	[D8,D9]	> D9
ESIFIC – Before	36.3	3.5	4.1	3.5	3.4	4.1	4.5	4.6	3.2	2.9	2.5
ESIFIC – After	60.5	5.3	6.0	5.5	6.2	6.2	5.7	6.6	5.5	5.9	5.2
FPIC – Before	48.3	4.9	4.9	5.3	4.9	5.6	4.7	5.0	4.5	4.8	3.6
FPIC – After	60.5	6.2	6.8	6.9	6.5	6.1	6.1	6.2	5.6	5.4	4.8

[35] The Kolmogorov Smirnov test does not indicate a significant difference in improvement in the average number of international co-publications before and after the grant of either of the two groups of researchers. Similarly, the Wilcoxon rank-sum test cannot reject the null hypothesis that the above mentioned distributions are coming from different populations (Annex 2, International co-publications related tests, 4a-b). This means that the changes (improvements) in the ESIFIC and FPIC groups may be of similar magnitude. Further K-S and Wilcoxon tests, performed this time separately on the before/after grant ESIFIC and FPIC samples confirm that these improvements are significant (Annex 2, International co-publications related tests 4c-f). Therefore one can conclude that in both ESIFIC and FPIC samples the number of after grant international co-publications are significantly higher than the number of before-grant international co-publications.

Overall the share of international co-authorship before the grant was at 48.3% for FPIC authors, somewhat higher than for ESIFIC authors (36.3%). Both increased substantially in the after-grant period, and the difference across the regions has practically vanished.

A similar trend can be seen from time trends in figure 13. Both the number as well as the impact of international co-publications increases in time and the differences between the two groups disappear. Although eyeballing would suggest that FPIC co-authored international co-publications maintain an impact that is higher than ESIFIC co-authored international co-publications, the difference is not statistically significant[36]. Likewise, there is no statistical difference in the number of international co-publications.[37]

Figure 13 Trends in international co-publications*



*: paper level analysis

International co-authorship ties between ESIFIC and FPIC researchers are analysed further. One observes that ESIFIC researchers experience an increase in the share of co-publications with FPIC researchers across the board (table 7). Most higher impact ("D8-D9" and ">D9" decile groups) ESIFIC articles before the grant are not the result of co-publications with FPIC researchers. However, after the grant a considerable share of the increase in co-authored high impact papers is with FPIC authors. This suggests that ESIFIC researchers do profit from moving and interlinking with researchers from FPIC countries:

Table 7 International co-publication with FPIC countries as of the total of ESIFIC publications by impact deciles

ESIFIC/FPIC Co-pubs %	Overall	< D1	[D1,D2]	[D2,D3]	[D3,D4]	[D4,D5]	[D5,D6]	[D6,D7]	[D7,D8]	[D8,D9]	> D9
Before MSCA	23	21	25	22	21	31	24	31	19	18	15
After MSCA	52	44	51	50	56	51	52	59	50	63	49
Growth	132	108	107	129	165	63	119	92	158	261	230

This increase may be one of the reasons behind the general increase of the impact of papers co-authored by ESIFIC applicants. Nonetheless, the citation impact of research articles from FPIC researchers remains higher than those of ESIFIC researchers in every decile group.

[36] t-test, p-value: 0.11204
[37] t-test, p-value: 0.509528

A simple pairwise correlation analysis to explore the variables correlated with "international co-publication behaviour after the grant" indicates that both indicators of pre-grant citation impact performance and pre-grant international co-publication behaviour are significantly positively correlated with post-grant co-publication behaviour (figure 14). This implies that the (size of the) early international network is strongly correlated with the size of the later international network.

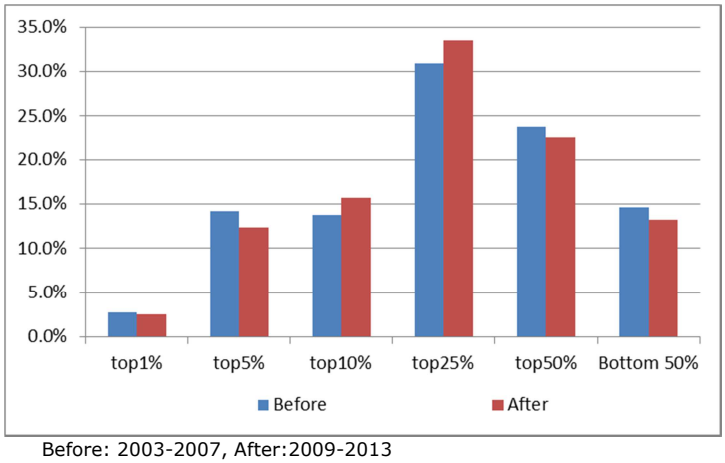
Figure 14 Pairwise Correlation analysis with Post grant international co-publications

3.4 Comparison with the performance of other researcher populations

This section compares our sample of successful MSCA applicants with a number of other researcher populations. First, we compare the MSCA fellows with the entire population of Swedish researchers. Sandström and Wold (2015) have made a bibliometric analysis of this population and classified them in percentile groups on the basis of their research impact performance. We find that among our sample of MSCA fellows, a small share performs at the same level as the top 1% of Swedish researchers (Figure 15). This number has practically not changed after the grant. For these individuals this is a remarkable feat as among the Swedish population there will be much more senior researchers with greater access to resources and reputational capital, who are potentially successful in very competitive funding schemes. If one considers the group of MSCA fellows which is comparable to the top 5% of best performing Swedish researchers, one observes a slight decrease (-1.8%). Still at 13% the share of MSCA applicants in this top 5% is considerably higher than the Swedish researcher population as a whole. Most of the researchers in our sample (64%) perform at the same level or better than the top 25% of Swedish researchers after receiving the fellowship. This is slightly higher (by 2.6 percentage points) than before they received the fellowship. These percentages appear high if one takes into account that our sample consists only of relatively young researchers, whereas the Swedish

researcher population also contains people on permanent contracts with established reputations. Other studies have also shown the relatively high productivity of post doctoral researchers such as the MSCA fellows as these researchers have on top undergone a strict selection procedure. Still 15% and 13% of our sample of researchers before and after the grant respectively, perform as the lowest performing half of the Swedish researcher population in terms of citation impact. In the post fellowship sample this may also include e.g. researchers who exited their research career and for that reason did not publish much in this period.

Figure 15 Comparison with the whole population of Swedish researchers (Non-cumulative, so Top 25% means top 10-25%)



Before: 2003-2007, After:2009-2013

Grant schemes such as the ERC starting Grants select a different type of researcher, often more senior and in the absolute top of research potential. Table 8 shows the academic age (years since PhD) of the ERC starting grants applicants at the moment of applying. This is considerably higher than the academic age of the MSCA applicants shown in table 2.

Table 8 Academic age of ERC StG applicants at the moment of applying

years	successful	All
2.5	2.6%	5.4%
3.5	6.9%	9.1%
4.5	15.4%	14.1%
5.5	19.7%	17.3%
6.5	37.1%	38.0%
7.5	8.6%	8.2%
8.5	4.9%	3.3%
9.5	3.4%	3.2%
>10.5	1.4%	1.5%

The grants provided in these schemes are also longer in duration and considerably more generous in terms of funding volume. We nonetheless engage in a provisional comparison between the post grant performance of MSCA fellows and a number of other grant instruments. We start with a comparison with the ERC Starting Grant scheme, and the Dutch VENI (start) grant. The latter is meant for researchers that have obstained their PhD less than three years before applying. For the former we only have the productivity before receiving the grant. Please be aware that the ERC

and the VENI samples are small, as they only include one year and only the granted applicants.

Table 9 Mean and median annual number of papers per funded researcher before and after the grant start year – MCSA, VENI and ERC StG,(full and fractional counting)&

		Publications		Fractional publ		years[&&]
Period	program	Mean[&&]	Median	Mean[&&]	Median	
Before[&&]	MSCA *	1.2	1.0	0.26	0.19	2003 - 2007
Before	VENI***	1.9	1.2	0.59	0.43	2002 – 2005
Before	ERC StGr**	2.2	1.6	0.32	0.26	2008 – 2012
After[&&]	MSCA *	1.9	1.6	0.39	0.30	2009 - 2013
After	VENI ***	3.4	3.0	0.90	0.70	2008 – 2012

& Only grantees;
&& Annual averages over the years in the "period" column; all periods are 5 years. VENI-before is 3 years, so we reweighted that.
&&& 'before' refers to the period before receiving the grant, 'after' refers to the period after the year the grant was received (MCSA) of the whole period (VENI).
* European Commission, MCSA Grant; Chemistry, Environmental, Life sciences ; N= 481
** European Commission, ERC Starting Grant; Life sciences; N = 40
*** Netherlands Research Council; VENI Early Career Grant, Economics and Psychology; N=14

One observes from Table 9 that the mean number of (full counted) papers per funded researcher increases for both the VENI grantees and the MSCA grantees after receiving the grant. In case of MSCA grantees the increase is higher (+58%) than in case of the VENI grant holders (+22%). However the latter started at a higher productivity level. Franctional counting points in the same direction.

The mean field weighted citation impact of the articles published by MSCA fellows before and after the grant shows a considerable increase (+23%). The starting level was equal to the VENI grantees, and much lower than the score of the ECR StG grantees. The VENI grantees show a small decline from 1.3 to 1.2 (8%). Robitaille et al, (2015) calculated the before and after impact of the ERC Starting Grantees, and found a decline from 3 (which is equal to our StGr 2014 estimate) to 2.7 which is of a similar size as the decline of the VENIs. The decline may be because the ERC grantees could already be at the top of their potential and merely sustaining this level can be conceived as a major achievement. But this argument does not hold for the decline of the VENIs who are in the very early career.[38]

Table 10 Comparing development in average impact MSCA, VENI and ERC junior grantees (for footnotes, see Table 9)s

Period	program	NCSf		Period
		mean	Median	
Before[&&]	MSCA *	1.3	1.1	2003 - 2007
Before	VENI***	1.3	1.3	2002 - 2005
Before	ERC StGr**	3.0	2.0	2008 – 2012
After[&&]	MSCA *	1.6	1.3	2009 – 2013
After	VENI ***	1.2	1.1	2008 - 2012

[38] An NCSf of 1.3 means that the MSCA fellows paper receive 30% more citations than the world average.

4 Conclusions and Discussion

In terms of mobility, it is clear that the grantees use the grant to find a better research environment: applicants from ESIFIC countries tend to move to FPIC countries. Unexpectedly, we found that this effect is especially strong for Spain and Italy, who are big 'senders' to the FPIC countries. In general the differential in the average impact of the home and host institution is bigger for applicants from ESIFIC countries than for researchers from FPIC countries. We can observe that there is a consistent increase in the impact of articles published by MSCA fellows before and after the grant. This holds for all fields and for researchers from ESIFIC and FPIC countries. Without an adequate control variable it is not possible to conclude whether these improvements are due to the impact of the grant or due to e.g. seniority effects or due to some combination of factors.[39]

We observe a significant difference between the impact of funded researchers from ESIFIC and FPIC countries before the grant: researchers from FPIC countries exhibiting stronger 'pre-grant' performance': the impact levels of granted ESIFIC applicants are on average lower than the impact of granted FPIC applicants. On the other hand, performance of researchers is affected by their environment. Given the different level of development of research systems in ESIFIC and FPIC one may assume that a researcher with a somewhat lower performance from an ESIFIC country has the same or higher potential as a somewhat better performing researcher from an FPIC country.

When comparing performance of the two groups before and after the grant one observes that there is convergence between FPIC and ESIFIC performance after the grant when considering median values, i.e. the difference in performance before the grant tends to be larger than after the grant. There is no statistically significant convergence between the performance of the two groups when one considers the mean value. The reason for this different finding is the influence of a larger number of outliers in the FPIC group, i.e. the top performers tend to be concentrated here.

When considering the annual performance evolution one observes that the median impact gap seems to be small in the year at which the applicants receive the grant. This might suggest that the preparation phase for getting an MSCA grant has a considerable effect as those ESIFIC researchers that receive the grant appear to have caught up with the FPIC researchers.[40] In so far as the grant application itself is concerned this is done together with the host institution. The grant application itself is

[39] The seniority effect is well document in the literature, even though there are also recent analyses which show that there is not statistical effect of age on the likelihood to publish high impact publications (ref to PLOS One article). A well-known example is that many Nobel prize winners do their prize winning work early on in their careers.

[40] At the PEERE conference in Rome there are various papers that do suggest this to be the case (REFS)

unlikely to have already led to (higher impact) publications. Preparation[41] for application and mobility is here thus considered in a broader sense: researchers seeking an international career through applying to the MSCA grant may on average devote more effort to publishing high impact publications. The remaining difference between the FPIC and the ESIFIC applicants is that the outliers (the exceptional top performers) come mainly from the FPIC countries.

Post grant performance and international collaboration intensity (as proxied by international co-publications) appear to be correlated especially to pre-grant performance and pre-grant international co-publication intensity respectively. Gender plays only a minor role in the case of both post grant performance and international co-publication behaviour. For promoting excellence (through training, enhancing skills and career development) as well as collaboration, the main aims of the MSCA instrument, pre-grant performance on these indicators may offer the best selection criteria. We also found that the increase of higher impact papers of the ESIFIC researchers is partially due to increased collaborations with researchers from FPIC countries. Other studies (Jonkers & Tijssen, 2008; Jonkers & Cruz-Castro, 2013) suggest that the mobility that is central to the MSCA programme can be an avenue to sustained improvements in international collaboration.

The motivation for including the quality of the host environment selection criterium is that MSCA[42] has to rely on precise selection criteria to induce a structuring effect in terms of conditions for the researchers and attractiveness of the hosts. The finding that post grant performance is mainly correlated to pre-grant performance begs the question whether it is necessary to consider the quality of the host organisation in selection decisions. Since excluding this criteria might lead to a more equitable spread of MSCA fellows across host countries, this is a finding that is worth assessing in greater depth in the future.

Evaluations of EC funding programmes (including the MSCA) can attempt to address the following questions: Is the scholarly impact of EC funded research (on average) higher than the impact of research funded by other research funding institutions? And is the selection process robust: are the best researchers selected?

A full answer to the second question would compare the selected candidates (the whole sample) with a sample of researchers who did apply but were not successful. For addressing the second general research question in full, access to non-successful applicant data is required. For legal (data protection) reasons it was not possible in this project to draw on this data. A strong recommendation coming out of this study is therefore that in future FP programme design and implementation the

[41] These preparatory activities may or may not have taken place in the home organisation, as we do not know whether the ESIFIC applicants have already left their home system at the time of application.

[42] In contrast to the ERC grants, which doesn't have such a criterion but which can rely on a high prestige also associated with the size of the grant, thereby inducing structural changes at the level of host organisations aiming to become more successful in attracting ERC grants.

possibility for robust ex post evaluation is considered from the outset. FP applicants should in the future be asked to accept that their personal data is used for research and evaluation purposes. If there would prove to be, given appropriate guarantees on data handling, possibilities to make use of this data also for FP7 and H2020 this would greatly improve the potential of DG JRC to come to adequate impact analyses.

Even in absence of access to counterfactual data, a potential follow up to this study includes a comparison between MSCA fellows and ERC starting grant awardees. In this report we already made a provisional start in comparing the outcome of the two programmes but a robust comparison will require the use of micro-data for the ERC starting grant scheme as well. For comparisons between the MSCA fellows and the awardees of national individual bound research fellowships, it may be possible to seek collaboration with researchers who have done studies on relevant national grant schemes, in order to pool the data about these funders.

Due to the nature of the ERC starting grant programme, the type of profiles selected (more senior) and the much larger size of the grants, the effect of ERC grants on individual performance (productivity and citation impact) is expected to be considerably higher. Provisional comparison with another evaluation carried out for the ERCEA suggests that the productivity and impact of MSCA individual fellows in terms of the number of papers they produce annually is, as expected, considerably below that of ERC grantees. The substantial increase in performance observed for the smaller and more junior MSCA individual fellowships, suggests that this programme can have an important role to play in building research capabilities of researchers from both ESIFIC and FPIC countries. Comparing the MSCA scheme with the Netherlands' highly competitive VENI scheme, intended to a large extent to fund researchers of a similar academic age, shows the MSCA fellows outperform the selected VENI scholars in post-grant performance by a considerable margin (at least in terms of impact, not in terms of productivity). Top MSCA fellows may be good candidates for the more senior and competitive ERC grant. Past analyses also suggests that MSCA fellowship holders have a relatively high chance to succeed in attaining an ERC starting grant or build careers in national research systems after their fellowship.[43] There is thus considerable rationale for funding the MSCA programme to build capacity and foster the creation and strengthening of international networks, while feeding in to excellence schemes at the European and national level.

There are many other relevant questions for assessments of the MSCA fellowships, including e.g. on the impact of MSCA funding on career development, cooperation with firms or issues relevant to programme design. Some of these questions are best addressed through other methodologies including surveys. For example, for the design of the

[43] "There is some evidence that former MSCA fellows tend to be more successful when applying for ERC grants. An analysis of ERC applicants under Horizon 2020 who were MSCA fellows in FP7 estimates their average success rate at 16%, compared to 12% among all applicants to the same calls." (personal communication with DG EAC)

programme it is relevant to know whether applicants see MSCA grants as a chance for mobility, or as a prestigious grant to stimulate their career and is the fact that they have to go to another country only the consequence? This type of questions could not be answered by the analysis presented in this report.

References

- Ackers, L.,(2005) Promoting Scientific Mobility and Balanced Growth in the European Research Area, Innovation: The European Journal of Social Science Research, 18:3, 301-317
- Ackers, L. (2008) Internationalisation, Mobility and Metrics: A New Form of Indirect Discrimination?, Minerva, 46(4): 411–435
- Ackers, L., and Gill, B., (2009) Moving people and knowledge: Scientific mobility in an enlarging European Union, Cheltenham, Edward Elgar
- Ackers, L., (2013) Internet mobility, co-presence and purpose: contextualising internationalisation in research careers, Sociologia y Tecnociencia
- Ackers L., (2005) Moving people and knowledge: scientific mobility in the European Union, International Migration, 43: 99–131
- Auriol, L., Misu, T., Galindo-Rueda, F., (2016) Doctorate Holders' Labor Market and Mobility: The Academic Career as the First Choice, in Gokhberg, L., Shmatko, N., Auriol, L., (eds) The Science and Technology Labour Force - the value of doctorate holders and development of professional careers, Springer International Publishing Group
- Azoulay, P., Graff Zivin, JS., Manso, G. (2011), Incentives and creativity: evidence from the academic life sciences, The RAND journal of Economics, DOI: 10.1111/j.1756-2171.2011.00140.x
- Baruffaldi, SH., Landoni, P., (2012) Return mobility and scientific productivity of researchers working abroad: The role of home country linkages, Research Policy, 41 (9): 1655–1665
- Beaudry, C., Allaoui, S., (2012), Impact of public and private research funding on scientific production: The case of nanotechnology, Research Policy, 41(9):1589–1606
- Bloch, C., Graversen, EK., Pedersen, HS. (2014). Competitive Research Grants and Their Impact on Career Performance. *Minerva* **52,** 77-96
- Bornmann, L., Leydesdorff, L., Van den Besselaar, P., (2010) A Meta-evaluation of Scientific Research Proposals: Different Ways of Comparing Rejected to Awarded Applications. *Journal of Informetrics* 4 (3): 211-220
- Cañibano, C., Vértesy, D. and Vezzulli, A., 2017, An inquiry into the return mobility of scientific researchers in Europe, JRC Technical Report, http://publications.jrc.ec.europa.eu/repository/bitstream/JRC106613/kjna28600enn.pdf
- Cañibano, C., Otamendi, FJ., Solis, F., 2011, International temporary mobility of researchers: a cross-discipline study, Scientometrics, Volume 89, Issue 2
- Cañibano, C., Bozeman., 2009, Curriculum vitae method in science policy and research evaluation: the state-of-the-art, Research

Evaluation, 18 (2): 86-94. DOI: https://doi.org/10.3152/095820209X44175
- Cruz-Castro, L., Jonkers, K., Sanz-Menendez, L., 2016, International Mobility of Spanish Doctorate Holders, in Gokhberg, L., Shmatko, N., Auriol, L., (eds) The Science and Technology Labour Force - the value of doctorate holders and development of professional careers, Springer International Publishing Group
- Cruz-Castro L.,Sanz-Menendez, L., 2010, Mobility versus job stability: assessing tenure and productivity outcomes, Research Policy, 39 (2010), pp. 27–38
- DASTI, 2015, The effects of participation in the European Framework Programmes for research and technological development – for researchers, institutions and private companies in Denmark, Ministry of Higher Education and Science – Danish Agency for Science, Technology and Innovation, http://ufm.dk/en/publications/2015/filer-2015/effects_eu_framework_programmes_pdfa.pdf
- Defazio, D., Lockett, A., Wright, M., Funding incentives, collaborative dynamics and scientific productivity: evidence from the EU framework program, Research Policy, 38 (2009), pp. 293–305
- Edler, J., Fier, H., Grimpe, C., 2011, International scientist mobility and the locus of knowledge and technology transfer, Research Policy, 40 (2011), pp. 791–805
- Enders J, Musselin C (2008) Back to the future? The academic professions in the 21st century. In
- OECD higher education to 2030, vol 1: Demography, chapter 4. Retrieved from: http://www.oecd.org/edu/ceri/41939654.pdf
- EC (2001a), Communication from the Commission to the Council and the Parliament: a mobility strategy for the ERA, COM(2001)331 final. Retrieved from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri¼COM:2001:0331:FIN:EN:PDF READ
- EC (2001b), High level expert group on improving mobility of researchers: final report. European Commission (DG Research), Brussels
- EC (2005), The European charter for researchers—the code of conduct for the recruitment of researchers. European Commission (DG Research), Luxembourg: Office for Official Publications of the European Communities. Retrieved from http://ec.europa.eu/eracareers/pdf/am509774CEE_EN_E4.pdf
- EC (2011), Horizon 2020: Commission proposes €80 billion investment in research and innovation, to boost growth and jobs, IP/11/1475, 30/11/201. Retrieved from http://europa.eu/rapid/press-release_IP-11-1475_en.htm?locale¼fr
- EC (2012a) Communication from the European Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: Horizon 2020—The Framework Programme for Research and Innovation,

COM(2011) 808 final. Retrieved from http://ec.europa.eu/research/horizon2020/pdf/proposals/communication_from_the_commission__horizon_2020_the_framework_programme_for_research_and_innovation.pdf#view¼fit&pagemode¼none
- EC (2012b) Marie Curie actions—research fellowship programme. Retrieved from http://ec.europa.eu/research/mariecurieactions/index_en.htm
- Fernandez-Zubieta, A., Guy, K. (2010) Developing the European Research Area: improving knowledge flows via researcher mobility, European Commission, JRC-IPTS Scientific and Technological Report.
- Fernandez-Zubieta, A., Geuna, A., Lawson, C. (2015) Mobility and productivity of Research Scientists, in Geuna, A., Global Mobility of Research Scientists, the economics of who goes where and why. Academic Press.
- Flanagan, K., (2015) Interational Mobility of Scientists, Chapter 17 in Archibugi, D., & Filippetti, A., The handbook of Global Science, Technology and Innovation, Wiley-Glackwell,
- Franke, J., Humburg, M., Souto Otero, M., FP7 Ex Post and H2020 interim evaluation of Marie Sklodowska Curie Actions, https://publications.europa.eu/en/publication-detail/-/publication/98885a02-c849-11e7-9b01-01aa75ed71a1/language-en
- Franzoni, C., Scellato, G., Stephan, P., (2014) The mover's advantage: The superior performance of migrant scientists, Economics Letters, 122(1):89-93
- Franzoni, C., Scellato, G., Stephan, P., (2015), International mobility of Scientists, lessons from the GlobSci survey, in Geuna, A., Global Mobility of Research Scientists, the economics of who goes where and why. Academic Press.
- Furukawa, T., Shirakawa, N., Okuwada, K. (2011) Quantitative analysis of collaborative and mobility networks, Scientometrics, 87 (2011), pp. 1–16
- Glänzel, W., Schubert, A. (2004) Analysing scientific networks through co-authorship in H. Moed, W. Glänzel, U. Schmoch (Eds.), Handbook of Quantitative Science and Technology Research, Kluwer Academic Publishers, Dordrecht (2004)
- Gulbrandsen, M.,Smeby, JC., (2005), Industry funding and university professors' research performance, Volume 34, Issue 6, Pages 932–950
- IDEA Consult, NIFU STEP, WIFO, LOGOTECH, The University of Manchester (2010) MORE - study on mobility patterns and career paths of researchers. Final report, Brussels.
- Jonkers, K., Tijssen, R. (2008) Chinese researchers returning home: impacts of international mobility on research collaboration and scientific productivity, Scientometrics, 77, pp. 309–333
- Jonkers, K., (2010) Mobility, Migration and the Chinese Scientific Research System, Routledge

- Jonkers, K., Cruz-Castro, L. (2013) Research upon return: The effect of international mobility on scientific ties, production and impact, Research Policy, Volume 42, Issue 8, Pages 1366–1377
- Jöns, H., (2007) Transnational mobility and the spaces of knowledge production: a comparison of global patterns, motivations and collaborations in different academic fields, social geography, 2(2): 97-114
- Jöns, H., (2011) Transnational academic mobility and gender, globalisation, societies and education, 9(2):183-209
- Kannankutty, N., Burrelli, J., (2007) Why did they come to the United States? A profile of immigrant scientists and engineers, Infobrief SRS-NSF 07, 2007
- Katz, JS., Hicks, D., (1997) How much is a collaboration worth? A calibrated bibliometric model, 40 (3): 541–554
- Katz, J.S., Martin, B., (1997) What is research collaboration?, Research Policy, 26:1–18
- Lee, S., Bozeman, B., (2005) The impact of research collaboration on scientific productivity, Social Studies of Science, 35: 673–702
- Leyman A, Jidkova S, De Grande H, Van der Goten G, Van Rossem R, Vandevelde K (2009) Resultaten van de 'survey of junior researchers' aan de UGent, ECOOM expertisecentrumonderzoek en ontwikkelingsmonitor. Universiteit Gent, Gent
- Martín-Sempere, MJ., Rey-Rocha, J., Garzón-García, B. (2002) The effect of team consolidation on research collaboration and performance of scientists. Case study of Spanish university researchers in Geology, 55 (3): 377–394
- Morano-Foadi, S., (2005) Scientific Mobility, Career Progression, and Excellence in the European Research Area, International Migration, 10.1111/j.1468-2435.2005.00344.x
- Musselin, C., 2004, Towards a European Academic Labour Market? Some Lessons Drawn from Empirical Studies on Academic Mobility, Higher Education, 48(1): 55–78Persson, O., Glänzel, W., Danell, R., (2004). Inflationary bibliometric values: The role of scientific collaboration and the need for relative indicators in evaluative studies. Scientometrics 60: 421-432.
- Pezzoni, Michele, Valerio Sterzi, Francesco Lissoni (2012). Career progress in centralized academic systems: Social capital and institutions in France and Italy. *Research Policy* **41**, 704-719
- Reale, E., forthcoming, Analysis of National Research Funding (PREF), Analytical report, contract number 0154321, doi:10.2760/849945
- Robitaille, JP, Macaluso, B., Pollitt, A., Gunashekar, S., Larivière, V., (2015) Comparative scientometric assessment of the results of ERC funded projects, Bibliometric assessment report Prepared for EUROPEAN COMMISSION, RESEARCH & INNOVATION DIRECTORATE-GENERAL Unit A1 – Support to the Scientific Council, ERCEA/A1/2014/20https://erc.europa.eu/sites/default/files/document/file/ERC_Bibliometrics_report.pdf

- Ryan, TK, Schneider, JW (2016), Examining to what extent the source of competitive funding influences scientific impact. a case study of danish eu fp7 funded projects. STI conference Valenca, Valencia
- Sánchez Barrioluengo, M., Flisi, S., Student mobility in tertiary education: institutional factors and regional attractiveness, JRC Science for Policy Report, http://publications.jrc.ec.europa.eu/repository/bitstream/JRC108895/student_mobility_in_tertiary_education_final(1).pdf
- Sandström U. & van den Besselaar P. (2016). Quantity and/or Quality? The Importance of Publishing Many Papers. PLoS ONE 11(11): e0166149. doi:10.1371/journal.pone.0166149
- Sandström U. & Wold A. (2015). Centres of Excellence: reward for gender or top-level research? In: Björkman J, Fjaestad, B (Eds.) Thinking Ahead: Research, Funding and the Future. Stockholm: Makadam Publ., pp. 69-91.
- Sandström, U., (2009) Combining curriculum vitae and bibliometric analysis: mobility, gender and research performance, Research Evaluation, 18 (2009), pp. 135–142
- Sandström, U., Wold, A., Van den Besselaar, P., (Forthcoming) Comparing research funders by impact
- Sanz-Menéndez, L.; Cruz-Castro, L., Alva,K., (2013), Time to Tenure in Spanish Universities: An Event History Analysis, PLOS-ONE, http://dx.doi.org/10.1371/journal.pone.0077028
- Tijssen, R., Visser, M., Van Leeuwen, T., (2002), Benchmarking international scientific excellence: Are highly cited research papers an appropriate frame of reference?, Scientometrics, Volume 54, Issue 3, DOI: 10.1023/A:1016082432660
- Van den Besselaar, P., Sandström, U., (2013), The effects of funding modes on the quality of knowledge production. In: Juan Gorraiz, Edgar Schiebel et. al., (eds), *Proc ISSI 2013*. Vienna: AIT, 664-676.
- Van den Besselaar, P., Leydesdorff, L., (2009) Past performance, peer review, and project selection: A case study in the social and behavioral sciences. *Research Evaluation* 18 (4): 273-288
- Van de Besselaar, P., Sandström, U., (2013) The effect of funding modes on the quality of knowledge production. Proceedings of 14th International Society of Scientometrics and Informetrics Conference (Vienna, July 15-20, 2013), pp. 664-676.
- Van den Besselaar, P., Sandström, U., (2015) Early career grants, performance, and careers: A study onpredictive validity of grant decisions. Journal of Informetrics **9**. 826-838
- Van den Besselaar, P., Sandström, U., (2016) Gender differences in research performance and in academic careers. *Scientometrics*, 106:143–162
- Van den Besselaar, P., Inzelt, A., Reale, E., de Turckheim, E., Vercesi, V., (2012) *Indicators for internationalization of research institutions*. Strasbourg: European Science Foundation

- Vandevelde K (2011) Mobiel en daarom excellent of excellent en daarom mobiel? Thema 2011:3
- Van de Sande, D., Ackers, L., Gill, B., (2005), Impact assessment of the Marie Curie fellowships under the 4th and 5th Framework Programmes of Research and Technological Development of the EU (1994-2002)
- Van Looy, B., Ranga, M., Callaert, J., Debackere, K., Zimmermann, E., (2004), Combining entrepreneurial and scientific performance in academia: towards a compounded and reciprocal Matthew-effect?, Volume 33, Issue 3, April 2004, Pages 425–441Wagner & Jonkers, 2017, Open countries have strong science, Nature
- Wagner, Whetsell, Baas & Jonkers, 2018, Openness and Impact of Leading Scientific Countries, Front. Res. Metr. Anal.
- Waltman, L., van Eck, N.J., (2015), Field-normalized citation impact indictors and the choice of an appropriate counting method, Journal of Informetrics 9:872-894.
- Waltman, L., Tijssen, RJW., Van Eck, N.J., (2011), Globalisation of science in kilometers, Journal of Informetrics, 5: 574–582
- Watson, J.,Ludden, V., Gutheil, M., Harrap, K., Ackers, L., Van de Sande, D., Ex-post Impact Assessment study concerning the 'Marie Curie Actions' under the Sixth Framework Programme, FRAMEWORK CONTRACT ON EVALUATION AND EVALUATION-RELATED SERVICES (Contract Notice 2006/S/64-066221)
- Ynalvez, W., Shrum, W., (2011) Professional networks, scientific collaboration, and publication productivity in resource-constrained research institutions in a developing country, Research Policy, 40: 204–216

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Annex 1. Geographic distribution of successful MSCA applicants

	Lower	%	Upper	%	Total	%
ES	36	47.4	68	58.6	104	54.2
EL	3	3.9	5	4.3	8	4.2
IT	16	21.1	23	19.8	39	20.3
PT	2	2.6	3	2.6	5	2.6
PIGS	57	75.0	99	85.3	156	81.3
CZ	1	1.3	3	2.6	4	2.1
HU	6	7.9	5	4.3	11	5.7
PL	8	10.5	5	4.3	13	6.8
SK	3	3.9	1	0.9	4	2.1
EE	0	0.0	0	0.0	0	0.0
LT	0	0.0	1	0.9	1	0.5
LV	0	0.0	0	0.0	0	0.0
RO	0	0.0	1	0.9	1	0.5
BG	0	0.0	1	0.9	1	0.5
HR	0	0.0	0	0.0	0	0.0
MT	0	0.0	0	0.0	0	0.0
CY	0	0.0	0	0.0	0	0.0
SI	1	1.3	0	0.0	1	0.5
Total ESIFIC	76		116		192	

	Lower	%	Upper	%	Total	%
AT	3	2.4	6	3.6	9	3.0
BE	6	4.7	3	1.8	9	3.0
CH	6	4.7	7	4.1	13	4.4
DE	28	22.0	35	20.7	63	21.3
DK	0	0.0	3	1.8	3	1.0
FI	3	2.4	4	2.4	7	2.4
FR	38	29.9	52	30.8	90	30.4
IE	6	4.7	5	3.0	11	3.7
NL	14	11.0	10	5.9	24	8.1
NO	0	0.0	1	0.6	1	0.3
SE	10	7.9	9	5.3	19	6.4
UK	13	10.2	34	20.1	47	15.9
Total FPIC	127		169		296	

Annex 2. Statistical tests

1. Test for researchers' mobility

EE: host-home system quality difference for ESIFIC researchers

WE: host-home system quality difference for FPIC researchers

1a. K-S test:

Test output:

Smaller group	D	P-value	Exact
EE:	0.0000	1.000	
WE:	-0.5579	0.000	
Combined K-S:	0.5579	0.000	0.000

1b. Two-sample Wilcoxon rank-sum (Mann-Whitney) test for researchers' mobility

Test output:

we_ee_rest~n	obs	rank sum	expected
EE	192	64761	46944
WE	296	54555	72372
combined	488	119316	119316

unadjusted variance 2315904.00

adjustment for ties -6930.39

adjusted variance 2308973.61

Ho: diff_h~e(we_ee_~n==EE) = diff_h~e(we_ee_~n==WE)

z = 11.725

Prob > |z| = 0.0000

P{diff_h~e(we_ee_~n==EE) > diff_h~e(we_ee_~n==WE)} = 0.814

2. Test for mean score of applicants

NSCf(EE): field weighted normalized citation score for ESIFIC researchers before grant

NSCf(WE): field weighted normalized citation score for FPIC researchers before grant

Smaller group	D	P-value	Exact

NCSf(EE)	0.1646	0.002	
NSCf(WE)	-0.0103	0.976	
Combined K-S:	0.1646	0.004	0.003

3. Test for MSCA impact magnitude

NSCf_EEA: field weighted normalized citation score for ESIFIC researchers after grant

NSCf_EEB: field weighted normalized citation score for ESIFIC researchers before grant

NSCf_WEA: field weighted normalized citation score for FPIC researchers after grant

NSCf_WEB: field weighted normalized citation score for FPIC researchers before grant

3a. Two-sample Kolmogorov-Smirnov test for equality of distribution functions

Smaller group	D	P-value	Exact
NCSf_EEA:	0.0260	0.878	
NCSf_EEB:	-0.2500	0.000	
Combined K-S:	0.2500	0.000	0.000

3b. Two-sample Kolmogorov-Smirnov test for equality of distribution functions

Smaller group	D	P-value	Exact
NCSf_WEA:	0.0574	0.377	
NCSf_WEB:	-0.1182	0.016	
Combined K-S:	0.1182	0.032	0.032

3c. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

EE	obs	rank sum	expected
EEA	192	42085	36960
EEB	192	31835	36960

```
------------+---------------------------------------------
   combined |      384   73920             73920
unadjusted variance  1182720.00
adjustment for ties       -0.50
adjusted variance    1182719.50
Ho: EE_full(EE==EEA) = EE_full(EE==EEB)
          z =   4.713
   Prob > |z| =   0.0000
```

3d. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

```
          WE |      obs           rank sum    expected
-------------+---------------------------------------------
         WEA |      296           91227           87764
         WEB |      296           84301           87764
-------------+---------------------------------------------
   combined |      592   175528      175528
unadjusted variance  4329690.67
adjustment for ties       -1.25
adjusted variance    4329689.41
Ho: WE_full(WE==WEA) = WE_full(WE==WEB)
          z =   1.664
   Prob > |z| =   0.0961
```

4. International co-publications related tests

EEA: number of ESIFIC researchers international copublications after grant

EEB: number of ESIFIC researchers international copublications before grant

WEA: number of FPIC researchers international copublications after grant

WEB: number of FPIC researchers international copublications before grant

4a. Two-sample Kolmogorov-Smirnov test for equality of distribution functions

```
Smaller group          D       P-value      Exact
```

ESIFIC copub dif: 0.0215 0.900

FPIC copub dif: -0.0790 0.239

Combined K-S: 0.0790 0.472 0.443

4b. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

we_ee_rest~n	obs	rank sum	expected
ESIFIC copub dif	188	47898	45402
FPIC copub dif	294	68505	71001
combined	482	116403	116403

unadjusted variance 2224698.00

adjustment for ties -15970.07

adjusted variance 2208727.93

Ho: d~int_~b(we_ee_~n==EE) = d~int_~b(we_ee_~n==WE)

z = 1.679

Prob > |z| = 0.0931

4c. Two-sample Kolmogorov-Smirnov test for equality of distribution functions

Smaller group	D	P-value	Exact
EEA:	0.0000	1.000	
EEB:	-0.3307	0.000	
Combined K-S:	0.3307	0.000	0.000

4d. Two-sample Kolmogorov-Smirnov test for equality of distribution functions

Smaller group	D	P-value	Exact
WEA:	0.0000	1.000	
WEB:	-0.2753	0.000	
Combined K-S:	0.2753	0.000	0.000

4e. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

EEcopub	obs	rank sum	expected
EEA	192	44919.5	36576
EEB	188	27470.5	35814
combined	380	72390	72390

unadjusted variance 1146048.00
adjustment for ties -20067.397
adjusted variance 1125980.03
Ho: EE_ful~p(EEcop==EEA) = EE_ful~p(EEcop==EEB)
z = 7.863
Prob > |z| = 0.0000

4f. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

WEcopub	obs	rank sum	expected
WEA	296	102644	87468
WEB	294	71701	86877
combined	592	174345	174345

unadjusted variance 4285932.00
adjustment for ties -73507.50
adjusted variance 4212424.50
Ho: WE_ful~p(WEcop==WEA) = WE_ful~p(WEcop==WEB)
z = 7.394
Prob > |z| = 0.0000

5. PxNCSf median difference significance tests for the upper and lower groups

L_B: lower group PxNCSf before grant

L_A: lower group PxNCSf after grant

U_B: upper group PxNCSf before grant

U_A: upper group PxNCSf after grant

5a. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

AUcode_L-	obs	rank sum	expected
L_A	203	44571	41310.5
L_B	203	38050	41310.5
Combined	406	82621	82621

unadjusted variance 1397671.92

adjustment for ties -0.50

adjusted variance 1397671.42

Ho: NCSf_L(AUcode_L==L_A) = NCSf_L(AUcode_L==L_B)

z = 2.758

Prob > |z| = 0.0058

5b. Median test (K-sample equality-of-medians)

Greater than the median	AU code_L L_A	AU code_L L_B	Total
no	87	116	203
yes	116	87	203
Total	203	203	406

Pearson chi2(1) = 8.2857 Pr = 0.004

Fisher's exact = 0.005

1-sided Fisher's exact = 0.003

Continuity corrected: Pearson chi2(1) = 7.7241 Pr = 0.005

5c. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

AUcode_U	obs	rank sum	expected

```
          U_A |      285       87790       81367.5
          U_B |      285       74945       81367.5
--------------+---------------------------------
     combined |      570      162735      162735
unadjusted variance  3864956.25
adjustment for ties       -1.25
adjusted variance    3864955.00
Ho: NCSf_U(AUcode_U==U_A) = NCSf_U(AUcode_U==U_B)
           z =   3.267
    Prob > |z| =   0.0011
```

5d. Median test (K-sample equality-of-medians)

```
  Greater |
 than the |       AU code_U
   median |    U_A       U_B |      Total
-----------+--------------------+----------
       no |      125       160 |       285
      yes |      160       125 |       285
-----------+--------------------+----------
    Total |      285       285 |       570
    Pearson chi2(1) =   8.5965   Pr = 0.003
    Fisher's exact =                 0.004
    1-sided Fisher's exact =         0.002
    Continuity corrected: Pearson chi2(1) =   8.1123   Pr = 0.004
```

5e. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

```
         AU_B |      obs    rank sum    expected
--------------+---------------------------------
          L_B |      203       43759       49633.5
          U_B |      285       75557       69682.5
--------------+---------------------------------
     combined |      488      119316      119316
unadjusted variance  2357591.25
adjustment for ties        0.00
```

adjusted variance 2357591.25

Ho: NCSf_B(AU_B==L_B) = NCSf_B(AU_B==U_B)

z = -3.826

Prob > |z| = 0.0001

5f. Median test (K-sample equality-of-medians)

Greater than the median	AU_B L_B	AU_B U_B	Total
No	121	123	244
yes	82	162	244
Total	203	285	488

Pearson chi2(1) = 12.8295 Pr = 0.000

Fisher's exact = 0.000

1-sided Fisher's exact = 0.000

Continuity corrected: Pearson chi2(1) = 12.1800 Pr = 0.000

5g. Two-sample Wilcoxon rank-sum (Mann-Whitney) test

AU_A	obs	rank sum	expected
L_A	203	44496	49633.5
U_A	285	74820	69682.5
combined	488	119316	119316

unadjusted variance 2357591.25

adjustment for ties -6.82

adjusted variance 2357584.43

Ho: NCSf_A(AU_A==L_A) = NCSf_A(AU_A==U_A)

z = -3.346

Prob > |z| = 0.0008

5h. Median test (K-sample equality-of-medians)

Greater than the median	AU_A L_A	AU_A U_A	Total
No	118	126	244
yes	85	159	244
Total	203	285	488

Pearson chi2(1) = 9.1856 Pr = 0.002

Fisher's exact = 0.003

1-sided Fisher's exact = 0.002

Continuity corrected: Pearson chi2(1) = 8.6373 Pr = 0.003

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