University characteristics and probabilities for funding of proposals in the European Framework Programs

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Funding: This work was supported by R-QUEST, Research Council of Norway [256223].

Conflict of interest statement: None declared.

Key words: University characteristics; European Framework Programs; Success rates

Abstract

Previous studies have pointed at participation in the European Framework Programs for Research and Innovation as elite driven, foremost by large and prestigious universities. By analysing all proposals (including rejected proposals) rather than funded projects only, we have investigated whether such findings also hold for *success* in proposal decisions. We study which university characteristics that are associated with successful proposal outcomes. Our study finds that university size is indeed an important driver for success, but independent of size; it is essential with a relative high volume of proposals. Those HEIs who submit relatively many proposals compared to their size performs better; especially in the ERC. What are important success criterions vary across thematic areas and to some extent over time, reflecting changing goals of the EU programs. Success is based on complex mechanisms, where many universities – irrespective of size – for different reasons perform well in the framework programs.

1. Introduction

Large, highly-reputed universities have been shown in previous studies to dominate participations in the European Union's Framework Programmes for Research and Innovation (EU FPs), where participation in general is driven by a stable core of key actors, functioning as nodes in European R&D networks. In this study, we aim to provide new insight into characterizing European research as 'elite-driven'. The aim of our study is to investigate which characteristics of Higher Education Institutions (HEIs) that are associated with acceptance – and thereby funding – of proposals. We also study whether previous findings about determinants for *participation* are the same as the determinants for *success* in the proposal process in the EU FPs. The novelty of our study is the use of *submitted proposals* to the EU FPs in order to study which characteristics of Higher Education Institutions (HEIs) that are associated with success – which to the best our knowledge has never been done before in a large-scale European study.

Large HEIs are for obvious reasons involved in more EU-projects than smaller HEIs but do also contribute to more proposals than what smaller HEIs do. It is fully possible that *success*, defined as the ratio between number of submitted proposals and number of funded projects is independent of the size of the HEIs. Without including

This is a post-print version of the publication. The final published version is available here: https://doi.org/10.1093/scipol/scaa037

submitted proposals in the analysis, the relationship between size and success, may more signal the HEIs' ability to submit many proposals than their ability to the get their proposals accepted. In a previous study of Norwegian applicants to the EU FPs we found that some of Norway's most successful contributors were relatively small and highly specialized research institutes, who did very successfully target appropriate calls (also with very strong consortia members) (1). We therefore believe it is essential to distinguish between *volume* of participation and *successful* participation. If volume alone (for example defined as the number of project participations) is defined as the success criterion in the EU FPs, any analysis of successful EU participations will be skewed in favour of large institutions, which is already seen as an ideal type of organizing in many European countries, with strong emphasis and encouragement towards merger of research units – both within and across institutions (2). Such a belief is often based on expected benefits in larger units by economies of scale and scope (3), and the concept of *critical mass* (4). Our study thus contributes to the understanding of whether important determinants to the overall participation in EU FPs, are also important determinants to 'successful' or efficient participation in the EU FPs.

1.1 Former studies on participation in the EU FPs oriented at networks and participation volume

Although the literature on participations and involvement in EU FPs is extensive, little research has been performed concerning one of the main key phrases of EU FP participation: *success rates.* The success rate gives the ratio between the number of submitted proposals and the number of proposals that have been granted funding from the EU. Existing studies have, to the best of our knowledge, used *project participation data* in EU FPs only, as application data has not been readily available (5).

However, studying *success rates* in the higher education sector is highly relevant from a research policy perspective. Most European countries strongly emphasize their intentions of participating in more EU funded projects. Hence, the monitoring of the national success rates is key in many European countries' year-to-year follow-up on how their institutions are performing in the EU FPs. At government level there is also a preoccupation for increased 'return rate', i.e. increasing one's share of the available competitive funding. Beyond obvious budgetary reasons, the HEIs themselves may claim to regard high success rates as a quality indicator, as research grant application review is about methods, intellectual and/or social significance and originality (6). Although researchers themselves may be more preoccupied by scientific criteria (7), thus making the European Research Council the 'gold standard' of peer review in funding agencies (8), most EU funded projects find themselves positioned somewhere in between assessments of past performance and assessments of future potential. Therefore, HEIs may mobilize participations through increasing professionalization of management and leadership (8), as documented in a Norwegian study, where large differences were observed in Norwegian research institutions regarding whether EU FP activities were based on individual initiatives or whether they sprang out of well-built administrative support schemes at the top-level (1). Good success rates in the EU FPs (and not only in the ERC) may signal a university's ability both to excel on scientific criteria and to be at the forefront of tackling societal needs. In the European Commission's (9) ex-post evaluation of the 7th Framework program, the low success rates in the new EU Member States, were thus explained as a result of "a comparably high number of weak proposals submitted". Among the Commission's suggested explanations for this were: 1) lack of professional contacts and research networks; 2) lack of leading Universities and Research organisations leaders in proposal matters, 3) weak training in preparing successful proposals, 4) lack of practice in project management, and 5) little experience in cross-country cooperation. It is thus clear that the Commission itself sees success rates as an indicator of the ability to effectively attract funding for research of high scientific quality and/or relevance to society. Several European countries have also adopted external funding (in some countries including funding from the EU FPs) as an indicator in their performance-based budgeting of the higher education sectors (10).

The strong emphasis in most EU programmes on collaboration across countries and sectors (very often a requirement for funding), has sparked a vast literature on network studies within the EU FPs. The main findings of this literature are that EU FP participations are concentrated around a few key actors, and that the central nodes of the networks remain stable over time. This indicates that past participations spur new participations, and that inclusion of new institutions into the EU FP projects does not change what has become a very stable set

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https://doi.org/10.1093/scipol/scaa037

of participating partners. This pattern is found in HEIs as well as in publicly funded research organisations and in private companies (11-17); but also, at national/regional level (18-19). According to Hoenig (20, p.4), members of the scientific community themselves "speculate that procedures of grant peer review might be subject to a massive 'Matthew effect'. Dynamics of cumulative advantage and disadvantage in gaining scientific recognition may partially explain a strong concentration of grants in only a few countries and institutions in Europe". Hoenig's findings of an ERC grant concentration in only a few countries and with a limited number of institutions support the Matthew effect hypothesis. Several mechanisms of such consolidation have been suggested. The most prominent is related to the scientific excellence or reputation of an institution. On a general level (not specifically related to EU FP funding), Frenken, Heimeriks and Hoekman (21) found that bibliometric research performance differences among universities mainly stem from size, disciplinary orientation and country location. Large universities systematically performed well on citation impact, measured by number of highly cited papers (indicating research excellence), in international co-publications (indicating international collaboration), and in university-industry co-publications (indicating innovation). In studies of factors influencing peer review and funding decisions, such bibliometric indicators have been shown to be strongly associated with positive outcomes, e.g. journal impact factor (JIF) and number of publications and citations (22-24), but also to size-independent measures like percentage of highly cited papers (24). In studies where the bibliometric indicators are weakly (or not) associated with positive outcomes, it may be explained by a self- (or pre-) selection of the 'inferior' organizations themselves, i.e. they do not participate, so that it is hard to find an effect of high values on e.g. journal impact factor, unstandardized publication and citation counts, or normalized citation scores (25,26). This has been found in the EU FPs at the overall level based on mean citation scores (27), and more specifically within the ERC (23), using JIF and the size-dependent number of publications.

The propensity to apply may be enhanced by prior participation in the EU FPs and the existence of complementary national funding schemes (27). In addition, the probability of succeeding is strengthened by prior participation as well as the scientific reputation of the applicant organization. Bibliometric indicators such as field normalized citation indexes and highly cited papers are also used for funding decisions in national research funding contexts (28). It has been claimed that the acquisition of research funds also at the individual level is more strongly correlated with the reputation of the research applicant than with the judgement of the proposal quality in the selection process (29-32).

Neufeld, Huber and Wegner (23) argue that if nearly all actual applicants pass a certain threshold, other reasonable funding criteria may dominate the funding decision, most notably the quality and/or originality of the proposal (33), or whether the proposal is well-articulated (with a high quality of discourse) and/or with a topical overlap between the proposal references and the applicant's prior publications (34). For ERC proposals, a correlation has been found between proposal success and the two indicators 'similarity to frontier research' and interdisciplinarity (35). However, the EU FPs are large and encompassing funding instruments with different criteria being emphasized in the review process. It has been suggested that the EU FPs is in fact more oriented at widening and integration (foremost of lagging countries) of the European R&D landscape than of research excellence itself (36).

Several studies have pointed at academic reputation and scientific productivity as strong markers of participating institutions in EU FPs (37-39). In a former study of success rates in the EU FPs, we have shown that bibliometric indicators (number of publications, field normalized citation scores and percentage of highly cited papers) were highly correlated with success rates; with the share of highly cited papers being the indicator most significantly correlated with success rates (40). Our study also revealed that bibliometric indicators varied greatly between different programmes/thematic areas of the EU FPs. The most consistent set of correlations between university characteristics and success rates was found for proposals to the European Research Council, while there was little or no correlation in the Marie Curie mobility programmes. Programmes characterized by much collaboration, industry involvement etc., showed moderate correlations.

With respect to R&D collaboration, Lepori et al. (39) argue that: "higher-reputed researchers and organizations will be sought to a greater extent as research partners and, therefore, move to the center of the network". However, such an assumption – at the university level – does not take into account that the highly reputed

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institutions may be participating in many collaborative projects, also because they submit many proposals, reflecting their large institutional size. Piro, Scordato and Aksnes (1) investigated all EU FP consortia in EUs Seventh Framework Programme (FP7) and Horizon 2020 (H2020), involving participation from six selected European countries and concluded that a strong determinant for success in the EU FPs was previous participation in FP projects and a large network of European partners from past and ongoing projects. These findings are in concurrence with the ‘centrality hypothesis’, indicating that institutions that are already central in the European research network will become even more central as they are attractive partners to engage with for other institutions (41), thus strengthening the ‘Matthew effect’ of FP participation. The most encompassing analysis yet of HEIs’ involvement in the EU FPs, is Lepori et al.’s (39) study of 861 European HEIs’ participations in EU projects in 2011. Here, the participations were highly concentrated in a small group of HEIs that are characterized by a large volume of scientific publications, which combined with high citation rates, provide these HEIs with a strong (academic) reputation. However, the ‘reputation’ indicator in this study was designed as the product of both citations and publications and was thus not size-independent. A group of about 150 universities accounted for over 70 per cent of the participations. The number of participations tended to increase proportionally to organizational size and was strongly influenced by international reputation. We find this result particularly interesting, as it implies that there are no differences in the HEIs’ ability to get their proposals accepted, i.e. the success rates are constant across the spectre of small and large HEIs.

We outline three main research questions for more detailed analyses, concerning the characteristics of HEIs and their association with success rates:

1) *Will they differ by thematic areas in the EU FPs?* Our hypothesis is that HEI characteristics associated with scientific excellence will be more important for success rates in the European Research Council than in other programs.
2) *Will they differ over time?* Our hypothesis is that HEI characteristics related to industry, e.g. third-party funding and orientation towards natural and technological sciences, will be more accentuated in Horizon 2020 than in FP7.
3) *Will the associations between HEI indicators and success rates become weaker in H2020 when we control for success rates in FP7?* Our hypothesis is that some of the observed effects stem from ‘Matthew-effects’, where some institutions over time have become key players in EU FP cooperation. At the same time, however, many smaller (specialized and not necessarily highly-reputed) HEIs (and research institutes) may have become very successful in building EU FP networks and portfolios, adding to high levels of success.
4) *Will institutional size and its scientific impact be strong determinants of success rates*? Former studies have pointed at these two factors as the most important explanations for universities’ overall participation in the EU FPs. Our hypothesis is that size will not be as strongly associated with success, based on former studies showing that ‘successful’ participants in the EU FPs can be found across the entire spectrum of institutional size, while scientific impact will be more important in the excellence-oriented programs, foremost in the European Research Council.

2. Methods

This study draws upon three main data sources: 1) data about EU FP proposals and projects from the European Commission’s data warehouse ECORDA, 2) data from the Leiden ranking produced by Centre for Science and Technology Studies (CWTS) at Leiden University, and 3) data from the European Tertiary Education Register (ETER). *ECORDA* covers FP7 and H2020 (2007-2017). We have used the November 2017 edition, which means that our FP7 data are complete, whereas the analysis of H2020 is restricted to the early results of that framework programme. In ECORDA, the institutional affiliations of applicants are not standardized. It is therefore not possible to use the data for calculating success rates without going through the process of standardizing the institutional names. The novelty of our study is the build-up of a completely new database for participation in both EU proposals and projects; we have standardized all institutional addresses from the period 2007-2017 (approximately 1.4 million institution names). To the best of our knowledge, such a standardized data file

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including both applicants and grant recipients does not exist anywhere else. This has enabled us to extract data about all institutions' total volume of applications and projects, thereby making it possible to calculate success rates for all institutions (for each EU FP separately and across different thematic areas, including different ERC grants).

The European HEIs identified in ECORDA were then matched with *ETER* data, so that we could calculate the same HEI indicators as those used by Lepori et al. (39). ETER currently includes 2,764 HEIs in 36 countries, but data on the relevant indicators are not available for all countries, or for all HEIs in each country.

From the *Leiden ranking*, including data on the publication output of the world's largest universities, all HEIs have been given a value representing their mean number of fractionalized scientific publications during the years 2011-2014 (the Leiden ranking does not provide numbers further back in time)[1].

In ECORDA we have identified 1,880 European HEIs that in the period 2007-2017 were involved in one or more proposals submitted to the EU FPs. Luxembourg and Liechtenstein are represented with *one* HEI each, and are therefore not included in Table 1, as legal restrictions permit us from showing application data that can be linked to one specific institution.

Table 1. Distribution of Higher Education Institutions across countries in EU FPs 2007-2017

		Submitted proposals				Funded projects				
Country	**HEIs (N)**	**N**	**Mean**	**Min**	**Max**	**N**	**Mean**	**Min**	**Max**	**Success rate**
Austria	57	11407	200.1	1	1959	1801	31.6	0	322	15.8
Belgium	30	12903	430.1	1	4798	2120	70.7	0	812	16.4
Bulgaria	38	1537	40.4	1	356	214	5.6	0	65	13.9
Croatia	20	1868	93.4	1	1267	211	10.6	0	154	11.3
Cyprus	14	2628	187.7	1	1311	358	25.6	0	172	13.6
Czech Republic	37	5013	135.4	1	1318	709	19.2	0	180	14.1
Denmark	23	12270	533.5	1	3670	2184	95.0	0	697	17.8
Estonia	9	2002	222.4	3	1000	295	32.8	0	165	14.7
Finland	40	10680	267.0	3	2482	1418	35.5	0	384	13.3
France	213	19164	90.0	1	1354	3354	15.7	0	268	17.5
Germany	278	46709	168.0	1	2268	8160	29.4	0	483	17.5
Greece	39	12766	327.3	1	1921	1687	43.3	0	298	13.2
Hungary	37	4263	115.2	1	914	662	17.9	0	141	15.5
Iceland	6	690	115.0	9	514	87	14.5	0	74	12.6
Ireland	25	10472	418.9	4	1943	1735	69.4	0	352	16.6
Italy	109	42036	385.7	1	2796	5431	49.8	0	443	12.9
Latvia	25	1199	48.0	1	424	202	8.1	0	78	16.8
Lithuania	30	1865	62.2	1	522	252	8.4	0	75	13.5
Macedonia	7	416	59.4	2	333	56	8.0	0	45	13.5
Malta	2	535	267.5	22	513	84	42.0	4	80	15.7
Montenegro	4	151	37.8	1	120	26	6.5	0	26	17.2
Netherlands	42	23749	565.5	1	3369	4454	106.0	0	640	18.8
Norway	30	5612	187.1	1	1693	846	28.2	0	243	15.1
Poland	148	8422	56.9	1	851	1160	7.8	0	149	13.8

[1] CWTS data is openly available, but the Leiden ranking only includes the largest European universities. We therefore asked for permission from the *RISIS project* to get access to the datafile where ETER data has been merged with CTWS data.

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Portugal	53	7745	146.1	1	1733	1064	20.1	0	306	13.7
Romania	70	4184	59.8	1	660	382	5.5	0	66	9.1
Serbia	15	1600	106.7	1	782	180	12.0	0	92	11.3
Slovakia	28	1764	63.0	1	360	218	7.8	0	46	12.4
Slovenia	25	2957	118.3	1	1872	324	13.0	0	231	11.0
Spain	75	29797	397.3	1	2164	3979	53.1	0	374	13.4
Sweden	32	19587	612.1	3	2671	3368	105.3	0	478	17.2
Switzerland	25	15107	604.3	1	3290	3066	122.6	0	779	20.3
Turkey	144	6014	41.8	1	656	760	5.3	0	103	12.6
UK	148	84961	574.1	1	4753	15628	105.6	0	1099	18.4
Total	**1880**	**412636**	**218.6**	**1**	**4753**	**66558**	**35.3**	**0**	**1099**	**16.1**

Germany and France have by far the highest amount of HEIs in ECORDA, but the largest volume of proposal participations is from the UK, whose HEIs account for 20.6 per cent of the proposal participations. This is much higher than second-placed Germany (11.3 per cent) and the other largest nations: Italy (10.2 per cent), Spain (7.2 per cent), Netherlands (5.8 per cent), Sweden (4.8 per cent) and France (4.6 per cent). The French case is very special and is arguably caused by the methodological challenges appearing when analysing France as the proposals have been submitted in the name of the National Center for Scientific Research (CNRS) or one of the many laboratories funded by the CNRS, or by other national funding agencies in France such as the National Institute for Health and Medical Research (INSERM). For this reason, and data unavailability of French HEIs in ETER, the French HEIs are not part of our analysis. Another nine countries have been left out of our study due to data limitations in ETER (Austria, Estonia, Greece, Iceland, Macedonia, Montenegro, Romania, Slovenia and Turkey).

The highest success rates are found in Switzerland (20.3 per cent), the Netherlands (18.8 per cent) and the UK (18.4 per cent). Some of the smaller nations stand out with high success rates, such as Denmark (17.8 per cent) with a relatively large volume of submitted proposals, and Montenegro (17.2 per cent) with a very low number of submitted proposals.

2.1 Independent variables

Many indicators were considered for the analysis, but not all included due to multicollinearity issues (which we will return to). Several of the indicators are identical to those used by Lepori et al. (39), but with several adjustments being made to fit our research questions.

Indicators of scientific excellence: We considered the two most common citation indicators, the average field normalized citation indicator (MNCS) and the percentage of highly cited papers, i.e. a university's percentage of its publications being among the world's ten per cent most cited publications (TOP10%) (42). The two indicators are complimentary. The former indicates the average value of a university (thus representing all researchers at a university), whereas the latter points at the ability to produce the world's most cited research (thus representing only a few of a university's researchers). For both indicators, each HEI is assigned an average value of the years 2011-2014, so that we avoid having universities represented with a non-representative value based on an 'outlier-year'. For some of the smallest HEIs in Europe, CWTS do not produce citation numbers, and we have therefore set their citation values equal to the lowest values in the sample of European HEIs. This is reasonably justified by studies documenting the correlation between publication size and citation impact (21).

A third indicator related to 'excellence' is based on data from the Shanghai-ranking (ARWU) in 2012. University rankings have many flaws (43) in measuring quality but may still better represent the 'fame' of a university than bibliometric indicators (which are largely unknown to most people). As an indicator of

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prestigiousness or 'fame' we use a dummy variable for whether the university is among the European universities being ranked in ARWU, or not.

Indicators of university size: We considered two different approaches to measure the size of a HEI. First, its publication output (number of publications in the Web of Science) (PUBS) (universities with missing values, were given the value equal to the lowest among other HEIs[2]), and second, number of academic staff (FTEs) measured by full time equivalents (FTEs). This includes employees who are mostly involved in education and research, excluding technical and administrative personnel.

Indicators of academic orientation: Following Lepori et al. (39), we included three indicators measuring the teaching and research orientation at the universities. *Teaching load* is a measure of the HEIs' orientation towards education, i.e. the ratio between the total number of undergraduate students and academic staff. High teaching load is usually expected to be associated with low research output and/or quality (44) but has also been found to be positively associated with research excellence at European universities (45). *Research intensity* is the ratio between the share of PhD graduates and the number of undergraduate graduates. Related to research intensity, is the indicator *Third-party funding*, i.e. the share of third-party funds of total HEI revenues. This includes grants from public funding agencies (for example research councils), contracts from the public sector and from private companies.

Indicators of scientific profiles: Subject specialization was included because EU FP funding is heavily skewed towards technological domains, with fewer funding options for scientists within social sciences and humanities (SSH). European HEIs display different subject composition and many, mostly either in technology or towards humanities, are highly specialized (46), making the subject specialization of the HEIs a plausible factor in explaining the overall volume of EU FP participations. Lepori et al. (39) therefore expected that a stronger orientation towards fields like ICT and engineering would be associated with a higher number of participations, whereas an orientation towards SSH would have a lower number. Such an assumption is much more intuitive when studying the number of participations compared to success rates, because even HEIs with a low number of submitted proposals may in fact be very successful. Several studies have found differences by subject specialization/profiles in both productivity and citation impact, thus adding support to such a factor as a determinant of institutional success (47-50). We use the same two indicators for subject specialization as Lepori et al. (39). *First*, a set of dummy variables for specialized HEIs, identifying the HEIs that had more than half of their undergraduate students in a field. The standard classification of Fields of Education adopted in international educational statistics was used (see Table 2). *Second*, the share of undergraduate students in natural and technical sciences (including ICT).

Table 2. Distribution of specialized HEIs

Fields of specialization	N	% of included HEIs
Education	27	2.1
Arts and Humanities	102	7.8
Social sciences, journalism and information	32	2.5
Business, administration and law	139	10.6
Natural sciences, mathematics and statistics	2	0.2
ICT, engineering, manufacturing and construction	105	8.0
Agriculture, forestry, fisheries and veterinary	13	1.0
Health and welfare	60	4.6
Services	37	2.5

[2] 191 HEIs were removed from the analysis, rather than being given the value 0. These are larger HEIs with a total volume of 20 or more proposal participations (the largest numbers of participations were 905, 660 and 557), and could thus not be given the value 0. For the other HEIs with missing values, the participations are so low in numbers, that we believe a fixed value is reasonable.

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Specialized universities in total	517	39.6

The dummy variables for subject specialization (Table 2) identify groups of specialized HEIs in individual fields, which include 40 per cent of our sample. Most specialized HEIs are in Business, administration and law (139), in ICT, engineering, manufacturing and construction (105) and in Arts and humanities (102).

Indicators of EU FP activity: We considered three types of EU FP activity measures. *First,* number of submitted proposals. This variable is included as it is plausible that 1) HEIs that submit many proposals do benefit from learning and network formation even though (many of) the proposals are rejected, and 2) the ability to submit many proposals may also indicate good administrative capacity, which will also be advantageous in connection with the evaluation criterion project implementation (it is of course also plausible to reason that good administrative capacity is related to institutional size; but not *a priori*). The numbers are calculated separately for different thematic areas of each Framework program (e.g. for *Industrial Leadership* in H2020). *Second*, number of funded projects (calculated in the same way). *Third,* proposal intensity, calculated as the number of academic staff (FTEs) divided by the total number of proposals (n) to FP7/H2020 respectively. We believe that high values on this indicator signals both a university's administrative ability to, and strategical choice of, engaging in the EU FPs. The university distribution on this indicator is strongly loglinear, with the first 800 universities being rather similar, and then a steep increase from 800 and upwards. We therefore chose to have this indicator represented by a categorical indicator (universities 1-400 equals 'low proposal activity', universities in the range 400-800 'moderate proposal activity' and universities from 800 and upwards as 'high proposal activity'. *Fourth,* past success rates. In a study of research consortia in six European countries (1), it was found that the institutions with the highest success rates formed consortia with other partners that fitted their own profiles well, e.g. substantial experience from past EU FP participations, being from highly cited and reputed universities. Hence, universities that are on the inside of the EU FP networks benefit from their institutional reputation, their know-how on how to write proposals and their networks that they can draw upon. The importance of strengthening one's degree of centrality in the European research network, has even been highlighted by the European Commission (51) as an important driver towards success, simply recommending that institutions should make efforts in increasing their networks: "Stamina, repeated participation, and a willingness to increase one's connections are the only way forward to better one's position when on the periphery" (p.112). However, the landscape of EU FP partners seems fixed. The growth in EU FP funding over time has not been followed by a corresponding increase in the number of units that receive funding (52). We found a significant correlation in European universities between the number of submitted proposals and success rates, i.e. 'new' institutions struggle to get funding. When studying the probability for having a proposal accepted in H2020, we believe the success rates (from the equivalent programs) in earlier EU FPs may be decisive for funding, indicating the ability to pick the right partners, submit proposals to relevant calls, be in possession of the necessary scientific quality etc. Former success rate is also a better indicator than e.g. former number of projects, as it is in theory completely independent of size, while number of projects is intuitively a function of size.

Country indicators: We have included dummy variables for each country. The reason for this is that we believe 'country' may be a relevant factor in EU decisions on funding. For example, some EU FP calls emphasize the inclusion of partners from certain countries or regions to be included. It is also a goal of the EU FPs to connect more peripheral countries and regions in the European science collaboration. In other parts of the EU FPs we can, by contrast, easily imagine that the ability of e.g. a German or Dutch university in attracting strong consortium partners will be greater than HEIs in many other countries, although they share many similarities with respect to size, teaching load, research intensity, etc.

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Table 3. Correlation matrix (Pearson's r, two-tailed) for university indicators

	Teaching load	Proposals	Projects	Success rate	Staff FTEs	Third Party	Nat/tech orientation	Research intens.	WoS pubs	MNCS	TOP10%	Proposals FTE	ARWU°
Teaching load	1	-,144**	-,135**	-,083**	-,183**	-,095*	-,113**	-,095*	-,341**	-,148**	-,145**	-,008	,285**
Proposals		1	,980**	,151**	,801**	,459**	,158**	,052	,888**	,314**	,328**	,271**	-,533**
Projects			1	,163**	,767**	,466**	,150**	,056	,871**	,320**	,338**	,254**	-,563**
Success rate				1	,161**	,114**	,105**	,068*	,288**	,212**	,238**	,087**	-,343**
Staff FTEs					1	,339**	,225**	,050	,874**	,278**	,269**	,119**	-,523**
Third Party						1	,142**	,025	,400**	,289**	,290**	,373**	-,237**
Nat/tech orientation							1	,122**	0,051	,051	,054	,160**	,083
Research intens.								1	,050	,020	,023	,037	-,032
WoS pubs									1	,304**	,318**	,354**	-,708**
MNCS										1	,792**	,309**	-,546**
TOP10%											1	,305**	-,547**
Proposals FTE												1	,112
ARWU													1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

° Please note that low ARWU score equals 'good' score, i.e. the lowest value (1) is the highest ranked university.

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Table 3 shows how the university indicators are correlated. To avoid multicollinearity problems, some of the variables were excluded from the regression analysis: *Number of projects* which is correlated above .75 with both number of staff (FTEs) and number of WoS publications. *WoS publications* is also strongly correlated with ARWU (.7) and is left out, as size is better measured by FTEs. As expected, the *field normalized citation indicator (MNCS)* is highly correlated (.79) with the Top10% indicator, and we chose to use Top10%, as it is more elite-oriented than the MNCS. In our regression models we have kept *Number of proposals* despite this indicator being strongly correlated with FTEs (.80) but ran the results for FTEs with and without number of proposals in the model. The same is done for ARWU in relation to Top10%. Despite the correlation between ARWU and Top10% being more modest (.547), a large part of ARWU is made up of a citation indicator (and related *excellence* features of publishing, such as publications in Science and Nature), and we therefore wanted to study the numbers for Top10% with and without ARWU in the models. In the analysis where we remove Number of proposals and ARWU, we have also removed a small part of the study sample: the HEIs without a Top10% value. Despite these HEIs' overall contribution being minimal (less than 1 per cent of all proposal contributions), it is theoretically correct to remove them as their fixed low values are partly size dependent. Finally, we calculated the variance inflation factors (VIFs) for the explanatory variables that were kept specified in a linear regression model. The VIF values did not indicate any serious multicollinearity problems.

Table 4 shows the HEI values of the independent variables of our study. The most skewed indicators are research intensity, where several universities have the value 0, and the proposal intensity indicator. The HEIs have made 397,122 proposal contributions, of which 57,703 (14.5 per cent) were accepted. Such a distribution of responses to rejection/acceptance is suitable for logistic regression.

Table 4. Descriptive statistics on independent variables for HEIs (n=1307)

Indicator	Included (N)	Missing (N)	Mean	St.dev	Skew-ness	Min.	1Q	Median	3Q	Max
Top10%	947	587	0.0828	0.04968	2.122	0.0	0.0535	0.0825	0.1063	0.50
ARWU	200	1334	261.1	136.29	0.023	5.0	125.5	250.5	350.5	450.5
Proposals per FTE	1247	287	0.1043	0.30251	24.616	0.0	0.0170	0.0460	0.1220	1.44
Acad. staff FTE	1246	60	763.8	1013.1	2.5	6.8	136.4	364.0	985.0	7083.8
Research intensity	784	523	0.08	0.53	24.98	0.00	0.01	0.03	0.06	14.89
Teaching load	1176	133	0.11	0.35	18.24	0.01	0.05	0.11	0.16	8.49
3rd Party %	802	505	0.13	0.12	2.08	0.00	0.04	0.09	0.17	0.88
Nat/Tech	1260	47	25.93	26.89	0.06	0.00	2.80	19.23	36.28	100.00
Number of proposals	1307	0	219.48	511.64	4.18	1.00	4.00	23.00	165.00	4798.00
FP7 success rate*	915	0	0.13	0.16	2.79	0.00	0.00	0.13	0.19	1.00

*Only for HEIs that did get proposals accepted

2.2 Data split by EU programs and thematic areas

We have split the analysis of the EU FP proposals and success rates by three distinctively different areas of the EU FPs. In research evaluation panels' assessments there are «significant differences in what is understood as 'good' research in varied research fields and organizational contexts" (7). We believe that the university characteristics may be unequally important in different programmes, where it might be assumed that bibliometric indicators are particularly correlated with success in the ERC and not so strongly correlated with success in programmes where high TRLs are required, e.g. the Industrial Leadership pillar of H2020.

In theory, the most appropriate way of comparing success rates is to do so for all programmes separately. We have, however, restricted our study to three main parts of the EU FPs:

- The European Research Council (ERC)

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- Marie Curie Actions (MCA in FP7)/Marie Skłodowska-Curie Actions (MSCA in H2020)
- Other programmes, i.e. the collaboration-intensive programmes (Cooperation of FP7, Societal Challenges of H2020, Industrial Leadership of H2020 and Science with and for Society of H2020)

The split-up into these categories, seemed fruitful in our earlier work (40), as bibliometric indicators were highly unevenly associated with success rates across such categories. The most distinct finding was between ERC and other thematic areas. Decisions on ERC funding are made based on criteria related to scientific excellence only. This criterion is applied for assessing both the proposed research and the Principal Investigator. As expected in our former study (40), university indicators measuring scientific excellence were more accentuated in ERC, but a startling discovery was how the split-up of FP7's Cooperation program to (at least) two new programmes in H2020 led to much weaker associations between these indicators and success rates. Furthermore, industry collaboration (measured as joint-publications with industry) became more evident as a factor in understanding success rates, which must be seen in light of the reorientation in H2020 towards commercialization and societal impact. Further, we found a lack of association between bibliometric indicators and the Marie Skłodowska-Curie actions, which aims at targeting young researchers, stimulating mobility and cooperation, and build effective cooperation between science and society; aspects that are unlikely to be reflected through the selected indicators.

3. Results

We use logistic regression analysis, displaying the results by odds ratios (with 95% confidence intervals), i.e. the probability of having a proposal accepted. The results are shown separately for three broad thematic groups: ERC (Table 5), Collaboration programs (Table 6) and MSCA (Table 7). Each analysis is conducted in two steps. We first analyse each independent variable separately for FP7 and H2020, before we limit the analysis to H2020 only, with HEIs' success rates from FP7 as an independent variable. These numbers are calculated separately per program, so that in the analysis of the probability for funding in e.g. ERC, the covariates are the HEIs' success rates from ERC in FP7.

In all models '*No specialization'* is the reference category for subject specialization. For proposal intensity '*high proposal level*' is the reference category. For ARWU, not being listed is the reference category. For the country dummies, the UK is the reference category (and we only show statistically significant country differences in the tables). All other variables are entered to the models as continuous variables. In Tables 5-7 we have run the regression analyses separately without the variables Number of proposals and ARWU; while excluding small HEIs that we do not have the Share of top10% publications values for. Doing this hardly impacted the regression estimates except for the variable *Research Intensity.* We therefore show the new estimates for this variable, in addition to those for Academic Staff FTEs and Share of Top10% publications (because of their strong correlations with the omitted variables). New estimates for other variables are not shown in tables (but are available upon request).

In the first model of Table 5, covering proposals submitted from the HEIs to the ERC, we find that number of proposals and size of a HEI, is not significant in any models, but after removing number of proposals from the models, institutional size measured by FTEs is indeed statistically significant in all models. Our interpretation of this is that larger HEIs benefit from submitting many proposals. Beyond this, proposal intensity is not significant. The indicators that we expected to be the most correlated with successful proposal decisions mostly do so in FP7. Universities that are research intensive, produce highly cited papers and are on the ARWU list, have significant higher odds ratios for acceptance of proposals. Removing ARWU does not change how Top10% is associated with success, implying that they do measure two different things (reputation and scientific impact respectively). Finally, universities specialized in ICT, engineering, manufacturing and construction have significant higher odds for proposal success than non-specialized universities. The same is the case for universities specialized in the social sciences.

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In Horizon 2020, only the latter (social sciences) of the two types of specializations are significantly associated with success, but in H2020 universities with strong emphasis on business, administration and law are also significantly associated. The fact that universities specialized in ICT and other technical fields stood out with very high success rates in FP7, and not so in H2020, does not indicate that decisions on ERC proposals have taken a direction towards more applied knowledge. Especially because HEIs specialized in Business, administration and law, and in Social sciences, journalism and information display very high significant odds ratios in H2020.

One striking finding in H2020 is that submitting a high volume of proposals to the ERC is now beneficial with regards to success. We may speculate that this is due to the ERC first being introduced in 2007, and there has been a learning effect from the proposal writing in FP7. In H2020, both (high) research intensity and (low) teaching load are being positively associated with success. When studying the ETER data, we see that several of the most prestigious universities of Europe are placed in the category with the lowest teaching load (e.g. the universities in Oxford and Cambridge, Imperial College, Karolinska Institutet, Technical University of Denmark and ETH Zürich). The highly cited papers indicator is still associated, but the ARWU effect is gone.

Adding success rates from FP7 to the H2020 model does not change the estimates much, with once noticeable exception: the top10% indicator is now not significantly associated with success (nor is it after the removal of ARWU). We do not believe this signal less emphasis on excellence in ERC in H2020, rather that those HEIs that were successful in FP7 are also successful in H2020 and have also increased their proposal activity. After removing number of proposals from the model, institutional size is significantly associated with success in the H2020 model where FP7 success is accounted for. At country level, it is HEIs from the Netherlands, Germany and Switzerland that consistently perform well

Initially, the size of a university was not associated with proposal decisions in any of the models for ERC in Table 5. After we removed number of submitted proposals, the size is associated in all models. This contradicts our hypothesis, as we assumed that success in ERC in H2020 would not be based on scaling effects from a large volume of submitted proposals in absolute numbers (from large universities), but rather on some HEIs having solid traditions for submitting strong proposals, thus leading to high success rates. Our interpretation of the size effect that we observe after proposal volume is excluded from the model, is that larger universities benefit from submitting many proposals.

Table 5. Logistic regression analysis (odds ratios and 95% CI) for associations between university characteristics and the probability of having a proposal accepted for funding in ERC

	FP7		H2020		H2020	
	OR	95% CI	OR	95% CI	OR	95% CI
Business, administration and law			* 1.50	0.93 - 2.43	** 1.64	1.02 - 2.66
Education						
Health and welfare	* 0.68	0.46 - 1.00				
ICT, Engineering, Manuf., Constr.	*** 1.51	1.12 - 2.03				
Social sciences	*** 2.09	1.32 - 3.31	*** 3.62	2.15 - 6.09	*** 3.03	1.77 - 5.20
Other categories						
Academic Staff FTEs	1.00	0.99 - 1.00	1.00	0.99 - 1.00	1.00	0.99 - 1.00
Academic Staff FTEs¹	* *1.00*	*1.00 - 1.00*	** *1.00*	*1.00 - 1.00*	* *1.00*	*1.00 - 1.00*
Research Intensity	** 1.84	1.11 - 3.06	* 1.83	0.99 - 3.39	1.59	0.84 - 2.99
Research Intensity¹	** *1.86*	*1.13 - 3.08*	** *1.86*	*1.01 - 3.42*	*1.58*	*0.84 - 2.97*
Teaching Load	0.96	0.91 - 1.03	** 0.92	0.85 - 0.99	* 0.93	0.86 - 1.00
Third Party Funding	0.79	0.46 - 1.35	0.80	0.43 - 1.50	0.86	0.46 - 1.62
Nat/Tech per cent	** 0.98	0.98 - 0.99	1.00	0.99 - 1.00	1.00	0.99 - 1.01
Number of proposals	1.00	0.99 - 1.00	1.00	0.99 - 1.00	1.00	0.99 - 1.00
Proposals per FTE - Low	0.89	0.70 - 1.12	*** 0.66	0.50 - 0.87	*** 0.66	0.50 - 0.88
Proposals per FTE – Medium	0.88	0.76 - 1.03	*** 0.69	0.55 - 0.87	*** 0.70	0.56 - 0.89
Share of top10% publications	*** 1.12	1.09 - 1.16	** 1.05	1.00 - 1.09	1.02	0.98 - 1.07
Share of top10% publications¹	*** *1.13*	*1.10 - 1.17*	** *1.05*	*1.01 - 1.09*	*1.03*	*0.99 - 1.08*

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ARWU Dummy	**	1.23	1.03 - 1.46		0.98	0.80 - 1.19		0.97	0.80 - 1.18
Germany	***	1.43	1.11 - 1.84	*	1.30	0.98 - 1.73			
Italy	***	0.58	0.46 - 0.73	***	0.59	0.45 - 0.78	***	0.62	0.47 - 0.81
Netherlands	***	1.29	1.09 - 1.52	***	1.38	1.14 - 1.68	***	1.32	1.08 - 1.61
Norway				*	0.66	0.41 - 1.07			
Portugal	**	0.58	0.34 - 0.99				*	0.67	0.41 - 1.08
Switzerland	***	1.52	1.23 - 1.88	**	1.37	1.03 - 1.81			
FP7 Success rate							**	1.02	1.00 - 1.03
Constant	***	0.03	0.02 - 0.05	***	0.12	0.06 - 0.23	***	0.13	0.07 - 0.24
LR chi2			1004.760			401.050			402.650
Prob > chi2			0.000			0.000			0.000
Pseudo R2			0.057			0.036			0.036
Log likelihood			-8365.141			-5376.820			-5372.574
Total proposals (N)			24680			13482			13460

*** Significant at the 1 per cent level, ** significant at the 5 per cent level, * significant at the 10 per cent level. [1] Excluding Number of Proposals, ARWU Dummy and HEIs with missing value on the indicator Share of Top10% Publications.

In Table 6 we analyse the collaboration programs, where the general trends deviate considerably from the ERC analysis. At country level, the Netherlands' superior success to that of UK in FP7 is changed to inferiority in H2020. At the same time, Swiss HEIs have higher success than UK in H2020. But in H2020, universities from Malta, Norway and Portugal also have significantly higher success than British universities. The main difference from the Collaboration Programs and the ERC is the fact that university size (FTEs) is significantly associated with success in all models (even when number of proposals is also in the model), while it is the opposite for Top10% publications (only significantly associated in FP7 after ARWU is removed).This truly underscores that different evaluation criterions are used in two program types (i.e. Top10% far more important in the ERC while large HEIs always perform well), but it may also imply a strong selection effect, where different university types are drawn towards different parts of the EU FPs. In the collaboration programs also, H2020 success in dependent on former success.

The transition from FP7 to H2020 does manifest in some noticeable changes in indicator values. First, in FP7 universities specialized in two broad fields (agriculture and health) and the narrower field services, were positively associated with success. There is no such specialization effect in H2020. Second, third party funding and orientation to natural sciences/technology was positively associated in FP7 but is not so in H2020. The most distinct difference between the ERC and the Collaboration programs – also developing over time – is how the Research intensity indicator (which is positively associated with success in the ERC and MSCA, Table 7), changes from being positively to negatively associated with success in the Collaboration programs as we go from FP7 to H2020. Unlike the ERC, there is also much more benefits from submitting a (relative) high number of proposals in FP7 than what is the case in H2020. A very interesting difference between the collaboration programs (where industry is more intensively involved) and the ERC, is that the ARWU indicator's effect on success in the Collaboration programs is consistent throughout all models, which it was not in the ERC (we return to this in the Discussion section).

Table 6. Logistic regression analysis (odds ratios and 95% CI) for associations between university characteristics and the probability of having a proposal accepted for funding in Collaboration programs

	FP7			H2020			H2020		
		OR	95% CI		OR	95% CI		OR	95% CI
Agriculture, forestry, fisheries, vet.	**	2.68	1.26 - 5.72						
Business, administration and law									
Education									
Health and welfare	***	1.24	1.07 - 1.45						
ICT, Engineering, Manuf., Constr.									
Services	**	2.94	1.24 - 6.96						
Social sciences									
Other categories									
Academic Staff FTEs	***	1.00	1.00 - 1.00	**	1.00	1.00 - 1.00	*	1.00	1.00 - 1.00
Academic Staff FTEs[1]	***	*1.00*	*1.00 - 1.00*	***	*1.00*	*1.00 - 1.00*	***	*1.00*	*1.00 - 1.00*

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Research Intensity		1.17	0.93 - 1.48		0.81	0.58 - 1.14	*	0.76	0.54 - 1.05
Research Intensity[1]	**	*1.30*	*1.04 - 1.63*	*	*0.75*	*0.54 - 1.04*	**	*0.71*	*0.51 - 0.98*
Teaching Load		0.99	0.97 - 1.01		1.01	0.98 - 1.03		1.01	0.99 - 1.04
Third Party Funding	***	1.50	1.23 - 1.82		1.27	0.95 - 1.69		1.14	0.85 - 1.52
Nat/Tech per cent	***	1.00	1.00 - 1.00		1.00	0.99 - 1.00		1.00	0.99 - 1.00
Number of proposals	***	0.99	0.99 - 0.99		1.00	0.99 - 1.00		1.00	0.99 - 1.00
Proposals per FTE - Low	***	0.69	0.63 - 0.75	***	0.85	0.75 - 0.96		0.90	0.80 - 1.02
Proposals per FTE – Medium	***	0.86	0.81 - 0.91	*	0.90	0.81 - 1.01		0.95	0.86 - 1.06
Share of top10% publications		1.00	0.99 - 1.01		1.00	0.98 - 1.02		1.00	0.98 - 1.02
Share of top10% publications[1]	**	*1.01*	*1.00 - 1.03*		*1.01*	*0.99 - 1.03*		*1.01*	*0.99 - 1.02*
ARWU Dummy	***	1.20	1.14 - 1.27	***	1.21	1.12 - 1.30	***	1.15	1.06 - 1.24
Belgium				***	0.81	0.69 - 0.94	*	0.85	0.73 - 0.99
Cyprus	***	0.60	0.47 - 0.78						
Italy	***	0.78	0.73 - 0.84	***	0.84	0.76 - 0.94			
Lithuania	***	0.72	0.56 - 0.91						
Malta				*	1.50	0.98 - 2.29	**	1.62	1.06 - 2.48
Netherlands	***	1.11	1.03 - 1.19	**	0.87	0.78 - 0.97	***	0.85	0.76 - 0.95
Norway							**	1.22	1.01 - 1.47
Portugal	***	0.82	0.72 - 0.93	**	1.21	1.02 - 1.43	***	1.32	1.11 - 1.57
Slovakia				**	0.67	0.49 - 0.93	**	0.72	0.52 - 1.00
Switzerland				***	1.22	1.05 - 1.41	**	1.18	1.02 - 1.36
FP7 Success rate							***	1.02	1.01 - 1.02
Constant	***	0.24	0.20 - 0.28	***	0.14	0.10 - 0.18	***	0.09	0.06 - 0.12
LR chi2			1056.320			259.300			304.550
Prob > chi2			0.000			0.000			0.000
Pseudo R2			0.011			0.005			0.006
Log likelihood			-45787.061			-23693.811			-23652.741
Total proposals (N)			89304			58998			58960

*** Significant at the 1 per cent level, ** significant at the 5 per cent level, * significant at the 10 per cent level. [1] Excluding Number of Proposals, ARWU Dummy and HEIs with missing value on the indicator Share of Top10% Publications.

In the ERC there was no effect from submitting a higher number of proposal (in absolute numbers), but in the Collaboration Programs, we observe in FP7 that two effects related to proposals operate simultaneously and with different outcomes. In FP7, the indicator *number of proposals* is negatively associated with success, whereas the indicator *high number of proposals per FTE* is significantly associated with success. This highlights the importance between analysing proposal submissions in absolute and relative terms.

Table 7. Logistic regression analysis (odds ratios and 95% CI) for associations between university characteristics and the probability of having a proposal accepted for funding in MSCA

	FP7			H2020			H2020		
		OR	95% CI		OR	95% CI		OR	95% CI
Agriculture, forestry, fisheries, vet.				**	2.72	1.11 - 6.64	**	2.73	1.12 - 6.67
Arts and Humanities				**	3.20	1.23 - 8.36	**	3.84	1.17 - 12.58
Business, administration and law				**	0.60	0.37 - 0.96	**	0.56	0.34 - 0.92
Education									
Health and welfare	*	0.79	0.61 - 1.02						
ICT, Engineering, Manuf., Constr.				*	1.22	0.99 - 1.50	*	1.21	0.98 - 1.50
Social sciences									
Other categories									
Academic Staff FTEs		0.99	0.99 - 1.00		1.00	0.99 - 1.00	*	1.00	0.99 - 1.00
Academic Staff FTEs[1]	*	*1.00*	*1.00 - 1.00*	*	*1.00*	*1.00 - 1.00*	*	*1.00*	*1.00 - 1.00*
Research Intensity		1.21	0.83 - 1.76	**	1.59	1.04 - 2.44	**	1.59	1.04 - 2.43
Research Intensity[1]	**	*1.48*	*1.04 - 2.10*	*	*1.49*	*1.00 - 2.23*	*	*1.46*	*0.97 - 2.19*
Teaching Load		0.99	0.96 - 1.02		1.02	0.98 - 1.05		1.02	0.98 - 1.05
Third Party Funding	***	0.59	0.41 - 0.84		0.85	0.56 - 1.28		0.91	0.60 - 1.38

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Nat/Tech per cent	**	1.00	0.99 - 1.00	***	0.99	0.99 - 0.99	***	0.99	0.99 - 0.99
Number of proposals	***	1.00	1.00 - 1.00		0.99	0.99 - 1.00		1.00	0.99 - 1.00
Proposals per FTE - Low		0.94	0.82 - 1.08	*	0.86	0.73 - 1.02		0.88	0.74 - 1.04
Proposals per FTE – Medium		0.94	0.85 - 1.03		0.98	0.85 - 1.12		0.99	0.87 - 1.14
Share of top10% publications	**	1.02	1.00 - 1.04	**	1.03	1.00 - 1.05	*	1.02	1.00 - 1.05
Share of top10% publications[1]	***	*1.03*	*1.01 - 1.05*	***	*1.03*	*1.00 - 1.05*	**	*1.02*	*1.00 - 1.05*
ARWU Dummy		0.99	0.90 - 1.08		1.03	0.93 - 1.14		1.03	0.93 - 1.15
Belgium	*	0.85	0.71 - 1.02	**	0.80	0.66 - 0.97	**	0.82	0.67 - 0.99
Germany	*	0.86	0.73 - 1.01						
Hungary	***	1.77	1.39 - 2.26	**	0.66	0.44 - 0.99	**	0.62	0.41 - 0.95
Italy	***	0.76	0.66 - 0.86	***	0.82	0.71 - 0.94	**	0.83	0.71 - 0.96
Lithuania	***	2.08	1.29 - 3.34						
Netherlands	*	0.90	0.81 - 1.01						
Norway	***	0.74	0.59 - 0.93						
Portugal	*	0.83	0.67 - 1.02						
Sweden	***	0.78	0.67 - 0.91						
Switzerland	**	0.86	0.75 - 0.98	**	0.82	0.68 - 0.99	**	0.83	0.69 - 1.00
FP7 Success rate							*	1.01	1.00 - 1.01
Constant	***	0.25	0.18 - 0.33	***	0.13	0.09 - 0.19	***	0.12	0.08 - 0.18
LR chi2			283.490			163.930			172.210
Prob > chi2			0.000			0.000			0.000
Pseudo R2			0.007			0.006			0.006
Log likelihood			-19373.160			-14983.538			-14960.249
Total proposals (N)			39318			37981			37918

*** Significant at the 1 per cent level, ** significant at the 5 per cent level, * significant at the 10 per cent level. [1] Excluding Number of Proposals, ARWU Dummy and HEIs with missing value on the indicator Share of Top10% Publications.

In general, significant associations found in the model for Marie Sklodowska-Curie Actions (Table 7), follow an at first less expected pattern, with e.g. higher odds ratios for Hungary and Lithuania than the UK in FP7, and a negative association for Swiss universities in H2020. Here, there is also much less signs of any scaling effects from the number of submitted proposals (either in absolute or relative numbers) and no ARWU effect. An orientation towards natural/technological sciences (share of undergraduate students) and high shares of third-party funding is even negatively associated with success. Despite MSCA's differences to e.g. the ERC, there are still signs of research excellence effects, because the Top10% indicator is significantly associated with success in all models, and high research intensity becomes significant in H2020. After removing number of proposals from the models, there is also a size-effect both in FP7 and H2020.

At the level of specialization, three fields emerge as 'favourable' in H2020. Whilst it may not be surprising that ICT (and agriculture) is amongst these, it is more surprising to observe the high success among universities specialized in Arts and Humanities (and where the business-oriented universities perform worse than in the ERC).This may not be as unexpected however, as the purpose of the program and criterions for funding are very different compared to ERC (with its strong emphasis on research excellence) and the collaborations programs (with its strong emphasis on innovation and industry relevance). Based on the results in Table 7, we may describe the overall funding decisions of MSCA as being the least predictable.

4. Discussion

Our study has demonstrated that using *proposal success* rather than project participations demonstrates different patterns of which university characteristics that are expedient in the EU FPs. Whilst institutional size is indeed associated with *success rates* in the EU FPs, and citation impact (indicating scientific excellence) foremost in the ERC, we also find a complex set of institutional characteristics that work differently across three broad areas: the ERC, collaboration programs and the Marie Curie mobility programmes. We believe our study has highlighted that EU FPs is a complex funding scheme that is not mainly for large and highly-reputed organizations.

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While many studies do document support for the assumption that the qualitatively best are the ones who succeed (53), and that reviewers may be biased based on the applicants' (either person or institution) reputation (54), such conclusions do not hold for such multifaceted programs as the EU FPs. In our opinion, studying the EU FPs as *one* funding scheme, is hardly ideal as the EU FPs have other purposes than stimulating the best research per se (55). The EU FPs are indeed a compilation of funding instruments with very different target objectives, where promoting research excellence is just one – the widening and integration of European R&D is another (18, 36), as clearly seen in the MSCA program where smaller and more peripheral nations have achieved great success.

Proposal success in the ERC is backed up by both large institutional size and high citation impact, whereas in the collaboration programs it is university size and visibility (i.e. presence in the Shanghai-ranking) that matters. The differences between these two funding schemes are massive, and it is logical that different university features come to play in them. In the ERC, scientific excellence alone is the criterion (higher education institutions is also the primary applicant type), and while an ERC grant is given to a principal investigator who may have established a consortium of partners for the project; in the collaboration programs close to all projects involves a consortium of partners from different sectors: higher education, research institutes and private sector. In these programs, universities often participate as partners in projects led by research institutes or industry. As the programs are more applied by nature and societal impact is more at the centre than scientific impact, it is not surprising that size and 'fame' become more relevant, especially in those cases when the universities are selected into a project as partners to carry out a specific role or work package, rather than conducting the entire project itself as in the ERC. That different organizational characteristics play different roles in the ERC and the collaboration programs could be seen as a sign of successful organizing of the EU FPs, i.e. the proposal decisions do not automatically distribute funding to certain types of universities. Rather the distribution is dependent on the specific aim of the program. On the other hand, from a European perspective, this may still not be entirely ideal, as it does signal an odd development among European universities (56) where seemingly the 'best' universities more frequently turn their attention to the ERC where they may freely conduct basic research, while the 'second best' universities have become more oriented towards the collaboration programs which aim at tackling the societal challenges of Europe. This trend may, however, be subject to a selection issue not accounted for in our study, i.e. that the threshold for applying to the ERC is arguably much higher than in other programs, thus making the selection effect strong in the ERC.

We acknowledge that several of the indicators used here may be plausible suspects for endogeneity issues. Although our statistical tests did not reveal any major endogeneity problems in the indicators that were used, research performance is "the outcome of a dynamic and nonlinear process" (cf. (45), p. 1148), which cannot be adequately dealt with using a cross-section research design. It is thus difficult to establish causal mechanisms between variables and success where several of the independent variables are (theoretically) undoubtedly related, albeit not to a degree that cause statistical noise to the models. We nevertheless believe our study has contributed with important additional findings to studies only focusing on project participations at the overall level of the EU FPs.

First, the number of EU-projects is higher in large (and reputed HEIs). Institutional size (by FTEs) proved to be a strong predictor of success in both ERC, collaboration programs and in MSCA. However, in the ERC during Horizon 2020, a relative high number of proposals per FTE was an even stronger predictor of success than size itself. Nevertheless, a scaling effect from size was found in all programs, unlike the effect of scientific impact (the Top10% indicator), which was not significantly associated with success in the collaboration programs except in FP7. Why do large HEIs have higher success rates than smaller HEIs? It appears that they benefit from submitting many proposals, but it is important to bear in mind that even smaller HEIs who do submit relatively many proposals per FTE also display good success rates in both the ERC and the collaboration programs. The key to success thus appears to be in committed efforts in proposal activities.

Second, high success may consequently be found in HEIs with relatively small number of projects, e.g. HEIs specialized in social sciences and in arts and humanities as we have found. While it is true that HEIs oriented towards natural sciences and engineering are involved in more projects, this does not mean that there is little chance for HEIs specialized in other fields to succeed. Our analysis clearly shows that HEIs specialized in e.g. social sciences have a very good chance for funding, once applying (to expedient calls). The fact that the EU FPs

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are skewed towards technical and natural sciences, does not mean that HEIs specialized in social sciences cannot perform very well (albeit with a smaller pool of calls to choose from).

From our study, it does not follow any policy recommendations at the university management level, beyond the fact that a relative high number of proposal participations compared to one's size appears beneficial. Still, the presence of a strong effect of former success on future success does indicate that the EU FPs are characterized by Matthew-effects based on established networks (57). Against this, and based on our findings, one can argue that there are enough examples of 'unexpected' university characteristics that are positively associated with proposal decisions, so that it is more a matter of finding the calls or the partners that rightly fit the individual universities. At the level of the EU, our study indicates that the EU FPs are organized in ways which ensure that the right criterions are being emphasized, because HEI characteristics play in differently in each program. At the level of research policy studies, we believe our study's disentangling of the EU FPs to three distinctly different programs has emphasized the importance of fitting the study design in ways that capture the different goals of these programs, although much more fine-tuned analyses may be performed than what we have done here.

In future research we would like to conduct more in-depth analyses of the EU FPs, with more focus on the coordinating role and the characteristics not only of the HEIs involved, but also of the consortium itself. Our study has not distinguished between a university's contribution to a proposal as for example the coordinator of a very large project compared to being one of many partners (in a limited role) in a financially small project. Especially in the collaboration programs, it would be expedient to use a multilevel design where the composition of the consortium is also studied. The importance of previous collaborations is emphasized in the literature (51, 58-59), while studies from the EU FPs about the importance of cross-sectorial collaboration (i.e. industry-academic cooperation) has not been subject to much research. We therefore believe that future studies of EU FP success and participations should expand focus from the importance of "who you are" to the importance of "who you work with and how that collaboration is composed".

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