The Factors Behind Participation: Evidence from the European Framework Programme, Horizon 2020

Thesis

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Summary

This thesis studies formal research collaboration in large, multi-year projects. The empirical setting is the European framework programme for innovation and research (EU FP), Horizon 2020, and the thesis seeks to understand the factors that influence participation in the programme. Such understanding is important for addressing gaps in our knowledge about collaborative research projects, specifically: what affects the decision to apply and attain funding? Why do certain research organizations persistently enjoy centrality and influence in collaborative research? Moreover, what decisions are made in establishing and managing research projects, and how does this affect participation?

The thesis is based on three papers focusing on participation in Horizon 2020 from 2014 to 2018. Two papers apply quantitative data to analyse participation in two different populations of research organizations – public Norwegian research organizations and higher education institutions across Europe. The third paper goes beyond the organizational level and is based on qualitative semi-structured interviews with project coordinators as the predominant method.

The analyses distinguish two important steps in research funding: the decision to apply and the funding phase. Results show that previous participation in EU FP projects and greater access to collaborative networks are important factors for both applying and participating. The effect of these factors is reinforced by having a high degree of productivity, large organizational size, as well as a strong scientific reputation. The results also show that project coordinators are under pressure from the regulatory control exerted by the EU Commission which affects how they set up and manage collaborative projects. In turn, this contributes to explaining the persistent participation of closely connected networks.

The thesis contributes to the science policy literature, in particular to the dynamics behind collaborative R&D, by highlighting the importance of several factors affecting collaboration in multi-partner projects. The improved understanding of these factors further adds to the literature concerned with explaining participation in EU FPs.

The findings have several implications for policy. At the national level, policy makers should provide sufficient funding to research organizations so that they are able to build and sustain sufficient research capabilities, and are able to establish and maintain their networks. Without sufficient funding, there is less flexibility to allocate resources for time-consuming applications and to finance in-house administrative support. At the EU level, the institutional environment imposed by the EU Commission partially results in self-reinforcing behaviour

where partners in collaborative projects are selected based on prior acquaintance and competencies. This reproduces already successful networks, which could be counterbalanced by reducing the level of formal control. Since persistent participation points towards accumulative advantages in EU FP collaborative research, incentivizing collaboration between newcomers and more seasoned participants could create more diverse networks. This could also address the issue of inequality in the EU FPs.

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1. Introduction

Scientific results are to a large extent the outcome of collaborative efforts (Melin, 2000), and research is often dependent upon attaining project funding through applications. Many funding agencies and research funding programmes require projects to be carried out in consortiums with multiple partners. Research organizations are therefore faced with complex decisions about distributing resources internally, selecting partners and developing networks, while dealing with the uncertainty that their applications might be rejected. The ability to apply and the chances for successful acquisition of funding for collaborative research hinge on several factors outside of the application itself, and organizations that are able to leverage these factors will hold a comparative advantage in the competition for funding.

One of the largest and longest-lasting arenas funding collaborative research is the European framework programme (EU FP). Following several initiatives to support research and technology at the supranational level in the 1950s and '60s, the first framework programme was launched in 1984 with the aim of supporting scientific and technological progress at the European level. Since then, seven FPs have followed, broadening the thematic scope and budget – simultaneously placing domestic participation on the agenda for national policy makers across Europe. Today, Horizon 2020 (H2020) marks the eighth and current FP, highlighting that high-quality research and innovation is best achieved through competitive funding and by striking a balance between individual level grants, collaboration across countries, sectors, and specializations, but also between applied and fundamental research.

In conjunction with increased attention from policy makers and the complexity of EU FPs, academia has shown a growing interest in understanding what explains participation in and the impact of EU FP funding. Part of the literature has devoted attention to the convergence of national and EU policies (Hakala et al., 2002; Langfeldt et al., 2012). Another part addresses the added value of EU FPs (Di Cagno et al., 2014; Luukkonen, 2000) or how EU FP funding shapes organizational structure and policies (Edler et al., 2014). The majority of studies, however, are interested in the collaborative nature of EU FP projects (see Breschi & Cusmano, 2004; Protogerou et al., 2013), because most of the resources available have been devoted to collaborative research and innovation projects. The main observation from these studies is that participation is concentrated among only a few entities over time, entities that have formed closely interlinked networks. However, little is known about how access to these networks affects participation, even less about the decisions behind selecting partners and managing these networks. Following these studies, a smaller segment of the literature has been concerned with the organizational capabilities and resources necessary for achieving funding (see Geuna, 1998; Lepori et al., 2015). Here it is discovered that organizations with the strongest research capabilities and resources have a far greater chance of securing funding than those with less. The research on organizational determinants and networks suggests cumulative advantages in favour of those endowed and networked.

1.1. Motivation and research aim

The key aspect motivating this thesis is to achieve a better understanding of what drives participation in EU FPs, specifically in H2020. To national policy makers, the funding offered through EU FPs serves to strengthen their domestic research sectors by supporting scientific quality, increasing access to expensive and complex research infrastructures, developing individual careers, and increasing the attractiveness of domestic research communities internationally. In Norway, participation in EU FPs is placed at the centre of the research policy agenda (Norwegian Ministry of Education and Research, 2014) and supported by several financial incentive schemes (Norwegian Ministry of Education and Research, 2018). To support increased and continued participation in the EU FP it is essential to understand what affects participation. Through such understanding, national policy makers will be better equipped to design and implement efficient policies supporting mobilization and successful applications in H2020 and future FPs.

A better understanding can also provide valuable insights and suggestions regarding how research organizations themselves can adapt to promote participation within their own institution. The improved understanding may also have implications for policies at the EU level on how the programme itself is structured and the practices of allocating funding – contributing to a continued support for increased investment in European research and innovation. With the next EU FP being decided in Brussels as we speak, this is more relevant than before.

The overall aim of this thesis is to study participation in the current European framework programme, Horizon 2020 – the seven year-long programme for research and innovation running from 2014 to 2020. The overarching research question is: *what explains research organizations' participation in Horizon 2020?*

1.2. My approach

This thesis is situated in the science policy literature, particularly among those contributions that address collaborative R&D (see for example: Bozeman et al., 2013; Katz & Martin, 1997; Mowery, 1998; Sonnenwald, 2007). Research collaboration has long been of interest from a policy perspective as well as from a scientific point of view, dating back to pioneering contributions by De Solla Price and Beaver (1966); Merton (1973b). Collaboration is studied in several areas, drawing on various literatures including social study of science, sociology of science, organizations, and innovation studies (D'Ippolito & Rüling, 2019). In this thesis, however, I view my point of departure as located within the literature on the dynamics behind collaboration: how different underlying aspects, such as reputation, resources and networks affect collaborative R&D. At the core of this literature are studies addressing cumulative advantages in science (see Cole & Cole, 1973; Fox, 1983; Merton, 1968), but also literature that emerges from the same assumptions of underlying dynamics – for example how collaborative networks evolve (Barabási & Albert, 1999) and how they are organized (Dhanaraj & Parkhe, 2006).

The ambition of the thesis is to establish a coherent view of what explains participation focusing on these dynamic factors, and thus contribute to both policy and the academic literature. Ideally, a complete study on the factors behind participation should be examined in a multi-level setting, including the country, organizational, project and individual-level characteristics. However, data covering all the different levels of analyses is not available, especially for cross-country comparison. Therefore, I study participation at the organizational (meso) level and at the project (micro) level. In doing so, I use both quantitative and qualitative techniques to capture the breadth and depth of what explains participation.

1.3. Thesis structure

The thesis consists of three articles and an introductory section. Each paper has its own specific research question, but the shared motivation is to better understand the factors behind participating in H2020. This introductory part compiles and combines the results and discusses the factors, in addition to offering suggestions for policy.

In section 2 of the introductory part, I describe the empirical context of European framework programmes, from the early development in the 1950s to the current EU FP, Horizon 2020. Since this thesis is written in a Norwegian policy context and the results are relevant for policy makers, I will also briefly describe the Norwegian government's policy for EU research and innovation. Finally, in this section, I summarize the literature that focuses specifically on participation in EU FPs and how the less studied elements in this literature support an answer to the research question in the thesis. In section 3, I introduce the theoretical framework used for studying and explaining the findings. In section 4, I describe the methodological choices, and in section 5 I summarize the three papers. Finally, in section 6, I discuss the results and their implications for research and policy, before pointing out some limitations of the thesis and how these can be addressed by future research.

2. The empirical setting

In this section, I introduce the empirical context for the thesis, which is the eighth European framework programme, Horizon 2020. Before outlining the characteristics of H2020 in section 2.2, I detail the historical backdrop, comprising the introduction of the first EU FP 36 years ago followed by succeeding FPs until FP7 (section 2.1). Next, I present the Norwegian government's perspectives and policies on domestic participation in EU FPs (section 2.3). In section 2.4, I summarize the landscape of research that focuses on participation in EU FPs. Finally, in section 2.5 I address how the more unchartered sides to this literature support the thesis in answering the overarching research question.

2.1. Evolution of European framework programmes

Supporting research at a European level can be traced back to the European Organization for Nuclear Research (CERN) in 1953 and the European Southern Observatory (ESO) in 1962 (Guzzetti, 1995; Nedeva & Wedlin, 2015; Reillon, 2017). In the 1960s, the widening technology gap between Europe and the USA fuelled discussions on supporting increased collaboration across Europe. This led to the foundation of the European Cooperation in Scientific and Technical Research (COST) in 1971, along with many other programmes and intergovernmental structures supporting research and technological development (see Reillon, 2017, p. 5 for a detailed description). Eventually, in 1984 the first EU FP was launched. Following an extension of existing initiatives in computing and energy, the FP supported collaborative research in the applied spectrum, reflecting the desire to bridge the technology gap (Arnold, 2012).

Since FP1, seven FPs have followed in a consecutive order. FP2 (1987–1991) resembled FP1, but added the support of infrastructures, mobility, and supporting innovation in small and medium enterprises (SMEs) (Reillon, 2017). FP3 (1990–1994) followed on the same lines but gave increased priority to human capital and mobility. FP4 (1994–1998) was influenced by the Maastricht Treaty of 1993, which empowered the EU Commission's attempt to coordinate national R&D policies. It introduced targeted socioeconomic research, but remained in line with previous FPs, focusing on ICT, industrial technologies, environment, life sciences, agriculture and fisheries, life sciences, non-nuclear energy and transport (Reillon, 2017). FP5 (1998–2002) marked a shift from mainly technologically-oriented research to also funding societal challenges, thus meeting basic social and economic needs.

In 2000, with FP5 already implemented, the policy of the European Research Area (ERA) was launched. With the rationale of funding research at the European level, ERA's objective was to address the fragmentation of national research systems, allowing better flow of knowledge, technology and people between them (Nedeva & Wedlin, 2015; Reillon, 2016). In the context of ERA, FPs would become the main vehicle to implement this policy, and first out of the blocks was FP6 (2002–2006).[1] One of the major shifts from FP5 to FP6 was the support of the implementation of ERA. A number of policy instruments aimed at aligning national funding were introduced in FP6: ERA networks (ERA-NETs), public-private partnerships, Networks of Excellence, and European Technology platforms (Nedeva & Wedlin, 2015; Reillon, 2016, 2017). Because of the accession of 10 new member states in 2004, and the entry of many new potential participants, FP6 received an increased budget.

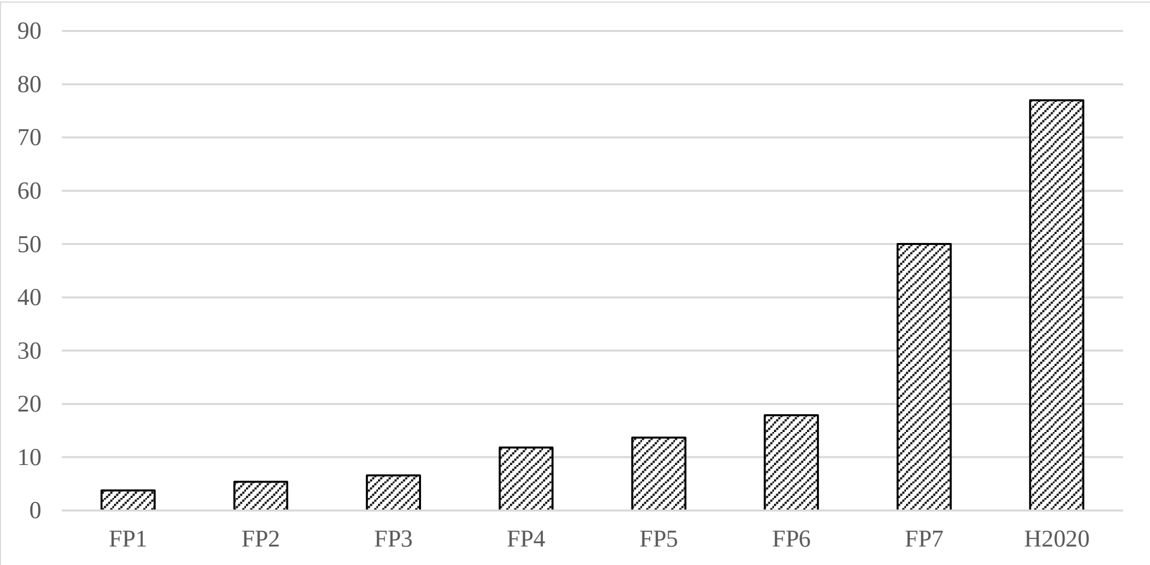
FP7 (2007–2013) marked a shift from previous FPs as it was both longer and larger, running for seven years with a total budget of 55 billion euros compared to FP6 with around 18 billion (European Commission, 2015a). The structure of the programme was organized around four aims: support for collaborative projects in 10 thematic areas, strengthening human capital and mobility and supporting aspects of European research and innovation capacities like infrastructures, regional clusters, and SMEs. Finally, within the IDEAS programme, an excellence initiative was also included to support fundamental research. Hence, investigator-driven research with individual grants became supported by the European Research Council (Reillon, 2017).

Summarizing the evolution of EU FPs, the purpose in establishing a common framework programme with FP1 was not only to seek a European effort in reducing the technological gap, something which worried policy makers. The first FP also provided a coherent long-term view in selecting research activities supported by the Commission. The first three EU FPs focused primarily on supporting pre-competitive research, while after the Maastricht Treaty, the mandate widened. FP4 supported exploratory research in addition to an increasing number of innovation-related calls (Krige & Guzzetti, 1997; Reillon, 2017). FP5 introduced the notion that research should address the societal challenges faced by European citizens. The ERA policy in 2000 further shook things up in FP6. Before ERA, the EU FPs could support transnational research projects, but not an EU research policy – as none existed. With ERA, the EU FPs became the main instrument in implementing a European research

[1] ERA was originally envisioned for 2010, but was renewed and included in the Europe 2020 strategy (Reillon, 2016).

policy. This resulted in the introduction of several instruments, implemented in FP6 and FP7 – for example the European Research Council and the European Institute of Innovation and Technology. Because of these new instruments – and new policies such as the Innovation Union Flagship in the Europe 2020 strategy (see European Commission, 2010) and the renewal of ERA 2020 – FPs have gone from supporting pre-competitive research to encompassing the whole value chain inherent in the innovation process. The growth of instruments and policies is further reflected in the increased budgets allocated to EU FPs, from FP1 to Horizon 2020 (Figure 1).

Figure 1. Evolution of the budget to EU FPs from 1984 to 2014 (in billion ECU/Euro).



Note: In current prices at the time of adoption. Source: (Reillon, 2017).

2.2. Horizon 2020

The eighth framework programme, Horizon 2020 (2014–2020), marks a change in European support of research and innovation reflecting the developments in ERA and the European strategies (European Commission, 2011). With the biggest budget ever at 77 billion euros,[2] H2020 seeks to support projects that cut across all phases of research and innovation, tackling societal challenges and strengthening the impact on job creation and growth (Reillon, 2015).

H2020 focuses on three distinct but still mutually reinforcing priorities, organized into three pillars. The first pillar, "excellent science" seeks to raise the level of excellence in

[2] Re-allocation of funding to the European Fund for Strategic Investments reduced the approved budget to 74.8 billion euros. Between 4 and 5 per cent of the programme's budget will be used for administration, leaving a budget of around 70 billion euros (Reillon, 2015).

Europe's science base. The pillar holds about 31 per cent of the total budget in H2020 and provides individual level grants through the European Research Council, mobility grants through Marie Skłodowska-Curie Actions (MSCA), funds collaborative research on new and promising technologies through the programme Future and Emerging Technologies (FET), and supports the establishment of infrastructures. The second pillar, "industrial leadership" accounts for 21 per cent of the budget and aims to support the growth potential of European industries by providing companies, including SMEs, with adequate levels of finance as well as supporting research and innovation within ICT, nanotechnologies, advanced materials, biotechnology, advanced manufacturing and processing, and space. From FP7, many industry-relevant themes continued in the third pillar, "societal challenges", that holds the largest proportion of the total funding (39 per cent). Addressing concerns shared by European citizens, the goal is to bring together resources and knowledge across fields, technologies and disciplines. Seven challenges have been identified as priorities: health, food, energy, transport, climate, inclusive societies, and security – see European Commission (2014) for a detailed description of the different challenges.

In addition to the three pillars, funding is allocated to cross-cutting programmes such as;[34] "spreading excellence and widening participation" which aims to promote coherence in Europe by supporting poorer performing countries,[5] "science with and for society" that support projects that involves citizens, The European Institute of Innovation and Technology, and, as of 2018, the European Innovation Council pilot (inspired by the European Research Council), which supports top innovators, SMEs and researchers with innovative ideas (European Commission, 2018b).

To some extent, H2020 continues on the same path of previous EU FPs supporting similar instruments, for example fundamental research through the ERC. On the other hand, H2020 is the first FP to support research and innovation, unlike its predecessors that were all "framework programmes for research, technological development and demonstration activities" (Reillon, 2017, p. 24). Instead, H2020 covers all phases of research and innovation

[3] Following up on the ERA instruments introduced in FP6 and FP7, the EU Commission aims to foster links between public and private actors in Europe through an increasing number of instruments. These can be grouped in two broad categories: innovation-related instruments, for example public-private partnerships, and instruments that seek to coordinate policy makers across the member states, for example public-public partnerships and ERA networks (European Commission, 2014).

[4] EURATOM is a programme outside the pillars and not regulated under the EEA agreement like H2020.

[5] The interim evaluation of FP7 showed that some countries (Annerberg et al., 2010), mostly among those that joined the EU after 2004, had low participation rates compared to others.

in order to support the production of excellent science, remove barriers to innovation and facilitate innovation and research between private and public sectors.

2.2.1. The nature of funding

Similar to past framework programmes, the great majority of the funding in H2020 is collaborative. This is because the EU Commission pursues added value from research and innovation that is thought to transcend the capabilities and concerns of single European states and organizations, creating an arena for collaboration between individuals, departments and organizations as well as countries. Furthermore, by encouraging collaboration across member states, the EU Commission's strategy is to promote greater cohesion and convergence of scientific and technological capabilities across Europe (Balland et al., 2019; David & Keely, 2003).

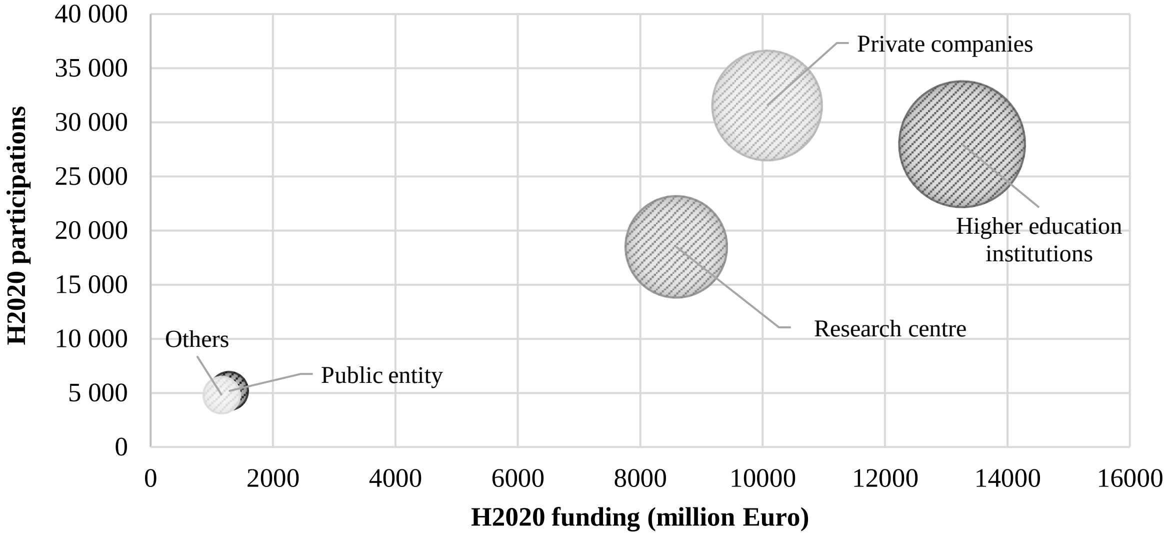
The calls for applications are typically pre-defined on a specific topic, inviting consortiums of at least three different organizations from different EU member states or associated countries to respond (European Commission, 2017). In addition, the funding is distributed in different types of instruments with different ambitions: *research and innovation actions* (RIA), and *innovation actions* (IA). RIA are projects tackling clearly defined challenges, which can lead to new knowledge or technology. IA calls, on the other hand, are closer to the market and typically involve demonstration and prototyping. While RIA and IA deal with funding of research and innovation, a third instrument, *coordination and support actions* (CSA) covers coordination and networking of research and innovation projects. In addition to these calls, and new to H2020, is the SME instrument that seeks to support bottom-up innovative activities at the firm level (see European Commission, 2014).

2.2.2. Participation so far

Horizon 2020 has operated since 2014, and is in its final stage before it will be replaced by the next EU FP, 'Horizon Europe' (HEU) in 2021 (see section 2.2.3 for the outline of HEU) (European Commission, 2018c).

Halfway through its lifespan, in 2017, H2020 was evaluated by the EU Commission (see European Commission, 2017). The interim evaluation concluded that the FP has successfully promoted collaboration between organizations, scientific disciplines and sectors – with higher education institutions accounting for most of the allocated funding (Figure 2).

Figure 2. H2020 funding by participation, organization type.

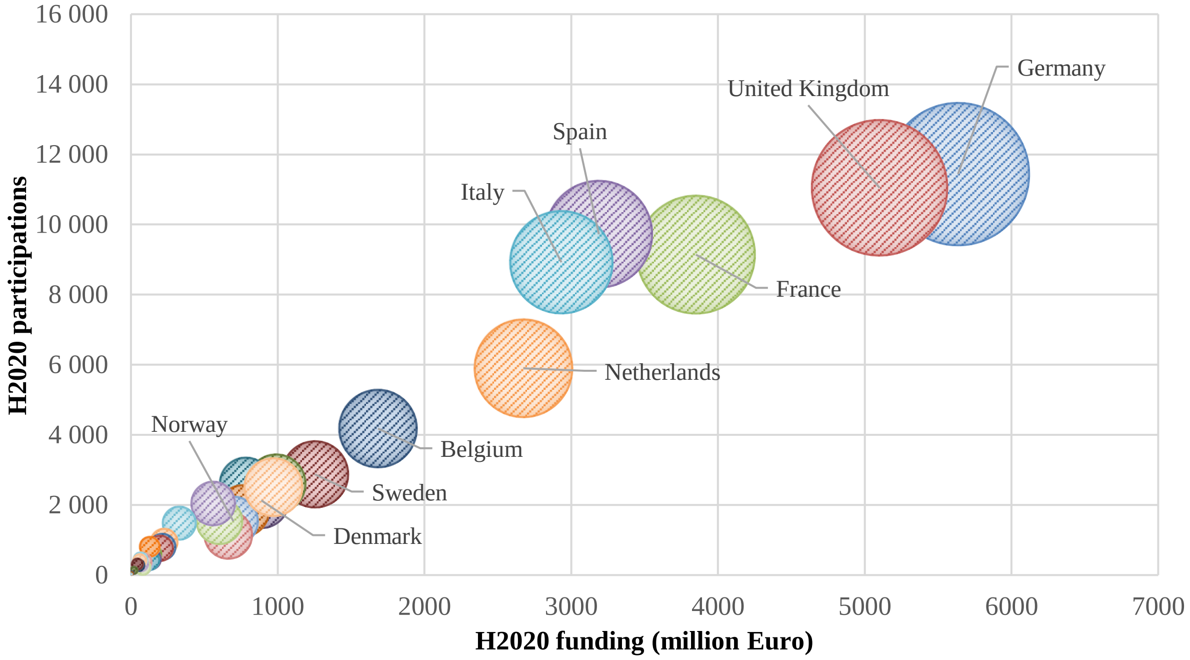


Note: EU 28 including associated countries and Switzerland. Source: webgate.ec.europa.eu/dashboard, data sample updated 19. October 2018.

By attracting the best research institutions in the EU, but also in collaborating with top scientists across the world, the first scientific publications were judged as world class – receiving twice as many citations as the average publication at world level (European Commission, 2017, p. 27). When it comes to supporting innovation, H2020 was assessed to have contributed to a large number of high quality, commercially valuable, intellectual property rights. H2020 projects generated a wide range of innovation outputs, including new technologies, products and services – for example supporting three of the leading vaccines used during the Ebola outbreak in 2014 (European Commission, 2015b).

The evaluation states that H2020 – to a greater extent than FP7 – suffers from oversubscription of high-quality proposals that otherwise would have received funding but did not because of limited budgets in certain calls (European Commission, 2017). As this is a waste of resources to many researchers, it can potentially lead to avoidance of EU FP calls and loss of research and innovation. Although the FP funds a wide range of stakeholders, including SMEs and many newcomers, a large share of the funding is still concentrated among a few players – a similar pattern was observed in the evaluation of FP7 (European Commission, 2015a). Concentration of funding as well as of participation can also be observed at the country level, where some argue an ‘innovation divide’ exists between old (EU15) and new member states (EU13), to the detriment of the latter (Pazour et al., 2018). See for example Figure 3, where countries such as UK and Germany account for the great majority of funding and participation. The recent study by Balland and Ravet (2018), shows that while several countries with similar size perform differently, the core of the network in collaborative projects – led by EU-15 states, i.e. the 'old member states' – remains stable over time.

Figure 3. H2020 funding by participation, countries.



Note: EU 28 including associated countries and Switzerland. Source: webgate.ec.europa.eu/dashboard data sample updated 19 October 2018.

2.2.3. The future research and innovation landscape

The next EU FP, Horizon Europe (HEU), has been called an 'evolution' and not a 'revolution' when compared to the current FP, which underlines that the broad lines of H2020 will remain (Roberts, 2018). The FP is intended to run for the next seven years following H2020, with a proposed budget of 100 billion euros (European Commission, 2018a).[6]

The three-pillar structure remains, but it has been revised into the following: the first pillar, "Open Science", will support bottom-up research projects through the European Research Council and MSCA, as well as infrastructures. "Open science" aims that access to data and funded research should be publicly available, and therefore looks to set up a European cloud as a repository. The second pillar, "Global Challenges and Industrial Competitiveness", seeks to reinforce technological and industrial capacities and fund a set of ambitious missions tackling some of society's biggest problems, for example Alzheimer's disease – see also

[6] 97.6 billion euros to HEU, and 2.4 billion to Euratom

Mazzucato (2018) for a discussion on how to adopt a mission-oriented approach at the EU policy level. The third pillar, "Open Innovation", aims to support market-creating innovation through including the EIC pilot from H2020 and the European Institute of Innovation and Technology.

In addition to the three-pillar structure, the proposal for HEU suggests several instruments that are intended for strengthening the European research area, hence "Sharing Excellence" and "Reforming and Enhancing the European R&I system" (European Commission, 2018a). These instruments are targeted at countries lagging in their effort to compete for and conduct research and innovation, and resemble the instruments in H2020 – for example "spreading excellence and widening participation".[7]

That the next FP represents an evolution and not a revolution compared to H2020 stresses the importance of learning from past successes and failures. Horizon Europe is currently in its final stages on the drawing board, and dealing with any issues in H2020 should be addressed in next EU FP wherever applicable.

2.3. Norwegian EU FP policy

Norway has participated since the first FP, but on a self-funding basis. Since 1994, with the European Economic Area (EEA) agreement that allowed Norway to become a full participant with equal rights to any EU member state, participation has grown (Hagen et al., 1997). As participation has expanded and the Norwegian government's commitment to the EU deepened, so the number and complexity of incentive schemes supporting domestic participation has increased in tandem (Gornitzka & Langfeldt, 2008; Langfeldt et al., 2012). Today, there is an outspoken goal to increase the degree of research and innovation funding channelling back to Norwegian entities (Norwegian Ministry of Education and Research, 2014), and the participation is seen in close connection to other national policies – for example the long-term plan for research and higher education (Norwegian Ministry of Education and Research, 2018).

The fact that Norway's contribution to the EU FP is calculated annually[8] and paid explicitly through the government budget has reinforced a policy focus on making the most out

[7] Recent developments in reaching an agreement on the next EU FP echo the importance of the 'innovation divide' in Europe, where 3.3 per cent of Horizon Europe's budget is suggested to support widening initiatives. Compared to 1 per cent in H2020, this proposal is a substantial increase. However, a final decision is pending an agreement on the next EU multiannual financial framework (Council of the European Union, 2019).

[8] The contribution is calculated based on a proportionality factor, which is Norway's gross domestic product divided by EU member states' GDP and multiplied by currency (Euro to Norwegian Krone). In addition, there is also a second round of calculation based on the actual used resources within the FP. It is estimated that Norway will contribute with approximately 18 billion NOK for the whole duration of H2020.

of the participation. This is also reflected in the growing body of evaluations on Norwegian participation in H2020, for example on collaborative networks (Piro et al., 2016), incentive schemes (Åström et al., 2018), and an in-depth analysis of the health, ICT and industry in H2020 (Åström et al., 2017).

The core of the Norwegian policy for participation, the “Strategy for research and innovation cooperation with the EU” sets out a quantitative target and four broad qualitative objectives for participation in H2020 and ERA (Norwegian Ministry of Education and Research, 2014). The government aims at reaching a return of 2 per cent of the total funding made available for competition by the end of H2020. In comparison, Norwegian participants brought home 1.67 per cent in total from FP7, amounting to 754 million euros. In March 2019, with 35 per cent of the competitive funding still reserved for future calls, the return rate stood at 2.22 per cent, an all-time high above the target and more than Norway collected from the whole of FP7.

Although the financial return is important, it is secondary to the qualitative goals for participation. First, that participation should increase the quality of Norwegian research and innovation and contribute to success internationally. Second, that it should contribute to increased innovation capacity, value creation and economic development. Third, that participation should help to improve social welfare and deal with major societal challenges. And lastly, that taking part in H2020 should help develop the Norwegian research and innovation sector, develop policies and instruments and forge new patterns of cooperation (Norwegian Ministry of Education and Research, 2014, p. 8).

2.4. EU FP specific studies

Ever since the first programme in 1984, EU FPs have ranked high on the political agenda due to the investments made into funding the programmes and because of the anticipated impact from participation. This has also motivated large parts of the academic literature to better understand the different aspects of participation – from converging policies, impact, collaboration, and determinants for funding.

Related to the interest from policy makers, a section of the literature has focused on the country level factors for participation, in particular the convergence between national and EU policies. Studies show that national R&D policies and instruments with a high degree of international orientation appear to mobilize domestic researchers (Dinges & Lepori, 2006). The positive effect of stronger convergence between national and EU R&D is supported by country-specific studies: in Norway (Langfeldt et al., 2012), France (Laredo, 1998), and Finland (Hakala et al., 2002), in addition to a non-exhaustive list of government contracted evaluations (see Åström et al., 2013). Although the commensurability of policies influences participation, studies at a lower level of analysis demonstrate that this is only a part of the picture when looking more closely at the participating organizations. For example, Lepori et al. (2015) and Geuna (1998) found only slight evidence of country level effects when studying participation among European higher education institutions.

Another portion of the literature attends to the additionality effects from participation rather than the determinants for accessing EU FP funding (Breschi et al., 2009; Luukkonen, 1998, 2000). Additionality is, in its simplest meaning, understood as the difference between what occurs because of policy support compared to what the situation would have been without it (Hall, 2002). Studies find that EU FP participation involves learning effects, or behavioural additionality, by generating new applications (Polt & Streicher, 2005), and also leads to increased scientific productivity (Defazio et al., 2009; Primeri & Reale, 2012), the transfer of knowledge and R&D (Di Cagno et al., 2014), and the support of networks which otherwise would not have been established (Matt et al., 2012). Recent research has even shown that the mere possibility of prestigious funding going to groundbreaking, individually-conducted, research influences how universities allocate their internal resources (Cruz-Castro et al., 2016; Edler et al., 2014).

Many of the studies of participation in EU FPs have been concerned with the networks and the collaborative structures underlying EU FP projects (Breschi et al., 2009; Breschi & Cusmano, 2004; Hoekman et al., 2012; Makkonen & Mitze, 2016; Must, 2010; Ortega & Aguillo, 2010a, 2010b; Paier & Scherngell, 2011; Pandza et al., 2011; Protogerou et al., 2010, 2013). The main message from these studies is the observation of stable scientific networks held by a small number of organizations over time resembling a oligarchic core, which has led others to suggest cumulative advantages or a 'Matthew effect' for those located at the centre (Breschi & Cusmano, 2004; Makkonen & Mitze, 2016; Protogerou et al., 2013).

Although most of the research is concerned with collaboration, a portion of the literature has shown interest in individual level grants, particularly those offered through the European Research Council (see Cruz-Castro et al., 2016; Edler et al., 2014; Hörlesberger et al., 2013; König, 2016; Laudel & Gläser, 2014; Luukkonen, 2012, 2014; Nedeva, 2013; Neufeld et al., 2013; Thomas & Nedeva, 2012). These studies focus on how this funding instrument has affected research organizations and the governance of breakthrough research (Cruz-Castro et al., 2016; Edler et al., 2014; Laudel & Gläser, 2014; Luukkonen, 2014; Thomas

& Nedeva, 2012), as well as what characterizes those that are awarded funding (Neufeld et al., 2013). Results from this last study show that researchers applying for this type of grant are already top tier scholars and there is no difference in terms of scientific productivity between those who are awarded funding and those who aren't – the distinguishing factor rather lies in the impact of their scientific productivity (Neufeld et al., 2013).

Finally, a smaller strand of research has studied organizational level determinants affecting participation (Geuna, 1996, 1998; Lepori et al., 2015; Nokkala et al., 2011). Focusing on higher education institutions, and one study of Spanish firms (see Barajas & Huergo, 2010), these studies emphasize the role of specific organizational characteristics on the chances for successfully participating in EU FPs. These are, for example, scientific capabilities such as scientific reputation and productivity, resources like the amount of researchers (Geuna, 1996, 1998; Lepori et al., 2015), and having previously participated in a EU FP project (Nokkala et al., 2011). Adding to the concern about cumulative advantages raised in the studies on EU FP collaborative networks, they demonstrate that only a few endowed HEIs account for most of the participation – institutions which are already among the highest ranked universities in Europe (Henriques et al., 2009; Nokkala et al., 2011).

2.5. Gaps and research focus

The main overarching research question in this thesis is *what explains research organizations' participation in H2020?* Following this, I set out to explain participation in collaborative R&D projects, and I focus on the underlying dynamics influencing participation. Guiding an answer to the research question are several uncharted aspects in the literature on EU FP participation. In combination with the theoretical framework, these unexplored elements are the focus of the papers appended to this introduction.

The first gap concerns the observation of oligarchic networks in EU FPs, where closely connected organizations participate together over time, and where the top performing institutions hold considerable repute, size, and resources. Results from two different strands on collaborative networks (e.g. Makkonen & Mitze, 2016; Protogerou et al., 2013; Roediger-Schluga & Barber, 2008) and on organizational characteristics (e.g. Lepori et al., 2015; Nokkala et al., 2011), suggest that an underlying mechanism behind EU FP participation could be accumulative advantage (see Merton, 1988). Hence, those organizations which are well off and connected experience success in retaining EU FP collaborative projects because these attributes act as a comparative advantage and are reinforced by increased EU FP funding to the detriment of those with less. So far, no study has addressed the underlying mechanism of accumulative advantage in EU FP participation and if there is a link between the network status of an organization and its characteristics on the chances of a successful funding application.

Closely related to the observation of persistent collaborative networks is another shortcoming in the EU FP literature. With the exception of a few studies on ERC grantees (e.g. Neufeld et al., 2013) and how EU FP grants affect researchers and their departments (see Primeri & Reale, 2012), there are few studies at a lower level of analysis that contribute to explaining participation beyond the statistical data. Therefore, little is known about how these networks can thrive, and what decisions are made by the organizations at the core of these networks to set up and manage new collaborative EU FP projects. Achieving a fuller conception about these networks can contribute to a better understanding of the participation pattern observed by studies on collaborative networks and organizational determinants.

The final gap concerns organizational level characteristics affecting participation. Currently, there are only a few studies examining the factors at the organizational level and, so far, none in H2020. Previous studies have provided interesting insights on what characteristics matter for successful participation, and found that the most endowed organizations outperform others (Geuna, 1996, 1998; Lepori et al., 2015; Nokkala et al., 2011). In part, this contributes to a better understanding of what characterizes the institutions that appear to exploit accumulative advantages in the competition for EU FP funding. However, in assessing the determinants for EU FP funding, these studies have done so without knowing if an organization in their sample has applied or not, only that some are successful in getting funding while others are not. First, not knowing what influences the decision to apply is a shortcoming as the motivation behind applying is equally as interesting as who actually wins the funding competition. Understanding what characterizes those that self-select to apply can have implications for both the literature and the policy seeking to support increased participation. Second, from a methodological point of view, not being able to show which group of organizations, in any sample, did not apply, may bias the results on what affects the chances for funding.

3. Theoretical framework

In this section, I will clarify the theoretical background that sets the stage for how I approach studying what explains participation in H2020. I will first give a brief account of the more fundamental side of collaborative R&D (section 3.1). Second, since I am interested in the underlying and dynamic factors explaining participation, I will examine the core literature on cumulative advantage, which addresses these dynamics (section 3.2). Third, to understand the decisions on how collaborative networks are set up and managed, I will present the framework of network orchestration in section 3.3.

3.1. Collaborative R&D

Research has become an increasingly collective activity for several reasons. First, it mirrors increased specialization in science where knowledge has reached a complexity outside single-investigator capacity (D'Ippolito & Rüling, 2019), a complexity which also applies to research organizations. New knowledge and innovation is discovered in-between firms, research organizations, universities and customers, rather than in any single organization (Powell, 1990). Second, there is a motivational[9] side attached to collaboration: from studies on innovation, it has long been established that collaboration can become a locus of innovation, supporting spillovers and facilitating the exchange of knowledge and technology (Faems et al., 2005; Powell et al., 1996), and can have a positive effect on research quality (see Rigby & Edler, 2005). Third, from a policy perspective, collaborative R&D is believed to save costs, and avoid duplication and fragmentation of research (Katz & Martin, 1997). Finally, the literature on collaborative networks – with research running from Simmel (1955), Merton (1957), Granovetter (1973) to Burt (1992) – shows that collaboration supports networks across organizations and individuals, and that there are benefits in having broad and diverse collaborations in terms of information, status, and resources. The success of these collaborative networks attract other researchers, thus increasing the growth and competencies of research teams (Parker & Hackett, 2012).

[9] I will not go into the micro-level motivations for collaboration in R&D. However, for a discussion on *instrumental motivations*, which refer to resource based rationales see: Beaver (2001); (Birnholtz, 2007; Duque et al., 2005; Katz & Martin, 1997). For *intrinsic motivations*, which refer to individual choice and preferences such as boosting productivity and personal gains, see Beaver (2001); Lee and Bozeman (2005) Katz and Martin (1997).

Collaboration as a research topic has been discussed in as many disciplines as collaboration occurs, and has developed into a major research area (Sonnenwald, 2007). Unsurprisingly, there are many definitions of collaboration, and in reaching a general understanding of research collaboration, Katz and Martin (1997) emphasise the unsatisfactory nature of collaboration – in that it may vary in different contexts, from a loosely connected community to a contracted project. That collaboration in science is referred to as, variously, research collaboration, collaborative R&D or team science, increases the complexity in defining it. Even so, the literature appears to agree that at centre of collaboration, is a "social process whereby human beings pool their experience, knowledge and social skills with the objective of producing new knowledge, including knowledge as embedded in technology" (Bozeman & Boardman, 2014, p. 2).

3.2. Cumulative advantage in science

In general, the scientific system tends to produce large differences between research organizations over time, awarding those well placed with more research funding, peer recognition and collaborative partners. Similar differences are observed in EU FPs, where large and endowed research organizations represent the most successful participants (Henriques et al., 2009), and where these organizations remain at the centre of successful collaborative networks, continually influencing power and attaining prominence in terms of network activities and composition (Breschi & Cusmano, 2004; Protogerou et al., 2013).

In this thesis, I seek to understand what explains participation in H2020 and in doing so I focus on the dynamic factors behind these differences. This leads to the literature that focuses on how such mechanisms produce inequality. Cumulative advantage theory has been applied broadly to describe differences among individuals and groups in society (see for example: Cole & Cole, 1973; Merton, 1968, 1988; Perc, 2014; Price, 1965, 1976). Its application can be traced to fields such as economics – with the notion of circular and cumulative causation (Myrdal, 1957) – to education (Stanovich, 1986), and to natural science (Sloman & Dunham, 2004). In essence, it describes how different processes, once they emerge, become self-amplifying in the absence of intervention, widening the gap between those who have more and those who have less (Rigney, 2010).

Robert Merton (1968) was the first to call out the phenomenon under the heading 'the Matthew effect' with reference to biblical passages[10] in his studies of the reward system in science.[11] Central to the theory are feedback processes as an underlying mechanism. Through a first positive event or 'tipping point', which can be sheer luck or a well-earned consequence, a self-reinforcing behaviour is induced, in turn influencing the occurrence of new events. Over time and through feedback, the outcomes from a sequence of smaller events gradually accumulate into major comparative advantage for some, depriving those who do not benefit from the events (Fox, 1983; Gladwell, 2000; Gulbrandsen, 2000).

In his studies, Merton found that prestigious scholars and institutions gain excessive attention and resources, which accumulate into further prestige and resources to the detriment of those with less stature. Although some view the effect as positive, serving to reward those who are successful (Cole & Cole, 1973), Merton (1988) was particularly concerned with the unintended and negative consequences for those less fortunate in science, in that advantages accrue based on reputation and not necessarily because of actual merit or quality. This means that reputed scientists would receive disproportionate amount of recognition (for example citations) for less significant work, compared to scientists with higher-grade contributions but less weighty reputations – ultimately resulting in the "inadvertent suppression of talent" (Merton, 1988, p. 613).

Cumulative advantage can be seen in many spheres. However, as this is not a universal law, it is not always the case that initial advantage leads to further advantage and the opposite for those disadvantaged. There are also relative and absolute effects (Rigney, 2010). In a zero-sum condition, where the total available resources are set, the well-off get more to the detriment of those with less who end up bankrupt as resources are depleted. This creates an absolute Matthew effect. However, in an open system where the overall resources are expanding, there is room for a win-win situation that benefits all parties, albeit at a different rate of growth. With the Matthew effect still in play, those who are well placed will accrue advantages at a greater margin, but not necessarily to the detriment of those with less (Rigney, 2010).

The Matthew effect has received much attention particularly at the individual level (see for example: Laudel, 2006; Van Looy et al., 2004; Viner et al., 2004) as well as in the literature predicting proposal success (e.g. Bornmann et al., 2010; Reinhart, 2009; van den Besselaar &

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[10] Merton's work (1968) on the Matthew effect in science is largely based on Harriet Zuckerman's later published studies of U.S. Nobel Laureates, see for example Zuckerman (1977).

[11] Later on, other studies have addressed different sides of the scientific system, for example gender differences in science, i.e. the 'Matilda effect' (Rossiter, 1993).

Leydesdorff, 2009). Still, Merton (1968), in his study of the scientific community observes that – like individuals – prominent institutions benefit from accumulative advantage. Elite institutions with strong scientific reputations and abundant resources will accrue more of those attributes, which makes them able to leverage their status in attracting better students and scholars, leading to mutual reinforcement. This shows that the Matthew effect is a very potent effect where different advantages work together in reinforcing each other, thus leading to the addition of new types of advantages (Van Looy et al., 2004).

The Matthew effect in science may not necessarily only apply to the researcher or the institution. It can also arise among networks of scientists or institutions through "invisible colleges". Invisible colleges are informal networks of researchers who form around a field of interest (Crane, 1972). These members tend to collaborate, cite and publish together, and because of that, they promote each other at the expense of those less connected or outside the network (Rigney, 2010). The notion of accumulative advantage in networks has spurred a strand of research within social network analysis, applying graph theory and its concepts in understanding the growth of networks (Abbasi et al., 2012; Newman, 2001; Perc, 2014). Central in this development are Barabási and Albert (1999) who translated accumulative advantage into "preferential attachment". They argue that new entrants to a network will not randomly connect to any pre-existing entity (i.e. researcher, institution), but will seek out those who are already well connected to others (i.e. reputation, networked). Over time, well-connected entities gain an even greater network to the detriment of those with inferior networks, essentially describing a Matthew effect in networks (Wagner & Leydesdorff, 2005).

In science, or in any other area, nothing grows forever. The reason why is because of what Merton (1988) called "countervailing forces" – either natural or constructed – that moderate accumulative advantages. In networks, the growth of networks is naturally limited by 'saturation' (Ghoshal et al., 2013) – a point where the network reaches a certain size and a peak level of linkages to the core entity such that it loses its attractiveness to those outside. In the economy, and in reference to Schumpeter's notion of creative destruction, the nature of competition itself ensures that no firm's success is stable as long as others are competing for dominance (see Schumpeter, 1994, pp. 81-87). On the other hand, in the scientific system, where oligopolies between institutions may gain resources and reputation, new governmental policies can be introduced to level out the inequalities – for example, by increasing the level of resources to those less equipped, creating new competitive programmes, or encouraging new collaborative constellations. In addition, the nature of the scientific system is also open enough so that any new entrant who makes a substantial new contribution that cannot be left unrecognized will accrue recognition, thus initiating a new feedback loop of accumulative advantage.

The Matthew effect is, in many ways, a phenomenon one would expect in any area where there is competition for resources, and because of that it has received its fair share of critique, for example Jon Elster (1990) who is particularly preoccupied with the fact that Merton only describes the consequences of behavioural patterns in science and makes no attempt to explain them. This critique applies particularly to the "latent functions", the unintended consequences of action. Therefore, he says: "[The] Matthew effect owes its fame, I believe, more to the lucky choice of phrase than to any surprising insights it has yielded" (1990, pp. 134-135). Even so, Merton's contributions on the Mathew effect have brought forth numerous studies in a wide array of fields, contributing to a better understanding of the processes behind inequality, for example in research funding.

3.3. Network orchestration

Even if actors' behaviour is influenced by the constraints inherent in processes of the accumulation of advantage and recognition-seeking, they still have to make choices about who to include in partnerships. From studies on collaborative networks in EU FPs, we know that persistent and close-connected networks of organizations retain large amounts of the available funding for collaborative R&D (Makkonen & Mitze, 2016). Second, from the literature on cumulative advantage we know that differences can also accrue among networks, between people and research organizations, for example through preferential attachment where those most connected are sought for (Barabási & Albert, 1999). Studies of collaborative networks have also demonstrated that centrally placed organizations in networks have greater chances of absorbing and diffusing complex information, resolving disputes, and holding the power to grant entry to newcomers to the network or not. Organizations lacking such connections fail to keep pace and fall behind (Powell, 1998; Powell et al., 2005). In other words, these centrally positioned organizations act to maintain and reinforce these networks. To understand how these organizations exert influence within these networks and how that could explain participation in H2020, I use a conceptual framework that spins out from network theory and describes how well-placed entities in a network build and manage networks, focusing on a series of objectives (Dhanaraj & Parkhe, 2006).

The network orchestration framework is a relatively new addition to the literature on the management of innovation (see Gausdal & Nilsen, 2011; Hurmelinna-Laukkanen et al., 2012; Levén et al., 2014; Nätti et al., 2014; Sabatier et al., 2010). However, it is not the only approach attempting to understand how collaborative networks are organized. Similar conceptual applications are, for example, “strategic networks” (Gulati et al., 2000), “valued networks” (Kothandaraman & Wilson, 2001; Möller & Svahn, 2006) and “anchor tenant firms” (Agrawal & Cockburn, 2003). Although this management-oriented framework regards the hub or the orchestrating entity to be an innovating firm, it has also been demonstrated to be useful in understanding the orchestration of other types of entities. For example, Batterink et al. (2010) studied collaboration between firms and research organizations, and Leten et al. (2013) investigated a research and technology organization.

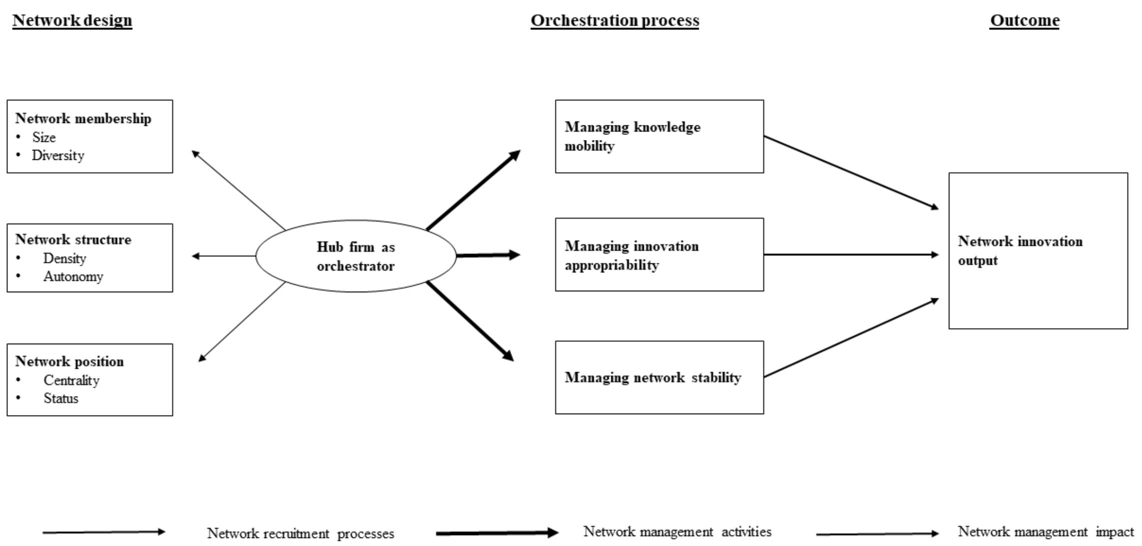
The framework, as first introduced by Dhanaraj and Parkhe (2006), is motivated to describe and enhance an understanding of how some firms over time enjoy influence in a network, and how they are able to build, preserve, coordinate and exploit collaborative networks towards a common goal. Within each network, and because of its attributes as well as its central network position, there is a designated ‘hub’ that exerts influence over the network members and orchestrates the network (Ritala et al., 2009). The framework provides a detailed perspective of the micro-level decisions affecting the formation and management of collaborative networks. How the hub chooses to organize and invite partners may say something about what influences participation. Additionally, how the hub orchestrates or manages the network once it is established, and to the extent they are successful in it, will say something about the survival of the network over time, as well as the reputation of the hub.

The orchestrator deals with two phases (see Figure 4) towards achieving an outcome from the collaboration. The first phase concerns the establishment of the network, or the ‘network design’.[12] With the intention to establish a network – a research project for example – the hub responds to three different objectives. The first objective is deciding the number of members as well as their diversity in terms of different competencies. For instance, is it necessary to include the whole value chain or just a group of scientific institutions? The second objective is to define the network structure. The hub must decide on the density and the autonomy of the members that constitute the network. For example, should partners who know each be placed together so as to build on strong and existing relations? Alternatively, should new partners work closely together, which could create new relations? The final objective in designing the network is network position. It refers to the centrality and status ascribed to the

[12] Although network design involves the selection of partners, i.e. recruitment, it does so in a broad sense with a focus on what is optimal for the network. For a review of the factors affecting the recruitment process in R&D projects, see Doz et al. (2000).

hub itself by the network members, and challenges the hub to leverage its reputation in attracting partners as well as symbolizing its own capability as an orchestrator in successfully managing collaboration (Batterink et al., 2010; Levén et al., 2014).

Figure 4. Network orchestration framework. Adopted from Dhanaraj and Parkhe (2006, p. 661).



Once the network is established, the challenges related to orchestrating the network are rooted in dealing with three management objectives: knowledge mobility, innovation appropriability and network stability (Dhanaraj & Parkhe, 2006). First, in managing knowledge mobility, the hub must ensure that each of the network members are able to identify, absorb and assimilate knowledge from each other, i.e. what Cohen and Levinthal (1990) called "absorptive capacity". This can be promoted through reinforcing a common identity among the members through socialization, which will strengthen the members' social and relational capital (Dyer & Nobeoka, 2000; Hurmelinna-Laukkanen & Nätti, 2012; Levén et al., 2014; Nätti et al., 2014). Managing innovation appropriability is the second objective, and the hub must ensure that collaboration in the network is achieved without any concerns of free-riding or opportunism, as this would impair the willingness to share knowledge (Nätti et al., 2014). In addition, both legal and social contracts must be put in place and communicated to mitigate any concerns. At the same time, protecting information should not hamper communication. The final objective is to manage the network's stability. Similar to how the hub's reputation as an orchestrator secures recruitment to the network in the first phase, the hub's past performance as a skillful orchestrator shores up commitment in the second phase. The hub must therefore communicate the benefits of staying with the project, and lead members of the network to anticipate them – for example new projects and access to the network.

4. Methodology

In this section, I will clarify and describe the empirical data that I have collected as well as how I analysed it. For a detailed description of the data and specific methods, I refer to the appended papers. I will first give a description of the quantitative data corpus used in all three papers (section 4.1), followed by the methods that underpin my quantitative analyses (section 4.1.1). Then I will clarify what qualitative data I have collected and the underpinnings for my analytical choices, in addition to discussing their validity (section 4.2). Table 1 briefly summarizes the empirical data and the analytical steps taken in each paper. Finally, I will briefly address how I have dealt with the ethical sides of doing research as a public sector PhD candidate, embedded in the Norwegian Ministry of Education and Research (section 4.3).

Table 1. Overview of papers, methods used and the data corpus

	Paper 1	**Paper 2**	**Paper 3**
Type of study	Quantitative study of the total population of Norwegian public research organizations' propensity to apply and probability to get funding in H2020	Quantitative study of European HEIs and determinants for applying and achieving funding in collaborative projects, with a particular focus on the network effects.	Qualitative study of project design and management among the ten most central organizations awarded grant funding in H2020, under the ICT programme.
Data	**Outcome variables**: Ecorda, covering applications and funded projects in H2020 matching the population (N=231) **Independent variables:** - EU FP participation from Ecorda (FP6 and FP7) - National funding schemes from Research Council of Norway (2013–2015) - Bibliometric data from SciVal database (2010–2014) - Bibliometric data from Norway Science Index (2013) - Organizational data from NIFU (2013)	**Outcome variables:** Ecorda, covering applications and funded collaborative projects in H2020 matching the population (N= 2216) **Independent variables:** - Organizational data from ETER (2013–2014) - EU FP participation from Ecorda (FP7)	- Ecorda, covering funded project collaborations in the ICT programme under FP7 and H2020. - 15 semi-structured interviews with project coordinators from central organizations
Methods	Two-step regression: - Step 1: Logistic regression	- Social network analysis of collaboration in FP7	- Social network analysis of project collaboration in FP7

	- Step 2: Zero-inflated Poisson	Two-step regression: - Step 1: Zero-inflated negative binomial regression - Step 2: Negative binomial regression	and H2020 to uncover the most central organizations - Semi-structured interviews - Pattern matching and coding

4.1. Registry data

In this thesis, I have extensively collected, structured, and analysed registry data. A common property of registry data is that it is not necessarily intended for research but for administrative purposes and typically collected by a public authority (Mellander, 2017). Examples are health documentation, public funding to higher education institutions and censuses. One of the noticeable features of registry data is that it is very often population data, hence holding information about the total population of applicants, beneficiaries, or taxpayers. In that way, it can be easily matched with other datasets if there is a common and consistent identifier, for example organization name or social security number. However, there are some downsides to using registry data. First, it may require a fair amount of handling due to duplications or errors, and second, it can be expensive to acquire. In recent years, new datasets have been collected, cleaned, and published for the purpose of research and policy. For example, on science and technology indicators, the RISIS project (risis.eu) has made detailed and comprehensive datasets available for innovation policy studies.

All three papers rely on registry data from the European Commission's external database, Ecorda, for the empirical analyses. The database contains information on funded research and innovation projects in all the EU FPs and is similar to what is publicly available through the Community Research and Development Information Service, CORDIS (cordis.eu). However, the database differs from CORDIS in two respects: first, Ecorda holds information not only on funded projects (i.e. contracts) but also on applications and their grant status – i.e. whether the proposal received funding or not. However, information about applications is covered by rules of confidentiality, and must be published in an aggregated form to comply, which means no names are to be disclosed. Being employed in the ministry has eased this access. However, this is not to say that access to this database is exclusive. Although more tedious to access, it has been used by several studies of EU FPs (see for example: Barajas & Huergo, 2010; Breschi et al., 2009; Must, 2010; Ortega & Aguillo, 2010b; Piro, 2019). Because of the confidential data, it has been important to describe the data in such detail that succeeding studies can trace the choices made and replicate my results. The second benefit with Ecorda is that the database is readily updated compared to its public sibling, CORDIS. This has been crucial in order to have as many observations as possible when analysing participation in H2020. If I were to rely on CORDIS, this would have affected the statistical analyses in terms of allowing very few observations of applications or funded projects. However, relying on the most recent data that is available through Ecorda also has a downside. The registry data, and particularly the application data, are riddled with errors – commonly misspellings of institution names and duplicates. This also applies to the data on contracts although to a lesser extent. Even so, checking names and cleaning the data has absorbed much of the time in preparing it for analysis in all three papers. In particular, breaking the data down to the faculty level involved numerous manual searches to allocate the application to the correct faculty.

Data from Ecorda that identifies successful and unsuccessful applicants at the organizational level made it possible to match it with data on two different populations of research organizations. The first is the population of public research organizations in Norway (collected from the Nordic Institute for Studies in Innovation, Research and Education [NIFU]), and the second is a comprehensive dataset of 2,216 European higher education institutions covering 27 countries (from the European Tertiary Education Register, ETER).[13]

In addition to Ecorda, I collected registry data to supply the analyses with independent variables, identifying different characteristics of the studied organizations. The collected data encompasses information on allocated research grants from the Research Council of Norway (RCN), publication points from the Norwegian Scientific Index (cristin.no), different R&D statistics from NIFU, bibliometric data[14] from Elsevier's SciVal database (scival.com), and organizational characteristics from ETER.

4.1.1. Quantitative analyses

The rich data available made it possible to find and distinguish between three types of organizations in a given population: those that do not apply, unsuccessful applicants, and successful applicants. This allowed for a two-step analysis,[15] where in the first step I assessed which organizational characteristics affected the decision to apply for EU FP funding. In the

[13] Eter-project.com – this database is part of the RISIS-project, collecting and disseminating science and technology indicators for future research.
[14] 'Bibliometric' data goes also under the name of 'scientometrics' and 'infometrics'. For a discussion on the similarities and differences see Hood and Wilson (2001).
[15] Depending on the structure of the data and the outcome variables, I employed different quantitative models and associated tests in the different papers. All statistical estimations were conducted with the software, STATA.

second step I removed those that did not apply, assessing the same characteristics but on the outcome of receiving funding. The ability to account for self-selection in the second step of the analysis was important, as not controlling for those who did not take part in the competition for EU funding would have biased the results – a well-known problem highlighted in the econometrics literature on selection bias (see Heckman, 1979).

The second main quantitative exercise in the papers was social network analysis because it made it possible to quantify the importance of each organization compared to others in the network. People in general interact with each other, and in doing so they establish certain preferences as to who they prefer to collaborate with (Abbasi et al., 2012). Whether these preferences relate to trust, convenience, culture or strategic reasons varies. However, what is clear is that consumers have preferred brands, buyers have their suppliers, and scientists have their co-authors. The pattern of connections forms a network with direct and indirect linkages, and from this, it is possible to assess each entity's relative importance. Some have less influence over the decisions made in the network, while others – through direct and indirect linkages – leverage influence (Newman, 2008; Scott, 2012; Wasserman & Faust, 1994). With greater influence, these entities can also accrue further advantages, for example by gaining an even stronger network position through the process of "preferential attachment" (see section 3.2). Thus, neglecting the social network component when trying to understand what explains participation in collaborative R&D would have been a caveat. The purpose of applying social network analysis in this thesis was twofold. First, for the quantitative analysis in paper 2, it was used to assess the effect of an organization's network position on the chances to apply and get H2020 funding. Secondly, it was used in paper 3 for finding the most centrally positioned organizations in EU FP networks for a later qualitative analysis.

4.2. Qualitative methodology

To understand the decisions that are made when research organizations build and manage their research projects, as well as why stable collaborative constellations occur among EU FP projects, I decided to narrow the analytical attention from a quantitative focus to semi-structured interviews with project coordinators in one of the papers. Although quantitative studies can provide a detailed description of how collaborative networks evolve, they can only explain to a limited extent the decisions that result in these networks. This is for example evident from the many studies of collaborative patterns in EU FP funding (see section 2.4).

Therefore, to understand how research projects are designed and managed I chose to follow a qualitative approach because it captures more of the decision-making complexity than its quantitative counterparts.

I decided to design the study on project coordinators as a case study, as this is an adequate guiding tool for answering both *how* and *why* questions (Yin, 2014). I followed a 'two phased approach' in selecting informants (Yin, 2014, pp. 95-96). The first stage involved collecting a large amount of quantitative data about the entire pool of possible informants (in this case funded collaborative projects in FP7 and H2020). Then in identifying those who would be interesting for interviews, a selection criterion had to be set, so as to reduce the pool of candidates. Because the literature on network orchestration (see section 3.3) regards the central hub as the entity that orchestrates a network, I conducted a social network analysis and identified the most central research organizations in collaborative EU FP projects. In the second step, I selected project coordinators from these centrally positioned organizations. In this selection, I relied on the principles of "purposive sampling" (Luborsky & Rubinstein, 1995), which means that I assumed that the informants are representative because they hold the designated leadership in the project, in addition to being employed in one of the organizations of interest.

The two-phased approach is considered an adequate tool to ensure reliability and that the results are applicable outside the sample, i.e. external validity. However, in this particular situation, in selecting project coordinators for interviews there was no opportunity in advance to screen each informant on whether they were completely new to the role as a coordinator or experienced. This means that some of the coordinators had many years of experience, while others had considerably less. Since all informants were in fact coordinators and affiliated to one of the central organizations, they offered information on how their projects were put in place and managed. However the richness of the information varied considerably.

Semi-structured interviews, transcription, coding, and the final analysis followed the selection of informants.[16] Each semi-structured interview followed an interview guide, which was structured similarly to how Dhanaraj and Parkhe (2006) display their model of network orchestration (see Figure 4). First, asking open-ended questions of how the project was set up, from the conception of the idea to the submitted proposal, and then how it was managed and how any challenges during the project were tackled. Once all interviews were completed, I transcribed and coded them. The subsequent coding was done in several sequences, not in terms

[16] See paper 3 for a detailed description

of counting occurrences but with the intention of capturing each respondent's perception and reasoning as regards how they dealt with the different tasks of orchestration (Saldaña, 2015). The information was analysed using pattern matching logic, which is based on comparing the empirical data to the theoretical assumptions about the same phenomenon (Trochim, 1989; Yin, 2014). Using pattern matching as a tool, especially if the observational realm coincides with the theoretical realm, helps to increase the study's internal validity (Yin, 2014).

4.3. Ethical considerations

There are certain ethical considerations that I wish to address in this project. My PhD project is part of a scheme supported by the Research Council of Norway (RCN). The RCN co-funds PhD projects for employees in the public sector with the intention of increasing the level of research-based knowledge in-house. To qualify for the scheme, the topic of the thesis has to be at the core of the international policy agenda of the Ministry of Education and Research. Because I work in the ministry, the close relationship may raise concerns about impartiality and my autonomy. In some respects, this research resembles contracted research, which is particularly vulnerable to impartiality qualms (Kalleberg, 2007; The Norwegian National Research Ethics Committees [NESH], 2016). I acknowledge that the choice of topic, specifically on H2020, was a mutual decision as an improved understanding of participation is important to the ministry. However, in my research I have attempted to detach myself from the ministry. From early on in the project, my colleagues and I have discussed the importance of maintaining autonomy over the decisions taken in the project. This means that the ministry has had no say on any of the choices taken in the initial research processes or over drafting the research design. However, as I encourage 'organized scepticism' in research – that science is to be open to scrutiny and falsification (Merton, 1973a), opening up for critique has been important. Therefore, my colleagues in the ministry have been given equal opportunity, together with those at the university, to comment and review earlier versions of the work. In addition, two of the papers have gone through double-blinded peer review in international journals before publication and the third is under review. This has been an effective way to ensure that my research is assessed according to high scientific standards, independently from the interests of my own employer. Through continuous reflection and actions, I hope to have conducted this project in line with the general ethical standards in science, seeking impartiality and opening up for critique.

5. Summary of papers and results

In this section, I will summarize each of the three appended papers. In these summaries, I will present the main motivation, followed by the theoretical and empirical background. Then, I will outline the data used and empirical methods chosen, before presenting the main results.

5.1. Paper 1: Who gets Horizon 2020 research grants? Propensity to apply and probability to succeed in a two-step analysis.

In the first paper, we aimed to advance the understanding of what determines participation in EU-funded research among the population of public Norwegian research organizations. We focused on the eighth European framework programme, Horizon 2020, which entered into the European landscape in 2014 proposing to devote almost 80 billion euros to research and innovation over the next six years. To Norwegian policy makers, increased participation in EU FPs has been placed at the centre of their research policy agenda, and there is a need to understand what drives participation (Norwegian Ministry of Education and Research, 2014).

In this paper, we engage in the debate on the effect of organizational-level factors for EU FP participation (see Geuna, 1996; Geuna, 1998; Hakala et al., 2002; Henriques et al., 2009; Lepori et al., 2015). These studies have emphasised the observation of skewed distribution of funding to a few endowed HEIs, suggesting cumulative mechanisms (Merton, 1968; Viner et al., 2004). Combined, these studies emphasise characteristics at the organizational level to be key determinants for successful project acquisition: scientific reputation and productivity, number of researchers, and funding. One caveat, however, is that due to the lack of data, these studies have not been able to separate an important step in research funding from the potential applicant perspective – the decision to apply or not. In our paper, we hold that to understand which organizational factors affect the chances for success, it is important to understand which factors influence the decision to apply in the first place.

We focused on the population of Norwegian public research organizations, consisting of university colleges, universities, research institutes and university hospitals. We collected data on all project applications (successful and unsuccessful) to H2020 in addition to data on funded projects from FP6 and FP7, matching it with the population of organizations (at the faculty level for the eight largest universities). The data collected for H2020 is unique in that it enabled us to separate the population into three different groups: those that do not apply (i.e. step 1), and those who are either successful or unsuccessful applicants (i.e. step 2). In addition, we collected R&D statistics at the organizational and faculty level from the Nordic Institute for

Studies of Innovation, Research and Education and NIFU (foustatistikkbanken.nifu.no), gleaned information on project grants from the Research Council of Norway, and added bibliometric data from Elsevier's SciVal database (scival.com) and the Norwegian Scientific Index (cristin.no). We employed a two-step econometric analysis of the likelihood of applying and the probability of success, focusing on three main explanatory dimensions: prior participation in EU FPs, complementary national funding, and scientific capabilities (i.e. citations and publications adjusted by organizational size).

Results show that earlier participation in EU FPs, in addition to the availability of national funding, positively affects the decision to apply. We also found that with greater size (i.e. number of researchers), the organizations enjoy scale effects in the phases of developing and administrating new applications to H2020. However, we observed a high scientific output to be negatively related with the likelihood to apply. This might be because some perceive the FP as too applied or bureaucratic and that other arenas of funding are preferred instead. In the second step, focusing only on the organizations that had applied, we found that the interaction of two main factors affected the chances of funding: prior participation and scientific reputation.[17] In both steps, we observed that prior participation is an important explanatory factor for new applications and for the chance of getting funding. However, with the data at hand, we cannot say whether this is due to learning effects and/or access to international networks for the first step, reducing the threshold to apply once more. Neither are we able to say for certain how this influences the evaluators in the EU Commission in deciding which project to fund. Nevertheless, it is likely that the evaluator will tend to prefer those applications where the candidates are able to demonstrate past successful EU FP participation.

5.2. Paper 2: Closed clubs: Network centrality and participation in Horizon 2020

The second paper is motivated by the observation of oligarchic networks in EU FPs, where closely connected organizations participate together over time (e.g. Makkonen & Mitze, 2016; Protogerou et al., 2013; Roediger-Schluga & Barber, 2008), and where the top performing institutions hold considerable repute, size, and resources (e.g. Lepori et al., 2015; Nokkala et al., 2011). The main assumption is that organizations with influential positions in FP networks will have a greater chance of success compared to others, and that this effect is reinforced by

[17] Although the way we measured scientific reputation (average number of citations) is considered a measure of output quality (Lindsey, 1989), a higher degree of quality output does also bear peer-recognition, and higher-cited organizations or individuals are likely to be sought after (Evans et al., 2011). A similar proxy for reputation was used by Lepori et al. (2015), while Nokkala et al. (2011) used university rankings.

the availability of increased resources and research capabilities. The underlying assumption in the paper is that through mutual reinforcement, the cocktail effect of advantages will – in addition to self-reinforcing – strengthen the disproportionate allocation of FP funding through what Merton (1968) dubbed the 'Matthew effect'.

I extracted a dataset on 2,216 European higher education institutions (HEI) from 27 different countries, from the European Tertiary Education Register (eter-project.com), covering the academic year of 2013–2014. The data contains detailed organizational-level statistics on research and education. I matched the data with project applications to collaborative projects in H2020, which I extracted from Ecorda. In addition, the sample of HEIs was matched to funded collaborative projects in FP7 from where I conducted a social network analysis, crafting a measure of how important each HEI had been relative to others under FP7, categorizing the HEIs into three groups – from a high level of centrality to none. The data was analysed in two steps, using the same explanatory variables. In the first step, I estimated the probability that the HEI would apply for participation in one or more collaborative projects in H2020. In the second step, after eliminating those HEIs that did not apply, I estimated the probability of a successful application.

The results show that network centrality has a strong positive effect on the likelihood to apply and achieve project funding in H2020. The group of HEIs holding the highest level of centrality have a far greater chance of obtaining funding compared to the other groups and account for the majority of successful project applications – both as partner and as coordinator. This means that those who already have a leading position in the EU FP continue on the same path. That the HEIs also prefer to collaborate with others holding a similar level of network importance suggests oligarchic networks. I also found a strong interaction effect between greater resources (number of researchers) and a higher level of centrality on the propensity to apply and participate. Once again, the effect is strongest among the HEIs with a high level of centrality. Together with greater size, these HEIs have the workforce needed for EU FP projects and the opportunity to select partners from a broad network. Thirdly, I found that increased research capabilities, together with network position, affect the chances to apply and take part. However, the interaction effect between scientific productivity and network position only holds a significant effect on the propensity to apply, while the interaction effect of scientific reputation affects both stages. I conjecture that strong research capabilities, together with an influential network position, might cause a symbolic effect, securing attractive HEIs access to consortiums and subsequent proposals. However, when it comes to funding, productivity symbolizes output, while reputation represents peer-recognition of the output and is more likely to play a part when the EU Commission selects projects for funding.

In the paper, EU FP funding is affected by the position an institution holds in a network, which is amplified in the presence of greater resources and scientific capabilities. Unfortunately, with the data at hand, I am unable to show whether EU FP participation is affected by non-meritocratic allocation of funding, or that networks, organizational characteristics and increased EU FP funding co-evolve based on accumulative advantage over time.

5.3. Paper 3: Orchestrating collaborative projects: inside oligarchic networks in Horizon 2020

The third paper is motivated by the notion that a few endowed organizations have been able to obtain large parts of the funding available in EU FPs over time, and that things have not changed in the current FP, H2020 (European Commission, 2017). From my two other papers as well as other studies (e.g. Breschi et al., 2009; Geuna, 1998; Lepori et al., 2015; Protogerou et al., 2013), we know from a quantitative point of view which factors affect participation at the organizational level and how networks play a part. However, what remains occluded are the decisions made by the scientists in setting up and managing their research projects.

In this paper, I focus on collaborative projects funded in the programme for information and communication technology (ICT), under H2020. ICT technologies are both complex and developing rapidly, creating a need for collaboration between multiple specialized entities. To guide the study, I followed the framework “network orchestration” (Dhanaraj & Parkhe, 2006). In line with this framework, I focused on the project and operationalized the ‘orchestrator’ as the project coordinator affiliated to the most influential organizations in the competition for EU FP ICT funding, and the orchestrated network as the funded consortium, i.e. a project. The empirical data consists of 15 semi-structured interviews with project coordinators affiliated to the 10 most influential organizations in collaborative EU FP projects under the ICT programme.

The results show that in establishing a project, the project coordinators co-develop the proposal while recruiting partners – starting with the best candidates in their own network and gradually extending invitations as the network grows with new members joining. When recruiting, expertise, capabilities and prior shared experience are valued. In particular, acquaintance is an important perquisite as it reduces the uncertainty of sharing information as well as ensuring some level of confidence between the members. This becomes a crucial element once the proposal has received funding and the partners need to be managed. However, the strategic choice of partners based on acquaintance is sometimes overridden. For example, if the consortium is in need of a specific competency, not available through their network, then the risk of involving newcomers might be set aside.

EU FP projects are not completely open-ended because the EU Commission defines the topic of the specific calls, which also limits the projects' scope, time, and budget. I found that the coordinator actively uses working packages (WP) in order to structure their consortium. With interdependent WPs, collaboration and cross communication is assured, in addition to the benefit that they offer some degree of autonomy for the WP partners. Although the coordinator lacks full authority in the project, as the consortium partners are also answerable to the EU Commission, any breach of confidence, appropriability agreement, or unwilling collaboration in the project may be sanctioned by the exclusion of that specific partner from succeeding consortiums. That much of the establishment and management of EU FP projects seem to hinge on pre-existing relations in order to effectively design and deliver on the proposed project goals in time and on budget, might explain why EU FP funding is concentrated among closely connected networks.

6. Discussion and conclusion

Although each individual paper can be read as an independent contribution, they all throw light on the overarching research question: what explains participation in H2020. In this section, I will discuss how they help to provide a better understanding of the underlying dynamics that affect participation. I structure this discussion in two sub-sections, addressing results accordingly at the organizational and the project level (section 6.1 and 6.2). Following this, I highlight how this contributes to the extended science policy literature that focuses on collaborative R&D as well as to the related literature on EU FPs, accumulative advantage, and network orchestration. In section 6.4, I address the thesis' policy implications, and finally (in section 6.5) consider the main limitations of this thesis and how future research can address them.

6.1. Organizational-level factors

As highlighted in the introduction section, in obtaining collaborative R&D from EU FPs, research organizations have to deal with several complex decisions about allocating and investing resources, selecting partners and accessing networks, all under the uncertainty of the competition for funding. The literature on EU FP participation demonstrates that several aspects characterize successful organizations in EU FPs, for example that they are located in certain networks, hold a strong scientific reputation, and are of sufficient institutional size. This body of research is mainly concerned with the final phases of taking part in collaborative R&D, hence the funding phase. However, an essential premise for taking part in the competition for funding is the self-selection phase, where an organization decides whether to apply or not.

One factor that influences the decision to apply is national funding. On a general level, this echoes arguments put forth by more policy-oriented literature suggesting a mobilizing effect towards EU FP participation from national funding sources (Hakala et al., 2002; Langfeldt et al., 2012). This means that national funding may act as a complementary asset in supporting application efforts if national priorities support synergies with EU funding. National funding might also offer opportunities to establish networks and strengthen capacities of the research organization, which over time can increase the likelihood of EU FP collaboration. A more practical aspect of national funding is that it empowers the organization, making it possible to allocate resources internally for the time needed to prepare EU FP applications (cf. Laudel, 2006). More funding also allows the organization to finance administrative resources for supporting the practicalities of drafting an application, for example employing specialized personnel on EU funding.

Second, previous participation in EU FP projects increases the chances of further applications. From previous experience, organizations have invested time and resources in how to apply and perhaps accessed relevant EU FP networks, thus reducing the effort needed for a new proposal. In addition, past participation, if experienced as something of value, motivates new effort.

Unfortunately, I am not able to provide a complete picture of why some organizations choose to opt out from applying EU FP projects, although I did observe that research organizations with a high number of scientific publications and previous EU FP experience did not apply for the first years of H2020. Even so, I was unable to find similar results later on in H2020, which suggests that some of these experienced and highly productive research organizations had not applied yet – for various reasons such as the relevance of the first calls or being too preoccupied with other ongoing projects. Furthermore, less is known about what motivated participation in the first place, hence what affected the measure of 'EU FP experience'. However, it is reasonable to think that an initial motivation to apply EU FP funding was likely to be that it offered opportunities not available elsewhere. Second, this motivation might also change with new policy agendas. For example, the increased emphasis on climate and the environment, which was less important in the scientific agenda of the first EU FPs, might motivate participation from previously inexperienced institutions specialized in this field, and perhaps discourage others.

Research on participation in EU FPs asserts that the chances for success (i.e. the funding phase) are affected by greater organizational size and stronger scientific reputation (Geuna, 1998; Lepori et al., 2015; Nokkala et al., 2011). My results support this claim, but also add the importance of past EU FP experience and access to collaborative networks. Together, these factors appear to lend the already well-off organizations a comparative advantage in the competition for EU FP funding, enabling a potent and positive feedback loop that reinforces and expands the advantages. Consequently, these organizations gain an even more dominant role in EU FPs.

Looking more closely at one of the advantages, specifically the network, I find that organizations with similar network positions prefer to collaborate with others of similar status, i.e. homogeneous networks.[18] This contributes to understanding why other network studies observe the clustering of organizations in 'oligarchic networks' (Breschi & Cusmano, 2004; Makkonen & Mitze, 2016). That the number of participating HEIs has dropped from FP7 to H2020 and in favour of those most connected, adds to the concerns about one of the unintended consequences of the Matthew effect – where the accumulation of advantages acts to the detriment of those with less going for them, ultimately limiting the possibility for participation for those outside these oligarch networks.

At first glance, the observation of homogeneous networks among HEIs stands in contrast to preferential attachment, where entities prefer to attach to others more central than themselves, not to those of similar rank (Abbasi et al., 2012). Although the observation of the networks suggests homogeneity, it does not rule out the possibility that the organizations attempted – and failed – to attach themselves to stronger collaborative networks. Not counting the organizations holding the strongest level of centrality and already located among the top tier hubs, those with less network influence might have pursued stronger entities and their networks but encountered a brick wall and ended up together with peers of similar status. Another possible explanation for homogeneous networks might lie in the fields of research where the projects are located. For example, if an organization attempts to engage in a project within a field already known, then there is less need approach a more central organization. Instead, time and resources can be spared by choosing partners of similar status. If, on the other hand, an organization wants to enter a new field of research, accessing new knowledge and technology, a sensible strategy would be to seek out the most central partners as most of the information is routed through them in addition to their role as gatekeepers (cf. Abbasi et al., 2012; Breschi et al., 2009). From what I observed in the study of project coordinators, some organizations will succeed in accessing the networks of these central bodies – conditional on them contributing with some sort of expertise or capability judged as attractive enough by the hub and the network.

In his study of the Matthew effect, Merton (1988) was particularly concerned about its potential negative consequences: a situation where advantages would accumulate on a reputational basis instead of actual merit, which could lead to the repression of talent. In H2020, it is currently not possible to say whether this is the case as I have no detailed information on the evaluation of the project applications. Even so, I believe that the competition for H2020

[18] I find a slight tendency towards homogeneity in collaborative links (with a quantitative measure called 'homophiliy'. See paper 2), which is strongest for the group with the most influential network position.

funding as a whole follows more the path of a relative, rather than an absolute, Matthew effect – where both the well off and those with less experience positive accumulative effects, although at different levels. This is due to at least two reasons: First, and despite the fact that the total budget allocated to H2020 holds a set limit (i.e. a zero-sum scenario), the FP manages and allocates a substantial amount of funding allocated to a broad range of topics cutting across research and innovation. Furthermore, the funding is allocated following priorities set in multi-annual working programmes, which enables the EU Commission and its stakeholders to shift priorities during the FP. The group of well-connected, reputed and large research organizations will retain its fair share of the funding, as research has shown. These institutions might even experience an absolute Matthew effect within specific topics where they are specialized. However, it is less likely that these institutions will have the capacity, or interest, to apply for all sorts of funding offered through the whole EU FP landscape. In addition, there are certain calls – for example the SME instrument (see section 2.2.1) – that have predefined recipients, ruling out participation from organizations such as large universities. Secondly, H2020 is not the sole source of funding, and comprises only a small proportion of the total funding available for European research organizations. With other domestic arenas supporting research in addition to the EU FP, the funding landscape is expanded and the concentration of competition reduced.

6.2. Project-level factors

An essential element of taking part in collaborative R&D is the research organization's ability to access or use a network of partners with enough expertise and motivation. The degree to which these organizations are successful in establishing and managing a viable consortium depends upon their position in a network, and organizations lacking such connections will fail to keep pace (Powell, 1998; Powell et al., 2005). In other words, these centrally placed organizations – as observed by research on EU FP collaboration (e.g. Breschi et al., 2009; Breschi & Cusmano, 2004; Makkonen & Mitze, 2016) – act to maintain and reinforce the stability of networks.

In their efforts to set up consortiums, project coordinators affiliated to the most central organizations rely largely on their network – both personally and through their organization. Partners are selected based on their expertise and capabilities necessary for solving the tasks promised in the project. This means that a partner will not be asked to join the consortium if they have no substantial contribution to make (cf. Breschi et al., 2009). Although this opens up for potential partners outside the network,[19] a main factor besides being competent is that they are known to the project coordinator, or any of the other partners, from past collaboration. That partners are recruited within the network is perhaps not very surprising, as it is less complicated inviting someone you already know. Even so, in EU FP projects, this strategy seems to be rooted in risk avoidance. In any collaborative project, there is always a chance that a partner might not do their job and are driven to participate for other reasons, such as exploiting funding or accessing new knowledge or technology without sharing (Gulati, 1995). So to reduce the inherent uncertainty in collaboration, partners are selected primarily by prior acquaintance, because previous behaviour is a primary indicator of future behaviour (Axelrod, 1984). Moreover, turning to the management of a collaborative project, past collaboration may support social and relational capital between partners, enhancing the likelihood of trustworthy behaviour (Ahuja, 2000; Gulati, 1995), and thus supporting the transfer of knowledge (Collins & Hitt, 2006).

A partial explanation for the intra-network recruitment strategy in EU FP collaborative projects relates to two exogenous factors. The first is the specific institutional environment surrounding collaborative EU FP projects. The EU Commission defines the topic, length and budget of any call, in addition to setting a minimum requirement to the composition of partners, as well as demanding regular reporting on progress. In itself, and compared to any other funding agency, this may not be unique. However, to the project coordinator, the regulatory control is experienced as reduced formal power. Therefore, to reduce the risk of any conflicts during the project and having to involve the EU Commission to sort things out, partners known to cooperate are preferred. The second aspect relates to the competitive nature of research funding acquisition. To cut time by not having to vet new partners or avoid running the risk of set-back in the drafting stages of the proposal or during the project itself, recruitment is rather done within the network or the "invisible college" (Crane, 1972). With greater uncertainty, Podolny (1994) argues along similar lines, entities are more likely to engage in repeated interaction with prior partners. Over time, this self-reinforcing behaviour contributes to explaining the skewed participation, which has led to oligarchic networks in EU FPs (Makkonen & Mitze, 2016).

However, being a part of a network does not necessarily mean that it is a fixed position, because the established confidence between the partners is somewhat unstable. For example, if the confidence in a partner is lost during the project, the project coordinators appear to

[19] See section 5.3 and 6.1 for a discussion on when coordinators invite newcomers to a project.

exercise social sanctions. This means that a partner can be excluded from future collaboration within the extended network of the consortium, at least to the coordinators' network. This threat appears to stabilize the consortium and secure adequate commitment and cooperation. Interestingly, these social sanctions also apply to the coordinators. Although, I find that their reputation plays an integral part of attracting members for their consortiums[20] and supporting difficult decisions during project, it may also be damaged if the coordinator is unsuccessful in managing the project. In other words, a partner's or coordinator's reputation is affected reciprocally – it can be enhanced by success and peer recognition but reduced by the lack of the opposite. However, this is not to say that a failed project resets the reputation to zero. It is reduced, but to what level will probably depend on the severity of the problem and the level of reputation before the incident.

6.3. Contributions to the literature

This thesis contributes to science policy studies, in particular to the branch of research interested in the dynamics behind collaborative R&D (Bozeman & Boardman, 2014; Cole & Cole, 1973; D'Ippolito & Rüling, 2019; Powell, 1998), by adding to the understanding of different dynamics affecting collaborative R&D in the context of European framework programmes. Results show that to apply and successfully participate in collaborative EU FP projects depends on a range of factors that increase the likelihood of being perceived as an attractive partner and research funding recipient – for example: scientific reputation, resources, past experience and sufficient access to a network. This is not to say that these aspects outweigh the content of the proposal, but rather play a part in concentrating those with strong comparative advantages together, establishing experienced and skilled consortiums. The results therefore add to one of the core theoretical contributions used in studying collaborative R&D, namely accumulative advantage (Merton, 1968, 1988). So far, accumulative advantage has received most attention at the individual level (e.g. Laudel, 2006), but its application in this thesis augments understanding of the stable participation pattern of already 'well-off' research organizations in collaborative projects (e.g. Breschi & Cusmano, 2004; Lepori et al., 2015; Protogerou et al., 2013). The results underline the importance of assessing a broader battery of factors, and their interactions, when studying collaboration in research and innovation.

[20] The process of attracting collaborative peers by reputation is similar to what network theorists describe as 'preferential attachment' (see section 3.2).

Second, by introducing a two-step approach in assessing participation and accounting for self-selection, the thesis adds to a more detailed and methodologically correct understanding of what explains participation. In general, this adds to the research on EU FP participation but also to the literature on the acquisition of research funding which would benefit from a similar methodological approach and account for self-selection (e.g. Boyack et al., 2018).

Third, this thesis contributes to a better understanding of how EU FP collaborative projects are established and managed. This perspective has, until now, remained unmapped in the literature on EU FP participation. In addition, it adds to the broader literature on collaborative R&D by describing how centrally positioned entities reinforce and reproduce their networks and their own chances for future funding. It also demonstrates the applicability of a conceptual framework traditionally applied to the study of innovative firm networks to publically funded R&D projects. However, more important are the results that point towards a deficiency within the framework of network orchestration. The institutional environment surrounding EU FP projects appears to constrain, or at least influence, the decisions made by the project coordinator in his or her efforts to build and manage projects. As the framework currently stands, the design does not account for how different exogenous conditions can affect the orchestrator's decisions. It is likely that similar external constrains also exist in the context of the more traditionally studied collaborative networks of firms as well. Furthermore, the notion of how regulatory control affects the participation dynamics in EU FPs, adds to the literature on accumulative advantage. To the extent of my knowledge, most attention has been directed towards how external aspects (natural and constructed) can countervail unwanted accumulation, and less to how they play a part in preserving it.

6.4. Policy and management implications

To national policy makers, EU FP funding for collaborative R&D is regarded as an important resource for the advancement of their domestic research organizations. This thesis contributes to explaining that there are a number of underlying factors affecting participation which should be addressed so as to design better and more efficient policies in support of mobilization and successful participation in H2020, and future FPs. How these incentives and new policies are designed and implemented should be decided independently, conditional on the different situations and compositions of research sectors across Europe. Nonetheless, there are certain implications of a more general nature from this thesis that concern the national policy maker, the research organization, and EU institutions.

To the research organization, there are several managerial implications to consider. First, seeking to increase participation in EU FPs, resources should be set aside and allocated so as to buy time from other responsibilities when drafting applications, for example from educational duties (cf. Edler et al., 2014; Laudel, 2006). Furthermore, this support should be differentiated based on whether the researcher seeks the role of a partner or a coordinator, where the latter requires more time and effort. Second, to lower the administrative burden of applying and managing an EU FP project, organizations should secure and provide adequate administrative support by recruiting personnel who are specialized in the practicalities surrounding the EU FP system. Third, in setting up new collaborative projects, researchers should be encouraged to look for partners not only within their own or their extended network but beyond, seeking out those with the best possible competencies, FP experience and networks. Furthermore, research organizations, and particularly higher education institutions, should also engage in collaborative arenas outside the EU FP as means to diversify their networks, for example through EUs educational programme ‘Erasmus+’. As of 2017, the ‘European Universities’ initiative offers funding for establishing bottom-up networks across Europe, enabling students to obtain a degree by combining studies at different institutions (European Commission, 2019). This does not only support students in building networks on their own – where some are tomorrow’s researchers – but also in establishing stronger links between institutions, which might prove useful in subsequent efforts to participate in EU FP projects.

At the national level, results underline the importance of domestic funding supporting research organizations’ efforts in submitting applications. Therefore, policy makers should look into their own funding systems and evaluate to what extent they support or hinder participation in EU FPs. In doing so, they should make sure that the topics supported at the national level do not crowd out, but complement, the research agenda at the EU level. At the same time, there is also a potential pitfall of too much national funding, particularly if it overlaps with the EU FP, in which case it can sap motivation for applying for EU FP projects (Annerberg et al., 2010; European Commission, 2009, 2015a). To strike a balance on national funding, policy makers could introduce performance-based allocation of basic funding (see Hicks, 2012), where research organizations are awarded additional funding for every euro won through EU FPs. However, a certain level of core funding should still be allocated to ensure that the organizations are able to build capacities and maintain other tasks, such as education and scientific activity deemed particularly important to the nation state.

To support domestic researchers in their efforts to access and strengthen existing collaborative networks, national authorities should look to how national research funding can support the development of international collaborative networks. Policy makers could, for example, develop specific calls for funding where international partners are encouraged to participate. As long as there are a minimum number of domestic partners in these consortiums, they might provide a stepping-stone for establishing competent networks for future EU FP participation within a research system familiar to the more inexperienced domestic researcher.

Finally, results from the thesis have several implications for policy at the EU-level. They show that the institutional environment, as applied by the EU Commission, in part results in self-reinforcing behaviour where partners in collaborative projects are selected based on prior acquaintance and competencies. In turn, this reproduces already successful networks and leads to oligarchy. In themselves, oligarchic networks do not necessarily require any policy intervention. However, countervailing measures should be taken if these networks become so dominant that they close off participation for those outside. In such cases, the EU Commission should investigate whether project calls could allow for less pre-defined proposals, similar to the ERC where less attention is given to steering the projects and the risk of failure is not necessarily a negative factor in the evaluation. Another measure would be to incentivize collaboration between newcomers and more seasoned participants in order to open up and broaden the established networks, for example grading proposals at a higher-level if newcomers are included. However, EU evaluators should be cautioned not to simply promote projects where newcomers are included, as this could be exploited for the sole purpose of reaching a higher grade. To avoid this, the EU Commission should devote extra attention to these partners in the evaluation process and grade the proposal accordingly by their level of contribution.

Second, that the already well-off organizations, in terms of resources and networks, accrue funding from EU FPs at a large scale and continue to do so in H2020, feeds into the debate about the "innovation divide" between EU15 and EU13 (for an introduction to the debate, see: Pazour et al., 2018). Currently, the EU's ambition to support both excellence and cohesion across Europe appears to be a trade-off in conflict. If the EU Commission wants raise the level of scientific and technological capabilities across Europe, it is possible that it would naturally tend to select consortiums with the strongest research institutions (David & Keely, 2003). This would give priority to networks with the highest average level of reputation. On the other hand, if it wants to support cohesion across Europe, so to reduce the "innovation gap", the Commission needs to encourage strong research institutions to collaborate with less advantaged organizations. This would increase the level of convergence, networks, and spillovers between the communities and across the divide. Currently in H2020, the programme "spreading excellence and widening participation" is designed to accommodate such interactions,[21] but unfortunately with limited resources.[22] Therefore, EU policy makers should adhere to the current consensus in the EU and ensure that this specific instrument is strengthened in the next framework programme. The EU Commission could also look more closely into how 'cohesion' and 'excellence' are valued and scored in the evaluation of project applications. Raising the value of cohesion, at least to the level of excellence in the handling of applications, could help to fund more projects that balance these ambitions.

Finally, strengthening institutions across Europe and particularly in countries with less well-off research organizations is part of the recipe for promoting cohesion. However, this task does not necessarily lie at the heart of the EU FP, which should support competitive collaborative R&D. A cure for the inequality revealed by the "innovation divide" rather calls for increased attention from national policy makers, in synergy with existing instruments, for example the European structural and investment funds supporting capacity building outside the EU FPs (European Commission, 2016; Pazour et al., 2018).

6.5. Limitations and suggestions for future research

There are two main limitations to this thesis. The first concerns the dynamic mechanisms behind participation in H2020. Instead of explaining participation over time, this thesis presents a snapshot of participation at a certain point in time. This means that I am not able to assess whether participation is affected by accumulative change over time, and particularly if the Matthew effect acts to the detriment of those less advantaged. In parallel, without a dynamic perspective, the thesis is not able to provide a more thorough insight into how collaborative networks evolve over time and give more complete picture of what affects the composition of these constellations.

[21] In H2020, to promote research excellence and to increase the reputation, attractiveness and networking capabilities, 'twinning' projects have been put in place to connect high-profile research institutions with poorer performing institutions (COWI, 2017).

[22] The budget for "spreading excellence and widening participation" represents only 1 per cent of the total H2020 budget (Pazour et al., 2018). However, in recent discussions on the next EU FP, Horizon Europe, policy makers have agreed on a current proposal suggesting increasing the budget to 3.3 per cent of the total (Council of the European Union, 2019).

Future research could tackle this challenge by collecting longitudinal data, preferably covering several consecutive EU FPs to accommodate for the stability in collaborative networks, changes in thematic priorities within the FPs, and more exogenous aspects like the 2008-9 financial crisis and the accession of the EU13-states in 2004. In addition, the data should also encompass all the different participating sectors as collaborative R&D cut across sectoral boundaries. Acquiring time series data for EU FP funding is possible, but complementing the dataset with population data for the different sectors so to account for self-selection would be demanding, in particular for profit seeking entities across Europe. To reduce the time and effort, future research could alternatively focus on specific sub-programmes instead of entire EU FPs. Another avenue worth exploring, which would support new insights into the micro-level decisions affecting the composition of collaborative projects and the dynamic processes influencing participation, could be to delve into more ethnographic research methods. For example from observational methods: following a number of researchers with various EU FP experience and observing their efforts in networking, setting up projects, negotiating and leading collaborative projects.

The second limitation in this thesis concerns the motives for participation among individual researchers. With the analysis of the choices made in setting up and managing collaborative projects, this thesis only scratches the surface of the individual decisions affecting participation. So far, little is known about the motives for taking part in EU FP projects. Besides the fact that EU FPs offer funding for research and innovation, what role does for example access to networks, the opportunity to define new standards, infrastructures, new markets or technology play in stimulating participation? Understanding the different motives could prove helpful in explaining why some choose not to apply, why some only participate once, or why some come back repeatedly. These insights would support future design and differentiation of national mobilizing schemes and support better synergies between national and EU funded research and innovation.

Future research could for example address this through mixed methods research: administering surveys to different populations of individuals (composed of non-applicants and applicants) and going deeper into their motivation (or lack thereof) for EU FP participation with the support of in-depth interviews. Such research should make sure to encompass individuals from a broad array of sectors, not primarily public research organizations addressed in this thesis, because the motives are likely to vary depending on whether the subject is a university researcher or a marketing director in a private company.

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APPENDIX

Article 1

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Who gets Horizon 2020 research grants? Propensity to apply and probability to succeed in a two-step analysis

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Abstract This paper presents a timely analysis of participation in the 8th European Framework Programme for Research and Innovation (EU FP) Horizon 2020. Our dataset comprises the entire population of research organizations in Norway, enabling us to distinguish between non-applicants, non-successful applicants, and successful participants. We find it important to distinguish two stages of the participation process: the self-selection stage in which organizations decide whether they wish to apply for EU funding, and the second stage in which the European Commission selects the best applications for funding. Our econometric results indicate that the propensity to apply is enhanced by prior participation in EU FPs and the existence of complementary national funding schemes; further, that the probability of succeeding is strengthened by prior participation as well as the scientific reputation of the applicant organization.

Keywords Horizon 2020 · EU Framework Programs · Research funding · Research policy · Higher education institutions · Public research organizations

Introduction

Since the first European Framework Programme (EU FP) was established in 1984 with the objective of strengthening scientific and technological collaboration in Europe, its importance has increased steadily (Breschi et al. 2009; Ortega and Aguillo 2010). The budget has grown from just below 4 billion Euros in the first framework program (FP1) to

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almost 80 billion Euros for the 8th and current Horizon 2020. With the establishment of the European Research Council in 2007, EU FPs have become a central source of funding for applied and basic research (Nedeva 2013).

With the increasing importance of EU research funding, national policymakers in European countries have put domestic participation in EU research at the center of the research policy agenda. In Norway, for instance, the government has explicitly stressed greater participation as an essential part of national strategies for internationalization of research. As of early 2015, Horizon 2020 had received 36,000 applications from all EU/EEA member-states; funding was granted to slightly less than 5000 of these. Norwegian researchers were involved in 1530 applications, but only 216 were granted funding. That amounts to 1.79 % of the available competitive funds—still below the national goal of at least 2 % (Norwegian Ministry of Education and Research 2014). For national policymakers, Norwegians and others alike, the need to understand what determines participation in EU FP, and how this can be strengthened, ranks high on the agenda.

Academic research has recently started to investigate the factors that affect participation in EU FPs. One of the factors noted in this research relates to the formation of collaborative networks and the enduring nature of these (e.g. Defazio et al. 2009; Protogerou et al. 2010). Some research organizations have been found to participate repeatedly in EU-funded research, and function as central nodes in EU FP networks (Paier and Scherngell 2011; Roediger-Schluga and Barber 2008; Protogerou et al. 2010).

Among the factors that have been investigated to explain these patterns, scientific capabilities of applying institutions (in particular, their academic reputation and scientific productivity) appear crucial (Geuna 1998; Lepori et al. 2015; Nokkala et al. 2011; Henriques et al. 2009). Another important dimension concerns the characteristics and structure of national funding, which may have complementarity or substitutability effects with international funding from the EU (Luukkonen and Nedeva 2010).

Due to limitation in terms of data availability, the literature thus far has analyzed the determinants of EU FP participation by focusing solely on the sub-sample of actual applicants, ignoring all the research organizations that decided not to apply for funding to EU FPs in the first place (e.g. because of lack of interest, time and/or resources). However, the latter group is relevant for this type of analysis. Knowing more about the research organizations that decide not to apply to EU FP may provide new insights on the underlying motivations for applying and the related obstructing factors.

Therefore, in order to advance our understanding of what determines participation in EU-funded research, we find it important to consider two distinct stages of this participation process. The first is the self-selection process, where some organizations decide to apply for funding, while many others decide not to. The second stage is the selection process carried out by authorities of the European Commission (EC), at the end of which some of the applicants are successful and are granted funding for one or more EU projects, whereas most other applicants are not. By distinguishing these two stages of the participation process, we seek to analyze the extent to which the factors highlighted in previous research have differing effects on the two stages of the participation process.

Our empirical analysis covers the entire population of Norwegian research organizations, using data on all 1402 applications submitted by Norwegian research institutions to Horizon 2020 (hereafter H2020) between 2014 and until early 2015. Aggregating these data at the organizational level, we match them with detailed national R&D statistics for the full population of public research organizations (PROs) and higher education institutions (HEI) in Norway, as well as registry data on whether they participated in FP6

(2003–2006), FP7 (2007–2013), and/or received national funding from the Research Council of Norway, RCN (2013–early 2015).

The empirical results show that the factors highlighted in the literature matter, but they do so differently in the two stages of the participation process: the propensity to apply to H2020 is enhanced by prior participation in EU FPs and by complementary national funding schemes; the probability of success in obtaining funding is strengthened by prior participation as well as the scientific reputation of the applying organization.

This paper is organized as follows: "Theory and hypotheses" section reviews the relevant literature on EU FP participation, and it points out our theoretical framework and hypotheses; "Context and data" section presents the empirical context, data and indicators; "Results" section discusses the econometric results; and "Conclusions" section summarizes the main findings and policy implications.

Theory and hypotheses

The literature on participation in European framework programs

Participation in EU FPs has come to rank high on national political agendas, motivating researchers to seek to understand the determinants and impact of EU research programs. The academic literature ranges from policy-oriented papers and evaluations to academic studies of the effect of EU FP participation on scientific productivity and innovation, as well as the organizational-level determinants of participation.

Much of the literature has focused on the establishment of networks and the collaborative structures underlying participation in EU FPs (Hoekman et al. 2012; Paier and Scherngell 2011; Breschi and Cusmano 2004; Protogerou et al. 2010; Defazio et al. 2009; Breschi et al. 2009; Roediger-Schluga and Barber 2008). This is because EU FP programs typically require collaboration between different research organizations and users in order for projects to be considered eligible for funding.

A part of the literature on collaborative networks has analyzed the additionality effects, in terms of increased scientific and innovative output, resulting from participation other than the formation of networks as such (Polt and Streicher 2005; Luukkonen 2000, 1998). Focusing on private companies, Matt et al. (2012) argue that EU FP participants are unlikely to contribute to radically new scientific knowledge, but are more likely to support networks in exploratory research than if the organizations form networks outside the EU frame. Defazio et al. (2009) hold that EU FP funding itself has a more direct effect on research productivity rather collaboration within the network. They found that it was only after the funding period had ended that collaboration affected the level of productivity.

Other studies, like Di Cagno et al. (2014), have held that EU FP participation has an effect on the transfer of knowledge and R&D spillovers. One case study of university participation echoes the results from company-firm oriented studies: according to Primeri and Reale (2012), the main output from participation was scientific papers, not commercial products or processes. The main argument for participation was the opportunity to collaborate with colleagues abroad, but also contribute to new scientific discoveries. A common result in studies of collaborative networks in EU FPs is the observation of continued persistence of some organizations that hold central roles in different networks continuously over time, indicating that prior participation matters for successful project applications (Protogerou et al. 2010; Paier and Scherngell 2011; Roediger-Schluga and

Barber 2008; Breschi and Cusmano 2004; Godø et al. 2009; Okubo and Zitt 2004; Makkonen and Mitze 2016). In particular, large, highly reputed European institutions seem to dominate as regards participation (Annerberg et al. 2010). Makkonen and Mitze (2016) argue that there exist well established oligarchic networks within the EU. Hence, even with new EU member-state participating in cross-country research, there are still strong networks among the large and older member-states. This has let several to suggest cumulative effects or a "Matthew effect" for organizations with already dominant positions in the research landscape (Protogerou et al. 2010).

The factors behind participation in EU research are complex and should in principle be investigated in a multi-level setting, simultaneously taking into account factors at the country level (characteristics of national science policy and research funding), the organizational level (strategies and funding characteristics of universities, faculties, research institutes, and departments), and the individual level (e.g. the capability and experience of the individual researchers applying for EU funding). All three levels of analysis are important and interact in complex ways. In practice, however, research has often focused on one level of analysis and neglected the others, depending on data availability and the specific objective of each study. Two sets of factors in particular have been discussed as possible determinants of EU FP participation, and for explaining the persistence and cumulative effects noted above.

One part of the literature has focused on country-level factors: the composition of national research systems and the national funding structure as a dimension affecting successful participations in EU FPs, investigating in particular whether there is commensurability between national and EU R&D policies (Dinges and Lepori 2006; Luukkonen and Nedeva 2010). National R&D schemes with a high degree of international orientation are said to have positive effects for building researcher capacity in applications to the EU (Dinges and Lepori 2006). Whether national policies are converging towards EU policies and if this promotes participation in EU FPs has been studied, as in the case of France (Laredo 1998), Norway (Langfeldt et al. 2012) and Finland (Hakala et al. 2002). The conclusions are basically the same: internationalization of national R&D schemes leads to greater mobilization and participation in EU-funded projects. For example, Langfeldt et al. (2012) found that for parts of the 6th and the 7th EU FP, where calls were closely related to Norwegian R&D policies and schemes, a high degree of participation was evident. By contrast, Lepori et al. (2015) and Geuna (1998) controlled for country effects, and found only find slight evidence of it affecting EU FP participation for European HEIs. Others (Okubo and Zitt 2004; Tijssen 2008) have argued that small countries (e.g. Ireland) are more oriented towards research collaboration in EU than larger countries (e.g. Germany) which tend to cooperate domestically or outside the EU. However, other researchers find that the patterns of small state–EU collaboration are far less homogeneous (Ukrainski et al. 2014).

Another part of the literature has focused on organization-level factors, emphasizing the importance of organizational characteristics and capabilities as key determinants of participation and success in EU FPs (Hakala et al. 2002). Drawing on the literature of cumulative mechanisms (Viner et al. 2004), Geuna (1996) have suggested that the participation process is driven by reputation of the organization. The few studies to deal with factors at the organizational level (Lepori et al. 2015; Geuna 1996, 1998; Nokkala et al. 2011) have shown that the distribution of participation is indeed skewed: a few universities account for most of the participation in EU funding in each country. These also tend to be among the top universities in Europe (Henriques et al. 2009). A key determinant, according to these studies, concerns the institution's level of scientific productivity—in terms of number of publications per full-time equivalents (FTE; measure of productivity) and number of citations per publication (measure of reputation, or scientific impact). Also other organizational-level factors appear to matter, especially the size of the applying organization, and its scientific field(s) (Lepori et al. 2015; Hakala et al. 2002; Geuna 1998). At the national level, Ukrainski et al. (2014, p. 854), argue that countries with high shares in overall scientific output collaborate more widely within Europe.

Hypotheses

Previous studies of the determinants of EU FP participation have focused on the organizational-level and country-specific factors that can explain why some project applications receive funding whereas others do not. These studies have typically made use of databases of organizations applying to EU FPs, often linked to other national data sources on the characteristics and capabilities of research organizations (e.g. Geuna 1998; Lepori et al. 2015). We follow the same general approach, focusing on research organizations as the main unit of analysis in the theoretical framework and empirical model. The decision to participate in EU-funded research, and the capacity to do so, entail complex processes that should ideally be investigated in a multi-level setting, studying the interactions between country-, organization- and individual-level characteristics. However, data on individual-level characteristics (such as research experience, the reputation of individual participants in EU applications) are often not available. For that reason, we have chosen to focus on public research organizations as the main unit of analysis.

One main issue with the standard empirical approach previously used in this field is that, due to the lack of relevant data, it has concentrated on those who actually applied for EU FPs funding, ignoring all other research organizations that decided not to apply. We hold, however, that, in order to understand what determines participation in EU-funded research, it is important to consider two distinct stages of this participation process. The first is the self-selection process, whereby some organizations decide to apply for EU funding while many others decide not to do so. The second stage is the selection process, in which some applicants are successful and are granted funding for one or more EU projects, whereas most other applicants are not. In other words, at any time, the population of research organizations in a given country can be divided into three distinct groups as regards EU funding: (1) non-applicants, (2) unsuccessful applicants, (3) successful applicants. The literature to date has focused on the second and third group, whereas we have had access to data for the first group, and this enables us to distinguish the two above-mentioned stages in the selection process.

We do not intend to introduce new explanatory factors, but seek to investigate the extent to which the factors highlighted in previous research have differing effects on the two stages of the participation process. Our empirical analysis takes into account many of the variables and control factors already investigated in the literature, but it focuses on the three explanatory dimensions emphasized in recent works: (1) whether the organization has previously participated in an EU FP project (indicating persistence and cumulativeness effects); (2) national funding characteristics (e.g. complementarities between national and EU funding schemes and R&D policy); and (3) organizational research capabilities (e.g. reputation and scientific productivity). We put forward three pairs of hypotheses, each focusing on one of these explanatory dimensions; further, we indicate whether they are expected to be more relevant in the first stage of the participation process, in the second, or in both.

First, we examine the role of prior participation in EU FPs. In line with the literature, we see this as a fundamental factor in strengthening the capacity of research organizations to get EU-funded projects. We argue that previous participation in FPs is an important determinant for both stages of the participation process, although for different reasons. In the first (self-selection) stage, when research organizations consider whether or not to invest time and effort in developing an EU project application, they make an assessment of the amount of time and resources they would have to invest in working on an application, and they compare these costs with the (uncertain) benefits that could accrue from participation. A first-time application to EU FP will entail a series of *sunk costs:* fixed costs (investments) that the organization must sustain in order to be able to apply for EU funding that first time—but these are costs the organization will not have to incur for subsequent future applications. Two types of sunk costs are relevant here. The first is related to the need to gather information and knowledge on the application procedure: the organization must build up specific administrative capacity for dealing with EU research. The second type of costs is instead related to network and team building. When a research organization wants to apply for EU funding for the first time, a major challenge involves finding suitable and competitive European partners in its field of research. This is no easy task, as the persistent and often closed nature of EU research networks makes it hard for new partners to be admitted into existing competitive networks. By contrast, an organization that has already participated in the recent past will not incur in these sunk costs: it already has in place the necessary administrative capacity and international network, making the prospect of working on a new application less costly and more attractive.

Once the decision to apply has been made, cost-benefit considerations will no longer be relevant, and the selection process will be affected primarily by the quality of the international project team and its application. These factors, in turn, are arguably strengthened by prior participation, since an organization that has taken part in an EU-funded collaborative project in the recent past has surely benefitted from *learning effects* concerning the application procedure, EU research priorities, and the quality of potential partners. These learning effects are likely to strengthen the organization's ability to submit a high-quality proposal and hence obtain funding. We summarize these arguments in the following hypotheses.

H1.1 Previous participation in FPs increases the probability that an organization will apply for H2020 funding.

H1.2 Previous participation in FPs increases the probability that an organization will succeed in getting H2020-funded projects.

Second, we shift the focus to national funding characteristics. As noted, the capacity of a research organization to participate in EU FPs may be affected by the characteristics and structure of national funding, especially whether there exist complementarities between national and EU funding schemes, and the degree of international orientation of national science and research policy. While agreeing with previous analyses on this point, we hold that the structure of national funding matters in the *first* stage of the participation process, not in the second.

Clearly, the availability of research funding serves as a primary motivation in the self-selection stage where organizations decide whether or not to apply to EU FP. On the one hand, with plentiful external funding to be obtained from domestic sources (e.g. RCN projects) there is less need to seek funds elsewhere. On the other hand, however, the availability of external funding from national sources may have complementarity effects, increasing the pool of resources that can be invested for international project applications. If the national authorities focus on the importance of EU programs in seeking to promote the internationalization of the national research system (as is the case in Norway and several other countries today), political priorities, discourse and specific financial support schemes may make a research organization more willing to invest time and resources in developing an EU project application.

However, these considerations are arguably not relevant for the second stage of the participation process. Once an organization has made a cost-benefit analysis and decided to submit a project application, the probability of success will not be directly affected by the structure and characteristics of national funding. The peer-review selection procedure conducted by the EC focuses on the quality and relevance of the project team and the proposal submitted, and it seems reasonable to expect the characteristics of national R&D policy to have little influence here. In principle, it could be argued that the experience with project acquisition and management gained by participating in national funding schemes can bring learning effects and perhaps foster the ability to obtain EU funds as well. However, that argument does not seem relevant for the specific case considered in this paper, as the procedures for project application and management in Norway (especially as regards the Research Council of Norway) differ from those adopted by the EC for H2020 projects. We therefore disregard the possible existence of learning and complementarity effects in the second stage of the participation process, and formulate our hypotheses as follows:

H2.1 Funding granted by national institutions increases the probability that an organization will apply for H2020 funding.

H2.2 Funding granted by national institutions does not increase the probability that an organization will succeed in getting H2020-funded projects.

Third, there is the role of organizational research capabilities, a factor that of increasing importance. It concerns two specific aspects: the scientific reputation of an organization (e.g. as measured by its citations and impact factor) and its scientific productivity (e.g. the number of recent publications or publication points). While finding this dimension generally relevant, we hold that research capabilities will matter differently in the two stages of the participation process: they will be largely irrelevant in the self-selection stage (or even go in the opposite direction from that indicated in earlier studies), but will be highly relevant in the second stage.

Regarding the first stage, when an organization makes an assessment on the opportunity to invest time in a new EU project application, the fact that the entity has a generally strong scientific reputation and/or productivity will not obviously increase its propensity to apply. On the one hand, EU research may be seen as providing opportunities to participate in international academic networks, which will in turn lead to expected benefits in terms of more publications and citations in the future. On the other hand, however, as researchers often point out, participation in EU projects is costly, requiring substantial time for managing and reporting procedures. Anticipating these costs, researchers—and talented and productive ones in particular—may be reluctant to become involved in EU applications because this type of activity may divert time and energy from basic and internally-funded academic research. If so, we argue, strong research capabilities will not increase an organization's propensity to apply—perhaps the converse.

When we shift the focus to the second stage of the participation process, however, the above arguments do not hold. In the selection procedure of determining which applications to accept for funding, research capabilities (reputation and/or productivity) will be a core element that increases the probability of success. Furthermore, it is reasonable to argue that in EU-FP programs and international research in general, well-reputed organizations will be more willing to cooperate with other well-reputed organizations (*homophily*). In EU applications it is the reputation of the entire research consortium that is evaluated, making research capability (and in particular reputation) all the more relevant. We therefore formulate the following hypotheses. Figure 1 below summarizes the hypothesised effect of all aforementioned hypotheses.

H3.1 Stronger research capabilities do not increase the probability that an organization will apply for H2020 funding.

H3.2 Stronger research capabilities increase the probability that an organization will succeed in getting H2020-funded projects.

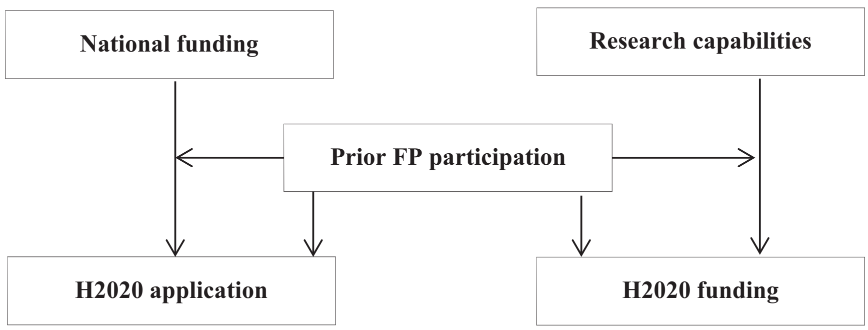

Fig. 1 Theory framework and hypotheses

Context and data

The Norwegian research system

Policymakers often compare the national research performance of Norway with that of other small economies in Europe like Denmark, Finland, Sweden, the Netherlands and Austria, as the systems and funding mechanisms are similarly structured, to a certain extent (Norwegian Ministry of Education and Research 2015; Langfeldt et al. 2012).

The Norwegian R&D sector consists of multiple university colleges of varying size, eight large universities, a large number public research organizations, hospitals,[1] state entities and a broad array of private firms—all with the possibility of participating in EU FP (Research Council of Norway 2015). Ever since Norwegian researchers began to become involved in EU FPs, national budgetary appropriations for participation and mobilizing schemes have increased considerably (Langfeldt et al. 2012; Gornitzka and Langfeldt 2008). A declared goal is to increase the degree of R&D funding from EU FPs, at the governmental policy level and the institutional level (Norwegian Ministry of Education and Research 2014; Gornitzka and Langfeldt 2008). In the 7th Framework Program, Norwegian researchers were awarded 1.67 % of the available EU funding—whereas the official goal is 2 % by the end of Horizon 2020 (Norwegian Ministry of Education and Research 2014). The steadily growing importance of internationalization of research, especially vis-à-vis the EU FP, has received considerable political interest (Langfeldt et al. 2012).

For policymakers, in Norway and elsewhere, there is considerable interest in improving project participation rates and in understanding the factors that obstruct or drive engagement and grant funding in EU FP. To increase participation, the Research Council of Norway (RCN) has established and administers two specific EU-mobilizing incentives. Both aim at getting more Norwegian R&D organizations to apply for EU FP funding. The Project Establishment support scheme, "PES2020," is available to all organizations in Norway that conduct research it is a financial instrument whereby research organizations can literally *buy* time to draft better proposals to EU FP. The second incentive is also a financial mechanism, and has been exclusively developed towards PROs. As EU FP project funding never covers the full costs of a project (given the high cost levels in Norway) this leaves many Norwegian PROs, particularly those with little or no core funding, with project-budget deficits. The "STIM-EU" program is aimed at avoiding this. The scheme provides a research entity with additional funding, based on the amount of total EU FP funding granted. Even though funding is granted only after an EU FP proposal has been accepted, the existence of the STIM-EU scheme incentivizes organizations to apply. In addition, the RCN administers a wide array of programs and schemes structured so as to have an indirect effect on mobilizing for EU FP participation. These are intended to strengthen the capacities of researchers and their organization, ultimately making them stronger competitors for subsequent EU FP grants. Here it should be noted that all of these policy funding schemes are implemented by the Norwegian government in order to encourage research organizations' to participate in EU research, and that they target organizations rather than individual researchers. This is consistent with the approach adopted in this paper, of focusing on the organizational level as the main unit of analysis, and not on the individual researchers or teams.

[1] Hospitals without university function are formally a part of the PRO sector, whereas those with university instruction functions fall within the HEI sector (Research Council of Norway 2015).

Data

Our analysis is based on data on project applications to the 8th European Framework Program Horizon 2020, using data from the European Commission's data warehouse, ECORDA. The database contains information similar to what is publicly available in the Community Research and Development Information Service (CORDIS; cordis.europa.eu), particularly for data on participations in the 6th and 7th FPs. However, for the current FP, Horizon 2020, data in the CORDIS database are not readily available, nor sufficiently updated. Access to ECORDA is restricted to the Commission itself and to the Ministries and Research Councils in the member- and associated countries. ECORDA contains applicant information covered by rules of confidentiality, unless presented in aggregated form—particularly for information on applicants that were rejected. The dataset we have collected for the present study covers 1402 applications made by Norwegian research organizations for the first period of the framework program (2014–February 2015).[2] Applications from profit-seeking enterprises such as private companies and state entities (municipalities and other public authorities) have been excluded. Our dataset focuses solely on non-profit research organizations, consisting of higher education institutions (HEIs, 810 applications), PROs (516), and hospitals (76).

Previous studies of EU FP participation have focused on HEIs, with the exception of a few grey papers (Godø et al. 2009). However, for countries like Norway, Germany, Italy and France, where a large portion of the research sector is made up of PROs, the inclusion of these alongside HEIs is warranted, as noted by Geuna (1998). Thus, our study offers an important addition to the literature.

Of the total population of 1402 applications, 192 are registered as "granted", 1110 as "rejected," and 100 as "reserved". The "reserved" status means that the EC has placed the application on a waiting list in case the grant winner is removed for some reason. In some (rare) instances, an applicant on the reserved list has been offered the grant. This means that some applications classified as "reserved" might sometimes receive funding, but in our study these are not considered as part of the "successful" group. In the retrieved data, organizations are listed by their legal name. It was a relatively straightforward matter to exclude profit-seeking organizations, like private firms, since we have information of the full population of HEIs and PROs.

The application data offer unique insights on the success and failures of organizations applying for funding. In previous studies (Geuna 1998; Lepori et al. 2015; Nokkala et al. 2011), only information on successful applications has been used for analysis. Recently, Lepori et al. (2015) used the large EUPRO database (Roediger-Schluga and Barber 2008; Primeri and Reale 2012; Protogerou et al. 2010), which contains highly detailed information on applications, but only on those that were granted funding. This does not make it possible to tell whether an organization that has not been granted project funding submitted an application in the first place. That puts non-successful applicants in the same category as those who choose not to apply at all, making it impossible to distinguish between the stage of self-selection (application decision) and the stage of actual EC selection. By contrast, our dataset can identify whether any given Norwegian research organization has applied to the H2020 program, whether it has received a rejection or an approval decision, and how many projects it has been granted. Hence, our database enables a two-stage analysis of the participation process outlined in the previous section.

[2] The data retrieved were entered into ECORDA in July 2015, but it covers project applications only until February 2015. The EU Commission has decided that there must be a time-lag of approx. 5 months from the application deadline until data are published.

Data from Horizon 2020 applications were matched with data from several additional sources. Two central national datasets have been used. First, we collected publicly available R&D statistics at the organizational and faculty level for 2013 from the Nordic Institute for Studies in Innovation, Research and Education (NIFU: foustatistikkbanken.nifu.no). NIFU collects data similar to the European Tertiary Education Register (ETER), but with more details on Norwegian R&D organizations. We collected information on the whole population of HEIs (41 university colleges and 8 universities), hospitals, including university hospitals (36), and PROs (96) in Norway. Eight of the HEIs are large universities. We decided to treat these at the faculty level, so as not to skew the data, as these universities are large in terms of productivity, funding and staff size, when compared to other HEIs and PROs. All subsequent information for these large universities in the analysis is thus at the faculty level (the number of faculties in Norway is 58).

Second, to assess possible complementarities between national R&D schemes and EU FP, we collected information on all RCN research project grants for the period 2013–2015. We also collected information on the specific support schemes emplaced buy the Norwegian authorities to encourage participation in EU FP, such as STIM-EU and PES2020 (see "The Norwegian research system" section). Further, we could control for the indirect effect of thematic research programs at the RCN that might have complementarity effects with EU-funded research, such as the research program KLIMAFORSK. Other thematic programs might possibly also be relevant, but we did not have sufficient observations to include them in the analysis.

Since the additional data sources noted above provide data at the organizational level (rather than the application level), we have had to aggregate our application dataset at the organizational level in order to combine these different data sources in a single database (as done by other previous studies on EU participation). In total, our dataset for the empirical analysis consists of 231 organizations (99 HEIs, 36 hospitals, and 96 PROs). The advantage of this empirical strategy is that it enables us to examine a rich variety of explanatory factors from these different data sources. A drawback, however, is that by focusing on the organizational level we are unable to study characteristics related to the individual application and/or researchers, and how these interact with other explanatory dimensions in a multi-level setting.

Variables

The dependent variable in the first step of the analysis is a binary measure indicating *if an organization has applied for a H2020 research project or not.* The dependent variable in the second step of analysis is a count variable indicating *the number of successful applications* (*i.e. projects granted funding*).

Regarding the main explanatory variables, *FP6 funding* and *FP7 funding* are indicators of prior participation (granted projects) to the 6th FP (2003–2006) and the 7th EU FP (2007–2013).[3] The next two explanatory variables account for organizational research capabilities. *Reputation* is the average number of citations per publication for the period 2010–2014. The bibliometric data were derived from Elsevier's SciVal database

[3] In additional exercises not reported in this paper, we used two corresponding variables indicating whether an organization has served as coordinator of an FP6 or FP7 project, in order to take into account the role of network centrality in previous participation. These results confirm the positive role of network centrality for participation in EU research. We have also sought to use "coordinated projects" (rather than mere participation) as the dependent variable in the regressions. However, our sample includes only a limited number of coordinated projects, so these additional exercises should be interpreted with caution.

(scival.com).[4] *Publication points* are the number of publication points awarded to an institution for the year 2013, divided by the number of full-time equivalent academic staff (FTEs). In Norway, a part of the funding system for research organizations is based on the number of publications that an institution produces each year. These publications are awarded points according to how highly a journal is ranked. Performance of each institution is registered and publicly available online from the Norwegian Scientific Index (CRIStin; cristin.no).

Shifting the focus to the variables measuring national support and other (non-EU) funding means, the main variables that we use in our regression model are two: (1) *national funding,* which includes funds from the Norwegian Research Council and other national funding agencies (excluding core and private company funding); (2) PES2020, STIM-*EU,* and *KLIMAFORSK*, which are dummy variables describing whether the organization has received funding from these specific RCN instruments during the period 2013–2015. As explained, *STIM-EU* and *PES2020* are direct financial schemes aimed at encouraging applications to EU FP. To control for additional funding means, we include two variables measuring the *share of funding received from private companies,* and the *share of funding received from other organizations abroad (excluding firms and EU)*.[5] Among the set of control variables, we include first of all the *scientific orientation* and *size* of the organization, as both have been shown to be relevant determinants of participation in EU FPs (Lepori et al. 2015; Hakala et al. 2002; Geuna 1998). *Scientific orientation* variables are measured as the amount of funding allocated to the specific scientific discipline to which the organization belongs, as a share of total funding. This is a pre-constructed measure in Norwegian R&D statistics, indicating the dominant scientific specialization of the institution (social sciences, humanities, medicine and health, technology, mathematics and natural sciences). *Size* is the number of full-time equivalents (FTE) of academic staff working in R&D activities. This measure excludes technical and administrative staff as well as time spent on teaching. Data were retrieved from the R&D statistics for 2013.

Next, as prior studies on EU FP determinants have focused mainly on HEIs (e.g. Lepori et al. 2015; Geuna 1998; Nokkala et al. 2011), we wished to see whether HEIs and PROs (both included in our dataset) behave differently. We therefore included a dummy variable to control for organizations classified as HEIs in the application data (1: HEI; 0: PRO). Furthermore, to control for *regional location* of the research organization, we add dummy variables for Norwegian regions in accordance with the Eurostats NUTS 2 classification system (Eurostat 2008).[6]

Table 1 provides descriptive information on the variables included in our analysis, and Table 2 reports the correlation coefficients. Table 1 shows that 56 % of Norwegian research organizations applied for participation in Horizon 2020 during the first period of this new EU FP program (between 2014 and February 2015). Further, 130 organizations applied to H2020, and of these, 62 organizations have been granted funding for participation in at least one project (average 0.83 projects).

[4] For this variable, we have positive citation data for only 89 institutions, because of the set threshold of minimum 500 publications for inclusion in this database. We set "reputation" for missing organizations at 0, as done by Lepori et al. (2015).

[5] Lepori et al. (2015) used external funding as an indicator for third-party funds, including external funding from the EU, Research Councils and private companies. We have chosen to treat these variables separately and divide them by total funding to get a measure of the amount of funding by total revenue.

[6] Some of our explanatory variables have skewed distribution, and in particular those measuring R&D capabilities, financial conditions, and size. We log transformed these variables before entering the regression model.

Table 1 Descriptive statistics

	N	Mean	SD	Min	Max
Dependent variables					
Application (dummy)	231	0.560	0.497	0	1
Granted projects (count)	149	0.83	2.480	0	25
Persistence					
FP7 participation (count)	231	5.34	16.515	0.00	206
FP6 participation (count)	231	3.02	7.973	0.00	74
R&D capabilities					
Reputation[a]	231	3.045	4.351	0.00	18.4
Publication points[b]	183	1.207	0.904	0.00	6.4
National funding schemes					
National funding (%)	222	18.329	18.874	0.00	100
PES2020 (dummy)	231	0.280	0.449	0	1
STIM-EU (dummy)	231	0.140	0.351	0	1
Klimaforsk (dummy)	231	0.190	0.397	0	1
Firm funding (%)	222	9.314	17.643	0.00	91.3
International funding (%)	222	2.918	9.029	0.00	100
Control variables					
Size[c]	222	91.783	147.458	0.50	1371.8
Higher education institution (dummy)	231	0.430	0.496	0	1
Humanities[d]	231	0.108	0.246	0.00	1
Social sciences[e]	231	0.277	0.340	0.00	1
Mathematics and natural sciences[f]	231	0.145	0.236	0.00	1
Medicine[g]	231	0.162	0.280	0.00	1
Technology[h]	231	0.259	0.372	0.00	1
Regional dummies					
Oslo and Akershus	231	0.424	0.495	0	1
Østlandet	231	0.091	0.288	0	1
Agder and Rogaland	231	0.074	0.262	0	1
Vestlandet	231	0.156	0.364	0	1
Trøndelag	231	0.143	0.351	0	1
North Norway	231	0.113	0.317	0	1

[a] Average number of citations (2010–14); [b] number of publication points/size; [c] number of full-time equivalents in R&D; [d,e,f,g,h] amount of funding allocated to a specific scientific discipline by share of total funding

Table 2 Correlation matrix

	Application	Granted projects	Reputation	Publication points	Firm funding	National funding	International funding	FP7 participation	FP6 participation	STIM-EU	PES2020	Klimaforsk	Size	HEI	Humanities	ocial sciences	Math. & nat. sciences	Medicine	Technology
Application	1	0.526***	0.404***	-0.079	0.411***	0.388***	0.432***	0.618***	0.510***	0.310***	0.409***	0.367***	0.613***	0.181***	-0.066	0.150**	0.391***	0.265***	-0.071
Granted projects		1	0.326***	-0.039	0.267***	0.378***	0.381***	0.645***	0.614***	0.378***	0.303***	0.374***	0.525***	0.044	-0.013	0.020	0.392***	0.152**	-0.013
Reputation			1	0.024	0.132**	0.165**	0.271***	0.440***	0.418***	0.004	0.043	0.195***	0.656***	0.508***	0.239***	0.075	0.582***	0.313***	0.060
Publication points				1	-0.403***	-0.109	-0.221***	-0.074	-0.111	-0.259***	-0.092	0.029	-0.164**	0.267***	0.095	0.036	-0.156**	0.039	-0.086
Firm funding					1	0.434***	0.442***	0.348***	0.332***	0.335***	0.414***	0.173***	0.351***	-0.121*	-0.154**	0.070	0.215***	0.141**	-0.076
National funding						1	0.502***	0.461***	0.531***	0.378***	0.398***	0.387***	0.327***	-0.130*	-0.180***	0.330***	0.288***	-0.037	-0.146**
International funding							1	0.532***	0.573***	0.419***	0.440***	0.307***	0.409***	-0.097	-0.124*	0.137**	0.322***	-0.061	-0.038
FP7 participation								1	0.693***	0.484***	0.417***	0.402***	0.657***	0.016	-0.023	0.033	0.428***	0.171***	0.019
FP6 participation									1	0.366***	0.341***	0.488***	0.590***	-0.026	-0.064	0.033	0.381***	0.029	-0.057
STIM-EU										1	0.438***	0.205***	0.205***	-0.329***	-0.228***	-0.008	0.136**	-0.132**	-0.002
PES2020											1	0.257***	0.220***	-0.165**	-0.171***	0.125*	0.121*	0.065	-0.023
Klimaforsk												1	0.323***	-0.006	-0.058	0.077	0.386***	-0.089	-0.076
Size													1	0.343***	0.218***	0.197***	0.533***	0.411***	-0.102
HEI														1	0.488***	0.311***	0.378***	0.329***	-0.009
Humanities															1	0.156**	0.179***	0.202***	-0.164**
Social sciences																1	0.043	0.053	-0.357***
Math. & nat. sciences																	1	0.184***	0.052
Medicine																		1	-0.237***
Technology																			1

* Correlation is significant the 0.10 level, ** at the 0.05 level, or *** at the 0.01 level (2-tailed)

Results

Econometric model

Our empirical model is estimated in two steps. The first stage estimates the probability that an organization applies for an H2020 research grant (dependent variable: APPLICATION dummy). This first step is carried out on the whole population of Norwegian HEIs and PROs. The second stage focuses solely on the sub-sample of research organizations that have applied for H2020 research grants. It estimates the probability that an organization will be granted one or more EU-funded projects (dependent variable: GRANTED, count indicator). The model is then specified by the following two equations:

$$\Pr\{\text{APPLICATION}_i\} = \alpha + \beta\ \text{PERSISTENCE}_i + \gamma\ \text{RDCAPABILITY}_i + \delta\ \text{NATFUNDING}_i + \eta[\text{CONTROLS}_i] + \varepsilon_i \quad (1)$$

$$\text{Nr}\{\text{GRANTED}_i\} = \zeta + \theta\ \text{PERSISTENCE}_i + \lambda\ \text{RDCAPABILITY}_i + \pi\ \text{NATFUNDING}_i + \rho[\text{CONTROLS}_i] + \mu_i \quad (2)$$

The explanatory variables included in the two equations are the same: previous participation in EU FP (PERSISTENCE), research capabilities, reputation and scientific productivity (RDCAPABILITY), and national funding conditions (NATFUNDING). The vector of control variables (CONTROLS) include, as indicated in the previous section, indicators of organizational size, scientific domain, type of organization (HEI vs. PRO), and regional location. We include the same set of regressors in the two equations because we want to investigate the extent to which the factors highlighted in previous research have different effects on the two stages of the participation process. We also include in the two equations a set of interaction variables in order to analyze whether prior participation in FP moderates the effect of the other variables on the likelihood of applying and/or being awarded an H2020 project.

The advantage of this econometric specification over previous works is twofold. First, Eq. 1 is meant to provide new insights on the factors that affect research organizations' propensity and motivation to apply for EU-funded projects, in turn offering indications as to what national and European authorities could do in order to mobilize domestic organizations towards greater participation in H2020. To the best of our knowledge, this aspect has not been investigated in previous research, probably due to the unavailability of data that can distinguish applicants from non-applicants.

Second, Eq. 2 has been analyzed in previous works (e.g. Geuna 1998; Lepori et al. 2015). However, while such research has typically estimated this type of equation on the entire population of research organizations (including applicants as well as non-applicants), we focus solely on the sub-sample of project applicants. This, we hold, can provide an unbiased estimate of the effects of the explanatory variables of interest on the probability of receiving H2020 funding.[7]

[7] In previous research, due the absence of data enabling to distinguish between non-applicants and unsuccessful applicants, both of these groups were combined together and typically given a value of 0 in the regressions, whereas successful applicants were given a positive integer value (1 if the dependent variable was defined as a dummy, and values equal or greater than 1 if the variable was measured as a count). However, combining together non-applicants and unsuccessful applicants in the same regression tends to

Table 3 Median values of main explanatory variables by group (H2020 participation)

Variables	No application	Applied—no success	Granted: 1	Granted: 2 or more
FP7 participation	0.000	1000	4500	15.000
FP6 participation	0.000	0.000	2000	8500
Reputation	0.000	1450	2750	6350
Publication points	1231	0.972	1034	0.951
National funding	5855	12.247	19.317	27.790
PES2020	0.000	0.000	0.000	1000
STIM-EU	0.000	0.000	0.000	0.500
Klimaforsk	0.000	0.000	0.000	1000
Firm funding	0.000	2440	5327	5679
International funding	0.000	0.287	1274	1486
Size	17.400	56.400	85.100	169.770
Higher education institution	0.000	1000	0.500	0.000
N	101	68	26	36

We estimate Eq. 1 using a logit model, and Eq. 2 using a zero-inflated Poisson regression model (ZIP). The ZIP model is useful when there is a fair amount of null observations in the outcome variable (Greene 1994). As the success rate for project applications to EU FP is quite low, many observations receive the value of 0 (no funded application). The ZIP model accordingly accounts for such a high presence of null observations. The Vuong test in our regressions confirms that the ZIP specification is significantly better than a standard Poisson regression (Perumean-Chaney et al. 2013). The test was significant ($P = <0.001$) in all regressions (Table 6).[8]

Footnote 7 continued
underestimate the estimated slopes of interest (the larger the mean of a given explanatory variable for the group of non-applicants, the larger the bias). We overcome this problem by estimating Eq. 2 only on the sub-sample of applicants. Table 3 reports the median of our explanatory variables for four groups of observations: (1) non-applicants, (2) unsuccessful applicants, (3) applicants that have been awarded one project, (4) applicants that have been awarded more than one project. The table shows that, for the group of non-applicants, three variables (publication points, national funding, and size) have positive median. Hence, our econometric approach yields more precise estimates for these three variables in particular. Table 4 reports a comparison of means of successful applicants (at least one project funded) and unsuccessful applicants (no projects funded) for all explanatory variables, along with t-tests of mean differences. The t-tests illustrate clearly that successful applicants have on average higher values in relation to the variables measuring previous participation, reputation and national funding. Hence, justifying the sample and the hypotheses.

[8] We have also estimated our model by following different econometric approaches. First, we have reproduced the approach used by Geuna (1998) and Lepori et al. (2015) on our dataset, i.e. estimating Eq. 2 by means of a logit (for a dummy dependent variable: funded vs. not-funded), and by means of a truncated regression (for a count-dependent variable that excludes organizations with 0 funded projects). The problem with these approaches is that, due to the relatively small size of our sample, the variability is limited and it is difficult to obtain precise results. Second, we have estimated Eqs. 1 and 2 jointly by means of a Heckman sample selection model (Heckman 1979). However, this approach requires the dependent variable in the second step to be dichotomous. Given the fairly small sample in our study, using a dummy-dependent variable greatly diminishes the data variability. Sample selection models that account for count outcomes are still under development and are not yet incorporated in standard econometric software. We tried using the sample selection model wrapper (SSM) based on generalized linear latent and mixed models (GLLAMM), developed by Miranda and Rabe-Hesketh (2006), but the procedure failed to produce the required output.

Table 4 Comparison of mean values between the groups of successful and unsuccessful applicants (group variable: 1 = at least one project funded, otherwise 0)

Variable	Mean (SD)			*t* test		
	Successful ($n = 62$)	Not successful ($n = 68$)	Mean difference	*t*	Df	Sig. (2-tailed)
Granted project	3.10 (4.00)	0 (0)	3.097	6.085	61.000	<0.001
FP7 participation	16.92 (28.76)	2.35 (3.21)	14.566	3.966	62.389	<0.001
FP6 participation	9.29 (13.26)	1.44 (2.60)	7.849	4.579	65.273	<0.001
Reputation	5.13 (4.69)	3.74 (4.28)	1.385	1.759	128	0.081
Publication points	1.07 (0.55)	1.08 (0.65)	−0.014	−0.122	113	0.903
National funding	26.27 (15.95)	19.10 (18.58)	7.167	2.309	123	0.023
PES2020	0.48 (0.50)	0.40 (0.93)	0.087	0.992	128	0.323
STIM-EU	0.35 (0.48)	0 (0)	0.034	3.056	128	0.003
Klimaforsk	0.42 (0.49)	0.24 (0.42)	0.184	2.252	120.876	0.026
Firm funding	11.42 (16.12)	10.65 (18.72)	0.766	0.245	123	0.807
International funding	3.87 (6.01)	2.34 (5.06)	1.530	1.542	123	0.126
HEI	0.50 (0.50)	0.60 (0.49)	−0.103	−1.177	128	0.242
Size	200.63 (225.62)	86.88 (91.87)	113.739	3.659	78.594	<0.001
Humanities	0.04 (0.06)	0.07 (0.18)	−0.028	−1.208	87.269	0.230
Social sciences	0.26 (0.29)	0.32 (0.34)	−0.065	−1.156	128	0.250
Mathematics and natural sciences	0.27 (0.29)	0.16 (0.26)	0.101	2.126	128	0.035
Medicine	0.17 (0.23)	0.22 (0.34)	−0.052	−1.030	117.772	0.305
Technology	0.17 (0.24)	0.17 (0.25)	−0.004	−0.085	128	0.932
Oslo and Akershus	0.45 (0.50)	0.46 (0.50)	−0.004	−0.048	128	0.961
Østlandet	0.02 (0.13)	0.15 (0.36)	−0.131	−2.835	85.109	0.006
Agder and Rogaland	0.05 (0.22)	0.06 (0.24)	−0.010	−0.261	128	0.794
Vestlandet	0.19 (0.39)	0.08 (0.29)	0.105	1.718	109.691	0.089
Trøndelag	0.19 (0.39)	0.13 (0.34)	0.061	0.943	128	0.348
North Norway	0.09 (0.29)	0.12 (0.32)	−0.021	−0.381	128	0.704

For a definition of these indicators see Table 1 above

Estimation results

Tables 5 and 6 present the results of the econometric estimations of Eqs. 1 and 2, respectively. Before discussing the results of the tests of the hypotheses formulated in "Hypotheses" section, let us take a brief look at the estimated coefficients of some important control variables. In particular, SIZE has often been pointed out as a relevant explanatory factor in previous research (Lepori et al. 2015). Our estimates show an interesting difference in the effects of this variable in the first and in the second equation. The variable has the expected positive sign in Eq. 1 (see Table 5), and the estimated coefficients are large and significant in all regressions. By contrast, the variable has lower

Table 5 Results of step 1. Dependent variable: application (dummy); estimation method: logit

	Baseline	Interaction 1	Interaction 2	Interaction 3	Full model
FP7 participation	1.302 (0.032)**	−0.788 (0.449)	4.001 (0.012)**	1.587 (0.061)*	2.099 (0.228)
FP6 participation	0.465 (0.481)	0.585 (0.421)	0.375 (0.581)	0.502 (0.450)	0.059 (0.941)
Reputation	0.080 (0.859)	0.266 (0.570)	0.220 (0.639)	0.241 (0.660)	1.062 (0.125)
Reputation × FP7 particip.				−0.275 (0.600)	−0.211 (0.743)
Publication points	0.545 (0.600)	0.604 (0.581)	1.371 (0.222)	0.608 (0.561)	2.608 (0.053)*
Publication points × FP7 particip.			−3.206 (0.039)**		−8.756 (0.002)***
National funding	0.114 (0.751)	−0.126 (0.735)	0.124 (0.746)	0.104 (0.772)	−0.082 (0.848)
National funding × FP7 particip.		0.893 (0.032)**			2.646 (0.002)***
PES2020	1.708 (0.031)**	1.714 (0.041)**	1.771 (0.033)**	1.629 (0.043)**	1.661 (0.077)*
STIM-EU	0.421 (0.717)	−0.482 (0.707)	0.191 (0.881)	0.314 (0.790)	−3.088 (0.129)
Klimaforsk	1.654 (0.114)	1.619 (0.154)	1.575 (0.141)	1.621 (0.123)	1.415 (0.264)
Firm funding	0.805 (0.028)**	0.902 (0.023)**	0.841 (0.034)**	0.872 (0.027)**	1.295 (0.013)**
International funding	−0.586 (0.216)	−0.631 (0.203)	−0.783 (0.128)	−0.605 (0.208)	−1.377 (0.052)*
Size	1.175 (0.015)**	1.365 (0.007)***	1.223 (0.014)**	1.158 (0.016)**	1.863 (0.003)***
Higher education institution	1.826 (0.049)**	1.716 (0.066)*	1.678 (0.073)*	1.861 (0.047)**	1.635 (0.105)
Humanities	−3.269 (0.347)	−3.821 (0.299)	−3.594 (0.348)	−3.286 (0.350)	−6.749 (0.193)
Social sciences	−1.648 (0.607)	−1.623 (0.627)	−1.561 (0.665)	−1.559 (0.631)	−2.084 (0.643)
Mathematics and natural science	−3.426 (0.338)	−4.735 (0.214)	−4.183 (0.302)	−3.634 (0.321)	−9.340 (0.090)*
Medicine	0.240 (0.942)	0.155 (0.964)	0.001 (1.000)	0.277 (0.934)	−0.661 (0.885)
Technology	−2.235 (0.498)	−2.321 (0.502)	−2.812 (0.446)	−2.235 (0.500)	−4.475 (0.339)
Oslo and Akershus	0.481 (0.626)	0.535 (0.592)	0.563 (0.575)	0.428 (0.669)	1.021 (0.363)
Agder and Rogaland	−1.765 (0.165)	−2.117 (0.109)	−1.915 (0.143)	−1.842 (0.152)	−2.747 (0.067)*
Vestlandet	−1.471 (0.179)	−1.671 (0.149)	−1.564 (0.159)	−1.624 (0.157)	−2.324 (0.078)*
Trøndelag	−0.822 (0.452)	−0.818 (0.464)	−1.020 (0.367)	−0.812 (0.459)	−1.356 (0.270)

Table 5 continued

	Baseline	Interaction 1	Interaction 2	Interaction 3	Full model
North Norway	−0.015 (0.990)	−0.110 (0.929)	0.205 (0.866)	−0.063 (0.958)	0.025 (0.985)
−2 log likelihood	92.463	88.229	88.167	92.203	74.632
Nagelkerke R-squared	0.75	0.76	0.76	0.75	0.81

Observations: 177

P values in parentheses

A constant is included in all regressions

Significant at * 0.10 level; ** 0.05 level; *** 0.01 level

Table 6 Results of step 2. Dependent variable: number of granted projects (count); estimation method: zero-inflated Poisson

	Baseline	Interaction 1	Interaction 2	Interaction 3	Full model
FP7 participation	0.313 (0.068)*	0.253 (0.141)	0.376 (0.027)**	0.297 (0.084)*	0.281 (0.104)
FP6 participation	0.388 (0.032)**	−0.256 (0.582)	0.107 (0.712)	0.060 (0.801)	−0.130 (0.809)
Reputation	0.089 (0.573)	0.125 (0.422)	0.182 (0.260)	−0.282 (0.250)	−0.316 (0.262)
Reputation × FP6 particip.				0.233 (0.023)**	0.242 (0.033)**
Publication points	−0.382 (0.598)	−0.506 (0.477)	−1.554 (0.115)	−0.673 (0.353)	−0.814 (0.401)
Publication points × FP6 particip.			0.364 (0.304)		−0.078 (0.836)
National funding	−0.116 (0.546)	−0.184 (0.410)	−0.234 (0.309)	−0.080 (0.679)	−0.171 (0.497)
National funding × FP6 particip.		0.204 (0.110)			0.072 (0.585)
PES2020	0.778 (0.009)***	0.789 (0.007)***	0.457 (0.114)	0.684 (0.024)**	0.521 (0.081)*
STIM-EU	−0.467 (0.148)	−0.449 (0.160)	−0.234 (0.481)	−0.262 (0.444)	−0.193 (0.575)
Klimaforsk	−0.064 (0.769)	0.035 (0.870)	0.010 (0.962)	0.053 (0.809)	0.109 (0.628)
Firm funding	−0.030 (0.840)	−0.041 (0.777)	0.103 (0.472)	−0.087 (0.575)	0.064 (0.679)
International funding	0.119 (0.559)	0.286 (0.178)	−0.013 (0.943)	0.046 (0.818)	−0.029 (0.878)
Size	0.109 (0.650)	0.075 (0.757)	0.069 (0.787)	−0.080 (0.742)	−0.090 (0.718)
Higher education institution	0.900 (0.090)*	1.236 (0.015)**	0.462 (0.396)	0.907 (0.077)*	0.626 (0.265)
Humanities	−3.109 (0.300)	−4.640 (0.130)	−0.608 (0.840)	−2.053 (0.449)	0.233 (0.938)
Social sciences	0.334 (0.628)	0.110 (0.872)	1.176 (0.087)*	0.345 (0.618)	0.695 (0.327)
Math. & natural science	0.600 (0.307)	−0.075 (0.900)	0.868 (0.175)	0.559 (0.339)	0.409 (0.545)
Medicine	0.740 (0.301)	0.552 (0.444)	0.937 (0.212)	0.829 (0.257)	1.085 (0.153)
Technology	1.110 (0.157)	0.494 (0.502)	1.185 (0.134)	1.288 (0.091)*	0.761 (0.340)
Oslo and Akershus	1.988 (0.069)*	1.316 (0.238)	1.104 (0.341)	1.883 (0.083)*	0.889 (0.440)
Agder and Rogaland	3.152 (0.011)**	2.598 (0.034)**	2.141 (0.090)*	3.098 (0.011)**	1.932 (0.126)
Vestlandet	2.545 (0.022)**	1.873 (0.098)*	1.716 (0.139)	2.385 (0.031)**	1.309 (0.257)
Trøndelag	2.154 (0.053)*	1.629 (0.146)	1.311 (0.259)	2.300 (0.038)**	1.390 (0.230)

Table 6 continued

	Baseline	Interaction 1	Interaction 2	Interaction 3	Full model
North Norway	1.920 (0.094)*	1.091 (0.343)	0.889 (0.446)	1.567 (0.165)	0.424 (0.717)
Log likelihood	−102.652	−101.219	−101.181	−98.624	−95.929
Vuong test of ZIP versus standard Poisson	5.52 (<0.001)***	5.36 (<0.001)***	5.34 (<0.001)***	6.52 (<0.001)***	6.58 (<0.001)***

Observations: 113

P values in parentheses

A constant is included in all regressions

Significant at * 0.10 level; ** 0.05 level; *** 0.01 level and weakly significant estimated coefficients in Eq. 2 (see Table 6).[9] We find a similar pattern for the HEI dummy variable that distinguishes higher education institutions from PROs. Taken together, these results indicate that larger research organizations, and HEIs in particular, are more likely to apply for EU FPs, arguably due to the economies of scale they can enjoy in the phases of developing, managing and administering new applications to H2020. These may lead to cost advantages that can prove crucial in the first stage of the participation process (self-selection), but not necessarily in the subsequent selection process (where it is quality, more than size, that matters).

Turning now to our set of main explanatory variables, the indicator of prior participation in EU FPs (PERSISTENCE) has positive and estimated coefficients in both Tables 5 and 6.[10] The magnitude of these estimated coefficients is one of the largest in the battery of regressors, confirming that prior participation in EU FP is a major factor that strengthens both the propensity of Norwegian research organizations to apply to H2020 *and* their ability to get H2020 projects. As note in our propositions H1.1 and H1.2 (see "Hypotheses" section), the variable is highly relevant in both stages of the participation process—although, in our view, for different reasons. In the first (self-selection) stage, previous participation in an EU-funded project means that the organization will not have to sustain the sunk costs of amassing information and knowledge on the application procedure, as well as network and team building costs. In the second stage, prior participation matters because an organization that has previously been involved in an EU project can be assumed to have benefited from learning effects regarding the application procedure, EU research priorities, and the quality of potential partners—and these learning effects will improve the quality of the application and its chances of success.

The second set of explanatory variables of interest relates to national funding characteristics. The specific hypothesis formulated in "Theory and hypotheses" section is that that the structure of national funding matters in the first stage of the participation process, but not equally so in the second. To test these propositions (H2.1 and H2.2), let us compare estimation results for the relevant variables in Tables 5 and 6. The national funding variable (share of research grants received from national funding agencies) does not prove to have a significant effect in Eq. 1. Interestingly, however, the variable is important and significant when we interact it with the PERSISTENCE variable (prior participation in EU FP7). This pattern indicates that previous participation positively moderates the effect of national funding availability on the propensity to submit an application for the new program H2020. In other words, the expected complementarity effects between nationally-funded and EU-funded research emerge more clearly for organizations that have previously sustained the costs of sunk information and network building (in other words: if an organization already knows how to play the EU game, having complementary national

[9] A possible reason why the size variable is not significant in the estimations in step 2 may be due to multicollinearity. The correlation coefficients in Table 2 indicate SIZE to be positively correlated with the FP6 and FP7 participation variables (although the VIF statistics for these variables are below critical threshold levels for multicollinearity). If we exclude the latter from the regressions, the size indicator becomes statistically significant. To test further the effect of size on H2020 participation, we have also carried out another exercise based on a matching approach. The results of matching results, reported at the end of this section, show indeed that size has a significant correlation to H2020 participation.

[10] A cross-classification table between participation to FP7 and H2020 shows that persistence is important in our sample, as expected, although it does not completely predict participation patterns. In fact, 24 % of organizations that got at least one project in FP7 also got funding from H2020, whereas 25 % were not able to succeed in H2020. On the other hand, 48 % of the organizations that did not have any funded project in FP7 did not have any H2020 project either; and only 3 % of organizations managed to get a H2020 project although they did not have any FP7 project.

funds available will further encourage it to continue to participate). Table 5 also confirms that the variable *PES2020*, one of the specific policy schemes in place in Norway to encourage participation in EU-funded research, has positive, significant and strong estimated coefficients.

We note the corresponding results for Eq. 2 (Table 6): the national fund availability variable is not significant (neither alone nor in interaction with PERSISTENCE), whereas the *PES2020* variable is still positive, significant, but its estimated coefficient has a much lower magnitude than the corresponding results in Table 5. On the whole, these patterns are in line with the hypotheses formulated in "Hypotheses" section, that external funding granted by national institutions increases the probability of an organization submitting an H2020 application (by making available additional resources to invest in the application process), but does not substantially increase the probability that an organization will succeed with its H2020 application (since that outcome depends more on the quality of the application than on the financial conditions of the applying entity).

Finally, we shift the focus to the results on the variables accounting for organizational research capabilities: academic reputation (measured by citations and impact factor) and scientific productivity (measured by the number of publication points in the recent past). In "Theory and hypotheses" section we argued that research capabilities matter differently in the two stages of the participation process, making it therefore important to distinguish these impacts: we hold that this dimension will be relevant only in the second (selection) stage (in line with the results of previous studies), and not in the first stage. To test this, let us compare again the estimation results for Eqs. 1 and 2. In Table 5, the reputation variable emerges as not significantly correlated to the propensity to apply for EU funding. The scientific productivity (publication points) variable is not significant either. Interestingly, however, when we interact this indicator with the PERSISTENCE variable, we find a negative, strong and significant effect. One interpretation could be that researchers often perceive involvement in EU projects as a costly, demanding, and bureaucratic process, and may therefore be reluctant to participate. To the extent that more productive researchers concentrate on academic recognition and publication activity, high scientific productivity will not make an organization more likely to apply to H2020—maybe even the converse.

However, as expected, the results of the estimations for Eq. 2 tell a different story, and one more in line with the results of previous research. Table 5 shows that the reputation variable, when interacted with the indicator of prior participation in FP6, has a positive and significant estimated coefficient. This suggests that scientific reputation does matter in the selection of proposal submitted to H2020, especially if an excellent reputation is combined with learning effects arising from having previously participated in EU-funded projects. Although the reputation variable emerges as important in Eq. 2, the publication variable is not significant, which would indicate that having a large number of publications does not increase the likelihood of success in the H2020 contest, whereas having a high scientific impact (reputation) does. In summary, in line with our theory arguments (H3.1 and H3.2), we find that stronger research capabilities (as measured by reputation) do not increase the probability that an organization will submit an H2020 application, but they do increase the probability of success in getting H2020-funded projects. A possible issue in our regressions is that some of the variables of interest—and in particular reputation, size and FP7 participation are positively correlated with each other. In our relatively small sample, this may make it hard to disentangle the effect of each of these variables on H2020 participation. The resulting multicollinearity patterns can lead to concerns that the effect of these variables cannot be estimated with statistical precision in a multivariate regression model given the relatively small size of our sample. We have therefore carried out an additional exercise in the attempt to disentangle the effects of the aforementioned variables, focusing on step 2 of the econometric model.

In Table 7, we report the results of a propensity score matching analysis that we have carried out in order to provide an alternative and more precise estimation of the effect of these variables. The main idea of the matching approach is to consider the explanatory variable of interest as a "treatment indicator", and estimate the effect of the treatment variable on the outcome variable (H2020 participation) (Caliendo and Kopeinig 2008; Cerulli 2010). More precisely, the propensity score matching exercise followed these steps: (1) We focused on one explanatory variable at a time and considered it as a treatment variable. (2) We transformed this variable into a dummy indicator (with value 1 for observations above the median, and 0 for observations below the median). (3) We estimated the predicted probability from a probit regression of the treatment dummy on a set of covariates (i.e. the same set of covariates used for the estimation of Eq. 2); this predicted probability is the so-called *propensity score*. (4) The matching algorithm (carried out in the statistical software Stata) then used the propensity score to construct two groups of observations: a treated and a control group. The identification of these two groups was based on the nearest-neighbour method, and the Mahalanobis distance metric. (5) The average treatment effect on the treated (ATT) was then estimated, which is the difference between the average of the outcome variable (H2020 participation) in the two groups. (6) We then repeated these five steps for the other explanatory variables in Eq. 2 that are possibly affected by multicollinearity.

The results show that the ATT of FP7 participation on the H2020 dependent variable is positive and significant, similarly to what previously found in our regression results reported in Table 6. The publication points indicator does not have a significant ATT effect, a finding that is also in line with our regression results. Interestingly, however, both the reputation and the size variables (in spite of their collinearity with the FP7 indicator) have a positive and signicant estimated ATT effect on H2020 participation. This is a pattern that we were not able to estimate with statistical precision in the multivariate regression analysis, and that the matching procedure reported here makes it possible to identify. These findings are also in line with the econometric results of previous studies in this field on the role of size and reputation for EU project participation (e.g. Lepori et al. 2015). On the whole, these matching results should be interpreted with some caution, due the relatively small size of our sample. However, they provide interesting evidence that extends and corroborates the findings of the multivariate regressions previously presented.

Table 7 Propensity score matching (nearest-neighbour method; distance metric: Mahalanobis)

Variable	ATT	z	Number treated	Number control	N
Size	1.862	3.17***	58	55	113
Reputation	1.857	3.13***	56	57	113
Publication points	−0.175	−0.38	57	56	113
FP7 participation[a]	1.402	3.35***	87	26	113

Significant at: *** 0.01 level

[a] Dummy. 1 equals to at least one FP7 project participation, 0 otherwise

Conclusions

This paper has analyzed Norwegian research organizations in terms of applying for participation in the EU's Horizon 2020 program during the first months of its implementation. Our dataset consisted of 1402 applications for the period 2014–2015, both rejected applications and successful ones, matched with R&D statistics for the whole population of higher education institutions and public research organizations in Norway. We analyzed this database by means of a two-step econometric analysis of the likelihood of applying (stage 1) and probability of success (stage 2), focusing on three main explanatory dimensions: prior participation in EU FPs, complementarity with national funding schemes, and scientific capabilities. What have we learned from this exercise—what are the main contributions and implications for research policy?

The main point is that it is essential to distinguish two separate stages in the participation process: the self-selection stage in which a research organization decides whether to invest time and resources in developing a project application, and the selection stage in which the European Commission evaluates and selects proposals. Both conceptually and empirically, these two stages differ, and different factors explain the likelihood of applying and the probability of succeeding in the competition for H2020 funding.

Regarding the first stage, our results indicate two key dimensions that determine whether a research organization is likely to prepare and submit an application: (1) if the organization has previously participated in EU FPs (and thereby already sustained the application-related sunk costs); and (2) the availability of national funding, which may act as a complementary channel and provide additional resources that encourage application efforts. These results provide new scholarly insights on participation in EU-funded research, with important potential implications for policy.

A first implication concerns the national authorities: given the important complementarities between national and international funding, the most effective way for domestic funding agencies to promote internationalization of research is not by outsourcing research funding tasks totally to EU authorities, but by strengthening their own national funding programs. A second implication concerns the EU authorities in charge of the H2020 program. From our results, it appears that this new program has not been able yet to mobilize Norwegian researchers with strong scientific reputations and high productivity: indeed, we find the likelihood of submitting an application to be negatively related to the organization's scientific productivity. This might have to do with the fact that researchers often see the H2020 program as basically applied in nature and quite demanding in terms of networking and management procedures. Perhaps the EU authorities should consider whether the program should have a more academic focus and simpler procedures, in order to attract a greater number of productive researchers.

Regarding the second stage of the participation process, the main advantage of our econometric approach *vis-à-vis* previous research is that carrying out estimations only on the sub-sample of applicants enabled us to obtain more precise, unbiased, estimates of the relationships of interest here. Our results indicate two main factors that strengthen the likelihood that a research organization will submit a successful application: prior participation in EU FPs (indicating persistence and learning effects from previous EU projects), and scientific reputation. Unlike earlier studies, however, we do not find any significant correlation between publication results and probability of success.

These results give rise to another question for research policy. For national authorities, it is important to emphasize the distinction between the role of academic reputation and the role of scientific productivity. Also in many European countries, including Norway, allocation of national funding to HEIs and PROs is currently based on scientific productivity (number of publication points), among other criteria. However, if the national authorities want to promote the internationalization of their research system and domestic participation in H2020 programs, it would seem advisable to adjust the funding allocation scheme so as to give more weight to academic reputation (quality, impact, citation indexes) and less to the number of publication points as such. This would give a clear signal to research organizations that scientific quality and impact matter more than productivity, spurring further efforts in this direction, and, one hopes, a higher success rate in the H2020 contest.

Finally, we must acknowledge two limitations of this work. The first is that, in seeking to provide a timely analysis of the first available data on H2020 participation, we have not been able to incorporate data for a lengthy period or for the entire duration of the program. This means that our assessment will need to be verified and extended when new data on H2020 participation become available. A second caveat: our analysis has focused on research organizations in Norway, for which rich and high-quality data and information are available. Some of our results might be affected by the specific characteristics of the Norwegian research system, and hence not necessarily hold for a larger sample of other European countries. It is therefore important for future research to reassess our two-step approach and hypotheses, analyzing their validity for the case of other European economies.

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APPENDIX

INTERVIEW GUIDE

INTERVIEW INTRODUCTION

- Briefly present the study and the outline for the talk you are about to have
- Approx. length (60 min)
- Anonymity
- Tape recording and informed consent

INTERVIEWEE

- What experience do you have with leading/coordination research projects?
  - In EU FP especially

CONCEPTUAL FRAMEWORK

- **DESIGN (building the network/project)**

I would like to talk about your role and actions taken when ***establishing*** *this project, which ended up being funded in a very competitive programme*

- **Network membership – selecting partners*:***
  - How were partners recruited and selected?
    - **Ques:**
      - Core consortia? Previous partners?
      - Long-term collaborations?
      - Cherry picking from a broad network of contacts?
      - Strategic selection of partners for the long run, and not necessarily for the specific project?
  - What qualities are looked for in a partner?
    - **Ques:**
      - Reputation, how does this matter?

  - What are the main differences between the partners in your project?
    - **Ques:**

        - Newcomer?
        - End users, industry?
        - Experience
        - Competitors?
  - Challenges with establishing the project?
  - What was necessary to build the project?

- **Network position – of the hub organization:**
  - Why do you take the leading role?
    - **Ques:**
      - Budget? Scientific? Long-term investment? IPR? Standards? Infrastructure?

  - Why do you think your partners prefer that you lead the project?
  - What decides who coordinates and invites partners?
  - How is the position preserved over time?
    - Do you experience that potential partners contact you with proposals rather than you contacting them?

- **Network structure:**
  - What is important when you put together a project? What works, and what can be better?
    - **Ques**:
      - Formal or informal composition?
      - The type of organizations, and why?

  - To what extent is the participant's **autonomy** in the project seen as important?
    - **Que:**
      - Hence, are the partners encouraged to act independently or are they needed to follow a predefined path to solve deliver on the project's main objectives.

- **PROCESS (management of the project/network)**

*Now, I would like to know how you **manage** the project. What are the more concrete actions taken by you as the coordinator in the project, to sustain the free flow of information, trust, and that you deliver on the proposal target?*

- Have you experienced any challenges with managing EU FP project(s)? If so, could you please elaborate?

- **Knowledge mobility** – the ease with which knowledge is shared, acquired and deployed
  - How do you ensure that information flows freely among the partners?
  - Experience with internal conflicts?
    - **Ques:**
      - Any specific measure taken?
        - For example: socializing the network through common workshops or conferences?
        - Forums or other arenas where they can share information? Online or in person?

- **Network stability:**
  - Have you experience with any dropouts from your projects?
    - **Ques**:
      - What happened?
      - Is there a risk for it?
  - What do you do to sustain stability in the projects?

  - Do you experience any goodwill from you partners because of your reputation as a scientist and from previous projects?
  - How do you divide the workload between the members?
  - How is the projects composition of private companies, higher education institutions and research institutes affecting the activities?
    - **Que:**
      - Is this diversity (multiplicity) a challenge or a benefit?

- **Innovation appropriability - ownership:**
  - How do you ensure that everyone shares information openly within the project?

        - **Ques:**
            - Can you recollect any challenges with this?
            - Avoid free loaders
            - Have you agreed on any formal or informal contracts?
    - Are there any conflicts between those producing the knowledge (the research organization) and those using it (i.e. users, profit-seeking firms)?
        - **Que:**
            - Specifics with EU FP projects?
    - How do you deal with outcome/innovations from the project that can be valorized?

- **END OF INTERVIEW**

    - Would it be possible to contact you later for a brief follow up interview to hear your thoughts on the results/conclusions?

    - Would you like to add something that you feel we have not talked about?