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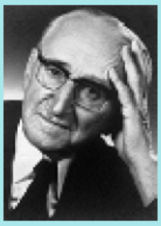



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International R&D Networks of Firms:

A Country-level Analysis of the EU Framework Programmes

Diskurs 2019 - 1

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Kadri Ukrainski; Hanna Kanep; Margit Kirs; Erkki Karo

Abstract

Empirical studies have shown that the internationalization processes of firms in research and development (R&D) are slower compared to those of trade or investments. The pioneers of R&D internationalization have been high-tech companies in small markets with little research resources in their home countries. The motives for internationalization in R&D besides widening the R&D resource base concern the search for the novelty value of collaboration for innovation, but the costs are associated with collaborative capacity and lack of experience. EU has aimed at boosting Europe's industrial leadership and competitiveness via different policy instruments, mainly R&D subsidies to SMEs and larger firms for collaborative partnerships with various institutional and geographical scopes. By comparing FP7 and Horizon2020, two recent Framework Programmes (FPs), the innovation focus has strengthened besides basic research within subsidized R&D activities. Additionally, the projects involve more partnerships between higher education and research institutions, private firms and public sector bodies. The picture of the network formed by supported projects shows a concentration around larger and older EU member states while the smaller countries, but also EU13 (the new member states) locating on the periphery. Individual countries are engaged in international R&D networks with different patterns, but for EU13 countries the networking barriers seem to be higher, even in the most successful cases the single partner (mostly SME) projects dominate. In gaining stronger hub roles in the private firm R&D networks, the economies in all countries need to improve connectivity within and outside their communities.

Keywords
R&D, innovation, EU13 countries

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Introduction

Empirical studies have shown that internationalization processes of firms in research and development (R&D) are slower compared to those of trade or investments (Pavitt 2001; Carlsson 2006). The pioneers of R&D internationalization have been high-tech companies in small markets with little research resources in their home countries. The motives for internationalization in R&D besides widening the R&D resource base, sharing costs, learning from partners, etc. concern also the search for the novelty value of collaboration for innovation, but the costs are associated to collaborative capacity and lack of experience (Nooteboom 2012). Globalization increasingly involves advanced know-how shared through value chains, which are tightly controlled by industrial corporations (Baldwin 2016). In this context, EU's industrial policy aiming at boosting Europe's industrial leadership and competitiveness is focusing on the variety of R&D subsidies to SMEs and larger firms for collaborative partnerships with various institutional and geographical scopes. The subsidies of these collaborative R&D programmes rest on the underlying assumption of failures in knowledge transfer and information flows rather than the production of R&D per se (Luukkonen 2000).

FP as a policy instrument has gained in importance witnessing the budget increase from about 4 billion euros in FP1 to budgets twenty-fold as large (80 billion euros) in H2020 and thirty-fold (120 billion euros) in FP9 (EC 2017). The rather complicated instrument design in H2020 involves funding of cooperation projects via the sequence of (thematically prioritized) calls, where specific instruments have different (minimum) requirements for the cooperating teams from different EU countries (only some single-partner instruments are available), the funding is on a shared-cost basis for firms and the applications are reviewed by committees of independent reviewers.

While all previous FPs (and hence also earlier research on networks formed in FPs) have focused on building of European Research Area (ERA) in the meaning of (public) research systems; H2020 has tried to provide a break with the past through the considerable changes in distribution mechanisms of FPs, the stated ambition to cover the entire innovation cycle, and the focus on closer-to-market applications and major societal challenges. As this shift has been pursued in the context still influenced by the last economic crisis (see EC 2017b; Karo et al. 2017; Young 2015), it has had a two-fold impact on participation patterns in H2020. On the one hand, all national governments across Europe have set participation in the EU research funding schemes as a central focus on their R&D policy agendas, in particular, to compensate for cuts in the investments in R&D at the national level (Enger 2017; Enger & Castellaci 2017). Private-sector activity has also intensified considerably as the total number of applications submitted by private actors has increased by over 130% between FP7 and H2020 (EC 2017). On the other hand, as the competition for H2020 funds has become fiercer than ever (30,000 applications per year over the first years of H2020 in comparison to 20,000 in FP7), vastly outstripping the supply, considerable problems of oversubscription have emerged (EC 2017a; EC 2017c). It is still noticeable that the firms have become the largest organization group participating in H2020 in numbers (considering the EC contribution, their prevalence decreases, Ukrainski et al. 2019). Firms have replaced in H2020 research organizations as main partners for universities and higher education institutions (HEIs) (EC 2017:97).

One essential aspect regarding the globalization of R&D networks, which has received not much attention, is that the connectivity to the outside-EU has slightly diminished compared to FP7 in relative terms. The number of participations with associated countries has decreased by 1.2% and with third countries by 1.7%; the decrease is visible already from lower application shares down by 1.3% and 2.5%, respectively (EC 2017: 40). In this respect, the H2020 seems to concentrate rather on strengthening the ERA vis-à-vis global R&D networks. As mid-term evaluations of H2020 reveal, the barriers for international cooperation within H2020 seem to be higher for participants from new member states (so-called EU13), but also for smaller member states (EC 2017b), which can potentially imply lower connectivity of business sectors of EU15 countries compared to EU13 ones.

The aim of the paper is to identify first, which sub-communities of countries are formed by R&D networks of firms in H2020 and second, which roles are played by different countries within the wide firm-based network of H2020.

Experience of FPs in supporting the cooperation between different types of partners

The underlying justification for FP funding is the assumption of failures in knowledge transfer and information flows related on the one hand to the localization of knowledge spillovers discussed in the literature on clusters, industrial districts, etc. (see Basant et al. 2002; Florida 2002, etc.), but also in institutional contexts discussed in the literature on innovation systems (see Lundvall 1995; Edquist 2001; Cooke 2002; Malerba 2004), which may hinder wider internationalization of R&D. At the same time, wider internationalization is desirable for firms searching for more radical innovations, as the novelty value of innovation can be larger from the collaborations with cognitively more distant partners. However, this kind of cooperation requires more absorptive capacity and collaboration experience to grant the expected value from it (Nooteboom 2012). Proximity vs. distance types can vary in cognitive, technological, institutional (formal and informal), social, cultural and physical dimensions when it comes to cross-border regional innovation systems (Makkonen et al. 2017). Thus, we can expect that the firms from different countries face quite diverse conditions in trying to internationalize their R&D activities via H2020 projects.

Earlier research has found that financial incentives have been a significant motivation for researchers from small and large countries in participating in EU-funded research collaboration (evidence for Finland is given in Hakala et al. 2002 and for France and UK in Pohoryles 2002). Other motives include gaining experience, increasing the international visibility, training and career advancement, but also opportunities to disseminate research results (Hakala et al. 2002). Scherngell and Barber (2009) show by analysing EU FP5 data that geographical distance effect is weaker than the technological distance in explaining the existence of public research networks. It is argued that collaboration within EU funding frameworks has led to more permanent links between collaboration partners (Pohoryles 2002, Barber et al. 2006). Okubo and Zitt (2004) argue that regardless of the FP-s, network patterns have remained quite fixed and are built on previous cooperation, and the EU policies have done little to change the collaboration ties especially for the large European countries such as Germany, France, and the UK, whereby co-authorship of articles remains primarily limited to national collaboration rather than international collaboration.

Europeanization has been more common amongst smaller European countries (Okubo, Zitt 2004; Tijssen 2008) as empirically; higher collaboration frequencies have been generally found in case of small countries (see for example the review in Thorsteinsdóttir, 2000a). Melin (1999) based on a sample of universities in the US and Northern Europe concluded that except for the very extreme cases in terms of scientific size (with Iceland on one end and the US on the other) there is hardly any indication on decreasing international collaboration with increasing size of the country.

FP as an instrument supporting the internationalization of R&D of firms

Typically, the internationalization processes of firms in R&D are understood to include five key elements (Paoli, Guercini 1997:3):

- possession of structured research laboratories abroad;
- international inter-exchange of know-how, patents, and licenses;
- cooperative agreements and joint ventures, participation in associations, consortiums, programs conducted together with other organizations (also with competitors in the field of pre-competitive and pro-competitive research);
- training of research personnel in foreign countries;
- recruitment and hiring of scientists and engineers from abroad.

The cooperation as understood in H2020 can potentially involve most of these elements, where the partners considered in H2020 include HEIs, government labs, other private firms, and other participants involving non-governmental and governmental bodies. The shift in innovation models towards open innovation suggested that the increasing trend towards public-private interactions in R&D could be explained by expanding widely the cognitive links between science and technology in the innovation process making the distinction between them more difficult (Narin & Noma 1985; Gibbons et al., 1994). Many concepts describe this increasing connectivity between the government, higher education, and business enterprise sectors in R&D as the triple helix model (Etzkowitz & Leydesdorff 2000), knowledge triangle (Unger & Polt 2017), etc.

In correspondence to the above-mentioned ideas, but also following the recommendations from FP7 ex-post evaluation, H2020 ambition was set to cover the entire innovation cycle and focus on closer-to-market applications and major societal challenges, which would also include more firms as partners in the program (EC 2017b). Several and complex instrument types have been designed in H2020 to incorporate different actors for different purposes of collaborative projects. These instrument types (also called Action types) in H2020 are described in details in Appendix 1. H2020 does not foresee any direct instruments for possessing labs abroad but is rather focused on the international exchange of knowledge, cooperative agreements, and training (see Table 1). It has to be noted that the international exchange of knowledge accompanies the agreements, but there are no instruments directly targeted for purchasing patents or licenses, etc. rather the creation and exchange of knowledge are supported via direct project costs. The only pure knowledge exchange instrument is CSA (Coordination and Support Action) involving standardization, dissemination, awareness raising and communication, networking, coordination or support services, policy dialogues, and mutual learning exercises and studies. It is necessary to note that the EU foresees minimum requirement for partners, which have to be present in funded projects from different member states (MS) or H2020 associated countries (AC) this way ensuring the international collaboration in R&D (Table 1).

Table 1. Motives of firms for internationalization and H2020 instruments

Motive for internationalization	Instrument (action) type	Network complexity	Role of the firm
Possession of structured research labs abroad	No instruments	Low-high	Initiator
International -exchange of knowledge	CSA	Low to high (min. 1 partner)	Initiator, partner
Cooperative agreements	IA, RIA, ERC, ERA_NET Cofund, PCP, PPI, EJP Cofund	Low (min. 1 partner in ERC) to high (min. 5 partners in EJP Cofund).	Initiator (IA, RIA; ERC); otherwise partner
Training of research personnel, recruitment and hiring	MSCA	High (min 3 partners, typically 6-10 partners)	Initiator, partner

Source: Authors' compilation

Most of the instruments are targeted to cooperative agreements in R&D, for example, Innovation Action (IA), Research and Innovation Action (RIA), European Research Grants (ERC grants), where firms can be initiators of R&D consortia. It has to be noted that ERC is mostly a single partner instrument (similar to SME-instruments, see also Appendix 1), although the involvement of multiple partners is allowed. There is a group of instruments, targeted to research funders (ERA-NET Cofund, EJP Cofund) or public procurers (PCP, PPI), where firms can act as project partners in roles of users or implementation partners. The training and hiring related support is given via Marie Skłodowska-Curie actions (MSCA) with quite complex network structures allowing the firms to train or hire Ph.D. students and advanced researchers while cooperating in an international network.

Methodology for the Analysis of Firms in EU H2020

Our appeal for using network analysis for the study of firms R&D cooperation in H2020 emerges from the fact that a network approach can recover the whole structure of interactions. For example, it is possible to specify the countries that hold a (more/less intense) cooperative relationship among them, but that also cooperate with another sub-community of countries. Similar analysis has been conducted for example in explaining trade integration via import and export flows data (see Fagiolo et al. 2007). Here the idea is to depict the web of private sector R&D relations as a network where countries play the role of nodes, and a link (an edge) describes the presence of an H2020 contractual relation between any two firms from two different countries. The intensity of those flows measured by the number of co-operations (projects). This methodology allows for a better description of the existing heterogeneity in the degrees of connectivity and, hence, of international integration of R&D of firms within H2020. Organizations in different countries can build larger networks participating in several projects of H2020 thus potentially forming different communities (sometimes also called clubs), which are more tightly connected, e.g. it is often claimed that EU13 countries are facing a “participation divide” in accessing H2020.

Following the methodology developed in Guimera and Amaral (2005: 5-6), we measure the roles of countries within different communities they form. The first characteristic (so-called z-score (1)) measures the connectivity of nodes in different countries within one community, which characterizes the level of decentralization of networks – if all nodes have similar (and lower) z-scores versus centralization – if only some nodes are highly connected to others.

The z-score is calculated as follows:

$$z_i = \frac{k_i - \overline{k_{s_i}}}{\sigma_{k_{s_i}}}, \qquad (1)$$

where:

z_i – z-score, which measures, how well-connected a node (a country) is to other nodes within the network or community;

k_i – the number of links (projects) of node *i* to other nodes in its network s_i;

$\overline{k_{s_i}}$ – the average of *k* over all the nodes in a network s_i;

$\sigma_{k_{s_i}}$ – the standard deviation of *k* in s_i.

The second characteristic shows the connectivity of a node to the other communities, it is defined as participation coefficient P_i:

$$P_i = 1 - \sum_{s=1}^{N_M} \left(\frac{k_{i_s}}{k_i}\right)^2, \qquad (2)$$

where:

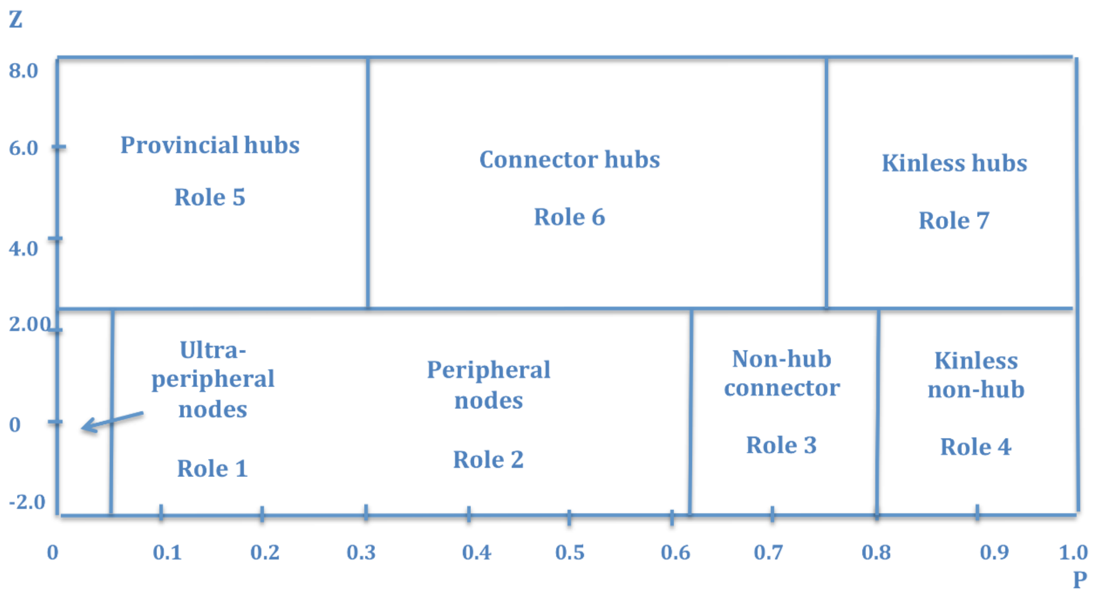
P_i - participation coefficient in a network

k_{i_s} - number of links of node *i* in network *s*.

k_i - the total degree of the node *i*.

The nodes can be further classified by plotting them on the (*P, Z*)-axis (Figure 1), where being a relative center (hub) of the community or having relations (kins) or not.

Figure 1. Partition of nodes and roles of network participants



Source: Adapted from Vonortas (2013) and Guimera & Amaral (2005)

Note: Z – Within-community degree (degree of connectivity within its own community); P – participation coefficient (fraction of links outside own module).

Guimere and Amaral (2005) define nodes with above *z = 2.5* hubs and below that value non-hubs; both categories are further characterised by using the value of *P* to play seven roles in the community as follows (Guimera & Amaral 2005, Supplemetary material, p.2):

- Role 1: Ultra-peripheral nodes, where all the links are within their module ($P \leq 0.05$)
- Role 2: Peripheral nodes, where most of the links are within their community ($0.05 < P \leq 0.62$)
- Role 3: Non-hub connector nodes with many links to other communities ($0.62 < P \leq 0.80$)
- Role 4: Non-hub kinless nodes, where links are homogenously distributed among all communities ($P > 0.80$)
- Role 5: Provincial hubs, where vast majority of links are within their own community ($P \leq 0.30$)
- Role 6: Connector hubs with many links to most of the other communities ($0.30 < P \leq 0.75$)
- Role 7: Kinless hubs with links homogenously distributed among all communities ($P > 0.75$).

We use *igraph* software in R (see Csardi & Nepuz 2006) for the detection of communities of countries within the H2020 network. There are different algorithms to detect the communities and we use here the *spinglass* algorithm, which is one of the most suitable for the small number of nodes and the basic principle of the method is that the edges should connect nodes with the same spin community, whereas nodes of different communities should be disconnected (Yang et al. 2016). We use for the estimation directed matrix of connections between the countries (Appendix 2), where rows represent project connections of country *i* firms and columns represent project connections via consortia partners from country *j*, where country *i* firms are present. This matrix is not symmetric but enables us to additionally detect the directionality of the edges. It is important to note that the projects with a single partner (mostly in SME and ERC instruments) are left out from the matrix. The diagonal of the matrix is representing the number of partners (except for the firms themselves) connected via partnerships from the same (home) country.

Participation of Firms in H2020

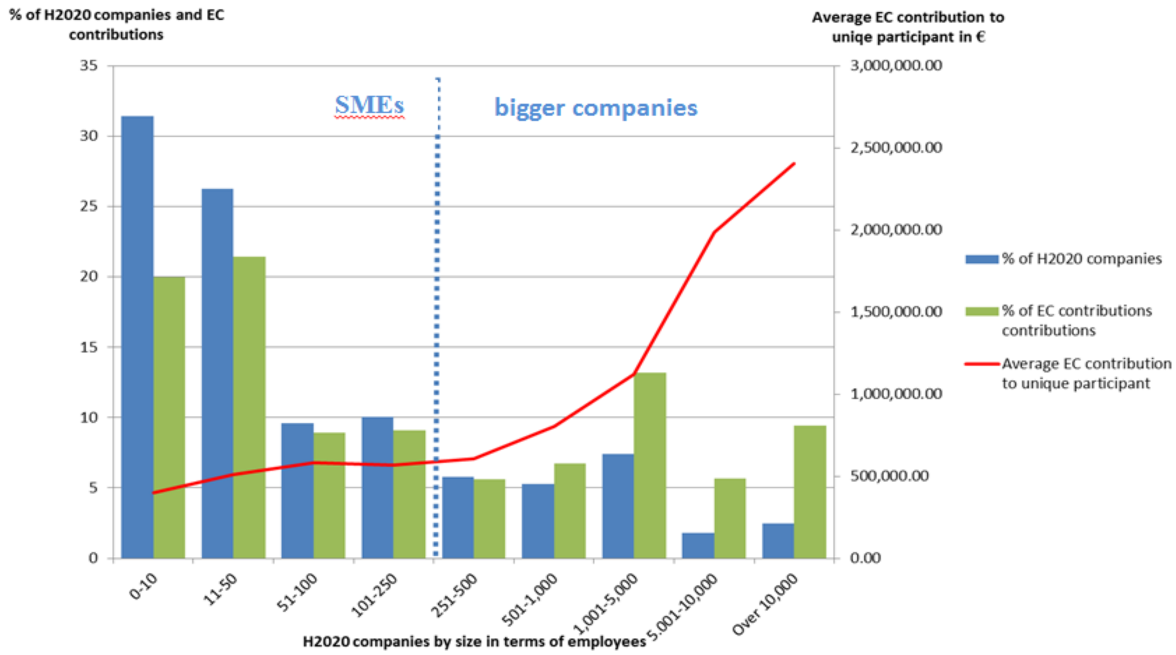
About two-thirds of participating firms in H2020 are SMEs (Figure 1), but the largest grants financially are given to older and more established firms, which is natural considering the size of the private co-funding rates (EC 2017). Sector-wise, the largest share of H2020 partners as recipients of funding are from manufacturing industries (35%), professional, scientific and technical activities (services) (30%) and ICT (16%) totaling to 80% of all grants (EC 2017).

Regarding the participation motives and abilities, small and large firms are very different. SMEs tend to strongly emphasize financial incentives and tangible results, for example developing new or improved tools, methods or techniques. For large companies, H2020 projects are not so much considered tools for technology commercialization, but often function as “technology-watch” instruments which allow companies to stay informed about the latest R&D developments as well as to network and establish relations with partners to gain access to knowledge and expertise (Performance of SMEs within FP7 ... 2014; EC 2016a; also Polt et al. 2009).

By looking at the consortia structures of projects, it becomes evident that the firms from EU13 countries have coordinated only very few R&D projects (Figure 3). Still, the differences are here not so large between EU13 and EU15 as compared to the projects coordinated by HEIs or public research sector reflecting much wider capability differentials. Some reasons could be related to a specific SME instrument, which is a single partner instrument (this partner is then automatically the coordinator). In SK 23% of coordinated projects are within SME instrument and in BG 14%. In other countries, this effect is smaller – DE (9.5%), CY (8.3%), EE (7.9%) and in other countries even less.

Other reasons may be associated with a kind of gaming behaviour described in Ukrainski et al. (2018). Some interviewed participants admitted the prioritization of the entrance or initiation of consortia with partners from certain countries usually represented in successful projects (e.g., DE, BE, NL, ES). But even more critically, many researchers from social sciences to ICT claimed to know situations where already more or less finalized project proposals are “traded” between different types of actors from different countries to increase the probabilities of funding success.

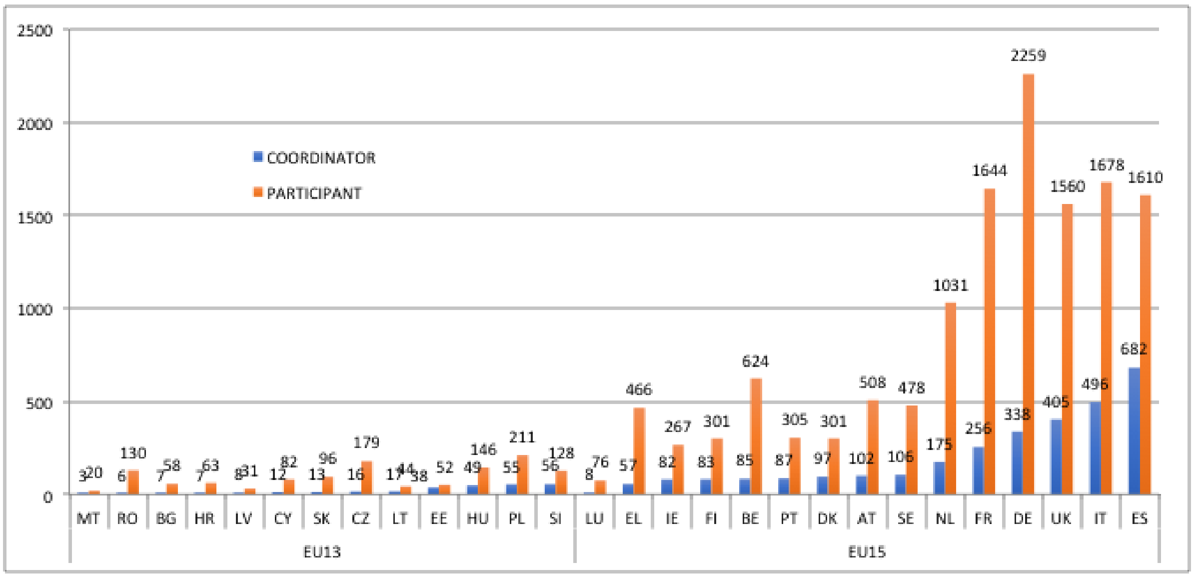
Figure 2. H2020 grants receiving companies by number of employees and EC contribution received.



Source: EC 2017:99 (Cut-off date 16/01/2017)

It is relatively obvious that such gaming will be detrimental to functional cooperation as well as to substantive research progress, but here it could also over-estimate the co-ordination role of the firms in H2020 if the greater participation of firms would be desirable by proposal evaluators. Since such co-operative experiences become manifested in networks (Ahuja et al. 2012), it is an open question, how the overall network is designed by perceived prioritization of expert committees or how this has changed since FP7, where inclusion of participants from EU13 was perceived obligatory.

Figure 3. The number of projects, where firms are acting as coordinators or partners in EU13 and EU15 countries (ordered by the number of coordinated projects).

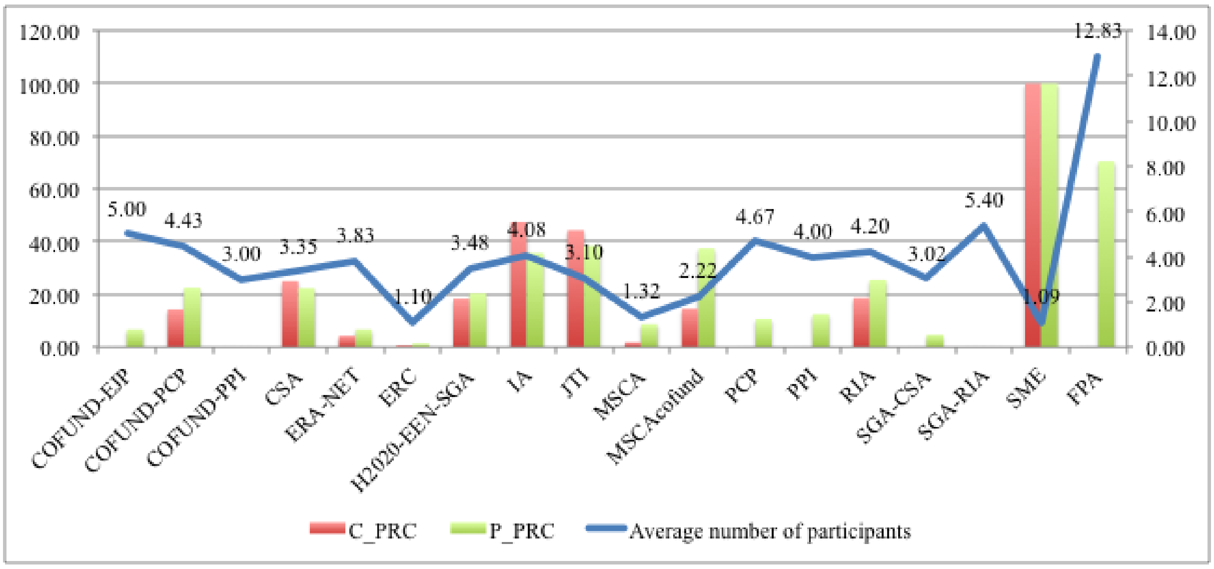


Source: Authors' calculations based on eCORDA (Cut-off date 28/02/2017).

By looking at the structures of projects by partner types, the roles of firms appear to correspond to the purpose and design of the instruments. Although in ERC, SME and MSCA instruments, the number of partners can be potentially larger, these seem to be single-partner projects also for firms. In EJP, ERA-NET, PPI, PCP, but also specific contracts (SGA), the relevance of firms is lower (e.g., in PCP and PPI less than 10% of firms are participants), but these are also the networks with higher complexity involving minimum 3-5 partners (including public sector ones) from different MSs. The size of the networks is much larger compared to the minimum standards summarized in Table 1.

The higher role of firms as partners is seen in FPA (Framework Partnership Agreement), which is long-term cooperation that sets out a work program and the terms and conditions for receiving grants to implement this program via RIA, IA and CSA instruments (see also Appendix 1).

Figure 4. The share of private firms as coordinators (C_PRC) or participants (P_PRC) on the left axis and average number of participants on the right axis across all action types



Source: Authors' calculations based on eCorda.

The higher role of firms as partners is seen in FPA (Framework Partnership Agreement), which is long-term cooperation that sets out a work program and the terms and conditions for receiving grants to implement this program via RIA, IA and CSA instruments (see also Appendix 1).

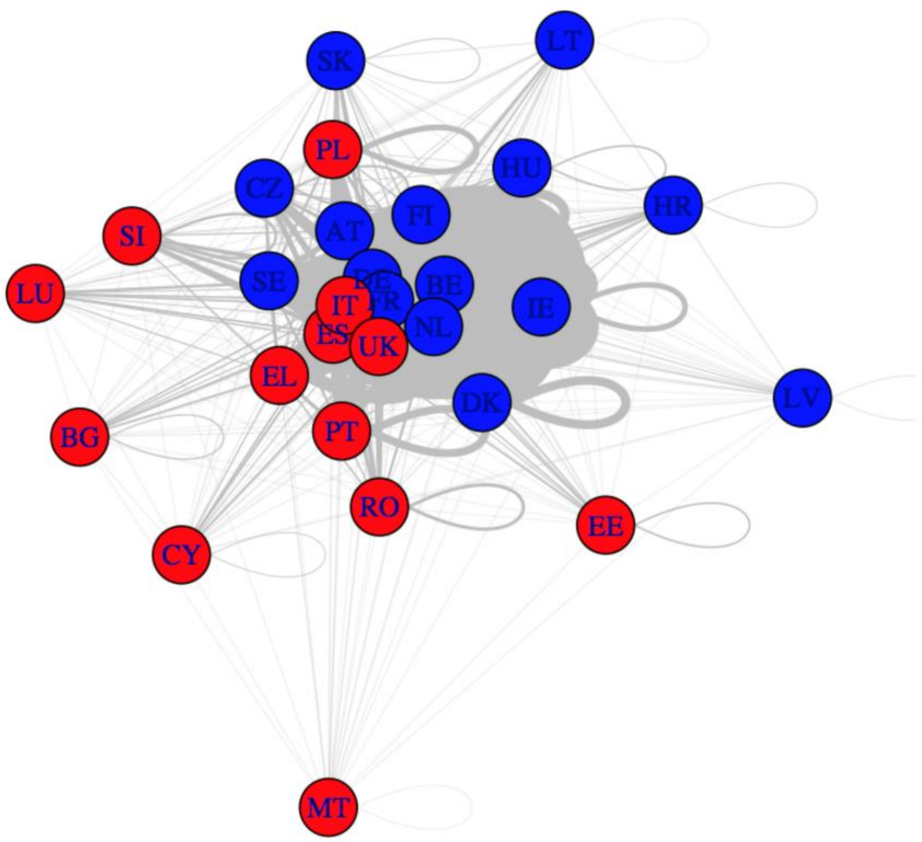
The firms act as coordinators in IA and JTI (Joint Technology Initiatives) (above 40% from all funded projects), but interestingly enough coordinates in more than 20% of projects in CSA instrument. The last aspects seem to confirm the “technology-watch” and access to knowledge and networks motives of firms.

The Networks of Firms in H2020 Projects

The network that is revealed by analysing the connections of firms between different countries is evaluated by using the matrix in Appendix 1. The number of nodes is 28 and the average degree (the number of other countries to which a country is directly connected to (including itself) is 28.79 in that network). Private sectors of most countries have connections with all other EU28 countries, except for small countries like MT (links to 26 other countries) and CY, EE, LU, and SK (links to 27 other countries). The number of connections that a given node has within a network is referred to as node degree, while the sum of all the valued interactions is referred to as node strength. These node strengths are presented as the thickness of the link between the countries in Figure 5.

As expected, smaller countries with correspondingly smallest numbers of connections are located on the margins of the whole EU-wide network, but so are the BG, RO, and SK. Indeed, we do not find based on our analysis pure EU13 vs. EU15 divide into communities; we rather see the partition into two groups on Figure 5: (1) A small country (LU, SI, EE, CY) group together with larger EU13 participants of PL, BG and RO and IT, ES, EL and UK from EU15 countries (red); (2) A Central-European (both EU13 and EU15) group with Nordic and Baltic (LV, LT) countries (blue).

Figure 5. The network of firms in H2020 projects forming two communities.

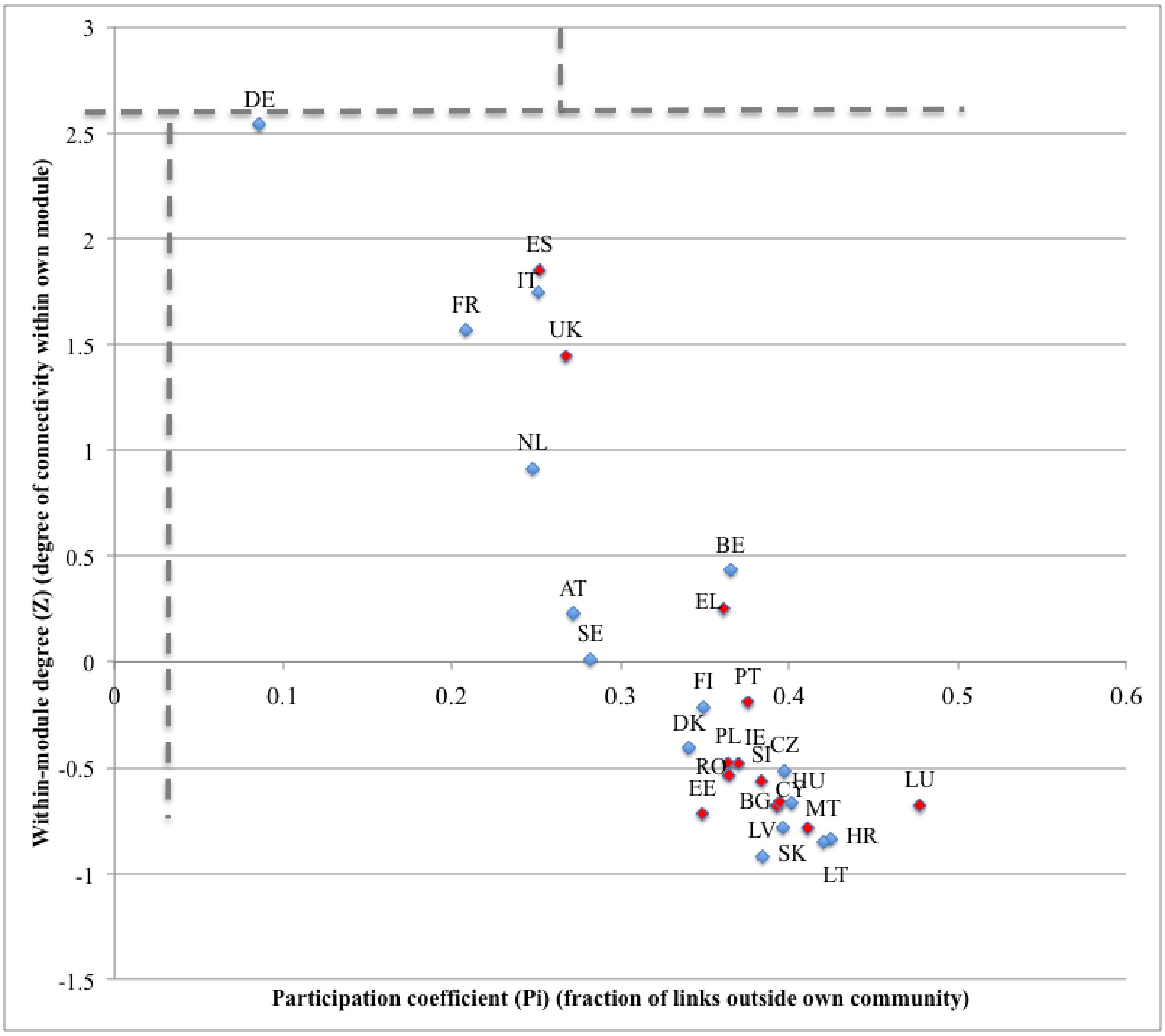


Note: The layout is created using Fruchterman-Reingold algorithm (nodes with the highest number of connections are located at the center of the graph). The links are representing the nodes proportionally (the number of nodes is divided by 100); the colors of nodes represent the communities. Source: Authors' calculations based on eCORDA

Regarding the sensitivity analysis, it has to be noted that next to the partition depicted in Figure 5; spinglass as an iteration-based algorithm, constructed in 40% of iterations (out of 20) another partition. This partition is placing most of the EU15 into one and CZ, HR, HU, IE, LT, LV, PL and SK to a second community, and mostly small countries CY, EE, MT, SI but also more weakly connected participants of EU13 like BG and RO to a third community. Thus, the EU15 vs. EU13 divide cannot be convincingly rejected, but besides that aspect, a small country community emerges in the periphery of the network based on the firm connections. As still in 60% of iterations the two-community division was detected, we continue by using this partition in our further analysis.

By identifying the roles of companies in networks, we use z_i to measure how well connected the country *i* companies to the country-community (recall, that high values of z_i indicate high within-community degree and vice versa (Guimera & Amaral 2005)). The results are depicted in Figure 6 revealing that the participation pattern of firms in H2020 brought forward only one country, which could take the role of a provincial hub (where the vast majority of links are still within their community ($P \leq 0.30$)) and this country is DE. All other countries are representing peripheral nodes, where most of the links are remaining within their community ($0.05 < P \leq 0.62$). The small country group, as well as that of the EU13 countries, is placed at the lower-right corner of Figure 6 showing relatively weaker within-community ties and relatively stronger ties outside the community.

Figure 6. Partition of nodes Source: Authors' calculations.



Note: The dotted grey lines represent the boundaries of the roles as set by (Guimera &Amaral 2005).

These results can be interpreted in several aspects. At first, the EU-wide network seems to be a decentralized one, where no connector hubs and kinless hubs, but also no non-hub connectors and kinless non-hub connectors could be detected. This means that most of the countries live in the network periphery; there are almost no highly connected centres (except, perhaps for DE). On firm level, Vonortas (2013) by analysing the ICT-RTD network comprising projects of FP6 and FP7 has found 2.6% of nodes in ultra-peripheral roles, 55.3% are peripheral nodes, 36% of nodes in non-hub connector roles, 3% in kinless non-hubs and almost 3% in different hub categories. As the networks of individual participating organizations in H2020 are much smaller compared to the countries, the variety of roles is larger, which may limit or alter the hub and non-hub categorization, and respective values.

For DE becoming a connector hub, it needs to increase the connectivity outside its group consisting of Central-European, Nordic and Baltic countries. For other large countries (ES, IT, UK, FR), the connectivity within the own communities need to be increased to become peripheral hubs and outside their own communities to become connector hubs.

Conclusion and Discussion

By comparing FP7 and Horizon2020, two recent FPs, the innovation focus has strengthened besides basic research within subsidized R&D activities. Additionally, the projects involve more partnerships between higher education and research institutions, private firms and public sector bodies. Individual countries are engaged in international R&D networks with different patterns, but for EU13 countries the networking barriers seem to be higher, even in the most successful cases the single partner (mostly SME) projects dominate.

The analysis has found two sub-communities of countries based on the networks of firms in H2020. The communities do not overlap with the typical EU13 vs. EU15 divide, but rather point to the Central-Europe and Nordic-Baltic cooperation on the one hand and the small country group, larger EU13, and peripheral EU 15 countries on the other hand. There is still only one hub-country (DE) identifiable based on the network of firms in H2020, the rest of countries are operating in the network periphery, especially smaller and EU13 member states. These smaller EU countries are also relatively less connected within their community. However, the fraction of connections outside their community is relatively larger compared to the Central-European group of EU13 countries. In gaining stronger hub roles in the private firm R&D networks, the economies in all countries need to improve connectivity within and outside their communities.

It is clear that H2020 is becoming more important to industry in bringing together and leveraging different competencies from all over Europe, which would be impossible within the national-level R&D support instruments. Projects have the potential for scaling effects, as new projects create new references and increase the reputation and potential visibility of the companies within the EU, but also globally. Financial sustainability of research groups and R&D-intensive companies is typically seen as an advantage. However, the industry in EU13 seems to prefer more instruments that fund sole beneficiaries (e.g., SME) than other more collaborative instruments pointing to the failures in domestic and international networks. It is also noted in the H2020 evaluation „However, they [SMEs] do not have the capacity and resources to go into product development, nor to get innovations quickly into the market. Thus, much closer interaction with large companies is needed. [...] It is unclear whether this arbitrary measure of share in participation and budget really reflects the real added value of SMEs". (Ex-Post-Evaluation of the 7th FP … 2015, 65; Performance of SMEs within FP7 … 2014, 95).

Current research has several other limitations. The network study does not examine disciplinary and sectoral aspects, but also the type of research project (such as basic or applied research), and also more precisely the type of interaction dimensions as we have only identified the project membership. These dimensions could be used simultaneously to elaborate on the firms' network structure and its determinants in H2020. The robustness of the analytical methods of finding the sub-communities of countries can be further checked by generating a random network with the same parameters and compare the correctly classified nodes of the network.

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