European Commission

COLLABORATION AND NETWORKS: EU13 PARTICIPATION IN INTERNATIONAL SCIENCE

NICHOLAS HARRAP, MATHIEU DOUSSINEAU

In this issue

- In the 2007-2013 period the overall international co-publication intensity of EU13 countries was low compared to EU15 countries.
- In FP7, the EU13 countries had low participation and were again largely on the periphery of the network.
- In the EU focussed co-publication network EU13 countries were outside of the core group comprised of EU15 countries. However, for the FP7 network some countries (Czech Republic, Hungary and Poland) had stronger links to the core again comprised of EU15 countries.

- Germany is an important collaborative partner for EU13 countries for both co-publication and FP7 participation, Austria also appears to have an important role linking to Central European Countries.
- This work suggests there is a need for EU13 countries to improve international research collaboration, particularly with EU15 Member States.

1. Rationale

The European Commission Stairway to Excellence (S2E) initiative aims to assist to EU Member States (MSs) and Regions in promoting R&I excellence across Europe. Work undertaken by the project identified several issues required to build R&I capacity in EU13 Member States (Conte & Ozbolat, 2016). Amongst these issues was the need to improve research collaboration with EU15 Member States.

Another aspect to consider is the hypothesis that EU13 countries do not succeed in competitive EU research programmes as there is a closed club composed of tight networks of organisations in EU15 MSs.

The evidence on this is mixed; Hoekman et al (2013) have shown that regions that co-publish frequently did not receive a disproportionate share of funding in the 5th and 6th Framework Programmes (FPs). Meanwhile, Lepori *et al* (2015) have presented analysis that has indicated that FP participation has less to do with network effects and more to do with institutional characteristics such as size and reputation.

However, earlier work by Roediger-Schluga & Barber (2006) showed a significant tendency for the same institutions to participate in consecutive FPs with recurring collaboration between the same organisations.

Cross border research collaboration and networks are not the only factor affecting the EU13 level of FP7 participation. However, understanding the characteristics of collaboration networks could help in designing strategies to overcome deficiencies.

The objective of this JRC Policy Insight is to better understand the research links of EU13 countries and the policy implications.

To study the international research links both international co-authorship and FP7 (Cooperation Specific Programme) project co-participation were used. The data used were extracted from the FP7 contracts database and the bibliometric indicators for collaboration patterns from the Scopus database of research output.

The time frame for extracted publications was 2007-2013 as the timeframe for FP7 is also 2007-2013 this assumes that many of the collaborations for the co-publications were formed prior to FP7. Consequently, we can have an indication of the effect of a country's integration in the international science system on the subsequent participation to FP7.

International collaboration intensity can be measured by the co-authorship of publications and is indicated when the authors' affiliation addresses are in two or more different countries. For the purpose of this work, where the interest is intra-EU collaboration, collaboration is counted if there are at least two EU countries.

As we are only interested in international collaboration and that the FP7 Cooperation Specific Programme was a programme that required trans-national collaboration, a normalisation[1] of the strength of the link between two countries was done based on the total number of co-publications or co participations in FP7 projects for each country.

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[1] The normalisation is based on Salton's index, which is a relational indicator of the strength of co-authorship links. It is calculated by taking the total number of joint publications between two countries and dividing it by the square root of the total number of publications of the two countries.

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3. Analysis of international collaboration links and networks

This section considers the collaboration links formed between countries through international co-authorship and FP7 projects.

3.1. Co-authorship

Figure 1 shows the proportion of international co-publications for the 2007-2013 period against the yearly average number of researchers and engineers for the country.

The lower proportions are populated by EU13 countries (in red) suggesting they are not as extensively linked in international research as the EU15 countries. If EU13 and EU15 countries are considered as two separate groups they both tend to follow the established pattern of smaller countries being engaged in international collaboration more than larger countries (OECD, 2010).
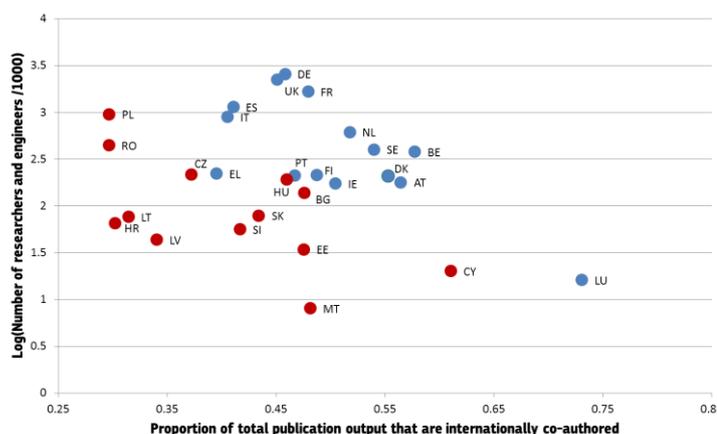

Figure 1: Proportion of international co-authored publications v number of researchers and engineers for 2007-2013 period

Figure 2 demonstrates that, when only considering EU countries, most of the EU co-publications produced by EU13 countries are proportionally more likely with EU15 countries. Only Slovakia has a greater value for EU13 countries than the EU15 countries, which is probably driven by historic collaboration with the Czech Republic.

Main issues related to international collaboration and FP7

- *EU13 countries generally have a low level of international collaboration. While they have more links with EU15, normalised links are stronger with other EU13 countries*

- *EU13 countries had low participation in FP7. In absolute terms Germany is the most frequent top partner. Normalised FP7 links are less EU15 dominated.*
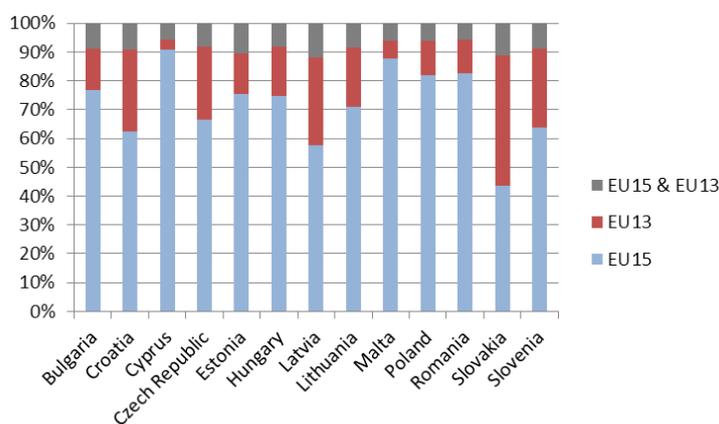
Figure 2: Proportion of EU13 countries' EU co-authored publications produced with EU15 and other EU13 countries

With the exception of the Slovakia and the Czech Republic link, the EU15 countries are the top partners for EU13 countries, which is not surprising given the greater number of publications produced.

In Table 1, Country B indicates the country with which Country A (one of the EU13 countries) has the strongest co-publication link.

Country A (EU13)	Ctry B norm.	% A of total co-pub.	% B of total co-pub.	Ctry B count
Bulgaria	PL	11.10%	2.20%	DE
Croatia	HU	7.60%	3.00%	DE
Cyprus	EL	36.00%	4.90%	EL
Czech Rep.	SK	11.90%	31.70%	DE
Estonia	LT	8.40%	9.30%	FI
Hungary	RO	6.50%	7.60%	DE
Latvia	LT	13.10%	5.90%	DE
Lithuania	EE	9.30%	8.40%	DE
Malta	UK	48.00%	0.10%	UK
Poland	DE	24.20%	3.50%	DE
Romania	HU	7.60%	6.50%	FR
Slovakia	CZ	31.70%	11.90%	CZ
Slovenia	HR	11.00%	13.90%	IT

Table 1: Top partner country (Country B) for co-publications

If we consider co-publication links using the normalisation method there are many more EU13 countries representing Country B (column 2) than for the non-normalised (column5). Furthermore, it is also revealing to consider the relative importance of the relationship for each country (Lampert, 2015). In general it is fairly close (see shares of co-publications for countries A and B), except when country B is an EU 15 country such as Germany for Poland and the UK for Malta.

When considering the non-normalised count of co-publications there is a bias towards Country B being large EU countries (column 5). Given the greater output of EU15 countries this result is not unexpected.

It is notable that taking both the number of co-publications and the normalisation produces Germany as the most important country for Poland indicating the importance of Germany to Poland's international collaboration activity. The same can be said for Malta's links with the UK and Cyprus's links with Greece.

3.2. FP7 Participation

In Figure 3, the percentage of FP7 projects in which each country participates can be seen. This is dominated by EU15 countries with Germany being involved in as many as 70% of projects, while Poland, the highest placed EU13 country, is in 14% of projects.

Figure 3: Proportion of FP7 projects in which a country participates

Table 2 shows the country Bs for FP7 based on the normalisation. As with co-publications Germany is the most important country for Poland. However, while only three of the countries in Table 1 are EU15 in Table 2 (FP7) it is six. This suggests that FP7 did foster stronger overall links between some EU13 and EU15 countries. There are larger differences in the number of co-participations as a proportion of a country's total participations if Country B is a EU15 country.

In absolute terms Germany is the most important country with regard to being a partner for EU13 countries in FP7, given the results in Figure 3 this is unsurprising. The UK and Italy are the only other countries acting as country B.

Country A (EU13)	Ctry B norm.	% A of total co-particip	% B of total co-particip	Ctry B count
Bulgaria	RO	29.80%	16.50%	DE
Croatia	SI	26.80%	10.50%	DE
Cyprus	EL	57.60%	6.80%	UK
Czech Rep.	DE	79.40%	10.20%	DE
Estonia	LV	15.00%	25.50%	DE
Hungary	DE	79.90%	10.30%	DE
Latvia	LT	22.80%	18.40%	DE
Lithuania	LV	18.40%	22.80%	DE
Malta	BG	41.30%	11.00%	IT
Poland	DE	77.30%	15.20%	DE
Romania	IT	67.10%	9.00%	DE
Slovakia	RO	25.10%	11.00%	DE
Slovenia	DE	76.30%	6.60%	DE

Table 2: Top partner country (Country B) for FP7 co-participation

3.3. Network Structures

So far only country pairs have been considered but a country will have links with more than one country and therefore have a position in a network. Figures 4&5 show network graphs, based on the normalised links for co-author collaboration and FP7 participation. The nodes that

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are more densely connected together are determined, thus identifying the different groups within each network[2]. The degree centrality of a node is based on the number of links the node has. The weighted degree centrality is the number of links to a node weighted by the strength of the link. In the networks considered for this analysis, where a country has a link to every other country, it is the weight, or strength of the links, that is of interest. The larger the size of the nodes for each country the larger the average weighted degree relative to the other nodes in the network and hence this indicates relative importance of countries in the network (larger nodes indicating greater importance).

In Figure 4 there are five groups. Groups 1, 2 and 3 are mostly EU15 countries. Malta is also in this group as it has many links with countries in Group 1, particularly the UK. The importance of geographic and cultural ties can be seen for Groups 2 (common language) and 3 (Nordic countries). Except for Greece, with its strong links to Cyprus, Groups 4 and 5 are predominately EU13 countries with a geographical bias towards Central European Countries in Group 4 and Baltic countries in Group 5. The largest node is Germany, closely followed by the UK, France, Italy and Spain. This signifies that they are involved in a large number of strong links and are the most central countries to the network.

In Figure 5 there is again a EU15 core around Groups 1, 2 and 3. The EU13 countries are again outside the core to varying degrees in Group 5 that also contains Luxembourg. However, an interesting development is in Group 4 where there are three larger central European countries that have frequent links to core countries in Groups 1 and particularly with Austria, which is also in Group 4. As with the co-publications the country with the largest node is Germany closely followed by the UK, France Italy, Spain and slightly further back the Netherlands and Belgium. It is notable that most of the Central and Eastern European countries have relatively smaller nodes in this network than in the co-publication network. This could be due to them having

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Main issues related to networks

- *The co-publication network shows a definite core of EU15 countries*

- *The FP7 network still shows a EU15 core but larger Central European EU13 countries are more strongly linked to these core countries*

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relatively more co-author links with other EU13 countries,

which produces stronger links based on the normalisation method[1]. In FP7, due to the higher frequency of EU15 in projects, they have relatively more links with EU15 countries which are frequently lower strength links due to the differences in rates of participation. This suggests FP7 did help to encourage links between EU13 and EU15 countries.
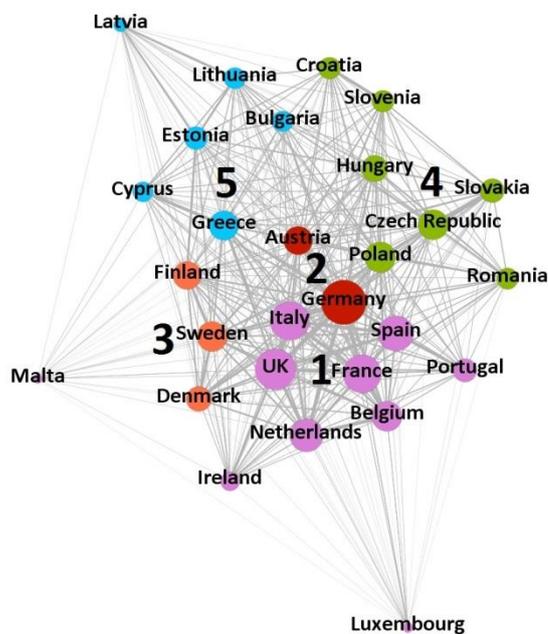

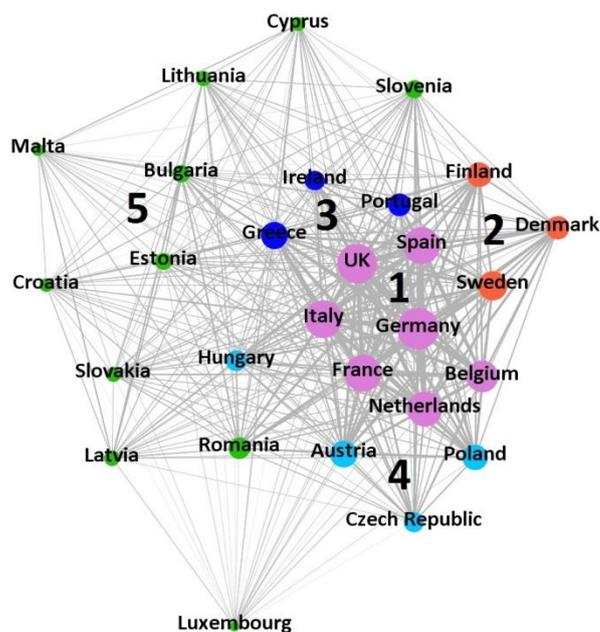*Figure 4: Normalised co-author collaboration network*

Figure 5: Normalised FP7 collaboration network

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[2] Community detection is through the Modularity settings in the network visualisation software Gephi, which utilises the Louvain Method (Blondel *et al*, 2008).

4. Summary and Issues

Overall, it can be seen that EU13 generally have a lower, and sometimes much lower, level of international collaboration than most EU15 countries. Furthermore, their co-publication profile and that for FP7 demonstrates the importance of links to EU15 countries. However, the EU13 countries do not have the same importance for the EU15 countries. This means that EU13 are often more dependent on their links to EU15 countries than EU15 countries are on their links to EU13. While this may not be unexpected, it is notable that there can be strong dependencies on particular countries: for example Germany seems to be very important for Poland whereas Poland does not have the same importance for Germany.

Within the EU there were countries that formed a core in co-author collaboration networks in the 2007-2013 period and they consisted of EU15 countries. In FP7 the same distinction existed, but to a lesser extent as some Central European countries appeared better integrated, particularly with respect to their links to Austria. So while there are countries in FP7 that appear to be in tighter networks and are more successful it may not be that these are "restricted access clubs" rather a reflection of the situation in the wider international R&I system. On the other hand, the smaller nodes for FP7 indicates that EU13 countries have weaker ties in FP7, this would be due to them having relatively more links with EU15 countries resulting from the normalisation procedure. This could indicate a variation on the club effect, where EU13 countries participate but with limited ''influence'' within the network.

Such difficulty accessing international networks could be one factor affecting FP7 participation of EU13 countries and there could be a case for specific policy action aimed at improving the conditions for international R&I. In this there could be a role for ESIF; however, international activities can be difficult as the regulations state that only up to 15% can be spent outside the OP territory.

Read more

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8. Blondel V, Guillaume J, Lambiotte R, Mech E (2008), ''Fast unfolding of communities in large networks'', in J Stat Mech: Theory Exp 2008:P10008

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About the authors

Nicholas Harrap, Researcher, "Stairway to Excellence" Team at European Commission's DG JRC – Territorial Development Unit (B3)
https://ec.europa.eu/jrc/en/person/nicholas-harrap

Mathieu Doussineau, Researcher, "Stairway to Excellence" Team at European Commission's DG JRC – Territorial Development Unit (B3)

http://s3platform.jrc.ec.europa.eu/stairway-to-excellence