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The Relationship Between Participating EU Framework Programmes and International Co-publication

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Introduction

In recent decades, the share of internationally co-authored scientific publications has remarkably increased (OST, 2019). Increasing complexity and specialisation in science, the growing importance of interdisciplinary fields, the rising costs of scientific activities, geographical dispersion of research, decreased costs of collaboration due to developments in ICT and transportation, and political support for "Big Science" are the most important factors behind this trend (Hoekman et al., 2010; Katz & Martin, 1997; Pike & Charles, 1995; Wagner, 2018). Besides, the higher citations and the advantages of belonging to a research network motivate researchers to collaborate internationally (Glänzel et al., 1999; Moed et al., 1991; Wagner, 2018).

Engaging in international collaboration consists of search and coordination costs for the researcher and demand more effort (Fry et al., 2020; Wagner, 2018). Governments and international bodies behave as the catalysts at that point through providing research programs with funds and practical mechanisms that reduce the costs and encourage researchers. European Union's (EU) Framework Programmes for Research and Technological Development (FPs), in operation since 1984, is the most extensive effort at the international level. As a part of its cohesion policy, the EU encourages, if not forces, countries to collaborate to access the funds provided with FPs (Erdil et al., 2021; Wagner, 2018).

While the specific objectives vary among FPs, the EU's primary goal is to enhance the competitiveness of Europe and to address societal challenges by strengthening the European knowledge base. Fostering collaboration and contributing to scientific cohesion are the foremost means to that goal. The contribution of FPs to promoting cooperation and collaboration is generally positive. FP projects increase co-publication, exchange of research materials, and mobility of scientists between the pairs (Dahl & Lahlou, 1991; Hakala et al., 2002; Persson et al., 2000). While some argue that FPs promote the cohesion in Europe in terms of science, technology and innovation (Higgins,1991; Erdil et al., 2021; Hoekman et al., 2013; and Di Cagno et al., 2016), the emergence of an "oligarchic core" through FP projects is also claimed (Breschi & Cusmano, 2004). FP funding has a significant and positive effect on

subsequent co-publications between regions (Hoekman et al., 2013); however, "integration in FP networks seems to be much higher than in the co-patent and co-publication networks", according to Lata et al. (2015).

The main aim of this study is to elucidate the relationship between participating FPs and co-publication patterns of European countries. Our central hypothesis is that the effect of cooperation through FP projects is not limited to the projects' timeline and proliferates the collaboration between actors by increasing social proximity. We test the effect of FPs on promoting cohesion among European countries by analysing a large dataset that covers all collaborative FP projects. We also examine various proximity measures affecting scientific collaboration between countries.

Literature Review

We follow Boschma's (2005) classification of proximity dimensions, namely geographical, cognitive, organisational, social, and institutional.[1]

Geographical proximity reflects the physical distance between actors. There is a consensus on the existence of an effect of physical distance on collaboration, yet the literature does not agree on the nature of its impact. Some assert that geographical distance affects collaboration both directly and indirectly (Broekel & Boschma, 2012; Katz, 1994). Yet, some argue that it has only an indirect effect on collaboration through other proximity dimensions (Crescenzi et al., 2016).

Social proximity refers to the socially embedded relations that occur when the actors engage in relations such as "friendship, kinship and experience", which create trust between them (Boschma, 2005). As recently reviewed by Fernández et al. (2021), the literature commonly uses previous collaborations between actors to measure social proximity. Social proximity is created at the micro-level while institutional proximity, based on formal and informal institutions, works at the macro-level (Boschma, 2005; Broekel & Boschma, 2012). Having similar institutions eases the knowledge transmission and reduces the transaction costs (Basche, 2021; Boschma, 2005; Broekel & Boschma, 2012; Fernández et al., 2021).

Cognitive proximity is the existence of a shared knowledge base, which determines the absorptive capacity and enables the interaction between actors (Cohen & Levinthal, 1990). The similarity between patenting activities (Basche, 2021; Marrocu et al., 2013; Scherngell & Barber, 2009), sectoral overlap (Broekel & Boschma, 2012), and correlation between previous publications (Fernández et al., 2021; Plotnikova & Rake, 2014) are among the measures to capture cognitive proximity.

With the standard dimensions, we use measures to capture the economic proximity between countries. The literature does not agree on the relationship between economic distance and international research collaboration (Acosta et al., 2011; Crescenzi et al., 2016; Fernández et al., 2016, 2021; and Plotnikova & Rake, 2014).

It should be noted that the effects of proximity dimensions on collaboration might vary by several factors such as scientific field, time, organisation type and geography.

[1] In a recent study, Fernández et al. (2021) reviews the literature on the proximity according to Boschma's (2005) classification.

Method and data

Method

This study uses the gravity model, which based on Newton's gravity equation, asserts that the relationship between two entities is dependent on their masses and the distance between them. These models have been frequently employed to examine the collaboration in science and technology (Acosta et al., 2011; Avdeev, 2021; Hoekman et al., 2010, 2013; Plotnikova & Rake, 2014; Scherngell & Barber, 2011; Scherngell & Hu, 2011; Zhang & Guo, 2017).

We employed a Poisson pseudo-maximum likelihood (PPML) estimator that is robust to heteroskedasticity and preferable for the dependent variables with a large proportion of zeros (Martin & Pham, 2020; Santos Silva & Tenreyro, 2006, 2011). The R package of "*fixest*" is employed for the estimations (Bergé, 2018). That package provided identical or almost the same results as the PPMLHDFE package of Stata with the same dataset.

Co-publication of a country pair in a calendar year is our dependent variable. The average numbers of publications of the pairs in the previous three years are used as the masses. We used fixed effects (FE) to control time-invariant and unobservable characteristics while adding several proximity dimensions, including FP co-projects, to capture the observable characteristics (Crescenzi et al., 2016).

Data

The study is limited to European countries and countries that have participated in FPs with associate status and contains data from 53 countries.[2] The official establishment dates of countries are taken into account to avoid any double counting.[3]

FP project data

Information on all of 114,248 FP projects[4] was downloaded from European Union Open Data Portal[5] on 12 June 2021 as individual XML files, and the detailed information was extracted using *xml2* package in R. We filtered out the projects with no information on starting and ending dates or country, and the participations terminated before the related projects ended. 53,979 projects which contain organisations from a single country are also excluded. In the end, the analysis is conducted by 56,649 projects and 285,788 participations at the country level (Figure 1).

[2] Albania (ALB), Andorra (AND), Armenia (ARM), Austria (AUT), Azerbaijan (AZE), Belarus (BLR), Belgium (BEL), Bosnia and Herzegovina (BIH), Bulgaria (BGR), Croatia (HRV), Cyprus (CYP), Czech Republic (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Georgia (GEO), Germany (DEU), Greece (GRC), Greenland (GRL), Holy See/Vatican City (VAT), Hungary (HUN), Iceland (ISL), Ireland (IRL), Israel (ISR), Italy (ITA), Kosovo (XKS), Latvia (LVA), Liechtenstein (LIE), Lithuania (LTU), Luxembourg (LUX), Malta (MLT), Moldova (MDA), Monaco (MCO), Montenegro (MNE), Netherlands (NLD), North Macedonia (MKD), Norway (NOR), Poland (POL), Portugal (PRT), Romania (ROU), Russia (RUS), San Marino (SMR), Serbia (SRB), Slovakia (SVK), Slovenia (SVN), Spain (ESP), Sweden (SWE), Switzerland (CHE), Tunisia (TUN), Turkey (TUR), Ukraine (UKR), and the United Kingdom (GBR)

[3] For instance, data related to Azerbaijan before 1993 are not included to the study.

[4] 3,282 projects from FP1 (1984-1987), 3,884 projects from FP2 (1987-1991), 5,527 projects from FP3 (1990–1994), 14,526 projects from FP4 (1994–1998), 17,205 projects from FP5 (1998–2002), 10,082 projects from FP6 (2002–2006), 25,778 projects from FP7 (2007–2013), and 33,964 projects from H2020 (2014-2020).

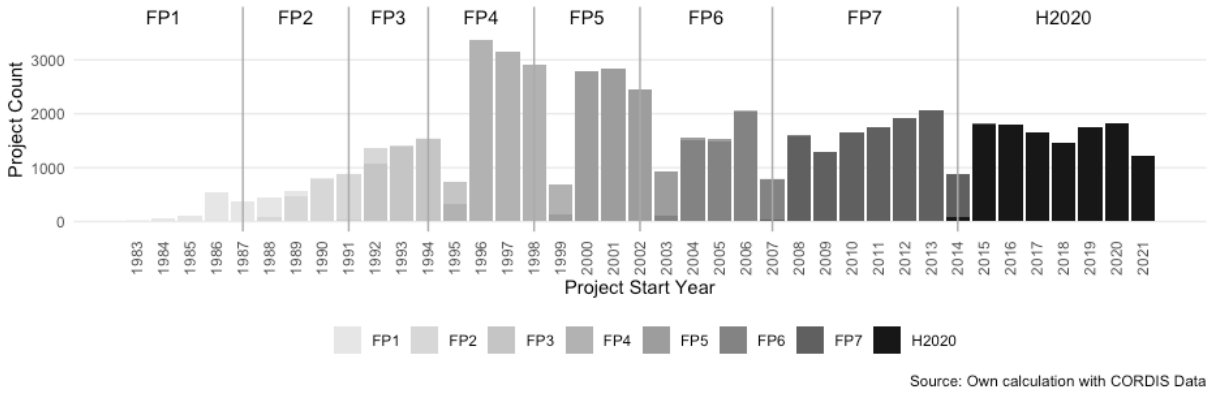
[5] https://data.europa.eu/en

Publication data
Data related to publications was drawn from Clarivate's InCites on 25 January 2022. The publication data is limited to peer-reviewed journal articles with 100 or fewer authors to avoid the problems created by hyper-authorship.

Proximity dimensions:

- Two different variables measure *geographical proximity*. *adjacent* is 1 if two countries are neighbours. *capdist*, calculated by Mayer & Zignago (2011), shows the distance between the capital cities.
- For *cognitive proximity*, we calculated the correlation between the vectors that include the share of publications of each country in each scientific subfield by using the OECD Category schema presented by InCites[6] (*subpre3cor*).
- Three variables represent *institutional proximity*:
  (i) We used *lang_cl*, a continuous index between 0 and 1, to capture the similarity of pairs in terms of language from Gurevich et al.'s (2021) Domestic and International Common Language Database (DICL).
  (ii) *siblingever* is a dummy variable and shows whether the pairs used to be under the same country. In our data set, we identified four groups of siblings: countries separated from the Soviet Union, Yugoslavia and Czechoslovakia, and Benelux countries.
  (iii) *botheumember* is 1 if both pairs were EU members.
- *Social proximity* is represented by the average of FP co-projects in the recent three years (*coprorec3avg*).
- *Economic proximity* is measured by the absolute difference between GDP per capita values of collaborating countries in the previous five years (*gdpdif_pre5avg*).

Figure 1. Collaborative projects by starting year and FP



[6] https://incites.help.clarivate.com/Content/Research-Areas/oecd-category-schema.htm

Table 1. Descriptive statistics for continuous variables

Variable	Definition	N	Mean	St. Dev.	Min	Max
copub	Co-publications of countries i and j (t)	43,916	117.729	519.311	0	15,331
capdist	Distance between capitals (km)	43,794	1,749.29	1,050.879	1	6,673.054
coprorec3avg	Co-projects of countries i and j (3-year average, from t-2 to t)	36,495	21.728	61.259	0	921.667
pubpre3avg_i	Publications of country i (3-year average, from t-3 to t-1)	42,233	11,467.810	22,304.760	0	153,382.0
pubpre3avg_j	Publications of country j (3-year average, from t-3 to t-1)	42,233	9,105.388	17,222.960	0	153,382.0
gdpdif_pre5avg	Diff. in GDP pc. current US $ (Log, 5-year avg., from t-5 to t-1)	34,594	9.456	1.397	0	12.063
lang_cl	Language proximity score	43,292	0.138	0.174	0	1
subpre3cor	Corr. btw publications of i and j (Subfields, 3-year, from t-3 to t-1)	31,060	0.724	0.209	-0.114	0.997

Table 2. Descriptive statistics for dichotomous variables

Variable	Definition	N	Share of zero values (%)
adjacent	Neighbour	43,916	93.253
botheumember	Both countries are EU member	43,916	82.853
oneeumember	Only one of pair is EU member	43,916	36.075
siblingever	Sibling under the same country ever	43,916	95.924

Table 3. Correlation between continuous variables

	1	2	3	4	5	6	7	8
1 copub	1							
2 coprorec3avg	0.779	1						
3 pubpre3avg_i	0.451	0.431	1					
4 pubpre3avg_j	0.478	0.421	0.026	1				
5 gdpdif_pre5avg	-0.028	-0.072	0.15	0.069	1			
6 subpre3cor	0.242	0.348	0.245	0.114	-0.13	1		
7 lang_cl	0.11	0.092	-0.013	0.001	-0.203	0.165	1	
8 capdist	-0.165	-0.193	-0.088	-0.022	0.209	-0.27	-0.494	1

Results and discussion

Our estimation results are in Table 4. In addition to the whole sample, we also estimated the model for the four decades covered by our data. We employed two different FE variations: time- and country-FEs (Models 1, 3, 5, 7, and 9) and time- and country pair-FEs (Models 2, 4, 6, 8, and 10).

The coefficients of variables regarding time-invariant proximity dimensions are generally significant in all models and have the expected signs. Geographical distance still matters for collaboration in science, although its effect decreases over time. The drop in the negative coefficient of distance since the 1990s indicates the developments in ICT that ease the interaction. Our estimates for language similarity and being under the same country confirm the literature regarding the positive impact of institutional proximity. As seen in Models 3, 5, 7, and 9, the coefficient of language similarity decreases over time. It might a result of the increasing role of English in the scientific community. The emergence of new countries from Yugoslavia and the Soviet Union might be behind the increase in the coefficient of "Sibling ever". On the other hand, the negative sign of the dummy variable showing both pairs are EU members is unexpected. Cognitive proximity is the most significant proximity dimension in our estimates. Both country- and pair-FE models indicate that scientific proximity is essential for co-publishing. The value of the coefficient of the cognitive proximity variable is more significant for the country-FE models than for pair-FE models.

The coefficient of economic proximity variable is significant in some models, but their magnitude is small. That can be interpreted as the inclination to work with peers in countries at a similar development level.

The likelihood of co-publication increases as the scientific production of country pairs increase. We should mention that the values of coefficients of those variables are greater in pair-FE models.

Table 1. Estimation results

Dependent Variable:	Co-publications									
Decade	Full sample		1980-1990		1991-2000		2001-2010		2011-2020	
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variables										
Co-projects (Log,3-year avg.t-2 to t)	0.1538***	-0.0114	0.0384*	-0.0210*	0.0036	-0.0293***	0.1453***	-0.1100***	0.4980***	0.0657***
	(0.0149)	(0.0098)	(0.0227)	(0.0124)	(0.0181)	(0.0062)	(0.0300)	(0.0119)	(0.0213)	(0.0108)
Publications_i (Log,3-year avg.t-3 to t-1)	0.6143***	0.7236***	1.063***	1.255***	0.0910	0.3174***	0.6936***	0.7187***	0.4185***	0.6578***
	(0.0276)	(0.0175)	(0.2609)	(0.1437)	(0.1554)	(0.0833)	(0.0835)	(0.0344)	(0.0935)	(0.0379)
Publications_j (Log,3-year avg.t-3 to t-1)	0.4897***	0.5847***	0.4110*	0.5686***	0.0380	0.2178***	0.5728***	0.6074***	0.7203***	0.6157***
	(0.0229)	(0.0144)	(0.2319)	(0.1259)	(0.0778)	(0.0332)	(0.0719)	(0.0276)	(0.1041)	(0.0363)
Diff.GDP pc (Log,5-year avg.,t-5 to t-1)	-0.0261***	0.0014	-0.0762***	0.0012	0.0098	-0.0106**	0.0124*	0.0090*	-0.0371***	-0.0025
	(0.0045)	(0.0030)	(0.0149)	(0.0092)	(0.0103)	(0.0053)	(0.0068)	(0.0054)	(0.0060)	(0.0036)
Corr.btw publications (t-4 to t-1)	1.475***	0.7028***	1.461***	0.1715	1.412***	0.2064	1.495***	0.9525***	1.281***	1.177***
	(0.0565)	(0.0726)	(0.4869)	(0.6151)	(0.1182)	(0.2276)	(0.0888)	(0.1682)	(0.0744)	(0.0891)
Language proximity	0.5024***		1.157***		0.6633***		0.5647***		0.4247***	
	(0.0306)		(0.1106)		(0.0583)		(0.0447)		(0.0368)	
Dist.capitals (log,km)	-0.2889***		-0.3244***		-0.3555***		-0.3179***		-0.2453***	
	(0.0096)		(0.0331)		(0.0210)		(0.0167)		(0.0120)	
Neighbor (D=1)	0.1531***		0.2583***		0.1511***		0.1407***		0.1527***	
	(0.0116)		(0.0382)		(0.0226)		(0.0183)		(0.0144)	
Both EU member	-0.1928***	-0.0773***	0.0192	0.1011	-0.0728*	0.0742***	-0.1481***	-0.0701***	-0.1714***	0.1808***
	(0.0169)	(0.0143)	(0.0692)	(0.0761)	(0.0373)	(0.0208)	(0.0239)	(0.0128)	(0.0266)	(0.0219)
Sibling ever	0.4554***		0.3461***		0.3185***		0.3807***		0.3847***	
	(0.0411)		(0.0825)		(0.0611)		(0.0533)		(0.0508)	
Fixed-effects										
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country_i	Yes		Yes		Yes		Yes		Yes	
Country_j	Yes		Yes		Yes		Yes		Yes	
Country_i-Country_j		Yes		Yes		Yes		Yes		Yes
Fit statistics										
Observations	22,176	22,152	645	637	3,238	3,138	8,792	8,582	9,485	9,474
Squared Correlation	0.97449	0.99355	0.96808	0.99500	0.96544	0.99642	0.97035	0.99619	0.98084	0.99812
Pseudo R^2	0.97002	0.98653	0.93460	0.96077	0.95552	0.98000	0.96668	0.98618	0.97724	0.99199
BIC	484,716.4	227,337.7	7,194.4	4,982.4	47,305.0	25,731.0	139,060.4	65,141.9	224,442.9	87,760.0

Heteroskedasticity-robust standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The effect of co-partnering in FP projects on co-publication, our main research question, is somewhat ambiguous. The estimate regarding our entire sample is significant only for the country-FE model (Model 1). While its sign is positive as expected, its magnitude is small. The changes in the sign and value of the coefficient of the related variable over decades might be a result of the evolution of FPs.

Conclusion

In this study, we examined the relationship between participating in FP and international co-authorship patterns by using a gravity model with proximity dimensions. Our estimates generally confirm the literature about the effect of various proximity types on scientific collaboration. We found that spatial proximity still matters for the cooperation between scientists, considering the progress in communication and transportation. Cognitive proximity appeared as the most influential factor in generating knowledge. Institutional proximity, represented by the similarity of language and being sibling countries, also affects the co-authorship tendencies.

Nevertheless, our estimates on the impact of working together in FP projects on co-publication are not as expected. The results show a relationship between co-partnering in FP projects and co-publication behaviours. Yet, the effect is ambiguous and small.

These results imply that further research is needed for the effect of international research programs on co-publishing. In addition to different proximity measures, we need meso- (such as regions) and micro-level (such as universities) analyses.

Using InCites, which is based on Web of Science (WoS) data, is one of the limitations of our study since WoS coverage favours some research fields and languages. Also, we used aggregated data in this study, while scientific disciplines vary publication and collaboration behaviours. Further research is needed to deal with these limitations.

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