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International co-authorships and the role of the European Union as a funder: an Eastern European perspective

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International co-authorships and the role of the European Union as a funder: an Eastern European perspective

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Abstract

The paper investigates internationally co-authored publications between countries between 1995 and 2015. The paper tests if the European Union funding agency (as defined by InCites Web of Knowledge) has favoured Eastern European countries (East-E) comparing all publications against EU funded ones. This research question tentatively exposes the advantages in publishing under European Union schemes *by* the type of affiliation to the European Union itself. To do so, it identifies three sub-regions a priori: members of the European Union (East-EU); being an affiliated country to EU research schemes (East-AC); or neither (East-Ext). This is tested at three levels: number of publications (articles co-authored with at least one East-E presence); centrality of a given country in the global network of collaborations; and influence of research (average of categorical normalised citations index – CNCI). The findings show that the EU as a funder does play a positive role, although national differences within these three types of affiliation are more relevant than those between the three sub-regions. Findings suggest further research directed at understanding national policies concerning research, and how the European Union might consider its contribution in the wider European Research Area. These findings also suggest further research concerning the future of Eastern Europe, especially in a possible scenario of “two-speeds integration” of the European Union and the European Research Area.

1. Introduction

The process of political, economic and social integration in Europe has been underway for more than a half century. The European Union and its institutions have, since their very inception, emphasised the importance of closer international relations in research – the establishment of the European Space Agency (ESA) in 1975 being a case in point. The Lisbon Strategy and the realisation of a European Research Area are respective attempts to construct mid and long term directions for scientific development (EC, 2000; Commission of the European Communities, 2000). The development of a European wide integration of research has, though, been far from straightforward (Lepori, Reale, Larédo 2014), with a strong concentration on national self-interest still apparent (Nedeva 2012).

Europe is far from becoming homogenous. Both differences between and within the “West” (the first 15 countries to join the EU) and the “East” (the last accessing countries) are cases in point.

Those countries that have joined the EU in the 21st century have experienced a more comprehensive process of “Europeanisation”, as the case of Poland indicates (Dakowska, 2015).

The problem of a “periphery” of countries adopting exogenous policies from one side, but simultaneously lacking a critical mass in research on the other hand, is another common feature in Eastern Europe (Zgaga 2014).

The issue has also geopolitical implications, as the more recent Ukrainian case puts in place as a contested “buffer zone” between Europe and Russia (Davydchuk, Mehlhausen, Priesmeyer-Tkocz, 2017). This is relevant to appreciate the state of research in non EU member states in Eastern Europe. The problem of reforms, funding, and greater recipients for R&D is also at the root of problems in keeping performative research in large countries like the Russian Federation or even Ukraine (Yegorov, 2009).

Restricting the focus to research and its output, the issue of Eastern Europe in scientific production began with the principle post-war geopolitical watershed: the fall of Berlin wall. Braun and Glänzel (1996) suggested that the steep increase of publications in the wake of collapse of the Council for Mutual Economic Assistance (COMECON), partially anticipated by Hungary and Poland in the 1980s, was more the result of a *substitution process* for insufficient national or regional funding opportunities than an overall participation also in contributing to funding schemes. If only publications funded by the European Union are taken into account, co-authorships held by Eastern Countries show a change, apparent in Table 1. Eastern European countries formerly co-published with the US, (West-)Germany and France respectively to a far greater extent than in more recent years where only publications funded by the EU are considered. (Braun and Glänzel, 1996). The final column in

Table 1 indicates the position of the US in terms of number of international collaborations, taking all publications (EU funded or not) into account. The high ranking of US in all publications by all countries under analysis demonstrates that the research funded by the European Union is contributing to the creation of a more integrated European Research Area.

Table 1. Domestic R&D expenditure and first three partners in international publications funded by the European Union and position of collaborations with the US (all publications). Selection of Eastern European countries (years from 2008 until 2015 included). Official two digits country codes.

	<i>Domestic R&D (%GDP average 1995-2015)</i>	<i>Affiliation</i>	<i>1st country for number of co-authored articles</i>	<i>2nd country for number of co-authored articles</i>	<i>3rd country for number of co-authored articles</i>	<i>Position of US in all publications</i>
BG	0.5	East-EU	DE	ES	IT	2 nd
CY	0.4	East-EU	GR	DE	US	2 nd
CZ	1.4	East-EU	DE	UK	FR	2 nd
EE	1.2	East-EU	UK	FI	DE	4 th
HR	0.9	East-EU	DE	UK	IT	1 st
HU	1.1	East-EU	DE	UK	US	1 st
LT	0.8	East-EU	DE	IT	FR	2 nd
LV	0.5	East-EU	EE	SE	UK	3 rd
MT	0.6	East-EU	UK	IT	FR	5 th
PL	0.7	East-EU	DE	UK	US	1 st
RO	0.4	East-EU	DE	FR	ES	3 rd
SI	1.8	East-EU	DE	UK	ES	1 st
SK	0.6	East-EU	DE	US	UK	1 st
RS	0.7	EastAC	UK	IT	DE	1 st
TK	0.7	EastAC	DE	US	UK	1 st
UA	0.9	EastAC	DE	UK	FR	2 nd
BY	0.7	East-Ext	DE	UK	PL,FR*	4 th
RU	1.1	East-Ext	FR	ES	IT	1 st

* Ex Aequo

Source: InCites database. Years: 2008-2015; World Bank for Domestic R&D.

The descriptive figures in Table 1 also highlight Eastern European countries with slightly different degrees of development in research, but that also participated in common funding schemes with “the West”.

These 18 Eastern countries in Table 1 differ in size and percentages of domestic GDP spent on research. The average percentage of GDP spent in the Euro Area is 1.9 and that in OECD member States is 2.3. Also, the countries listed in Table 1

differ in terms of membership of the EU, as indicated in the affiliation column. They also differ in terms of being affiliated countries or not, involved in European Union research schemes.

The paper focuses on international scientific collaborations and the supposedly positive influence of European Union schemes for Eastern European countries. It tests the thesis that less developed countries cannot rely solely on internal research investment to generate positive outcomes for GDP (Vinkler 2008). Although this has impacts on future economic growth, the paper focuses on international scientific collaborations and the supposedly positive influence of European Union schemes for Eastern European countries. In fact, the process of de-fragmentation of the European Research Area and its schemes is of interest to policy makers (EC 2007; McGuinness & O'Carroll 2010).

2. Literature and research questions

The prevalence of internationally co-authored papers presents a useful way of analysing whether the enlargement of European Union had any effect in terms of publications (Makkonen & Mitze 2016).

Social Network Analysis applied in the global web of outputs (Kozak, Bornmann and Leydesdorff 2015), and other works focusing on global networks and their centrality indicators, have aimed at demonstrating the importance of European schemes in promoting research (Ovalle-Perandones et al. 2013). However, funding agencies are absent in these studies – or are merely mentioned (Wang et al. 2012). The studies tend to be narrowly focused on multi-funding schemes in specific fields, such as nanotechnology (Wang & Shapira 2011). Centrality in these networks can provide a specific measure of the change in the position of a country over time, and so having a central position in international collaboration is a traditional topic in the field (Luukkonen et al. 1993). Social Network Analysis particularly fits this topic (Luukkonen et al. 1993; Wagner & Leydesdorff 2005; Hoekman, Frenken, Tijssen 2010; Pajić 2015; Kozak, Bornmann, Leydesdorff 2015), as it is implicit in the concept of (international) collaborations between authors affiliated in different institutions or, in this case, affiliated in different countries. In the specific case of European Union partnerships, Moed et al (1991), Glänzel et al. (1999), Frenken (2002) and Tijssen (2008) explored some “Europeanisation” via co-authorships, but these studies need updates and preferably the use of less aggregated data.

The fragmentation of the European schemes (Georghiou 2001) – and the non-availability of funding agency labels by output until the mid 2000s – makes the assessment of transnational funding agencies relevant.

There is scant literature concerning Eastern European countries that are not members of the European Union, whether they are associate countries of the main EU schemes (e.g. Serbia), or not (e.g. Russia). Israel is a specific example of a country that has not joined the European Union but has frequently joined EU research schemes. Israel's increased engagement with Europe, at the expense of the US, has been noted since the 1990s (Zimmerman, Glänzel, Bar-Ilan, 2009). Must (2006) studied the increase of publications, concluding that Turkey, an associate country, was not higher than other countries.

Kozak, Bornmann and Leydesdorff (2015) looked at Eastern countries, although without distinguishing their status in relation to the European Union, nor in relation to any funding agency; they concluded that the East has still not completely realised its full potential in terms of research output. Geodesic distance-related analyses of sub-national collaborations found that new member states of the EU are nevertheless getting closer to the "West", and that the distance factor is being reduced over time.

The first 15 EU members (the "West") maintain higher performances (Hoekman 2010). The Framework Programmes have in fact contributed to expanding the ray of collaborations and making networks more dense as well (Scherngell & Lata 2011). Another study in the field of nanotechnology provides figures about rate of growth by each EU member country, the number of collaborations among countries, and the role of European schemes, appreciating the contribution of European Union schemes (Ovalle-Perandones et al. 2013).

The issue of the advantages of belonging to the European Union as a member state, or perhaps only as an associated country, has often been missed in analyses, with the exception of Mattsson (Mattsson et al 2008) who gives no empirical definitive answer to this research question. Those data also date back to no later than 2004, which preceded the main enlargement (25 members) by at least a year.

Yet, the possibility of a "two steps pace of integration" in the EU (EC 2017) raises the question of the future directions of the process of European integration. This might affect especially Eastern Europe, both for those countries that are in the EU and those that are candidates for EU membership. The question is also relevant for those countries that have a political trajectory of diffidence, known as the Visegrád Group. Forthcoming possible changes in the fluctuating pattern of European integration can have a remarkable impact for the future development of a European Research Area.

The issue of influence in Eastern countries follows previous studies, which did not look at funding agencies, but only at West-East collaborations (Glänzel, Schuert, Czerwon 1999; Braun & Glänzel 1996), or specifically at social sciences when publications remain in domestic peripheral circuits (Pajić 2015). This is also true when comparing Eastern countries within the EU ("Eastern European Union"), as Allik (2013) does for the Baltic States. Co-authorships might also be part of a strategy of navel gazing circles, or cliques, of regional researchers. Some recent research (Teodorescu & Tudorel 2014) finds that this practice may produce

artificially boosted impact factors, which is detrimental to actual relevance and connectedness to other more influential parts of the world. Any analysis of influence should disentangle this possible pattern. This hypothesis takes into account collaborations within the East, collaborations with the West of the European Union, and with the US as well.

The general hypothesis is that members of the European Union (East-EU) should benefit more than those that are an affiliated country to EU research schemes (East-AC), which in turn should benefit more than those that are external (East-ext). Three hypotheses test the topic of co-authored publications and the contribution of EU-funded ones.

Hp1: The European Union can increase the pace of growth in the number of publications over time, as already analysed (Teodorescu & Tudorel 2011).

Hp2: The *centrality* of country in the global network of collaborations is higher for publications funded by the EU, and enables Eastern European countries to have better scores in indicators of centrality for EU-funded publication networks.

Hp3: The *influence* of research (CNCI, categorical normalised citation index) is greater for co-authored publications funded by the European Union.

3. Methodology

Scientific articles retrieved by InCites within the Thomson Reuters repository represent individual observations. A dataset has been constructed in order to account for bilateral co-authored publications, whether funded by the European Union or not. A symmetric adjacent matrix has been computed to check all the possible bilateral dyads. These data also include year of publication. Since the aim of the article is to test the outputs of Eastern European countries and the contribution of a particular transnational funding agency like the European Union, all European countries have been included.

Extra European countries have been aggregated, in terms of their respective continents/ sub-continents, i.e. Africa, Australasia, Latin America, Middle East (with exception of Turkey and Israel as they are associate countries and both represent individual countries) and other former Soviet Union countries (Georgia, Armenia, Azerbaijan, Kazakhstan, Tajikistan, Turkmenistan and Kyrgyzstan). This choice is consistent with the relative marginal contribution of distinguishing by all countries of the world. Appendix 1 reports the set of the 49 countries (or aggregation of countries – see Appendix I).

The observations in the dataset are unique publications with countries represented by dummies. Two or more valid values for the 49 nodes identify international co-authorships. If only one country or region has a valid entry, that paper is not recognised as being internationally co-authored.

Articles without international co-authorship are included in order to compare their prevalence with internationally co-authored publications.

Other bibliometrical variables available from the Web of Science are: journal impact factor, number of citations (as for 2017), journal expected citations, category expected citations, category normalised citation index, percentile in subject area.

For the second hypothesis concerning the centrality or periphery of countries, some adjacent matrices derived from the previous one are used. Adjacent dataset(s) by year and UciNET package were used. In particular, *Continuous Coreness Model* was chosen, omitting no-collaborative outputs (cells in the principal diagonal) (Borgatti & Everett 1999).

This latter point would be detrimental in the case of comparison of nodes whose size and importance may vary, but it is deemed compatible with the field of Eastern Europe countries whose size in terms of research active personnel – in comparison with the rest of the world – does not vary greatly. Some micro-countries in the production of international scientific papers may be irrelevant (i.e. Malta, Bosnia-Herzegovina or Albania). From this analysis, some countries like Albania, Montenegro, Moldova or Bosnia-Herzegovina will inevitably yield minimal results due to a paucity of publications in the Web of Science.

4. Data analysis

a. Pace of growth of international co-authored publications

Table 2 looks at some simple statistics about the pace of growth in these regions of Europe. It's clear that between 1995 and 2015, or 2008 and 2015, the 13 countries of the Eastern European Union did not see higher growth rates than those countries belonging to the "West".

The gross number of publications in 2015 is 3.7 times those achieved in 1995 in the EU15 (Portugal and Luxembourg are outliers; the other countries show a distinct similarity) and a little more than three times in the Eastern EU.

Among those accessing countries to the European Union, Bulgaria showed the least increase and Cyprus the greatest. In the Eastern associate countries, this increase is up to five times. Those countries defined as "external" had an increase of just 56.9%

in 21 years, a pace largely below the European and world rate. Belarus in particular has flatlined in terms of number of publications. The same statistics regarding the last eight years do not indicate very different figures, with the West performing better, and the Eastern EU showing no apparent advantage against those countries that are just affiliated.

The external Eastern countries have grown at almost the same rate. Table 2 also shows the pace of growth for only those publications funded by the European Union. In this case, data is available only from 2008-2009. Publications funded by the European Union (i.e. Framework Programs or other precedent schemes) did exist, but weren't identified as such in the Web of Science. This detail significantly restricts the possibility of analysing time series data, although 2008 or 2009 are years from which it is realistic to suppose Eastern European Union countries began to publish as member states, assuming a possible larger participation in comparison to previous years when they were not part of the EU.

It will clearly take a number of years from grant application to the appearance of publications that acknowledge specific funding agencies.

For ten out of 13 countries of the East-EU, membership of the EU commenced in 2005. It is therefore reasonable to assume that the older Eastern European member countries might have shown a greater rate of increase of publications than newly joined Eastern European member countries. At least in comparison with AC in the East, or even those that are not AC but may have collaborated in some projects funded by the EU.

Romania, Bulgaria and Croatia joined the EU later than 2005. Their figures are distributed as are the other 10 Eastern European countries. As the last row of Table 2 indicates, there is a greater rate of growth for non-Western countries. There is also a lower rate of growth for external countries: the presumed differences between being AC or full member of the EU are not supported by the data.

Table 2. Rate of growth of total publications and publications funded by European Union. Countries and aggregation of regions (Aggregations do not double count co-authorships among countries of the same group)

		1995 (ALL)	2015 (ALL)	2015- 1995 (%)	2008 (ALL)	2015- 2008 (%)	2008 (EU FUNDED)	2015 (EU FUNDED)	2015-2008 (EU FUNDED, %)
WESTERN ASSOCIATE COUNTRIES	CH	5,786	28,685	395.8%	16,499	73.9%	341	1,305	282.7%
	IS	129	1,114	763.6%	551	102.2%	19	51	168.4%
	NO	1,654	10,466	532.8%	5,466	91.5%	125	509	307.2%
	IL	3,172	9,556	201.3%	6,354	50.4%	106	461	334.9%
	TOT West- AC	10,458	47,917	358.2%	28,104	70.5%	571	2,012	253.4%
EUROPEAN UNION 15	AT	2,324	14,368	518.2%	8,275	73.6%	206	854	314.6%
	BE	3,530	19,393	449.4%	10,699	81.3%	302	1,070	254.3%
	DE	15,716	69,509	342.3%	43,921	58.3%	1,298	4,113	216.9%
	DK	2,695	13,542	402.5%	6,980	94.0%	233	793	240.3%
	ES	4,443	39,404	786.9%	19,404	103.1%	1,278	6,305	393.3%
	FI	2,115	10,528	397.8%	5,798	81.6%	210	721	243.3%
	FR	13,654	58,056	325.2%	35,466	63.7%	978	3,133	220.3%
	GR	1,205	8,409	597.8%	5,055	66.4%	235	875	272.3%
	IE	806	7,027	771.8%	3,758	87.0%	99	522	427.3%
	IT	8,757	46,546	431.5%	25,800	80.4%	764	2,576	237.2%
	LU	39	1,290	3207.7%	382	237.7%	12	41	241.7%
	NL	5,200	29,995	476.8%	16,334	83.6%	551	1,882	241.6%
	PT	812	11,253	1285.8%	5,053	122.7%	381	1,534	302.6%
	SE	5,203	22,540	333.2%	12,544	79.7%	379	1,107	192.1%
	UK	17,936	92,171	413.9%	52,625	73.6%	1,224	4,215	244.4%
tot EU15	60,023	284,011	373.2%	167,575	69.5%	5,448	18,220	234.4%	
EASTERN EUROPEAN UNION	CY	156	1,840	1079.5%	828	122.2%	11	195	1672.7%
	CZ	4,130	22,193	437.4%	12,610	76.0%	93	933	903.2%
	EE	490	2,658	442.4%	1,635	62.6%	31	334	977.4%
	HU	4,132	9,975	141.4%	8,174	22.0%	118	1,205	921.2%
	LT	448	3,454	671.0%	3,237	6.7%	23	166	621.7%
	LV	355	1,875	428.2%	1,049	78.7%	7	69	885.7%
	MT	58	580	900.0%	203	185.7%	2	18	800.0%
	PL	9,626	37,793	292.6%	25,427	48.6%	198	1,257	534.8%
	SI	1,100	5,240	376.4%	4,178	25.4%	42	381	807.1%
	SK	2,339	6,740	188.2%	3,998	68.6%	27	342	1166.7%
	BG	1,916	3,330	73.8%	3,176	4.9%	22	147	568.2%
	HR	1,184	5,089	329.8%	4,470	13.9%	14	157	1021.4%
	RO	1,683	16,758	895.7%	9,594	74.9%	41	349	751.2%
Tot East- EU	26,992	109,819	306.9%	75,606	45.25%	557	4,136	642.5%	
EASTERN ASSOCIATE COUNTRIES	AL	53	397	649.1%	140	183.57%	0	1	nil
	BA	25	796	3084.0%	541	47.13%	0	4	nil
	MD	253	392	54.9%	321	22.12%	2	7	250.0%
	ME*						0	2	nil

	RS*						6	239	3883.3%
	TK	3,420	40,791	1092.7%	25,374	60.76%	49	329	571.4%
	UA	4,717	6,667	41.3%	6,541	1.93%	19	162	752.6%
	MK	122	751	515.6%	457	64.33%	1	8	700.0%
	Tot East-AC	8,543	55,685	551.8%	36,993	50.2%	77	507	558.4%
EXTERNAL COUNTRIES	RU	30,878	49,616	60.7%	33,890	46.40%	143	558	290.2%
	BY	1,465	1,496	2.1%	1,356	10.32%	5	185	3600.0%
	othFSUC**	1,588	4,516	184.4%	2,528	78.64%	10	206	1960.0%
	Tot-Ext-East	32,239	50,593	56.3%	35,057	44.3%	146	572	291.8%

Source: InCite Web of Science, own elaboration

* Republic of Serbia (RS) for 1995 refers to Serbia and Montenegro. Montenegro (ME) is dropped from 1995.

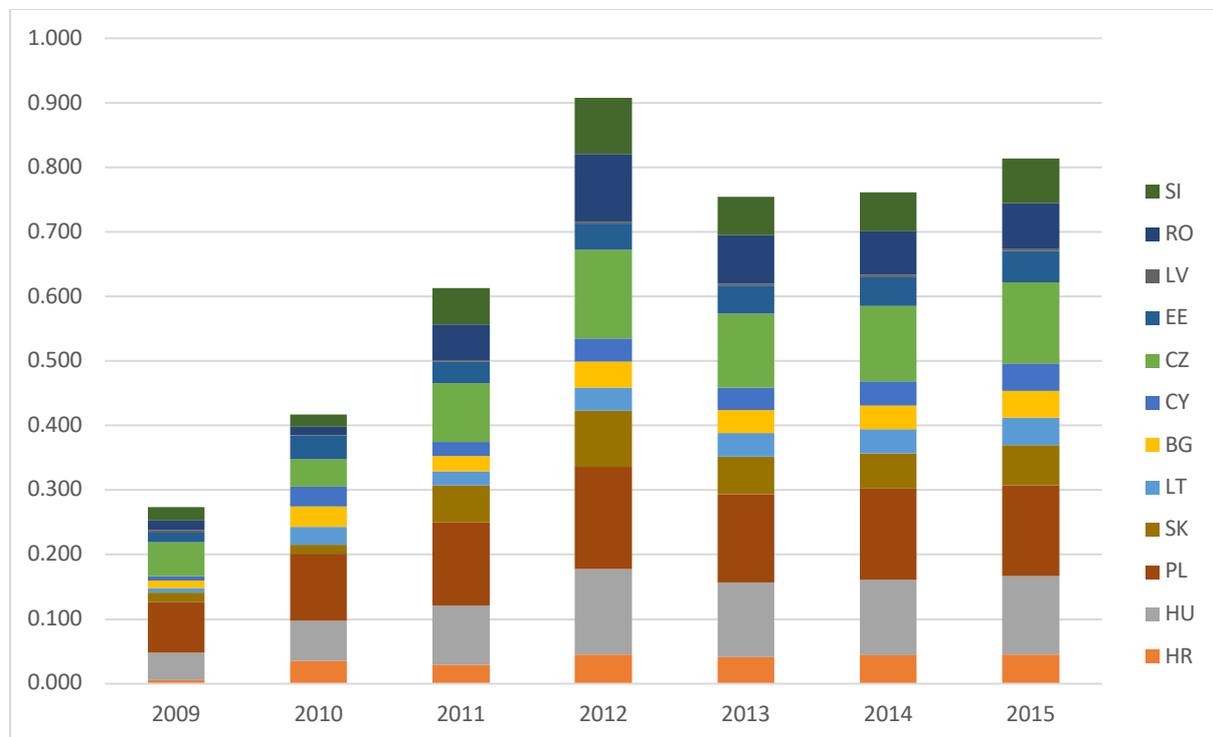
** Other former Soviet Union countries comprise: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

b. Centrality in global co-authorships

The hypothesis concerning centrality similarly shows better improvements for the “East” in comparison to the “West” along the time series, but without any notable differences between the three identified sub-regions of the “East”.

Figure 1 indicates that, on aggregated terms, Eastern European Union countries showed an increasing benefit from EU-funded research over time: from 2009 onwards, each year these countries increased their centrality in the global web of publications. The only exception occurs in 2013, when a notable increase in centrality for Asian countries occurred (not shown in this section). Without doubt, the schemes by the European Union have helped Eastern countries increase their involvement.

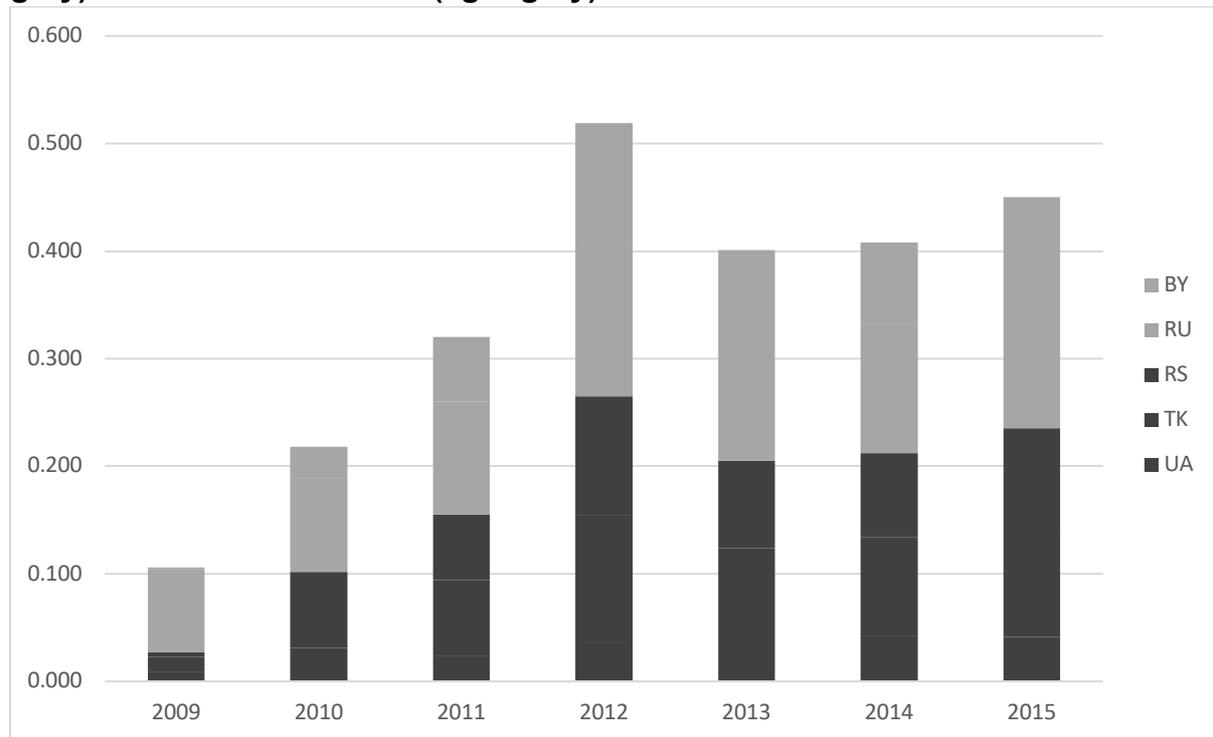
Figure 1. Coreness index of countries in the global web of international co-authored publications funded by EU. Times series 2009-2015. Eastern European Union countries.



Source: InCite Web of Science, own elaboration

Figure 2 shows that this same pattern also holds for other Eastern European countries, which effectively fails to support the second hypothesis relating to the supposed consequences associated with being part of the EU, being an AC country, or being an external country. The cases of Belarus and the Russian Federation indicate that the European Union contributed to both these countries attaining more “centrality” in the global context.

Figure 2. Coreness index of countries in the global web of international co-authored publications funded by EU. Times series 2009-2015. Eastern AC (dark grey) and not AC countries (light grey)



Source: InCite Web of Science, own elaboration

Figure 3 shows some marginal gain in centrality for international co-authored publications obtained via EU funding, compared to all co-authored publications. These data take into account the overall network of international co-authored publications. Consequently, it is possible to determine whether a country is improving its centrality in co-authored networks of publications due to EU-funded research, or because of its overall development in research (which is arguably a function of all funding agencies used by its scientists for publishing research outputs).

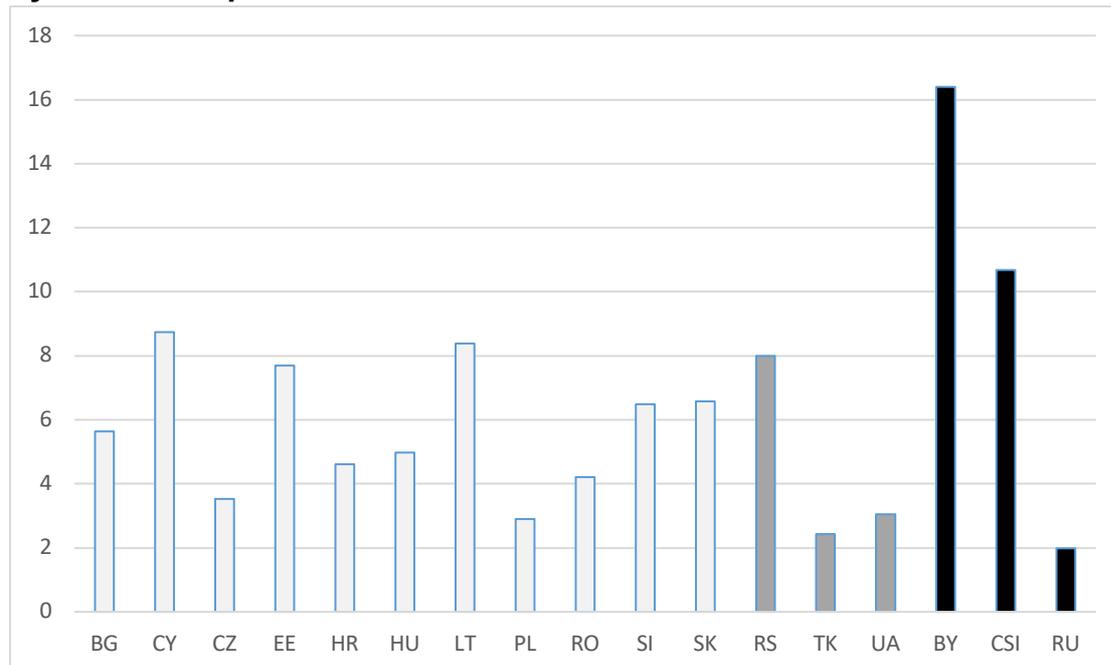
Any positive value would mean that a country is benefitting from EU involvement, because the difference compares against any other possible source of funding.

When it comes to analyse the increasing of embeddedness in the international sphere, a negative result from Figure 3 would mean that the EU as a funding agency is not directly benefitting a particular country.

As Figure 3 shows, from 2009 to 2015, the EU played a positive role. Nevertheless, there are marked differences between countries. These differences are not just a result of their relation to the European Union. The Eastern European Union countries in fact show little difference between themselves; however, for the other countries (grey and black ones in Table 3) there are greater differences. Belarus in particular owes much of its international presence to EU-funded research: it is more than 16

times more central when publishing articles funded by the EU than as a result of other sources of funding. The effect of EU-funded research “only” doubles or triples the “coreness” scores of Turkey or the Ukraine (the average scores of the EU-funded set of international co-authored publications and the overall network of publications). The case of Belarus and the set of other former Soviet Union countries in Asia (other former Soviet Union countries – FSUC) are further considered in the concluding section.

Figure 3. Marginal gain in centrality of international co-authorships obtained by EU funded publications



Source: InCite Web of Science, own elaboration

c. Influence of research

Any analysis of scientific publication cannot avoid the implicit evaluation, usually measured by number of citations or similar indices.

The citations used in the analysis not only relate to the discipline and the type of journal, but the year of publication. The Categorical Normalized Citation Index (CNCI) is an efficient way of comparing different groups or sets of publication irrespective of discipline and allows grouping by year.

The data in Table 3 allow an assessment of hypothesis 1.3. It is possible to appreciate which is the influence of research funded by the EU in comparison with the total publications in a country (excluding internationally co-authored publications). The final column in Table 3 also indicates a marginal gain in this measure of influence, expressed in a simple percentage. Among the Western

European Union countries (EU15), the effect of the European Union as a funding agency for research does not have an appreciable impact on the *influence* of these countries: for Spain and Luxembourg, influence is higher when they publish under different schemes or agencies. For Western European Union countries the average of CNCI is just +8.4% higher when publishing under EU schemes.

For the affiliated countries that are not from the “East” (Switzerland, Iceland, Israel and Norway), the gain in publishing under this funding agency is much higher, with Israel gaining a third more from this funding agency (+55.6%). The average of CNCI index for these countries just listed is also higher than for those of the EU15 (2.538 vs. 1.917). For East-EU countries, the average CNCI is 1.812, well above the average of global publications worldwide (1 is considered the averaged normalised number of citations for a typical article in a given journal which is present in the Web of Science – this is the average of East-EU countries for their total publications: 1.021). The average increase for East-EU countries is as great as 86.3% when compared to overall publications.

Again, percentages vary greatly by country: Croatia more than tripled its influence when publishing EU-funded research; Lithuania, Bulgaria and Romania more than doubled their influence. In other cases, such as Latvia or Slovakia, the increase is much lower. The overall CNCI average by country in East-EU is very different, with Estonia having almost caught up with the EU15 (Estonian publications are on average 1.458, higher than those of the lowest EU15 country, Portugal, which is 1.439).

For the East-AC countries, the gain from EU-funded research is even higher. The EU appears to exercise some *compensatory* effect in allowing poorer performing countries to increase their level of international research activity.

In the case of the only two Ext-EU countries, Russia and Belarus, it appears that the lower the averages of influence in a country, the higher the CNCI averages of those publications funded by the EU.

It is possible that the EU only establishes partnerships with Russia or Belarus when they can offer cutting-edge collaborations, increasing the influence of research and allowing Russian or Belarusian scientists to carry out research that they might not otherwise be able to do with domestic, or other international, funding.

Table 3 does not allow for a definite account as to why there are so many differences among Eastern countries. Moreover, it is not clear whether the aim of greater integration induced by the European Research Area is resulting in greater amalgamation/integration or exacerbating differentiation.

Table 3. Averages, Standard Deviations and marginal differences of CNCI by funding agency. Totals are unweighted.

	COUNTRY / REGION	AVERAGE CNCI (EU FUNDED PUBLICATIONS)	S.D. (EU FUNDED PUBLICATIONS)	AVERAGE CNCI (ALL PUBLICATIONS)	S.D. (ALL PUBLICATIONS)	% GAIN IN EU PUBLICATIONS
WESTERN ASSOCIATE COUNTRIES	CH	2.516	6.130	1.983	7.674	26.9%
	IS	3.372	6.511	2.167	7.794	55.6%
	NO	2.217	6.007	1.769	5.907	25.3%
	IL	2.047	5.940	1.761	6.302	16.3%
	Total Western AC	2.538		1.920		31.0%
EUROPEAN UNION 15	AT	2.258	6.401	1.734	5.498	30.2%
	BE	2.082	4.947	1.986	7.008	4.9%
	DE	1.995	4.929	1.784	5.922	11.9%
	DK	2.261	5.658	2.145	8.727	5.4%
	ES	1.414	3.292	1.720	6.153	-17.8%
	FI	2.045	5.527	1.713	5.527	19.4%
	FR	1.854	4.159	1.744	6.635	6.3%
	GR	1.723	5.664	1.585	5.209	8.7%
	IE	1.949	4.216	1.746	8.113	11.6%
	IT	1.900	4.354	1.774	6.019	7.1%
	LU	1.497	2.200	1.555	4.133	-3.7%
	NL	2.168	4.482	1.959	6.381	10.7%
	PT	1.490	5.202	1.439	4.377	3.5%
	SE	2.042	4.769	1.800	6.910	13.4%
	UK	2.080	4.525	1.822	6.082	14.2%
Total EU15	1.917		1.767		8.4%	
EASTERN EUROPEAN UNION	CY	2.366	9.652	1.335	6.060	77.2%
	CZ	1.745	6.524	1.163	4.881	50.0%
	EE	1.989	6.981	1.458	6.287	36.4%
	HU	1.416	5.537	1.071	4.421	32.3%
	LT	2.296	9.876	0.809	3.012	184.0%
	LV	0.998	1.400	0.945	3.936	5.6%
	MT	1.318	1.687	1.065	4.044	23.8%
	PL	1.449	4.948	0.986	4.473	47.0%
	SI	1.739	6.816	0.938	2.921	85.3%
	SK	1.279	6.021	1.080	6.356	18.4%
	BG	2.225	9.815	0.837	4.495	166.0%
	HR	2.732	10.033	0.793	2.886	244.4%
	RO	2.002	9.719	0.795	4.365	152.0%
Eastern EU	1.812		1.021		86.3%	
EASTERN ASSOCIATE COUNTRIES	AL	1.316	1.653	0.418	1.876	215.2%
	BA	1.586	2.630	0.633	3.141	150.6%
	MD	1.269	2.638	0.774	2.845	63.9%
	ME	1.105	1.045	0.749	3.679	47.4%
	RS	2.917	12.553	0.698	3.117	317.9%

	TK	2.329	9.390	0.721	3.666	223.0%
	UA	2.104	9.616	0.654	4.240	221.5%
	MK	3.577	6.462	0.818	3.894	337.3%
	Eastern AC	2.026		0.683		197.1%
EXTERNAL COUNTRIES	RU	2.048	7.459	0.706	4.161	190.0%
	BY	3.189	13.545	0.592	2.208	438.6%
	FSUC	3.189	13.577	0.848	5.610	276.1%
	External Eastern	2.809		0.715		292.6%

Source: InCite Web of Science, own elaboration

Conclusions

Considering the general research question regarding the role of the European Union and the research it funds, Eastern European EU accessing countries clearly benefit from European Union schemes.

It is less clear whether being part of the European Union, being an associate country or being neither of these is most advantageous.

The working paper addresses three specific ways to look at this general problem, analysing time series, centrality in networks of co-authored publications, and the differences of publishing under European Union-funded research as compared to those associated with total publications.

For each of the three hypotheses (rate of increase of publications; centrality in networks; increase of influence via higher CNCI scores), the evidence indicates that: the time series revealed a better pace for Eastern European Union countries in comparison to Eastern associate countries, and an even better pace than for other Eastern European countries.

For this first hypothesis (rate of increase of publications in time series perspective), it seems that Eastern European Union countries that started to look at their Western neighbours saw improvements in their publication rate.

Russia and countries in its geopolitical orbit have experienced a massive delay in the rate of publishing.

The second hypothesis regarding centrality in networks is much less clear. Although there are evident advantages across countries (all figures in Figure 3), there exist large scale differences in these advantages, which exist irrespective of country status (EU member; associate country; external). The evidence relating to the third hypothesis regarding the incremental influence that having European Union funding

ought to secure indicates that external Eastern European countries improve more than other sets of countries.

In terms of the findings, this paper shows that in research Europe has put in place mechanisms to reinforce co-authorships. It is also remarkable that this regional player is able to be inclusive, allowing many countries to participate in research streams that they may well otherwise have been unable to pursue. Nevertheless, more analyses are needed to clarify what the maze of European institutions are individually responsible for producing.

This exploratory analysis of co-authored international publications and publications funded by the European Union has shed some light on the dynamics within the European Research Area. Nevertheless, several caveats apply and the study raises further questions concerning the role of international (or regional) funding agencies in terms of fostering marginal gains for slightly less developed countries.

For instance, further research could extend the analysis to other European funding agencies, such as the European Research Council. It would also be of great interest to examine the role of European *national* schemes in funding research beyond national borders. Funding agencies such as German Research Foundation (DFG), Wellcome Trust and the French National Research Agency (ARN) have a presence in many Eastern countries.

Such research is still in its early stage and is absent in the literature.

It is possible that increased partnerships between Western countries have occurred not only due to geographical proximity or economic ties, but also as a by-product of being subject to the same set of regulations imposed by the EU.

Co-authorships in this dataset do not indicate who the first author is, which can act as a proxy to understand who is triggering the initiative (Wang & Wang 2017). Although co-authorships are suitable for symmetric adjacent matrix, further information could be used to determine the “direction” of the collaborations – who is really proposing/leading the collaboration.

There are several issues in terms of limitations that are worth mentioning. It is possible that some international collaborations are initiated by the Eastern country. Second, it is possible that Eastern countries are included because international collaborations are necessitated by specific funding schemes. Third, countries with less well funded domestic research programmes may be more inclined to use the EU as a supplementary funder or as a transnational-regional subsidiser. This possibility could also apply to West-EU countries that have poorer domestic investments in research and development (e.g. Italy – whose average of GDP spend for R&D from 1995 until 2015 is only 1.2%) or a high percentage of EU-funded publications (i.e. Spain or Portugal – see Table 2).

Fourth, some countries in Eastern Europe may have interesting niches of expertise in place before the EU started to play a big role. These niches could have been “discovered and valorised” by European new partners. Fifth, to connect inputs (awarded grants) with outputs would pave the way to analysis of productivity and “ROI” by a given funding agency.

Although the pace of growth (rate of increase of publications) is higher on average for the “East”, data from a simple number of publications indicate that joining the EU does not really play a critical role, especially if the status of an associate country is taken into account.

It is probable that, with respect to research activity, there is little difference between being a member of the EU or just an associate country. Notably, countries like Russia and Belarus, or other former Soviet Union countries, do not appear to prosper. Further analyses may assess the domestic investments in research and development to test any substitution effect.

In terms of centrality in the global web of co-authored publications, the EU plays a positive role in promoting partnerships in scientific research and publications, standardising the status of countries, irrespective of their size. Furthermore, the EU does not discourage co-authorships with the US, the most important country in terms of number of publications and influence.

Although favouring European collaboration, many Eastern countries do not just substitute US collaborations with European ones; they add further opportunities to pre-existing partnerships.

Through the EU-funded schemes, Eastern countries are able to increase the influence of their research, which would be less likely without the presence of EU-funded programmes inasmuch as these single states separately or together as a region wouldn't arrive close to the magnitude of European Union scale. EU-funded research has resulted in a greater degree of “centrality” to Eastern Europe publications, but not necessarily so with respect to EU members, or associated countries.

It is probable that national strategies for obtaining EU funds, and disciplinary differences by countries, may explain some differences noted within the subgroups in all the tables provided in this paper.

The *influence of research* of EU-funded publications is relatively marginal in West-EU. In other Eastern countries EU funding is associated with remarkable improvements as measured by CNCI, perhaps due to quality of partners that these schemes require (US included).

Overall, in many ways, it looks as though the EU is working as an *equaliser* funding agency, giving opportunities to smaller or peripheral countries. This happens regardless of the exact status of a country in relation to the European Research Area – Belarus being the clearest case in point as it benefits a lot from co-authorships with other European countries, especially from EU-funded agencies, although it is not an associate country.

Overall, the EU is extremely successful in incentivising international collaborations, and so realising its stated aim of developing research within the EU framework programmes.

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Annex – Affiliation of countries in regions (official two digits country code)

Sets of the countries or grouping of countries:

- West-EU (Western European Union countries) {FR, DE, IT, NL, BE, LU, GR, ES, PT, FI, AT, DK, UK, IE, SE}
- West-AC (Western Associate Countries) {NO, CH, IS}
- East-EU {MT, CY, EE, LV, LT, PL, CZ, SK, SI, HU, BG, RO, HR}
- East-AC {AL, BA, UA, MD, ME*, RS*, TK} RSME (RS + ME) replacing ME and/or RS until 2004.
- East-ext {MK, BY, RU}
- RestW {US, CA, AFR, ASIA, FSUC, MID}
 - ASIA {Australasian countries}
 - AFR {African countries}
 - LAT {Latin American countries}
 - FSUC {TM, TJ, UZ, AZ, AM, GE, KG, KZ}

Ignored countries/territories in Europe: Liechtenstein, Andorra, Monaco, Vatican City, San Marino, Faroer Islands, Kosovo and Greenland.

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