Danube-INCO.NET

Advancing Research and Innovation in the Danube Region

Co-publication and co-patenting analysis among countries in the Danube Region

(Deliverable D4.16)

Project	Danube-INCO.NET
Project Number	609497
Deliverable Number:	D4.16
Submission Date	27.04.2015
Responsible author(s):	Dietmar Lampert (ZSI)

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no [609497]

Document Control Sheet

Work package Number	WP4
Work package Title	Analytical Evidence on Research and Innovation in the Danube Region
Task Number	T4.1
Task Title	Monitoring research and innovation cooperation
Deliverable Number	D4.16
Deliverable Title	Co-publication and co-patenting analysis among countries in the Danube Region
File Name	Deliverable_4.16_Co-publication_and_co-patenting_analysis_among_countries_in_the_Danube_Region__final.docx
Number of pages	125
Dissemination level	Public
Main author	Dietmar LAMPERT (ZSI)
Contributors	Philipp BRUGNER, Katharina BÜSEL, Elke DALL, Alexander DEGELSEGGER, Johannes Simon, Isabella WAGNER, Ivan ZUPAN (all ZSI); Florina Piroi (Vienna University of Technology)
Quality Assurance	Christian Hartmann (external), Gabriela Cikikyan (internal)

Versioning and Contribution History

Version	Date	Author/Editor	Contributors	Description/Comments
_v01	08.12.2014	Dietmar LAMPERT	Elke DALL, Alexander DEGELSEGGER	detailed structure
_v02	02.02.2015	Dietmar LAMPERT		First contents
_v03	27.02.2015	Dietmar LAMPERT	Philipp BRUGNER, Katharina BÜSEL	Co-publication analysis, main sections
_v04	13.03.2015	Dietmar LAMPERT	Philipp BRUGNER, Katharina BÜSEL, Elke DALL, Alexander	Co-publication analysis, further results; first draft of co-patent analysis

			DEGELSEGGER	
_v05	27.03.2015	Dietmar LAMPERT	Philipp BRUGNER, Katharina BÜSEL, Elke DALL, Alexander DEGELSEGGER, Florina PIROI (Vienna University of Technology)	Revision of chapters according to internal quality control; substantiated co-patent part; revision according to feedback from external expert on co-patent analysis
_v06	01.04.2015	Dietmar LAMPERT	Philipp BRUGNER, Katharina BÜSEL, Elke DALL, Alexander DEGELSEGGER	Finalisation of all chapters
_v07	13.04.2015	Dietmar LAMPERT		Executive summary revision Version sent to QA
_v08	21.04.2015	Dietmar LAMPERT	Christian HARTMANN (QA), Katharina BÜSEL, Elke DALL, Alexander DEGELSEGGER, Gabriela CIKIKYAN	Quality Assurance comments and revision in response to the QA's remarks, inclusion of partner comments
final	27.04.2015	Dietmar LAMPERT	Christian HARTMANN (QA)	Accepting all Quality Assurance comments and final revision in response to the QA's remarks

Document last saved on	30.04.2015

1 Content

List of Tables

List of Figures

List of Abbreviations

AL	Albania
ASJC	All Science Journal Classification
AT	Austria
BG	Bulgaria
BA	Bosnia and Herzegovina
CPC	Cooperative Patent Classification
CZ	Czech Republic
Danube-INCO.NET	Danube Region INCO-NET
DE	Germany
DoW	Description of Work
DR	Danube Region
DRC	Danube Region countries
DRRIF	Danube Region Research and Innovation Fund
FYR of Macedonia, FYROM	Former Yugoslav Republic of Macedonia
HR	Croatia
HU	Hungary
KO-Kosovo*	Kosovo* Kosovo – 'This designation is without prejudice to positions on status, and is in line with UNSC 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.'
MK	Macedonia
MD	Moldova
ME	Montenegro
PCT	Patent Cooperation Treaty
PATSTAT	the European Patent Office's patent statistics database that offers a offers extensive patent data coverage
RO	Romania
RS	Republic of Serbia
SI	Slovenia
SK	Slovakia
UA	Ukraine
WB	Western Balkan
WBC	Western Balkan countries
WoS	Thomson Reuter's *Web of Science*
WP	Work Package
ZSI	Centre for Social Innovation, Vienna

2 Executive Summary

The study underlying this deliverable scrutinises both the co-publications and the co-patents in Danube Region Countries (DRC) and the Western Balkan countries (WBC)[1] for the years of 2003-2013. Each analysis has its distinct methodology and yields specific results which are shortly presented below.

The methodology of the co-publication analysis, presented as a first input, is based on the two main academic citation databases, namely *Web of Science* and *Scopus*. The unification of the data of those two sources is fairly unique and entails a number of complex operations to ensure the quality and compatibility of the data, which goes hand in hand with a considerable data normalisation effort. The gain achieved by this unification both in terms of quantity (a roughly 25 % higher publication coverage) and quality (each data source can be taken as a quality check for the other or as an additional source for missing information) is well worth the effort.

The actual analysis of the publication data was carried out along several dimensions: overall co-publication output numbers per country to provide an overview, the internationalisation of publications, the strongest co-publication links among the countries under scrutiny, main scientific research fields, and finally some highlights regarding scientific impact.

As regards the overall co-publication output, the results suggest three country groupings: (1) Austria, Czech Republic, Romania, Hungary, and Ukraine; (2) Serbia, Croatia, Slovenia, Slovakia, Bulgaria; and (3) Bosnia and Herzegovina, FYR of Macedonia, Albania, Moldova, Montenegro, and Kosovo*. However, a common denominator for all of the country groupings is the growth rate which remains relatively stable over the covered period of time.

Internationalisation is defined in this analysis as a proportion of international co-publications with authors from at least two different countries (at least one of which is a DRC or WBC) in the overall publication output of a country. In general, the DRC's share of international co-publications is between 40-50 %. Smaller countries tend to have a higher share, which is not surprising as their need to collaborate with researchers abroad is usually higher. Moreover, the share of intra-regional co-publication activity in the region's overall co-publication activity is also between 40-50 %.

Speaking of key regional players in terms of co-publication linkages in the region, Germany is a key leader. Outside the region, France plays the most important role for the researchers from DRC and WBC.

The analysis of the thematic focus of the DR and WBC co-publications revealed a focus on Physics & Astronomy, Chemistry, Biomedical Research, Biology, Mathematics & Statistics, Earth & Environmental Sciences, General Science & Technology.

[1] The Danube-INCO.NET project focuses on the countries included in the EU Strategy of the Danube Region, but for arguments of comparison, inclusion and cooperation, the project tries to include analysis on the Western Balkan countries as far as possible.

In terms of scientific research fields, we distinguish two topics of strongest co-publication appeal: most of the countries under scrutiny have especially strong regional links in the area of Physics & Astronomy (e.g. BG, CZ, MD, SI, SK, UA), while other countries are relatively more specialised in the field of Clinical Medicine (e.g. AT, AL, BA, FYROM, KO-, ME, HU).

Apart from those two fields, the data show a comparatively[2] strong output in the following research fields: Chemistry (BG, CZ, RO, ME, MD, MK, RS, SK, SI, UA), Earth & Environmental Sciences (AT, BG, RO, CZ, HR, HU, MK, RS, SI, UA), Biology (AL, AT, BG, BA, RO, CZ, MK, HR, RS, SK), Biomedical Research (AT, BG, HR, KO-, RO, SI), Enabling & Strategic Technologies (BA, ME, HR, HU, SI), Agriculture, Fisheries & Forestry (AL, BA, HR, KO-, MK, RS, SI) and Engineering (BA, MD).

The co-publication activity in research fields shows different levels of growth over the studied period. In particular, between the years 2003 and 2013, many countries show high growth rates in General Science & Technology (AT, BG, CZ, DE, HU, RO, SI, SK). Examining the fields Physics & Astronomy and Chemistry, the research fields with quite a high overall Danube Region co-publication output, many countries have a rather low growth (AT, BG, CZ DE, HU, MD, SK, UA - their annual co-publication output does not even double from 2003 to 2013), while the co-publication output more than doubles in other countries (e.g. in Romania, Montenegro, Slovenia, or Serbia). In research fields with medium co-publication output, some countries have rather a strong growth in the fields Public Health, Social Sciences and Economics & Business (e.g. AT, BG, or DE).

As regards the patent output of the countries at hand, the analysis – based on the EU Patent Office's PATSTAT database – examines the co-invention and foreign ownership patterns in the Danube region between 2003-2013 and shows that inventors from the region[3] produced almost 800,000 national ('A') and over 200,000 PCT[4] patent applications.

In terms of thematic specialisations, the region's patent application output is comparatively[5] strong in the 'mechanical engineering', textiles, 'operations and transport' and, to some degree, the 'fixed constructions' area. The share of DR and WBC applications in global applications is beyond 20 % in all the mentioned fields, which means that one DR inventor is involved in every fifth patent application globally. In other areas like 'human necessities', physics or electricity, these shares are around 10%. In the area of 'emerging cross-sectional technologies', the share of DR and WB inventors is relatively high, but only in PCT applications.

These thematic strengths in applications with inventors from the region are also visible in applications with Danube region applicants, i.e. IP owners. There is no technology area with large scale knowledge flow out of the Danube region (this would be indicated by a mismatch between inventor and applicant shares with the latter being significantly lower). The numbers

[2] compared to their overall publication output

[3] Please note that, unlike the co-publication analysis which includes all DRC and the WBC Albania, Kosovo*, and Macedonia, the patent analysis includes the same countries with the exception of Kosovo*. The co-patenting part thus always refers to the WBC and DRC minus Kosovo* when speaking about the ´region´ or ´DR and WBC´

[4] Patent Co-operation Treaty, which indicates that applicants seek patent protection internationally

[5] compared to the other patent categories in the CPC classification

rather indicate that the region is a *net recipient of knowledge flows* (indicated through IP ownership).

Patenting in the region is more internationalised than the global average: Around 12 % of the patent applications with at least one DR or WBC inventor involve inventors from two or more countries. The global average is a co-invention share of around 6 %.

The smaller countries in the study (e.g. FYR of Macedonia or Bosnia and Herzegovina) feature higher international co-invention shares. However, not all variation is explained by the size of the market and the research community. Austria, for instance, shows a significantly higher share of internationally co-invented patent applications (almost 30 %) than Slovenia (12.5 %), despite the differences in application output in general. Croatia and Moldova are also relative outliers with low co-invention rates.

Apart from the linkages between Germany and other major countries from the region, relevant co-invention relationships exist between: CZ-SK, MD-RO, AT-SK, MD-UA, AT-HU, and AT-CZ. Interestingly, if we exclude Germany, Austria's co-invention linkages are not the dominating ones as one might expect given its overall application output. Other countries' inventive behaviour is more integrated. But considering its patent application output, Ukraine is less integrated into the regional co-invention networks.

Examining the main patent application gateways, Germany and the EPO receive most of the patent applications with co-inventors from the Danube region. However, Asian patent application authorities (in particular: Korea and Taiwan) play a major role in most of the applications, especially in DE-UA and DE-RS, but also DE-RO patent applications. This indicates the relevance of the Asian markets for DR co-inventions. A partial relevance of the USA could be observed: The BG-DE co-invention link is the only major one in the Danube region where most of the applications are first filed in the US. The CZ-SK co-inventions are most often filed in CZ (not in DE where a potential major market lies, EPO or others!), indicating their relevance for the local market (or at least the preference to seek protection in the Czech market first).

As to country-level specificities in DR and WBC co-inventions, some co-invention links clearly reflect thematic patterns in the overall output (CZ-DE, DE-HU, BG-DE, DE-RO). One particularity is the links involving Slovenia, especially DE-SI, where the human necessities area is the most important one. CZ-DE and DE-UA have a comparatively high output in the 'emerging cross-sectional technologies' section.

As regards the share of exclusively foreign-owned patent 'A' kind, applications in the region vary considerably. On one extreme, less than 4 % of Moldova's applications are exclusively foreign-owned. On the other, over 90 % of FYR of Macedonia's are. The prevalence of foreign ownership in the countries at hand roughly matches the shares of international co-inventions in their patent application output. Austria's relatively high share (1/3) of exclusively foreign owned patents seems noteworthy. None of the other cases show more than a third of the applications as exclusively foreign owned. Among the countries of comparable mid-range application output, Slovakia and Hungary show a fairly high share of foreign owned patents, while Croatia, Slovenia and Ukraine feature very low shares.

Major foreign ownership linkages involve German applicants and inventors from all other Danube region countries (i.e. knowledge flow to Germany); Czech Republic-based applicants and inventors from Slovakia or Germany; Moldova-based applicants and Romanian or Ukrainian inventors; Austria-based applicants and inventors from Germany, Hungary, Slovakia or Slovenia; Hungary-based applicants and inventors from Germany; Romania-based applicants and inventors from Germany; Slovakia-based applicants and inventors based in Germany or the Czech Republic.

As in the case of co-inventions, the relevance of Asian patent authorities could be noted in general, but especially for UA->DE and of local patenting authorities (thus markets), links like SK->CZ or RO->MD were apparent.

In foreign ownership flows beyond the Danube region, the relevance of the US (e.g. strong RO->US links), Switzerland (AT->CH!), France (for DE and HU-based inventors), the Netherlands, or Japan is apparent. In addition, ownership flows with the Cayman Islands, as an off-shore tax heaven harbouring many international corporation headquarters, are prominent in the available data.

3 Introduction

The objective of this deliverable (D4.16) of Danube-INCO.NET[6] is to capture and analyse co-publications and co-patents among countries in the Danube Region in order to provide a solid base for the identification of intra-regional thematic strengths and collaboration patterns, to bring to the fore the most active players, centres of excellence, and existing "hot" links between R&I institutions. Consequently, the analysis covers the amount of co-publications and co-patents per country and their development over time (2003-2013). In addition to presenting thematic and geographic patterns in scientific cooperation (using scientific co-publications as an indicator), the bibliometric analysis takes into account the impact in terms of number of citations. The co-patenting analysis takes into account patterns of foreign ownership as well as co-inventorship, thematic patterns, and developments over time (2003-2013).

The deliverable also compares the thematic patterns in co-publishing and co-patenting. The results of this comparison can fuel qualitative expert discussions interpreting causes and effects of these patterns. The deliverable presents the descriptive analysis results to inform policy-makers on priority fields and to serve as an input source for the development of the Danube Region Research and Innovation Fund (DRRIF), smart specialisation strategies or other strategic approaches, and for analytical needs in the frame of EUSDR priority areas 7 and 8.

Deliverable 4.16 relates to Task 4.1 "Monitoring research and innovation cooperation" in WP4 "Analytical Evidence on Research and Innovation in the Danube Region" of the project. As such, it firstly reflects objectives of WP4, i.e. to provide analytical evidence on the cooperation in research and innovation, and contributes to providing an overview of current cooperation activities, and secondly offers input to a number of other project activities.

Moreover, there are a number of events that could be used to either qualitatively discuss or disseminate the results analysis. For instance, a bibliometric workshop took place in the context of the PA7 Steering Group Vienna meeting, 10 December 2014, to present and qualitatively discuss interim results of the analysis.

It needs to be noted that the co-publication analysis predominantly captured the more prolific authors, not necessarily the more relevant to industry; as such, predominantly academic stakeholders from research organisations were identified that might be used e.g. for triple helix events. It also needs to be noted that the co-patent analysis did not yield contacts that may have been useful for other project activities (such as identification of relevant stakeholders). This was expected due to the limited quality and coverage of patent data in general (especially concerning missing or incomplete contact data).

[6] cf. project website at http://danube-inco.net

4 Co-publication analysis

4.1 Introduction

This chapter describes the main processes involved in the study underlying this deliverable and presents the analysis results. Due to the sheer number of countries involved, this chapter is further divided into the following sections: (1) overall numbers that provide an overview of the publications and especially co-publications of the DRC and WBC, in the time span from 2003 to 2013; (2) the internationalisation of publications as well as short profiles of the individual DRCs; (3) a more detailed view in terms of research fields, and (4) as a means to measure the quality of the recorded publications, their calculated impact in the last section of this chapter.

Whereas the Danube-INCO.NET project in fact only comprises the fourteen Danube Region countries, this report goes one step beyond and includes – with Albania, FYR of Macedonia, and Kosovo* – three more countries. This report uses the term Danube Region Countries (DRC or DR countries) when referring to the 14 countries along the river Danube as defined in the EU Strategy for the Danube Region (EUSDR) and the three listed Western Balkan countries – despite the fact that these latter states are not bordering the Danube river, they have strong connections to the region.

The analysis of Danube Region co-publication output in the years 2003 to 2013 is based on the two best known and most comprehensive multidisciplinary academic citation data bases:

- Elsevier's *Scopus*
- Thomson Reuter's *Web of Science* (short: WoS; at present containing the following databases: Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index)

To understand and adequately interpret the results presented in this deliverable, a few basic terms need to be defined at this point. More details are provided in the Annex I – Key definitions for co-publication analysis (see page 78 and following).

An ‘affiliation’ links an author to her/his institution(s). As these can be more than one and also located in different DR countries, several affiliations are counted and also included as international co-publications. The analysis uses ‘categories’ and ‘main categories’ that are basically thematic keywords to classify the scientific literature. Those categories are based on the Science Metrix Ontology for journal classification.

The study consolidates different document types from the databases and used articles, conference papers, meeting abstracts, reviews, editorials, letters, and others to describe the units of analysis. As a specific sub-chapter of the report deals with the ‘impact’ of publications, readers should keep in mind that the impact given below is just a snapshot: since there is a lag between the publication of a work and the occurrence of references to it in later works, the most recent works will typically show no or few citations.

With the term ‘record’ we refer to an entry in our database containing the meta-data of a uniquely identified publication. So, as soon as the same publication is identified in both data sources, it is treated as one record.

The study analyses all publications from both databases that featured any affiliation to one of the countries of the Danube Region in order to be able to draw conclusions on the differences between "all publications" and the "co-publications". The exception is Germany, in whose case the sheer number of publications would have by far exhausted the resources available for this study; consequently, only Germany's co-publications with Danube Region countries are covered in this report. Another constraint due to limited resources and data is that, although only Bavaria and Baden Württemberg are "official members" of the Danube Region based on the definition used in the EU Strategy for the Danube Region and DANUBE-INCO.NET, it was not possible to separate publications with affiliations in those two "constituent states" and the other constituent states of Germany. Therefore, Germany is treated as one "Danube Region country". The same is true for the Ukraine and its concerned Oblasts. Many results showing the dominance of Germany could be better understood if it were possible to analyse data on the sub-regional level for this country, as the two before-mentioned constituent states would be more similar to other countries of the region both in terms of the population size and in socio-economic terms. Again, such an investment in data cleaning and assessment is beyond the capacities of a project such as Danube-INCO.NET.

The study does not discriminate by document types, meaning that scientific articles are taken into account the same way as conference proceedings, academic letters, and other document types that were tracked by the both data sources (see Annex I – Key definitions for co-publication analysis). The reason for this procedure is the idea that jointly published conference papers can indicate international cooperation activity, which is of prime interest to the Danube-INCO.NET project. The data are available only with partly different field names and different quality (depending on the data source). A bundle of software tools was especially developed to assure (1) that the formats of the data allow unification and (2) the rise of quality of metadata of publications tracked in both sources after unification. The steps involved are described in detail in Annex II – Data cleaning, consolidation of data sources and thematic areas (see page 80 and following). There are a few things to be kept in mind when interpreting the results and data presented:

- First of all, the sample was huge. Especially with regard to Germany, as noted above, the study had to limit itself to covering only those co-publications that involve at least one other DRC.
- The number of average authors per (co-)publication typically is significantly higher in some fields (e.g.: Physics) than in others. This skew in author count statistics has to be taken into account (and is indicated in the analyses below).
- We have put a lot of effort in data cleaning and processing. Depending on the type of analysis (overall figures, subject areas, impact data, etc.), a rough analysis of possible errors points to an error probability of 2-8 %. This may become especially important for those results, which are based on only a small number of publications.
- Impact data are a snapshot at a given point in time. While the number of publications in the two databases is stable approximately half a year after the end of the year of publication, the times cited counts are constantly being updated in the future as new publications refer to already recorded ones. In addition, older publications had more time to get cited than recent publications, i.e. the citation count for the latter is typically lower.

4.2 Results of the bibliometric analysis

4.2.1 Overall numbers – descriptive statistics

This study bases its analysis on both Thomson Reuter's *Web of Science* and Elsevier's *Scopus* databases. The number of involved records amount to **more than one million records**, which constitutes the ***overall publication output*** of all Danube Region (DR) countries[7] from 2003 – 2013, with the exception of Germany, for which only co-publications with at least 1 DR country were taken into account.

The following pie chart (Figure 1) shows the share of *Web of Science* and *Scopus* records within the total amount of covered datasets. One can immediately see, that the highest amount of covered data is overlapping, meaning it both was contained in Scopus and WoS.

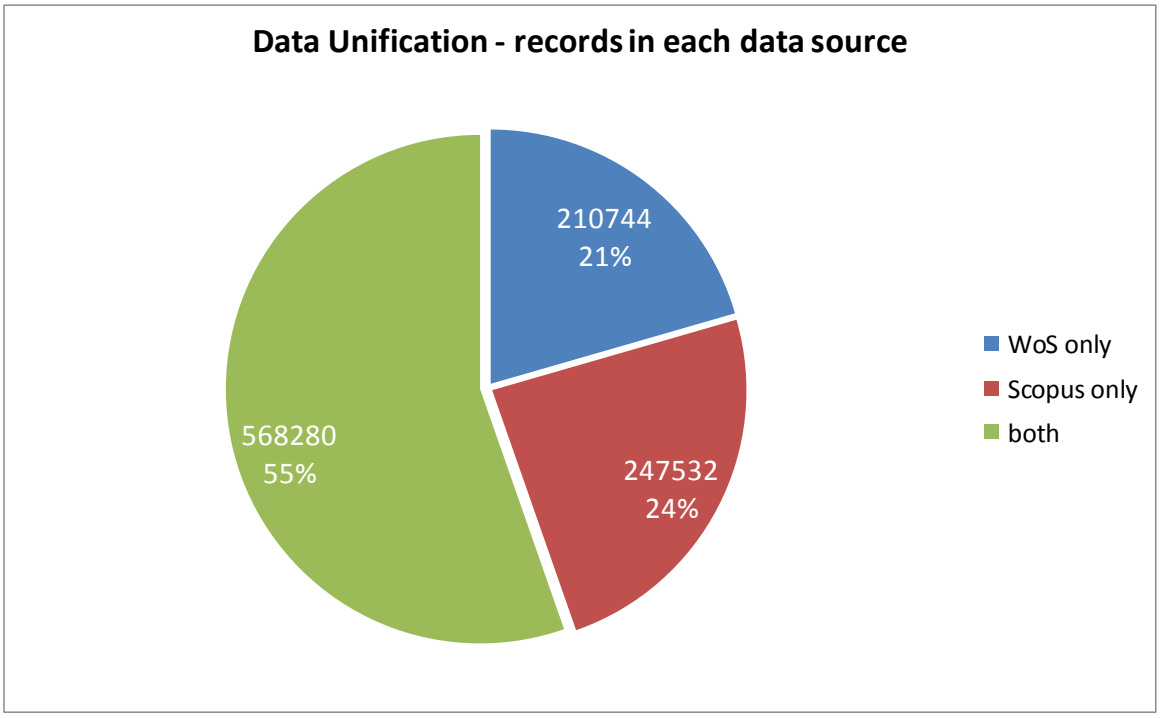

Figure 1: Data coverage of the citation databases *WoS* and *Scopus* for the Danube Region publications

[7] Danube Region countries: Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Montenegro, Romania, Serbia, Slovakia, Slovenia, Ukraine. Beyond the countries as defined in the Danube-INCO.NET, this report also includes Albania, FYR of Macedonia and Kosovo*.

This bibliometric analysis covers the co-publication patterns of both the DR in its entirety and the individual DRC. A *DR co-publication* refers to an *international co-publication*, i.e. a co-publication between at least one DR member state and east least one other state outside the DR[8,9]. In contrast, an *intra-DR co-publication* refers explicitly to a co-publication between at least two member states of the DR, as defined in this report.

Of the slightly over 1 million records that were analysed, each has, on average, been authored by 7 researchers affiliated in 1.8 countries and been cited about 6.5 times. Of those overall publications, around **394,000** are **Danube Region co-publications**, each involving at least one DRC and one other country outside the DR in the period between 2003 and 2013. Each of those co-publications has, on average, been authored by about 13 researchers affiliated in 3 countries and been cited 11.87 times.

Output patterns suggest the following three country groupings[10]:

- Austria, Czech Republic, Romania, Hungary, and Ukraine (between 8,000 and 25,000 publications per year)
- Serbia, Croatia, Slovenia, Slovakia, Bulgaria (between 1,000 and 8,000 publications per year)
- Bosnia and Herzegovina, FYROM, Albania, Moldova, Montenegro, and Kosovo*[11] (between 40 and 1,000 publications per year)

Apart from the absolute number of DR publications, the growth rate of their publication output within the examined period of eleven years is of interest. All DRC countries experienced a more or less stable increase in their publication output, with particularly strong growth patterns in Romania and Serbia. Ukraine and Hungary, in contrast, experienced relatively limited growth of their publication output. Albania, Bosnia and Herzegovina, Moldova, FYROM, Montenegro, and Kosovo* are those countries that have by far the lowest output in absolute terms, which is not surprising given the size and nature of their national research system. The line chart below shows the publication output of all DRC[12].

[8] A general overview of the exact share of DR co-publications and international co-publications within the total co-publication output of a country can be found in Table 1 on page 20.

[9] At this point it should be noted that the common indicator using the share of international co-publications always includes biases, such as the scientific profile, the type of publication, year of publication, place of publication, etc. (cf. Pohl et al. 2014). However, if the intention is to only present the overall numbers in terms of international co-publications, as this study does, the use of share as an indicator is appropriate.

[10] apart from Germany, which is a category of its own

[11] This designation is without prejudice to positions on status, and is in line with UNSC 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

[12] With the exception of Kosovo*, whose output would not really be noticeable on this type of chart

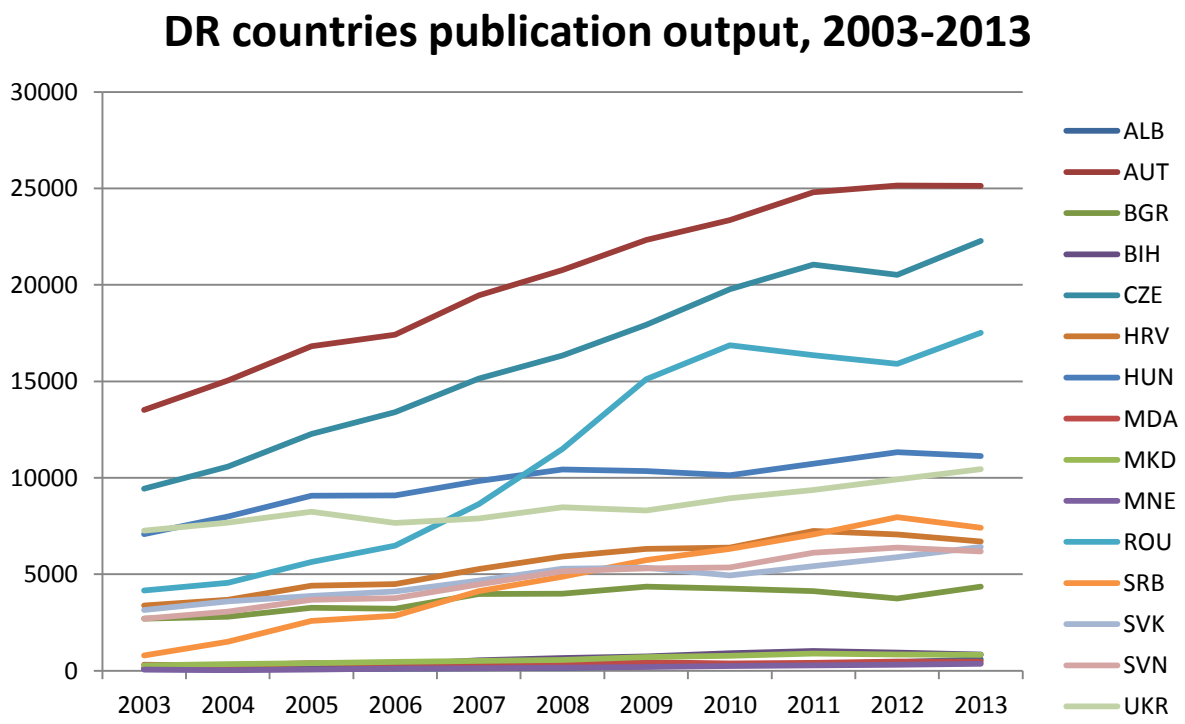

Figure 2: Danube Region countries' publication output 2003-2013

Glänzel and Schubert (2005) have made an important observation with regard to the relation between the size and the publication output of a country:"Big countries have […] lower shares of international co-publications than medium-sized or small countries have. Nevertheless, the growth of the share of international co-publications can be observed independently of the country's size. The increase is thus a global law." This global law does not only apply to their analysis of the global co-publication output between the 1990s and the beginning of the 2000s, but also, as this reports illustrates, to the observations of the DRC between 2003 – 2013.

As already indicated above, the Danube Region is a very diverse geographical area, especially in terms of national research and innovation systems, ranging from highly developed countries like Germany or Austria to less developed ones like Moldova. One must take this into account, when looking at the numbers of publications, since a less developed country usually also spends smaller money on its scientific infrastructure, hence affecting herewith also the publication output of its scientific/academic institutions.

4.2.2 Internationalisation of co-publications

In general, the share of internationally co-authored publications is between 40-50 %. Further, the general estimation that smaller research communities are, due to limited national capacities, better internationally connected seems to be valid. As Glänzel and Schubert (2005, p. 271) point out, this "international ambition" in producing publications has another positive consequence: International co-publications are more likely to appear in high-impact journals and have a better chance to be cited, than "domestically" produced papers.

Some outliers in the share of internationally co-authored publications can be observed, though. Austria, for example, has one of the highest shares of internationally co-authored publications

(approx. 50%), next to Moldova and Montenegro (approx. 57-58%). This, in fact, would contest the previously mentioned assumption regarding the scientific landscape of a country (Austria has available a broad range of scientific institutions). To gain a better understanding of the data, one must think of a next layer in that discussion: Better developed countries do not only provide the necessary broad scientific infrastructure to allow nationally co-authored publications but also allow researchers to work in an environment which makes it possible for them to expand their networks internationally.
We registered fewer international co-publications for Croatia (26%), Romania (26%), Serbia (31%), Czech Republic (33%), and Ukraine (34%).

In most of the DR countries, the share of DR co-publications of the total co-publication output amounts to 40-50%. In the case of Montenegro, Slovakia, Bosnia and Herzegovina the share is considerably higher, whereas for Croatia it is only slightly higher. On the other end, Germany, Romania, and Ukraine have a considerably lower share of DR co-publications within the total amount of their co-authored publications. The share of DR and international co-publications within the total number of co-publications of all DR countries is given in the following table.

Country	% of int. co-publications within total co-publication output	% of intra-DR co-publications of overall co-publication output
AT	**49.7**	47.6
BG	43.3	41.9
B&H	41.5	**79.1**
CZ	*32.9*	42.1
DE[13]	*43.0*	25.6
HR	*25.6*	53.6
HU	42.8	39.3
MD	**56.7**	40.9
ME	**58.7**	**70.2**
RO	25.6	*33.1*
RS	*30.7*	48.9
SK	40.6	**59.3**
SI	36.6	48.4
UA	33.7	*30.0*

Table 1: Percentage share of DR and international co-publications within the total co-publication output of all DR countries

4.2.3 Strongest co-publication linkages in the Danube Region

Not surprisingly, Germany appears as the strongest "co-player" in scientific co-publication activities in the Danube Region. Germany as the biggest and one of the wealthiest countries within the region, offers certainly a lot of collaboration possibilities to its surrounding and even more distant neighbours. Internationally well-connected researchers and research institutions from Germany are active both world-wide and in the Danube Region.

[13] Data for Germany were retrieved from scimago.com

The following chart displays the country linkages with the highest number of co-publications between the DR countries (country A shows the case country, country B shows the country from the DR, which has the highest number of co-publications with the case country). Only for the combinations Austria - Hungary and Austria – Czech Republic respectively, this proves not completely true. For a complete overview please refer to section 4.3.4., where all collaboration partners for each country are listed. In 9 of 12 cases showing the strongest collaboration partners in the Danube Region, Germany is part of this collaboration.in terms of collaboration in co-publications.

Country A	Country B	number of co-pub. in DR (in thousand)
AT	DE	41,685
CZ	DE	13,946
HU	DE	11,061
UA	DE	6,812
RO	DE	6,311
CZ	SK	6,220
BG	DE	4,846
SK	DE	4,491
AT	CZ	4,318
AT	HU	3,644
SI	DE	3,603
HR	DE	3,507

Table 2: Strongest co-publication partners within DRC

In contrast to the absolute terms, the table below looks one step further, i.e. at the strongest country linkages in relative terms. The last two rows in the Table 3 shed light on the proportion of the joint country co-publication output within the total national co-publication output in the country A (row 4) and B (row 5), respectively. It is important to add that this chart only describes the strongest country linkages according to the share of one involved country's overall co-publication output (including both DR and international co-publications) and is not meant to be exhaustive in terms of involvement of all DR countries as defined in this report.

Country A	Country B	Number of joint co-pubs	as % of A's output	as % of B's output
ME	**RS**	589	**31.26%**	1.17%
AT	DE	41685	**19.43%**	2.88%
RS	**BA**	842	1.67%	**13.01%**
BA	**HR**	834	**12.89%**	1.40%
CZ	SK	6220	3.57%	**12.05%**
DE	BG	4846	0.33%	**12.03%**
DE	**MD**	480	0.03%	**11.50%**

HU	DE	11061	**10.59%**	0.76%
SK	DE	4491	**8.70%**	0.31%
CZ	DE	13946	**7.99%**	0.96%
DE	UA	6812	0.47%	**7.28%**
MK	**RS**	465	**7.16%**	0.92%

Table 3: Percentage share of DR country's co-publication output with a partner country compared to the overall national co-publication output

When considering both countries' overall co-publication output, the picture appears again slightly different. This comparison is made possible with the Salton's measure method.[14]

Country A	Country B	joint co-publications	S	as % of A's output	as % of B's output
AT	DE	41685	0.07483	19.43%	2.88%
CZ	SK	6220	0.06555	3.57%	12.05%
ME	RS	589	0.06039	31.26%	1.17%
RS	BA	842	0.04658	1.67%	13.01%
BA	HR	834	0.04252	12.89%	1.40%
SI	HR	2000	0.03632	3.92%	3.36%
HU	DE	11061	0.02846	10.59%	0.76%
CZ	DE	13946	0.02776	7.99%	0.96%
MK	RS	465	0.02567	7.16%	0.92%
AT	HU	3644	0.02435	1.70%	3.49%
RS	**SI**	1214	0.02392	**2.40%**	**2.38%**
AT	CZ	4318	0.02232	2.01%	2.47%

Table 4: Percentage share of DR country's co-publication output with a partner country compared to the overall output

Table 4 shows some observations about the number of produced co-publications among two countries and the share of the jointly produced co-publication output within the total co-publication output (meaning both DR and international co-publications) of both countries. The value of S indicates Salton's Measure for the two countries, as defined in the Methodology section. Of additional interest is, apart from the co-publication output between two certain DR countries, the share of this amount for each individual country in terms of the absolute output. If one takes the example of Austria and Germany, the higher dependence of Austria on Germany than vice versa is quite obvious (19.43% in contrast to 2.88%). This can be explained by the fact that Germany has better established international linkages, hence does not depend on one single country so much as Austria does in this case.

[14] Cf. the definition in the Methodology section

Other important links that should be highlighted are:

- **Bosnia and Herzegovina:** Interestingly enough, for Bosnia and Herzegovina none of the four mentioned countries belongs to the strongest partners. The strongest partners in co-publications are Serbia, Croatia and Slovenia
- **Croatia:** Slovenia is a stronger collaboration partner than Austria, Czech Republic and Hungary
- **Moldova:** After Germany, Romania and Ukraine appear as the second and third strongest partners
- **Montenegro:** The strongest partner for Montenegro is Serbia. Then follows Germany, Croatia and Romania
- **Romania:** Hungary is the second most important partner country
- **European Research Area (ERA):** As a side note, the strongest collaboration partner for the whole ERA is France averagely.

4.2.4 Scientific research fields

To examine the scientific research topics in the Danube Region co-publication output in the following section, we use the Science-Metrix Ontology of Science classification[15] (mostly on the area of the research field and only those scientific (co-)publications, which are citable[16]).

Table 5 shows the thematic foci in the overall Danube Region publication output – the 10 Science-Metrix fields with the highest publication output of all publications published in the Danube Region (except Germany) with at least one author (including all article and article-like publications and co-publications) from 2003 to 2013. The figures for mean number of countries and authors involved are also calculated for the whole Danube Region publication output.

Apart from Physics & Astronomy, a research area with a generally high share of authors involved in a co-publication, Biomedical Research, Biology, and Clinical Medicine are the scientific research fields with the highest mean number of authors and countries involved (see Table 5). We can conclude that those are the research areas with a more intense (national and international) co-publication activity.

No of publications	Science Metrix field	Mean n involved countries	mean n involved authors
231,091	Clinical Medicine	1.83	**5.94**
132,477	Physics & Astronomy	2.60	**25.12**
86,604	Engineering	1.35	3.28
85,349	Information & Communication	1.40	3.04

[15] Science Metrix, a Canada-based company, developed a multi-lingual three-level journal subject classification system: the Science Metrix Ontology of Science. It builds on comprehensive work on standardisation and classification of journals, partly financed by the European Commission. The main difference between the Science Metrix Ontology and classification systems used by Scopus and Web of Science is the disjunct classification, i.e. each journal is attributed to one (not one or more) subject category.

[16] Here we are only using (co-)publications which are citable, which means we are using only (co-)publications which are published in citable document types: Article, Conference/Proceedings Paper, Letter and Review (and don't count normally not cited documents like Editorials).

	Technologies		
83,498	Enabling & Strategic Technologies	1.55	4.44
80,143	Chemistry	1.57	4.46
62,987	Biomedical Research	1.99	**6.35**
39,048	Biology	1.85	4.34
38,096	Mathematics & Statistics	1.53	2.16
33,098	Agriculture, Fisheries & Forestry	1.45	4.18

Table 5: Science Metrix fields publications involving at least one author from a Danube Region country (except Germany), 2003-2013 (Source: WoS+Scopus)

Figure 3 illustrates the differences in the distribution of scientific research fields in the overall Danube Region publication output (except Germany as a whole) and the overall Danube Region co-publication output (including Germany). Whereas the share of publications in the scientific fields Clinical Medicine, Engineering, Information & Communication Technologies, Agriculture, Fisheries & Forestry, Enabling & Strategic Technologies, Economics & Business in the area of Physics & Astronomy, Social Sciences, Historical Studies, etc. is lower in the Danube Region co-publications than in the Danube Region publication output, for the fields like Physics & Astronomy, Chemistry, Biomedical Research, Biology, Mathematics & Statistics, Earth & Environmental Sciences, General Science & Technology and Philosophy & Theology the situation is contrary: here their share in the Danube Region co-publications is higher than in the overall Danube Region publications.

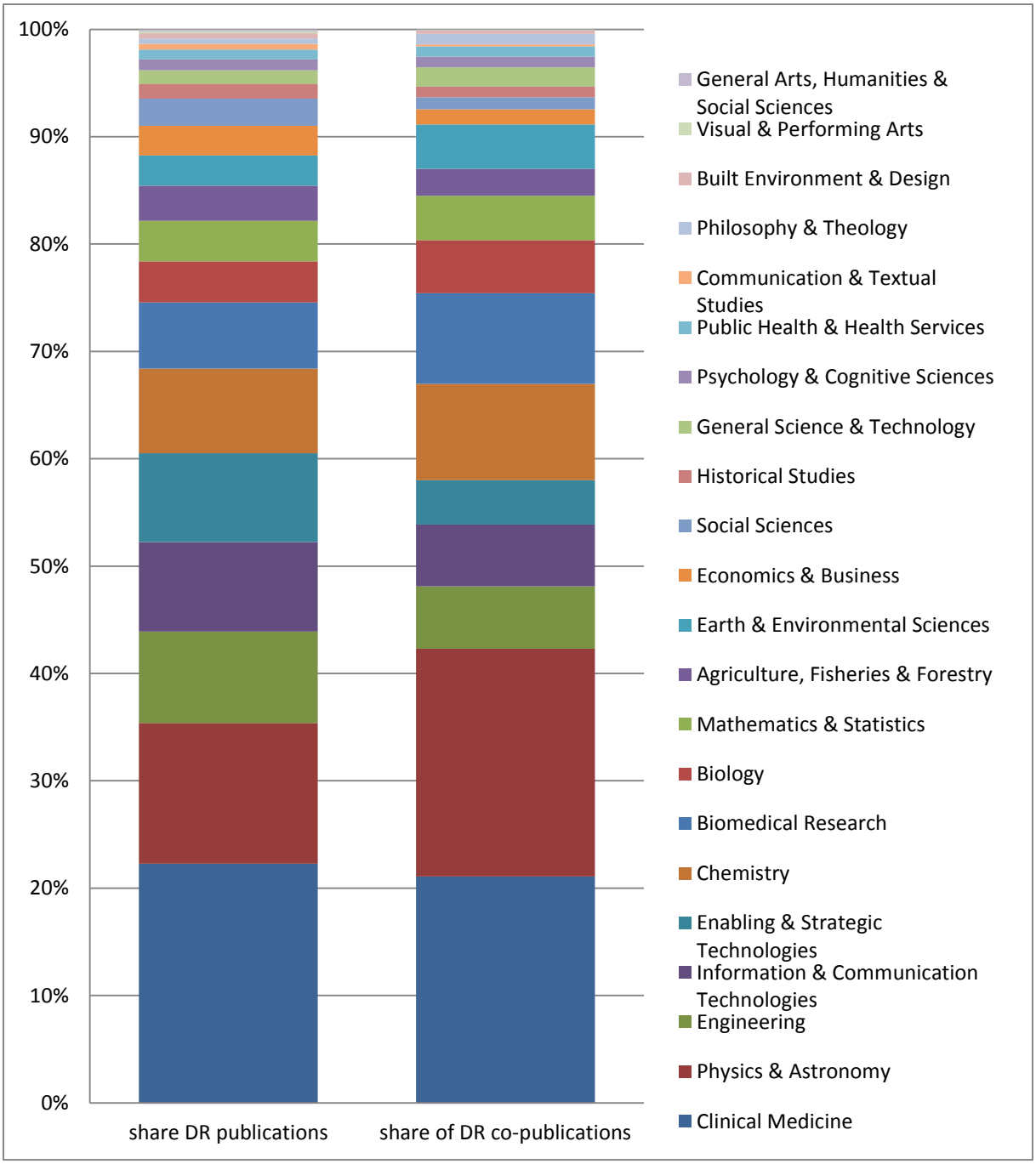

Figure 3: Comparison of scientific fields distribution in overall Danube Region publication output to overall Danube Region co-publication output, 2003-2013 (Source: WoS+Scopus)

In the next sub-sections, the thematic portfolios of each Danube Region country are discussed and compared with two relevant benchmarks: Firstly, each country´s overall publication output (including Danube Region co-publication links as well as further international links of each country beyond the Danube Region) is compared to the country's international co-publications (including all Danube Region co-publication links) and secondly, the Danube Region co-publication activity of each country is compared to the thematic distribution of the country's overall publications and international co-publications. In particular and to go a little bit into more detail, the 14 scientific research fields with the most Danube Region publication output were examined for this comparison at the country level.

4.2.4.1 Scientific research fields in Albania's (co-)publications

Albania's specialisation in the area of Clinical Medicine in the Danube Region collaboration is clearly visible – whereas the share of Clinical Medicine co-publications in Albania's overall international co-publications is 21.76%, the share of Albania's Danube Region co-publications in Clinical Medicine amounts to 25.26%, but the overall share of Albania's publications in Clinical Medicine compared to the overall publication output is even bigger: 29.32%. Biology is a rather important research field in the Albanian Danube Region co-publications, the share of this field amounts to 16.72% (and is thus research field with the second most Danube Region co-publications for Albania after Clinical Medicine), whereas the Albanian overall co-publications have a share of 7.72% in Biology and the Albanian overall publications only a share of 4.89%. A similar situation is visible for Agriculture, Fisheries & Forestry and Engineering, where the Danube Region co-publications have a higher share than the overall co-publications which have in turn a higher share than the overall publications of Albania. (Table 6)

Science Metrix fields (most important)	AL overall publications	share	AL co-publications	share	AL-Danube Region co-publications	Share
Agriculture, Fisheries & Forestry	89	**3.51%**	51	**5.04%**	18	**6.14%**
Biology	124	**4.89%**	78	**7.72%**	49	**16.72%**
Biomedical Research	121	4.78%	76	7.52%	20	6.83%
Chemistry	72	2.84%	37	3.66%	8	2.73%
Clinical Medicine	743	**29.32%**	220	**21.76%**	74	**25.26%**
Earth & Environmental Sciences	144	5.68%	85	8.41%	23	7.85%
Economics & Business	88	3.47%	40	3.96%	9	3.07%
Enabling & Strategic Technologies	170	6.71%	49	4.85%	7	2.39%
Engineering	132	**5.21%**	55	**5.44%**	20	**6.83%**
Historical Studies	44	1.74%	34	3.36%	6	2.05%
Information & Communication Technologies	166	6.55%	103	10.19%	8	2.73%
Mathematics & Statistics	63	2.49%	21	2.08%	4	1.37%
Physics & Astronomy	98	3.87%	35	3.46%	11	3.75%
Social Sciences	79	3.12%	25	2.47%	6	2.05%

Table 6: Science Metrix fields in Albanian (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.2 Scientific research fields in Austria's (co-)publications

Austria's specialisation in the area of Clinical Medicine in the Danube Region collaboration is clearly visible – whereas the share of Clinical Medicine co-publications in Austria's overall international co-publications is 31.14%, the share of Austria's Danube Region co-publications in Clinical Medicine

amounts to 34.3%. A similar situation is visible in the scientific fields Earth & Environmental Sciences, Physics & Astronomy, Biology and Biomedical Research, where Austria's Danube Region and overall international co-publications have a higher share than in Austria's overall publications. Austria's publications in Information & Communication Technologies amount to 9.22% of the overall publication output, which can be considered as a thematic strength, but only 6.3% of the overall co-publication output and even less (4.8%) of the Danube Region co-publication output. (see Table 7)

Science Metrix fields (most important)	AT overall publications	share	AT co-publications	share	AT-Danube Region co-publications	Share
Agriculture, Fisheries & Forestry	5,389	2.41%	2,690	2.54%	1,164	2.30%
Biology	6,471	**2.90%**	4,175	**3.93%**	1,669	**3.30%**
Biomedical Research	15,988	**7.15%**	9,430	**8.89%**	4,439	**8.78%**
Chemistry	11,235	5.03%	6,003	5.66%	2,702	5.35%
Clinical Medicine	74,126	**33.17%**	33,046	**31.14%**	17,345	**34.32%**
Earth & Environmental Sciences	6,955	**3.11%**	4,759	**4.49%**	2,088	**4.13%**
Economics & Business	5,211	2.33%	2,272	2.14%	851	1.68%
Enabling & Strategic Technologies	13,441	6.01%	6,392	6.02%	3,080	6.09%
Engineering	16,065	7.19%	5,667	5.34%	2,360	4.67%
Historical Studies	2,429	1.10%	955	0.90%	456	0.90%
Information & Communication Technologies	20,609	**9.22%**	6,639	**6.3%**	2,446	**4.84%**
Mathematics & Statistics	5,371	2.40%	2,734	2.58%	951	1.88%
Physics & Astronomy	20,879	**9.34%**	13,879	**13.08%**	7,529	**14.90%**
Social Sciences	5,266	2.36%	1,449	1.37%	586	1.16%

Table 7: Science Metrix fields in Austrian (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.3 Scientific research fields in Bulgaria's (co-)publications

Bulgaria has a definite strong Danube Region link in the scientific area of Physics & Astronomy – whereas 17.55% of all Bulgarian publications are published in the field Physics & Astronomy, 25.7% of all Bulgarian international co-publications cover this research area and more than 31% of all Bulgarian Danube Region co-publications are published in this field, which indicates that these are most likely big science collaborations. A similar situation is visible in the scientific fields Chemistry, Biomedical Research, Biology and Earth & Environmental Sciences where Bulgaria's Danube Region and overall international co-publications have a (slightly) higher share than in Bulgaria's overall publications. Similar to Austria, Bulgaria's co-publications in Information & Communication Technologies have a smaller share than Bulgaria's ICT publications: Bulgaria's publications in ICT amount to 6.59% of the overall publication output, but only 4.9% of the overall co-publication output and even less (2.7%) of the Danube Region co-publication output. Same applies to Enabling &

Strategic Technologies, where Bulgaria's overall publication output is, compared to the co-publication output with other Danube Region countries, bigger. (see Table 8Table 8)

Science Metrix fields (most important)	BG overall publications	share	BG co-publications	share	BG-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	1,399	3.43%	384	2.21%	152	2.09%
Biology	1,901	**4.67%**	957	**5.50%**	417	**5.73%**
Biomedical Research	2,543	**6.24%**	1,221	**7.02%**	484	**6.65%**
Chemistry	4,054	**9.95%**	1,847	**10.62%**	767	**10.5%**
Clinical Medicine	6,969	17.11%	2,188	12.58%	1,110	15.26%
Earth & Environmental Sciences	1,154	**2.83%**	697	**4.01%**	242	**3.33%**
Economics & Business	319	0.78%	137	0.79%	36	0.49%
Enabling & Strategic Technologies	4,846	**11.90%**	1,941	**11.16%**	645	**8.87%**
Engineering	2,720	6.68%	966	5.55%	313	4.30%
Historical Studies	418	1.03%	153	0.88%	60	0.82%
Information & Communication Technologies	2,683	**6.59%**	860	**4.94%**	199	**2.74%**
Mathematics & Statistics	1,427	3.50%	684	3.93%	208	2.86%
Physics & Astronomy	7,146	**17.55%**	4,464	**25.67%**	2,275	**31.28%**
Social Sciences	543	1.33%	147	0.85%	53	0.73%

Table 8: Science Metrix fields in Bulgaria's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.4 Scientific research fields in Bosnia and Herzegovina's (co-)publications

Bosnia and Herzegovina's specialisation in the area of Clinical Medicine in the Danube Region collaboration is clearly visible – whereas the share of Clinical Medicine co-publications in Bosnia and Herzegovina's overall international co-publications is 31.7%, the share of Bosnia and Herzegovina's Danube Region co-publications in Clinical Medicine amount to 33.0%, but the overall share of Bosnia and Herzegovina's publications in Clinical Medicine compared to the overall publication output is even bigger: 38.38%. In the scientific fields Engineering, Agriculture, Fisheries & Forestry, Enabling & Strategic Technologies, Historical Studies and Biology, Bosnia and Herzegovina's Danube Region collaboration is quite strong likewise. Similar to Austria and Bulgaria, Bosnia and Herzegovina's co-publications in Information & Communication Technologies have a smaller share than Bosnia and Herzegovina's ICT publications: Bosnia and Herzegovina's publications in ICT amount to 10.23% of the overall publication output, but only 5.5% of the overall co-publication output and even less (4.8%) of the Danube Region co-publication output. Bosnia and Herzegovina's publication output share in the research field Social Sciences is rather high compared to other countries in the Danube Region. (see Table 9)

Science Metrix fields (most important)	BA overall publications	share	BA co-publications	share	BA-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	237	**3.61%**	158	**5.87%**	138	**6.50%**
Biology	223	**3.40%**	170	**6.32%**	139	**6.55%**
Biomedical Research	189	2.88%	106	3.94%	85	4.01%
Chemistry	257	3.92%	120	4.46%	105	4.95%
Clinical Medicine	2,518	**38.38%**	854	**31.72%**	701	**33.03%**
Earth & Environmental Sciences	77	1.17%	50	1.86%	43	2.03%
Economics & Business	177	2.70%	46	1.71%	28	1.32%
Enabling & Strategic Technologies	325	**4.95%**	193	**7.17%**	149	**7.02%**
Engineering	589	**8.98%**	218	**8.10%**	172	**8.11%**
Historical Studies	208	**3.17%**	133	**4.94%**	127	**5.98%**
Information & Communication Technologies	671	**10.23%**	149	**5.53%**	101	**4.76%**
Mathematics & Statistics	134	2.04%	72	2.67%	34	1.60%
Physics & Astronomy	211	3.22%	168	6.24%	146	6.88%
Social Sciences	379	**5.78%**	128	**4.75%**	84	**3.96%**

Table 9: Science Metrix fields in Bosnia and Herzegovina's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.5 Scientific research fields in the Czech Republic's (co-)publications

The Czech Republic has a definite strong Danube Region link in the scientific area of Physics & Astronomy – whereas only 11.14% of all Czech publications are published in the field Physics & Astronomy, 20.79% of all Czech international co-publications cover this research area and 24.09% of all Czech Danube Region co-publications are published in this field, which indicates that these are most likely big science collaborations. Likewise in the scientific fields Chemistry, Biology, and Earth & Environmental Sciences, the Danube Region co-publications of the Czech Republic are, compared to the overall publication output of the Czech Republic in these fields, quite high. For Clinical Medicine the share of Czech Danube Region co-publications is higher than the share Czech international co-publications but lower than for the overall publication output of the Czech Republic. Similar to most of the other Danube Region countries co-publications in Information & Communication Technologies have a smaller share than the overall Czech Republic's ICT publications: the Czech publications in ICT amount to 7.9% of the overall publication output, but only 5.23% of the overall co-publication output and even less (4.17%) of the Danube Region co-publication output. The share of Biomedical Research in Czech international co-publications is, compared to the share of the overall publications, rather high, but this trend does not fully translate to the Czech Danube Region co-publications. (see Table 10)

Science Metrix fields (most important)	CZ overall publications	share	CZ co-publications	share	CZ-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	8,738	4.90%	1,602	2.80%	745	3.10%
Biology	8,519	**4.77%**	3,894	**6.81%**	1,493	**6.20%**
Biomedical Research	12,455	**6.98%**	5,334	**9.33%**	1,858	**7.72%**
Chemistry	14,840	**8.31%**	5,705	**9.98%**	2,151	**8.94%**
Clinical Medicine	42,185	**23.63%**	10,775	**18.85%**	5,321	**22.11%**
Earth & Environmental Sciences	5,323	**2.98%**	2,444	**4.28%**	980	**4.07%**
Economics & Business	5,560	3.11%	512	0.90%	194	0.81%
Enabling & Strategic Technologies	13,447	7.53%	4,188	7.33%	1,710	7.11%
Engineering	13,145	7.36%	2,530	4.43%	873	3.63%
Historical Studies	2,135	1.20%	540	0.94%	254	1.06%
Information & Communication Technologies	14,163	**7.93%**	2,992	**5.23%**	1,004	**4.17%**
Mathematics & Statistics	5,232	2.93%	2,264	3.96%	656	2.73%
Physics & Astronomy	19,877	**11.14%**	11,886	**20.79%**	5,797	**24.09%**
Social Sciences	4,004	2.24%	410	0.72%	160	0.66%

Table 10: Science Metrix fields in the Czech Republic's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.6 Scientific research fields in Croatia's (co-)publications

Like the Czech Republic or Bulgaria, Croatia has a strong Danube Region link in the scientific area of Physics & Astronomy – whereas only 7.19% of all Croatian publications are published in the field Physics & Astronomy, 19.45% of all Croatian international co-publications cover this research area and 22.89% of all Croatian Danube Region co-publications are published in this field, which indicates that these are most likely big science collaborations. The share of Croatian international co-publications in Chemistry, Biomedical Research and Earth & Environmental Sciences is higher than for the Croatian publications overall and in these fields the share Croatia's Danube Region co-publications are higher than the share for Croatian publications as well but slightly lower than for the Croatian international co-publications. For the fields Biology and Enabling & Strategic Technologies the share for Danube Region co-publications is even higher than for the international co-publications. The share of Danube Region co-publications in Agriculture, Fisheries & Forestry is higher than for the overall publications and for the Croatian international co-publications the share is even lower than for the Croatian overall publications. Croatia has, compared to other Danube Region countries, an output strength in Historical Studies (nearly 5%) and the share of Historical Studies in Croatia's Danube Region co-publications is higher than for the Croatian international co-publications overall but lower than for Croatia's publications overall. (see Table 11)

Science Metrix fields (most important)	HR overall publications	share	HR co-publications	share	HR-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	3,267	**5.37%**	767	**5.06%**	500	**6.17%**
Biology	3,132	**5.15%**	919	**6.06%**	536	**6.61%**
Biomedical Research	2,927	**4.81%**	1,330	**8.77%**	658	**8.12%**
Chemistry	3,946	**6.49%**	1,258	**8.30%**	672	**8.29%**
Clinical Medicine	17,118	28.14%	3,090	20.38%	1,593	19.65%
Earth & Environmental Sciences	1,344	**2.21%**	488	**3.22%**	249	**3.07%**
Economics & Business	2,176	3.58%	241	1.59%	111	1.37%
Enabling & Strategic Technologies	2,696	4.43%	898	5.92%	534	6.59%
Engineering	5,306	8.72%	802	5.29%	405	5.00%
Historical Studies	3,034	**4.99%**	430	**2.84%**	269	**3.32%**
Information & Communication Technologies	3,684	6.06%	549	3.62%	182	2.24%
Mathematics & Statistics	1,594	2.62%	616	4.06%	156	1.92%
Physics & Astronomy	4,375	**7.19%**	2,948	**19.45%**	1,856	**22.89%**
Social Sciences	1,862	3.06%	169	1.11%	71	0.88%

Table 11: Science Metrix fields in Croatia's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.7 Scientific research fields in Hungary's (co-)publications

Like the Czech Republic, Bulgaria and Croatia, Hungary has a strong Danube Region link in the scientific area of Physics & Astronomy – whereas 11.55% of all Hungarian publications are published in the field Physics & Astronomy, 18.18% of all Hungarian international co-publications cover this research area and 23.46% of all Hungarian Danube Region co-publications are published in this field. For Biomedical Research and Chemistry the share of Hungarian overall co-publications and the Danube Region co-publications are higher than the share for Hungary's overall publications, but the Danube Region co-publication share is lower than for the international co-publications. The share of Danube Region co-publications is higher than for the Hungarian overall publications and co-publications in Enabling & Strategic Technologies and Earth & Environmental Sciences. In the field Mathematics & Statistics the share for Hungarian co-publications is higher than for Hungarian overall publications but the share for Danube Region co-publications is lower than for the Hungarian publications overall. Whereas for the most Danube Region countries the share of Danube Region and overall co-publications for Biology is higher than the share for their overall publications, for Hungary the Biology share of Hungarian publications is higher than for their international and Danube Region co-publications. (see Table 12)

Science Metrix fields (most important)	HU overall publications	share	HU co-publications	share	HU-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	3,886	3.64%	1,202	2.71%	436	2.50%
Biology	6,391	**5.98%**	2,301	**5.18%**	881	**5.05%**
Biomedical Research	8,445	**7.90%**	4,437	**9.99%**	1,420	**8.14%**
Chemistry	8,339	**7.80%**	3,855	**8.68%**	1,402	**8.04%**
Clinical Medicine	28,690	26.84%	11,112	25.02%	4,508	25.85%
Earth & Environmental Sciences	3,117	**2.92%**	1,467	**3.30%**	680	**3.90%**
Economics & Business	1,796	1.68%	516	1.16%	168	0.96%
Enabling & Strategic Technologies	5,694	**5.33%**	2,297	**5.17%**	956	**5.48%**
Engineering	5,949	5.56%	1,631	3.67%	536	3.07%
Historical Studies	1,598	1.49%	404	0.91%	170	0.97%
Information & Communication Technologies	7,951	7.44%	2,465	5.55%	676	3.88%
Mathematics & Statistics	4,036	**3.78%**	1,725	**3.88%**	493	**2.83%**
Physics & Astronomy	12,344	**11.55%**	8,074	**18.18%**	4,092	**23.46%**
Social Sciences	2,668	2.50%	608	1.37%	191	1.10%

Table 12: Science Metrix fields in Hungary's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.8 Scientific research fields in Kosovo's (co-)publications*

Kosovo*'s specialisation in the area of Clinical Medicine in the Danube Region collaboration is clearly visible – whereas the share of Clinical Medicine co-publications in Kosovo*'s overall international co-publications is 37.27%, the share of Kosovo*'s intra-DR co-publications in Clinical Medicine amount to 38.28%. The overall share of Kosovo*'s publications in Clinical Medicine compared to the overall publication output is lower: 36.06%.

In the scientific fields Agriculture, Fisheries & Forestry, Biology, Chemistry, Enabling & Strategic Technologies, Historical Studies, and Physics & Astronomy Kosovo*'s Danube Region and overall international co-publications have a (slightly) higher share than in Kosovo*'s overall publications. Compared to many other Danube Region countries Kosovo*'s share of Physics & Astronomy publications in their overall publications is low (1.71%). Kosovo*'s share of Danube Region co-publications in the field of Biomedical Research (12.21%) is higher than the share of the Kosovar international co-publications (10.45%) and overall publications (11.72%) in this field. (see Table 14)

Science Metrix fields (most important)	KO- overall publications	share	KO- co-publications	share	KO-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	24	**2.73%**	20	**4.55%**	15	**4.95%**
Biology	20	**2.28%**	14	**3.18%**	13	**4.29%**
Biomedical Research	103	**11.72%**	46	**10.45%**	37	**12.21%**
Chemistry	21	**2.39%**	16	**3.64%**	11	**3.63%**
Clinical Medicine	317	**36.06%**	164	**37.27%**	116	**38.28%**
Earth & Environmental Sciences	31	3.53%	9	2.05%	9	2.97%
Economics & Business	18	2.05%	10	2.27%	5	1.65%
Enabling & Strategic Technologies	56	**6.37%**	33	**7.50%**	22	**7.26%**
Engineering	68	7.74%	23	5.23%	19	6.27%
Historical Studies	15	**1.71%**	10	**2.27%**	10	**3.30%**
Information & Communication Technologies	47	5.35%	16	3.64%	7	2.31%
Mathematics & Statistics	23	2.62%	11	2.50%	7	2.31%
Physics & Astronomy	15	**1.71%**	9	**2.05%**	10	**3.30%**
Social Sciences	68	7.74%	31	7.05%	11	3.63%

Table 13: Science Metrix fields in Kosovo*'s (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.9 Scientific research fields in Macedonia's (co-)publications

FYR of Macedonia's specialisation in the area of Clinical Medicine in the Danube Region collaboration is clearly visible – whereas the share of Clinical Medicine co-publications in FYR of Macedonia's overall international co-publications is 21.37%, the share of FYR of Macedonia's Danube Region co-publications in Clinical Medicine amount to 23.06%, but the overall share of FYR of Macedonia's publications in Clinical Medicine compared to the overall publication output is even bigger: 30.94%. In the scientific fields Chemistry, Biology and Agriculture, Fisheries & Forestry, Earth & Environmental Sciences and Mathematics & Statistics FYR of Macedonia's Danube Region and overall international co-publications have a (slightly) higher share than in FYR of Macedonia's overall publications. Compared to many other Danube Region countries FYR of Macedonia's share of Physics & Astronomy publications in their overall publications is rather low (6.14%), the FYR of Macedonia's overall co-publications have a higher share (10.97%), the FYR of Macedonia's Danube Region co-publications have a higher share (10.70%) than the overall FYR of Macedonia's publications but a slightly lower share than the overall FYR of Macedonia's co-publications. (see Table 14)

Science Metrix fields (most important)	MK overall publications	share	MK co-publications	share	MK-Danube Region co-publications	share
Agriculture, Fisheries &	169	**2.61%**	112	**4.57%**	80	**6.34%**

Forestry						
Biology	195	**3.01%**	136	**5.55%**	80	**6.34%**
Biomedical Research	411	6.34%	133	5.42%	67	5.31%
Chemistry	460	**7.09%**	255	**10.40%**	161	**12.76%**
Clinical Medicine	2,007	**30.94%**	524	**21.37%**	291	**23.06%**
Earth & Environmental Sciences	152	**2.34%**	87	**3.55%**	54	**4.28%**
Economics & Business	100	1.54%	46	1.88%	15	1.19%
Enabling & Strategic Technologies	390	6.01%	162	6.61%	81	6.42%
Engineering	541	8.34%	234	9.54%	90	7.13%
Historical Studies	36	0.56%	11	0.45%	9	0.71%
Information & Communication Technologies	850	13.11%	231	9.42%	71	5.63%
Mathematics & Statistics	147	**2.27%**	75	**3.06%**	48	**3.80%**
Physics & Astronomy	398	**6.14%**	269	**10.97%**	135	**10.70%**
Social Sciences	331	5.10%	53	2.16%	26	2.06%

Table 14: Science Metrix fields in Macedonia's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.10 Scientific research fields in Moldova's (co-)publications

Once again, like the Czech Republic, Bulgaria, Croatia and Hungary, Moldova has a strong Danube Region link in the scientific area of Physics & Astronomy – whereas 26.65% of all Moldovan publications are published in the field Physics & Astronomy, 33.38% of all Moldovan international co-publications cover this research area and 35.96% of all Moldovan Danube Region co-publications are published in this field. Compared to the other Danube Region countries, Moldova's share of Physics & Astronomy in all their (co-)publications is, with exception of the Ukraine, particularly high. Apart from Physics & Astronomy the field Chemistry has a remarkably high share (21.35%) of Moldova's publications and an even higher share of Moldova's co-publications (26.28%) and of Moldova's Danube Region co-publications (26.84%), followed by publications in Enabling & Strategic Technologies, but here the share of overall and Danube Region co-publications is considerably lower. Whereas the field Engineering in all Danube Region countries the co-publication share is lower than the share of the country's overall publication output respectively, for Moldova the share in Danube Region co-publications is higher. In the field Information & Communication Technologies the share for overall Moldovan co-publications and Danube Region co-publications is only slightly lower than for Moldova's overall publications unlike for all other Danube Region countries where the share of (Danube Region) co-publications is always notably lower. (see Table 15)

Science Metrix fields (most important)	MD overall publications	share	MD co-publications	share	MD-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	67	1.60%	21	0.89%	10	1.04%
Biology	65	1.55%	45	1.91%	22	2.28%
Biomedical Research	68	1.62%	42	1.79%	11	1.14%
Chemistry	894	**21.35%**	618	**26.28%**	259	**26.84%**
Clinical Medicine	511	12.20%	159	6.76%	65	6.74%
Earth & Environmental Sciences	35	0.84%	24	1.02%	7	0.73%
Economics & Business	31	0.74%	9	0.38%	4	0.41%
Enabling & Strategic Technologies	614	**14.66%**	294	**12.50%**	101	**10.47%**
Engineering	199	**4.75%**	94	**4.00%**	51	**5.28%**
Historical Studies	66	1.58%	19	0.81%	8	0.83%
Information & Communication Technologies	175	**4.18%**	97	**4.12%**	40	**4.15%**
Mathematics & Statistics	187	4.47%	86	3.66%	16	1.66%
Physics & Astronomy	1,116	**26.65%**	785	**33.38%**	347	**35.96%**
Social Sciences	62	1.48%	15	0.64%	5	0.52%

Table 15: Science Metrix fields in Moldova's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.11 Scientific research fields in Montenegro's (co-)publications

For Montenegro the field Physics & Astronomy is less important for their (co-)publications when compared to the share of (co-)publications in this field of other Danube Region countries. Montenegro's specialisation in the area of Clinical Medicine in the Danube Region collaboration is clearly visible – whereas the share of Clinical Medicine co-publications in Montenegro's overall international co-publications is lower than for the Montenegrin overall publication output, 20.90%, the share of Montenegro's Danube Region co-publications in Clinical Medicine amount to 27.96%. Besides the field Clinical Medicine, a specialisation in Information & Communication Technologies is visible in the Montenegrin publication output, but the share of Montenegrin (Danube Region) co-publications is remarkably lower, contrary to e.g. the field Biology, where the share for Montenegro's publications amount to 11.16% but for Montenegro's co-publications it is 15.02%. For Montenegro's Danube Region co-publications in Biology the share is lower with 12.11%, but overall Biology is the field with third highest number of Danube Region co-publications for Montenegro (slightly behind Physics & Astronomy). The Montenegrin Danube Region co-publications have a bigger share in Enabling & Strategic Technologies (6.06%) than the in the Montenegrin overall publications (5.82%), the Montenegrin overall co-publications have a slightly lower share, 5.07%, which also holds true for Chemistry, where Montenegrin Danube Region co-publications have a bigger share (7.47%) than the

Montenegrin overall co-publications (5.79%) and the Montenegrin overall publications (3.88%). (see Table 16)

Science Metrix fields (most important)	ME overall publications	share	ME co-publications	share	ME-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	32	1.68%	31	2.81%	28	3.61%
Biology	213	**11.16%**	166	**15.02%**	94	**12.11%**
Biomedical Research	41	2.15%	29	2.62%	21	2.71%
Clinical Medicine	401	**21.02%**	231	**20.90%**	217	**27.96%**
Chemistry	74	**3.88%**	64	**5.79%**	58	**7.47%**
Earth & Environmental Sciences	33	1.73%	19	1.72%	13	1.68%
Economics & Business	39	2.04%	17	1.54%	12	1.55%
Enabling & Strategic Technologies	111	**5.82%**	56	**5.07%**	47	**6.06%**
Engineering	196	10.27%	119	10.77%	65	8.38%
Historical Studies	17	0.89%	10	0.90%	9	1.16%
Information & Communication Technologies	328	**17.19%**	127	**11.49%**	47	**6.06%**
Mathematics & Statistics	122	6.39%	48	4.34%	31	3.99%
Physics & Astronomy	206	**10.80%**	147	**13.30%**	99	**12.76%**
Social Sciences	36	1.89%	12	1.09%	9	1.16%

Table 16: Science Metrix fields in Montenegro's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.12 Scientific research fields in Romania's (co-)publications

Romania's specialisation in Engineering (14.55% of all Romanian publications) is rather a national one as the share of this field in Romania's co-publications amounts to 10.02% and is even lower for the Romanian Danube Region co-publications (5.83%). Romania's share of Physics & Astronomy in its overall co-publications is nearly double than the share of Physics & Astronomy in their overall publications and even higher in Romania's Danube Region co-publications. For Clinical Medicine Romanian Danube Region co-publications have a remarkably higher share than Romanian overall co-publications or publications, a similar situation is visible, but with a smaller difference, in the field Biology and an even smaller difference for Biomedical Research and Earth & Environmental Sciences. Chemistry is a rather important field for Romanian publications (10.13% share of their overall publications) and even more so for Romanian co-publications and, to a slightly lesser extent, for Romanian Danube Region co-publications. Enabling & Strategic Technologies has a slightly higher share for Romanian co-publications than for Romanian publications but does play a less important role for Romanian Danube Region co-publications. (see Table 17)

Science Metrix fields (most important)	RO overall publications	share	RO co-publications	share	RO-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	2,974	2.43%	375	1.22%	152	1.49%
Biology	1,609	**1.31%**	610	**1.98%**	322	**3.16%**
Biomedical Research	3,934	**3.21%**	1,210	**3.93%**	472	**4.63%**
Chemistry	12,419	**10.13%**	3,646	**11.85%**	1,136	**11.13%**
Clinical Medicine	14,346	**11.70%**	3,849	**12.51%**	1,740	**17.05%**
Earth & Environmental Sciences	2,406	**1.96%**	1,001	**3.25%**	423	**4.15%**
Economics & Business	6,855	5.59%	379	1.23%	96	0.94%
Enabling & Strategic Technologies	12,295	**10.03%**	3,303	**10.73%**	835	**8.18%**
Engineering	17,843	14.55%	3,083	10.02%	595	5.83%
Historical Studies	2,719	2.22%	335	1.09%	132	1.29%
Information & Communication Technologies	11,603	9.46%	2,114	6.87%	455	4.46%
Mathematics & Statistics	7,770	6.34%	2,583	8.39%	428	4.19%
Physics & Astronomy	14,534	**11.85%**	7,070	**22.98%**	2,948	**28.89%**
Social Sciences	5,444	4.44%	336	1.09%	92	0.90%

Table 17: Science Metrix fields in Romania's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.13 Scientific research fields in Serbia's (co-)publications

Serbia's specialisation in the area of Clinical Medicine is clearly visible but does not translate to the situation in Serbia's co-publications - whereas the share of Clinical Medicine co-publications in Serbia's overall international co-publications is 22.89%, the share of Clinical Medicine in Serbia's publications is 29.11%. Danube Region co-publications in Clinical Medicine have a bigger share than Serbia's overall co-publication, 23.83%, but are still lower than the share in their overall publication output. Physics & Astronomy is the research field with the second highest publication output for Serbia (10.43%) with even a higher share for Serbia's co-publications (17.50%) and Danube Region co-publications (18.74%). For Chemistry and Enabling & Strategic Technologies Serbia's co-publications have a slightly higher share of these fields than Serbia's overall publications, but whereas for Chemistry the share is higher in Serbia's Danube Region co-publications than in Serbia's overall co-publications, for Enabling & Strategic Technologies it is contrariwise. For Mathematics & Statistics the Danube Region co-publications display a particularly low share (3.50%) compared to Serbia's overall co-publications (7.6%) which have a considerable bigger share than the share of Mathematics & Statistics in Serbia's overall publication output (5.33%). Serbia's Danube Region co-publications have, compared to Serbia's overall publications and co-publications, a higher share in

the research fields Biology, Agriculture, Fisheries & Forestry and Earth & Environmental Sciences. (see Table 18)

Science Metrix fields (most important)	RS overall publications	share	RS co-publications	share	RS-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	1,833	**3.59%**	502	**3.27%**	311	**4.14%**
Biology	2,688	**5.27%**	865	**5.63%**	503	**6.69%**
Biomedical Research	2,177	4.26%	709	4.62%	333	4.43%
Chemistry	4,239	**8.30%**	1,298	**8.46%**	671	**8.92%**
Clinical Medicine	14,858	**29.11%**	3,514	**22.89%**	1,792	**23.83%**
Earth & Environmental Sciences	943	**1.85%**	320	**2.08%**	185	**2.46%**
Economics & Business	708	1.39%	169	1.10%	82	1.09%
Enabling & Strategic Technologies	4,085	**8.00%**	1,344	**8.76%**	642	**8.54%**
Engineering	3,847	7.54%	958	6.24%	528	7.02%
Historical Studies	338	0.66%	121	0.79%	77	1.02%
Information & Communication Technologies	3,979	7.79%	941	6.13%	366	4.87%
Mathematics & Statistics	2,715	**5.32%**	1,166	**7.60%**	263	**3.50%**
Physics & Astronomy	5,324	**10.43%**	2,687	**17.50%**	1,409	**18.74%**
Social Sciences	1,334	2.61%	238	1.55%	141	1.88%

Table 18: Science Metrix fields in Serbia's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.14 Scientific research fields Slovakia's (co-)publications

Similar to Serbia, Slovakia's specialisation in the area of Clinical Medicine is clearly visible but does not translate to the situation in Slovakia's co-publications - whereas the share of Clinical Medicine co-publications in Slovakia's overall international co-publications is 16.63%, the share of Clinical Medicine in Slovakia's publications is 18.11%. Slovakia's Danube Region co-publications in Clinical Medicine have a bigger share than Slovakia's overall co-publication, 17.88%, but are still lower than the share in their overall publication output. Physics & Astronomy is the research field with the second highest publication output for Slovakia (13.33%) with even a higher share for Slovakia's co-publications (22.74%) and Danube Region co-publications (23.98%). Chemistry is the research field for Slovakia's overall (co-)publications with the third most frequent publications, with an even higher share in their overall co-publications (and nearly the same share in their Danube Region co-publications). (see Table 19)

Science Metrix fields (most important)	SK overall publications	share	SK co-publications	share	SK-Danube Region co-publications	share
Agriculture, Fisheries	2,488	4.74%	796	3.83%	553	4.48%

& Forestry						
Biology	2,586	4.92%	1,114	5.36%	707	5.73%
Biomedical Research	4,171	7.94%	2,072	9.97%	1,039	8.42%
Chemistry	4,613	**8.78%**	2,332	**11.22%**	1,375	**11.15%**
Clinical Medicine	9,511	**18.11%**	3,457	**16.63%**	2,206	**17.88%**
Earth & Environmental Sciences	2,003	3.81%	894	4.30%	490	3.97%
Economics & Business	1,799	3.42%	222	1.07%	137	1.11%
Enabling & Strategic Technologies	3,558	6.77%	1,408	6.77%	830	6.73%
Engineering	3,821	7.27%	984	4.73%	585	4.74%
Historical Studies	401	0.76%	184	0.89%	111	0.90%
Information & Communication Technologies	3,700	7.04%	970	4.67%	528	4.28%
Mathematics & Statistics	1,492	2.84%	588	2.83%	256	2.08%
Physics & Astronomy	7,004	**13.33%**	4,728	**22.74%**	2,947	**23.89%**
Social Sciences	1,650	3.14%	225	1.08%	139	1.13%

Table 19: Science Metrix fields in Slovakia's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.15 Scientific research fields Slovenia's (co-)publications

Like for Slovakia, Physics & Astronomy is the research field with the second highest publication output for Slovenia (11.90%) with even a higher share for Slovenian co-publications (20.59%) and Danube Region co-publications (23.16%) – for Slovenian co-publications Physics & Astronomy is the research field with the highest publication output. Clinical Medicine is Slovenia's research field with the highest publication output (18.18%), but for Slovenia's co-publication and Danube Region co-publications it is the field with the second highest publication output (16.30% and 16.86% respectively). Chemistry is the research field for Slovenia's overall co-publications with the third most frequent co-publications (9.25%), with a slightly higher share in their Danube Region co-publications (9.39%).A similar same pattern is visible in the research fields Biology, and Earth & Environmental Sciences, Enabling & Strategic Technologies. In Agriculture, Fisheries & Forestry the Slovenian Danube Region co-publications have a higher share (4.53%) than the overall publications (4.18%) and co-publications (4.53%). (see Table 20)

Science Metrix fields (most important)	SI overall publications	share	SI co-publications	share	SI-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	2,178	**4.18%**	680	**3.65%**	408	**4.53%**
Biology	1,521	**2.92%**	810	**4.35%**	398	**4.42%**
Biomedical Research	2,775	5.32%	1,449	7.79%	574	6.38%
Chemistry	3,984	**7.64%**	1,722	**9.25%**	845	**9.39%**
Clinical Medicine	9,478	**18.18%**	3,033	**16.30%**	1,518	**16.86%**
Earth & Environmental Sciences	1,649	**3.16%**	597	**3.21%**	307	**3.41%**

Economics & Business	1,493	2.86%	426	2.29%	159	1.77%
Enabling & Strategic Technologies	4,481	**8.59%**	1,616	**8.68%**	838	**9.31%**
Engineering	4,788	9.18%	1,226	6.59%	587	6.52%
Historical Studies	1,122	2.15%	182	0.98%	105	1.17%
Information & Communication Technologies	4,163	7.99%	1,138	6.11%	451	5.01%
Mathematics & Statistics	1,714	3.29%	735	3.95%	203	2.26%
Physics & Astronomy	6,205	**11.90%**	3,833	**20.59%**	2,085	**23.16%**
Social Sciences	2,903	5.57%	306	1.64%	118	1.31%

Table 20: Science Metrix fields in Slovenia's (co-)publications, 2003-2013 (Source: WoS+Scopus)

4.2.4.16 Scientific research fields Ukraine's (co-)publications

The Ukraine has a strong link with co-publication partner countries in the Danube Region in the scientific area of Physics & Astronomy – whereas 28.67% of all Ukrainian publications are published in the field Physics & Astronomy, 42.01% of all Ukrainian international co-publications cover this research area and 49.90% of all Ukrainian – Danube Region co-publications are published in this field. Compared to most of the other Danube Region countries, this share of Physics & Astronomy in Ukrainian (co-)publications is particularly high. For Ukrainian co-publications Chemistry is the research field with the third most, for Ukrainian-Danube Region co-publications Chemistry is the research field with the second most co-publications, with a share of 10.62% and 11.57%, which is higher than for the Ukrainian overall publications (9.56%) and where Chemistry is the research field with the fifth most publications. For Ukrainian Danube Region co-publications the field Biology has a slightly higher share (2.27%) than for Ukrainian international co-publications (2.23%), which have a higher share than the Ukrainian overall publications (1.98%). (see Table 21)

Science Metrix fields (most important)	UA overall publications	share	UA co-publications	share	UA-Danube Region co-publications	share
Agriculture, Fisheries & Forestry	391	0.42%	227	0.72%	45	0.48%
Biology	1,779	**1.89%**	700	**2.23%**	214	**2.27%**
Biomedical Research	3,792	4.03%	1,372	4.36%	267	2.83%
Chemistry	8,994	**9.56%**	3,341	**10.62%**	1,091	**11.57%**
Clinical Medicine	5,876	6.24%	1,790	5.69%	570	6.05%
Earth & Environmental Sciences	1,951	**2.07%**	1017	**3.23%**	228	**2.42%**
Economics & Business	2,160	2.30%	141	0.45%	35	0.37%
Enabling & Strategic Technologies	14,869	15.80%	4,015	12.76%	1,031	10.94%
Engineering	10,194	10.83%	1,933	6.15%	384	4.07%
Historical Studies	420	0.45%	209	0.66%	54	0.57%
Information & Communication	9,345	9.93%	1,121	3.56%	192	2.04%

Technologies						
Mathematics & Statistics	5,733	6.09%	1,811	5.76%	475	5.04%
Physics & Astronomy	26,976	**28.67%**	13,214	**42.01%**	4,704	**49.90%**
Social Sciences	487	0.52%	111	0.35%	29	0.31%

Table 21: Science Metrix fields in Ukraine's (co-)publications, 2003-2013 (Source: WoS+Scopus)

Summary of findings concerning the scientific research fields

Summing up the discussions of this chapter it can be said that the main research loci in the Danube region are Clinical Medicine and Physics & Astronomy. Based on this statement, we can divide the Danube Region countries into two thematic groups: Albania (25.85%), Austria (34.32%), Bosnia and Herzegovina (33.03%), FYR of Macedonia (23.06%), Montenegro (27.96%) and Hungary (25.85%) is relatively more specialised in their Danube Region collaboration in the area of Clinical Medicine; whereas most of the other countries, like Bulgaria (31.28%), the Czech Republic (24.09%), Moldova (35.96%), Slovenia (23.16%), Slovakia (23.89%) and Ukraine (49.90%) have stronger DR links in the area of Physics & Astronomy.

The country-level share of DR co-publications in Biomedical Research is rather high (share above 7.5% of all Danube Region co-publications) for Austria, the Czech Republic, Croatia, Kosovo*, Macedonia, Hungary and Slovakia, in Earth & Environmental Sciences the share of Danube Region co-publications is quite high (share above 3.5% of all Danube Region co-publications) for Austria, the Czech Republic, Romania and Hungary and for Bulgaria, Slovenia, Serbia, Ukraine and Moldova the country-level share of Danube Region co-publications in Enabling & Strategic Technologies can be considered as a thematic specialisation (share above 8.5% of all Danube Region co-publications). Biology is prominent in Danube Region co-publications for Albania, Bosnia and Herzegovina, the Czech Republic, Croatia, Macedonia, Montenegro and Serbia (share above 6% of all Danube Region co-publications), Engineering for Bosnia and Herzegovina and Montenegro (share above 8% of all Danube Region co-publications), Historical Studies for Bosnia and Herzegovina, Croatia and Kosovo* (share above 3% of all Danube Region co-publications), Agriculture, Fisheries & Forestry for Albania, Bosnia and Herzegovina, Croatia, Kosovo*, Macedonia, Serbia, Slovakia and Slovenia (share above 4% of all Danube Region co-publications). For nearly all Danube Region countries – except Bosnia and Herzegovina – Chemistry can be considered as a specialisation in Danube Region co-publications.

Findings regarding the development of thematic fields over the years

The main overall trends of the development of the 12 scientific research fields with the most Danube Region publication output, of the scientific fields of Danube region co-publications are as follows:

- Many countries have more than decupled their annual Danube Region co-publication output in General Science & Technology from 2003 to 2013 (like e.g. Austria from 16 co-publications in 2003 to 244 in 2013, Bulgaria from 12 co-publications in 2003 to 246 in 2013, Czech

Republic from 39 co-publications in 2003 to 158 in 2013 or Hungary from 4 co-publications in 2003 to 60 in 2013)[17]

- Many countries have a rather 'low' (their annual co-publication output does not even double its output from 2003 to 2013) growth in the fields Physics & Astronomy and Chemistry (like Austria, Bulgaria, Czech Republic, Germany etc.) – while the annual Physics & Astronomy co-publication output more than doubles in other countries from 2003 to 2013 (e.g. in Romania, Montenegro, or Slovenia) or is even eight times higher in 2013 compared to 2003 in case of Serbian Danube Region co-publications.
- In research fields with medium co-publication output many countries have a rather high growth in the fields Public Health, Social Sciences and Economics & Business (like Austria, Bulgaria, or Germany).

In the period 2003 to 2013 we observe minor (2% in the case of Bulgarian Earth & Environmental Sciences) to extraordinary (3300%, read further) growth spurt in all thematic categories in all Danube region countries regarding their Danube Region co-publications. The one and only exception with decrease in the co-publication output shows FYROM in the Chemistry field (falling from 14 to 11 co-publications), but as the numbers of co-publications in this field are rather low a clear trend can't be stated. On the other, rather extreme, note, the General Science & Technology category reports in more countries an increase of more than a 1000%, top being Romania with a 3300% increase.

Generally positive trend in the Danube Region publication cooperation can be explained largely by an increased scientific interconnectedness linked to the accession of the vast majority of the Danube Region countries to the EU.

In the following paragraphs the development of the thematic specialisations of each country is analysed, where relevant, (a) in relation to the overall development in the volume of each country's publications over the years (see **Error! Reference source not found.** in Chapter 4.2.1) and (b) compared to the thematic specialisation of DR co-publications of each country (see Table 6 to Table 21). This is particularly important in the case of countries where output growth is especially strong (like Romania or Serbia) in order to clarify whether the growth is sustained over all topics. All data can be found in Table 51 in the Annex IV.

[17] Countries with no Danube Region co-publications in the year 2003 are not considered here but might have a high growth rate as well, but as the number of co-publications are rather small they are not included e.g. Macedonia or Ukraine.

Albania

As Albania's annual output is rather limited in each research field (never more than 20 Danube Region co-publications in one field in one year) the annual number of co-publications varies a lot and growth rates are not really meaningful as even a modest growth from nothing is always dramatic in relative terms. The growth in Clinical Medicine (annual co-publication output more than quadrupled from 2003 to 2013) and in Biology, nonetheless, can be considered as a relevant growth. In all other research fields it does not make sense to take the growth rates into account.

Austria

Besides the already mentioned remarkable growth in General Science & Technology, Austria shows, when considering only the fields with an output of over 1,000 Danube Region co-publications from 2003 to 2013, a growth rate of 100 up to nearly 400%: Clinical Medicine nearly triples, Agriculture, Fisheries & Forestry, Biology, Engineering and ICT triple or quadruple their yearly output from 2003 to 2013, in Physics & Astronomy and Chemistry, as already mentioned, the growth rate is compared to the growth rates in the other research fields rather low (the yearly output in 2013 is not even double the output from 2003). In the fields with an overall output below 1,000 Danube Region co-publications from 2003 to 2013, for the fields Economics & Business (2013 nearly six times as many Danube Region co-publications as in 2003), as well as in Public Health and Social Sciences show a comparatively big growth is visible.

Examining thematic strengths of Austria over the time period 2003-2013 we notice continuity in the three strongest categories - Clinical Medicine, ranking first both in 2003 and 2013, Physics & Astronomy, ranking second, and Biomedical Research, ranking third in both cutoff/reference years.

Bulgaria

For Bulgaria in many fields with comparatively high output (more than 400 Danube Region co-publications from 2003 to 2013) like Chemistry, Clinical Medicine, Biology, Biomedical Research or Enabling & Strategic Technology, a rather low growth is visible: they don't even double their yearly output from 2003 to 2013. In Physics & Astronomy the growth of Bulgaria's Danube Region co-publications is especially low, in 2003 there were 530 Danube Region co-publications in this field, in 2013 614. High growth is visible in Agriculture, Fisheries & Forestry, where the yearly Danube Region co-publication output in 2013 is nearly six times higher than in 2003 pushing this category from the second last place in the ranking in 2003 to the fourth place in 2013; and, as already mentioned, in General Science & Technology.

Regarding thematic orientation, Bulgaria shows similar continuum in the ranking of the development of research fields like Austria: the three strongest categories remain on their first (Clinical Medicine), second (Physics & Astronomy) and third place (Enabling & Strategic Technologies) in 2003 as well as in the year 2013.

Bosnia and Herzegovina

As Bosnia and Herzegovina has a rather low yearly output in most research fields, the growth in most of the research fields is 300% or above. Additionally the yearly output is not always continually rising but varies a lot. In Clinical Medicine, a field with rather big output for Bosnia And Herzegovina, overall 701 Danube Region co-publications from 2003 to 2013, the yearly Danube Region co-publications in 2013 is six times higher than in 2003, in Agriculture, Fisheries & Forestry they are nearly five times higher (but with an overall Danube Region co-publications output of overall 138 co-

publications from 2003 to 2013). In Engineering Bosnia and Herzegovina's Danube Region co-publications grew from 5 co-publications in 2003 to 33 co-publications in 2013 which is more than six times higher (overall Danube Region co-publication output from 2003 to 2013 is 172). General Science and Technology is a field not relevant for Bosnia and Herzegovina's Danube Region co-publications.
Clinical Medicine has remained in 2003 and 2013 s the strongest thematic category, Engineering is the third strongest in 2003 and moves up to second strongest place in 2013 whereas Physics & Astronomy was second strongest in 2003 and fourth strongest in 2013. Biology has moved from 3 Danube Region co-publications in 2003 to 23 in 2013, ranking as third strongest thematic field.

Czech Republic
In the research fields with comparatively big output (over 1,000 Danube Region co-publications from 2003 to 2013) the yearly number of Danube Region co-publications (nearly) doubles in Biomedical Research, Chemistry and Physics & Astronomy and nearly triples in Enabling & Strategic Technologies. A rather faster growth is visible in Biology and ICT (nearly quadrupled) as well as in Clinical Medicine, where the yearly output in 2013 has tripled from the output in 2003. General Science & Technology is growing exceptionally strong – like in Austria or Bulgaria etc.
Whereas Clinical Medicine is the second strongest thematic field in Czech Republic's Danube Region co-publications in 2003 it moves up to the strongest thematic field in 2013, for the Danube Region co-publications in Physics & Astronomy it is the other way around. Chemistry remains in both reference years the third strongest thematic field in Czech Republic's Danube Region co-publications.

Germany
Like in Austria, Bulgaria or the Czech Republic Germany's yearly number of Danube Region co-publications in the field General Science & Technology are growing rapidly. In other research fields with more than 2,000 overall Danube Region co-publications from 2003 to 2013, the growth rate is rather low, in many fields the yearly output not even doubles from 2003 to 2013: e.g. in Biomedical Research, Chemistry, Enabling & Strategic Technologies, Earth & Environmental Sciences, Mathematics & Statistics and Physics & Astronomy. Germany's Danube Region co-publications in Biology and ICT are growing compared to the fields mentioned above somewhat faster – they tripled from 2003 to 2013, in Engineering and Clinical Medicine they nearly tripled.

Croatia
Like many other Danube Region countries the growth rate in the research field Chemistry is rather low (below 100 %) for Croatia's Danube Region co-publications. Strong growth is visible for Croatia's Danube Region co-publications in the following fields with comparatively big output (more than 400 Danube Region co-publications from 2003 to 2013): in Biology the yearly co-publication output nearly quintupled from 2003 to 2013, in Clinical Medicine and in Engineering it more than quadrupled. The research fields Biomedical Research and Enabling & Strategic Technologies nearly tripled their yearly output from 2003 to 2013, in Agriculture, Fisheries & Forestry they more than tripled. Compared to other Danube Region countries the growth of the yearly Danube Region co-publications of Croatia in the research field Physics & Astronomy is strong as it nearly tripled. Croatia's yearly ICT Danube Region co-publications output quintupled as well, but this research field has a rather low yearly output (overall not even 200 Danube Region co-publications from 2003 to 2013). The growth rate for Croatia's Danube Region co-publications in General Science & Technology is very strong but as there are not many co-publications (from 2 co-publications in 2003 to 26 in 2013) the growth does not indicate a major growing relevance of this field.

Hungary

Like Hungary's overall scientific publication output growth, which is relatively limited, Hungary's Danube Region co-publications are growing slow in most of the research fields when compared to other Danube Region countries (with exception of Bulgaria) and their growth rates in the research fields of their Danube Region co-publications. Especially in Enabling & Strategic Technologies, Chemistry and in Physics & Astronomy of Hungary's yearly Danube Region co-publication output the growth rate over the years is rather modest (both not even doubled their yearly output from 2003 to 2013). Like many other Danube Region countries Hungary's Danube Region co-publications have a particularly strong growth pattern in General Science and Technology (in 2013 the co-publication output is more than ten times as high as in 2003). Comparatively strong growth of Hungarian Danube Region co-publications is visible in the following research fields with rather big output (more than 500 Danube Region co-publications from 2003 to 2013): Biology (yearly output more than tripled from 2003 to 2013) and Engineering (yearly output tripled from 2003 to 2013). Rather strong growth in Clinical Medicine and ICT where the output more than doubled and, to a lesser extent, in Biomedical Research and Earth & Environmental Sciences (yearly output more than doubled as well from 2003 to 2013).

Moldova

For Moldova it is rather difficult to have reasonable findings about the growth rate of Moldovan Danube Region co-publications in the different research fields as most fields have a rather low Danube Region co-publication output (below 100 Danube Region co-publications from 2003 to 2013). The overall trends for Physics & Astronomy and Chemistry, research fields with comparatively big co-publication output (more than 200 Danube Region co-publications from 2003 to 2013) but a rather low growth rate, is visible for Moldovan Danube Region co-publications as well: both fields have a high co-publication output but the growth rate is below 50%. Moldovan Danube Region co-publications in Clinical Medicine doubled in their yearly output from 2003 to 2013 (but in 2012 there were more co-publications than in 2013) and, in Engineering, a field with rather high Danube Region co-publication output for Moldova (all in all 51 Danube Region co-publications from 2003 to 2013; but the yearly distribution of annual co-publication output is low) is the research field with the biggest growth rate (700%; from 1 to 8), but as there are not many co-publications each year, the growth does not indicate necessarily a major growing relevance of this field.

Macedonia

Similar to the Moldovan DR co-publications, Macedonia's DR co-publication output is rather small. As a consequence, for many research fields it is difficult to have solid findings about their growth over time. However, especially for Macedonian Danube Region co-publications in Clinical Medicine and Agriculture, Fisheries & Forestry, and for Engineering, ICT, comparatively strong growth is visible, their yearly Danube Region co-publication output nearly or more than quadrupled from 2003 to 2013. The overall trend for Physics & Astronomy and Chemistry is visible here as well, the yearly output in 2013 remains nearly the same or is even lower than in 2003: the Macedonian yearly co-publication output in Chemistry diminished from 2003 to 2013, in Physics & Astronomy it is rather stagnant.

Montenegro

For Montenegro, the situation is rather similar to those of Macedonia and Moldova – rather low Danube Region co-publication output and for many research fields no clear statements can be made about their trends in their development over time. Like Macedonia the growth of yearly Danube

Region co-publication output in the research field Clinical Medicine is particularly strong, and to some extent in the fields Biology, Engineering and ICT as well. Whereas in Physics & Astronomy the yearly co-publication output was rather stagnant as well, the yearly Montenegrin co-publication output in Chemistry nearly tripled from 2003 to 2013.

Romania

For Romania's Danube Region co-publications, a strong growth can be observed in the fields of Agriculture, Fisheries & Forestry, Clinical Medicine, Biology, Engineering and ICTs as their yearly output in 2013 in those fields is nearly or more than six times as high as their yearly output in 2003. This is also visible for the development of most of Romania's Danube Region co-publications' research fields when comparing it to other DRC and their thematic development of Danube Region co-publications: especially strong growth could be observed in Biology, Biomedical Research, Clinical Medicine, Biology, Agriculture, Fisheries & Forestry, and General Science and Technology; similarly with Economics & Business, Enabling & Strategic Technologies, Engineering and Social Sciences. Thus Physics & Astronomy is not the main driver behind the output growth of Romania these two countries.

Serbia

For Serbia's DR co-publications, a strong growth (more than 800% growth rate) is visible in Agriculture, Fisheries & Forestry, Biology, Biomedical Research, Clinical Medicine, Enabling & Strategic Technologies, Engineering and ICT. Contrary to Romania, there is a rather strong growth visible in Physics & Astronomy as well, from 34 Serbian DR co-publications in 2003 to 288 Danube Region co-publications in 2013. Compared to the growth rate of the above mentioned fields with strong growth, this is not as much, but nevertheless the yearly co-publication output is more than six times as high as in 2003. But, Physics & Astronomy, like for Romania, is at least not the main driver behind the output growth of Serbia.

Slovakia

Slovakia's DR co-publications were growing particularly strong in Engineering[18]; there is also rather strong growth in the research fields Agriculture, Fisheries & Forestry and ICT – the yearly output more than tripled from 2003 to 2013 in both of those fields. Rather low growth could be noted not only in the fields Chemistry and Physics & Astronomy but in Clinical Medicine and Biomedical Research as well, as their yearly output has not even doubled from 2003 to 2013.

Slovenia

Slovenia DR co-publications show, compared to the other Danube Region countries and their Danube Region co-publications, a strong growth in Chemistry and Physics & Astronomy – in most of the other Danube Region countries these two research fields the growth rate is below 100%, for Slovenia's Danube Region co-publications in both fields the yearly output more than doubled from 2003 to 2013 (more than 160% growth rate). Growth rates above 250% of Slovenia's Danube Region co-publications are visible in General Science & Technology (but in this field the overall Slovenian Danube Region co-publication output is rather low, 129 Danube Region co-publications from 2003 to

[18] in General Science & Technology as well but there is a rather low overall number of co-publications in this field

2013) and in Mathematics & Statistics, Clinical Medicine, ICT, Biology and Agriculture, Fisheries & Forestry as well.

Ukraine

Ukraine's overall publication output growth is limited (annual publication output not even doubles from 2003 to 2013; see **Error! Reference source not found.**) and for Ukraine's Danube Region co-publications the situation is the same in most of the research fields i.e. the yearly output rarely even doubles from 2003 to 2013. Exceptions are Clinical Medicine, where the yearly output triples from 2003 to 2013, ICT, where the yearly output in 2013 is more than ten times as high as in 2003 (but this field has low overall co-publication output, 192 Danube Region co-publications from 2003 to 2013), and to some extent for Agriculture, Fisheries & Forestry, Engineering and Biology as well, where the yearly Danube Region co-publication output more than doubles from 2003 to 2013.

4.2.5 Impact highlights

In bibliometrics, *impact* is regarded as the impact on the research community. One fairly straightforward means to measure such an impact is *citations per publication* or – simply put – *citation counts*. This section highlights simply and concisely the most noteworthy observations. More details on a thematic and country level can be found in ANNEX V – Impact Analysis Results – Average Citations of Intra-Danube-Region Co-publications, pp. 99.

The matter of the impact of research output in the Danube region becomes relevant on the following levels:

- Impact of output of countries
- Impact of collaborative output of DR partners (by pair)
- Impact of DR countries in specific topics

4.2.5.1 General country-level:

Every Danube Region record covered in this study is cited on average 6.7 times. The countries with the highest average citation counts in their general output are[19]:

- Hungary: 8.94
- Austria: 7.67
- Slovenia: 7.38

4.2.5.2 Collaborative output of DR partners

The DR collaboration country pairs with the highest impact (in terms of average citations) and a co-publication output of at least 250 (2003-2013) are:

- RS-UA (27.8; 477 records)
- UK-HU (26.8; 859 records)
- CZ-HR (24.7; 1,175 records)
- HR-UA (24.0; 550 records)
- BG-HR (23.6; 603 records)
- CZ-HU (23.5; 2,484 records)
- DE-HR (23.1; 3,507 records)

Given that the thematic area of collaboration influences the average impact count, a separate consideration by topic is recommended via a so-called field normalisation. However, such an effort lies beyond the scope of this project.

[19] Germany is not considered here as the number of records involving Germany would have far exceed the resources this study had at its disposal

4.2.5.3 Impact of DR countries in specific topics

Compared to the average *times cited* counts in the Danube Region collaboration output, the following country strengths could be noted[20]:

- AT: physics & astronomy
- BG: clinical medicine; physics & astronomy
- BiH: physics & astronomy
- CZ: clinical med.; physics & astronomy; ICTs; enabling & strat tech; biology; psychology & cognitive sciences; public health & health services; historical studies; social sciences
- HR: physics & astronomy; biomedical research; general S&T
- HU: physics & astronomy; clinical medicine; biomed. research; earth & env sciences; economics & business; social sciences; historical studies; psych. & cognit.; public health
- ME: physics & astronomy
- RO: clinical medicine; physics & astronomy; public health
- RS: physics & astronomy
- SK: ICTs; mathematics & statistics; economics & business; public health
- SI: physics & astronomy; ICTs; general S&T; public health
- UA: clinical medicine

[20] we only consider thematic areas with a minimum of 100 records between 2003 and 2013

5 Co-patent analysis

5.1 Introduction

5.1.1 Patents as indicators

The Swiss Federal Institute of Intellectual Property (2014) defines patents as "titles conferring the right to an invention granted by intellectual property authorities. Legally, an invention is something that solves a technical problem with technology". The OECD's (2013) definition focuses less on the technology dimension and more on the aspects of publication and transfer of rights: „A patent is a right granted by a government to an inventor in exchange for the publication of the invention; it entitles the inventor to prevent any third party from using the invention in any way, for an agreed period".

Patents can thus be seen as an outcome of inventive and often research-intensive activity that is used most often by firms in order to protect and codify new knowledge. At the same time, patents are public and the knowledge they contain can thus be used to inspire further inventive activity[21].

Patents are protected and published results of inventive activities that contain codified knowledge on novel technological solutions.

From an innovation analyst's perspective, literature has long discussed the value of patents in order to assess innovation performance. As the direct outcome of inventive processes aiming at commercial impact, patents seem to be an appropriate indicator to capture technological change, particularly the latter's competitive dimension (cf. Archibugi/Pianta 1996, 452). As filing patents is a costly process, it can be expected that applications are filed "for those inventions which, on average, are expected to provide benefits that outweigh these costs" (ibid., 453).

A number of drawbacks of patents as innovation indicators are also apparent, though: Not all inventions are technically patentable (software in most cases), neither are all technically patentable inventions patented. Firms might opt to avoid the time and resource-consuming patenting process for strategic reasons. Furthermore, decisions on who features as inventor and as applicant (i.e. owner of the intellectual property) or where a patent is filed first are strategically taken, which analysts need to keep in mind when drawing conclusions.

Maybe most importantly, patents are an indicator of inventive activity and, relatedly, of innovations with economic potential. What actually happens to and with patents is however difficult to estimate. The patent offices do not track information on actual use and commercialisation of patents, neither on mergers and company (and, thus, patent portfolio) acquisitions. Studies using survey methodology to get information on the usage and commercialisation of a limited set of patents estimate that around 40% of patents reach the market launch stage (Webster/Jensen 2011) or that

[21] Whether or not the knowledge codified in patents is enough to follow up on the research that they embody, or whether significant tacit knowledge would be needed to do so, is a separate question that we will not discuss here.

around 65% of inventions involving academics are commercially used (Meyer 2006)[22]. In the early 2000s, the European PatVal-EU 1 Survey questioned the inventors of 9,017 patents granted by the European Patent Office (EPO) between 1993 and 1997 and found, among other things, that around 36% of the patents are not used in any economic activities (Giuri et al. 2007). About half of these are so called 'blocking patents' that are neither internally used nor licensed, but block competitors. The other half are 'sleeping patents' with no use, not even in blocking competition. Another finding of the PatVal-EU 1 Survey is that large companies have higher shares of unused patents than SMEs (around 40% blocking and sleeping patents vs. around 20% in SMEs). Public research institutions and universities were found to also have around 40% of their patents unused. In a second wave of the PatVal-EU Survey, carried out from 2009 to 2011 for over 20,000 patents granted by the EPO between 2003 and 2005, this share was higher: 43% unused patents, and over 50% unused patents in public research institutions and large companies (Gambardella et al. 2012).

Among the patents that are commercially used there exists a significant difference in their economic impact as Pakes and Griliches (1984) or Scherer and Harhoff (2000) have already pointed out. A very small number of patents is responsible for the largest part of the economic value in a firm's or a country's patent portfolio.

Patents are outputs of inventive processes with expected benefits. The patent itself offers no indication of economic value. Only a share of the patents granted generates economic returns, only a few of them most of the returns.

With these limitations in mind, patents can be an informative and relevant indication of inventive as well as research and development activity and a proxy pointing to economic and intellectual potential for innovation. This also and especially applies to collaboration in applied research, technology development and inventive activity. Studies show that the level of collaboration in technology and inventive activities has not reached the level of co-authorship in scientific research (Meyer/Bhattacharya 2004). The share of patents with a single inventor is significantly higher than in the case of academic publications and the relevance of small collaborations with two to three inventors is also higher than co-authorship networks of similar size (ibid., 449f). The reason for this is partly that co-inventions are still more of an intra-mural phenomenon involving small groups of inventors from one firm or research group only. Other reasons include strategic decisions and hierarchical considerations in assigning or not assigning patent "authorship".

Studies (Bergek/Bruzelius 2010) have also shown that the majority of internationally co-invented patents are not the result of R&D collaboration in a narrow sense (as collaborative research between independent entities). In most cases, the collaboration takes place between subsidiaries of a firm or within the same firm rather than between completely independent firms. R&D advice, support in patent writing or other industrial services can also lead to the indication of a co-invention. If we take co-inventions as a proxy for research collaboration, what we get is an indication of invention-

[22] mostly if they are produced already in collaboration with industry; of the purely academic inventions, only between 10 and 40% are commercially utilised

oriented collaboration in the broadest sense: between or within entities located in different countries, as a result of a variety of invention and research related activities. For our purposes in this aggregate analysis, this limitation is acceptable as we are interested in identifying and assessing innovation-related network linkages in the Danube region regardless of their intra- or inter-institutional nature. At this aggregate-level, international technological and invention-oriented collaboration results in knowledge flows between countries, in innovation networks and in externalities to other countries (De Prato/Nepelski's 2014).

Co-invented patents are an indication of collaborative invention-oriented activities (including, but by no means limited to collaborative research) carried out within a firm, between its subsidiaries or involving independent entities.

Generally speaking, the share of patents that are collaboratively produced and actually filed with more than one inventor is increasing. More importantly for us, the share of patents with inventors from at least two countries is still marginal, but increasing. Using the global patent application data of the European Patent Office's PATSTAT, De Prato and Nepelski (2014) calculated a share of internationally co-invented patents of 0,8% (6.229 out of 777.551) in 2007 compared to 0,18% in 1990 and 0,59% in 2000. The related growth rate in co-inventions is nearly ten times higher than the growth of patent applications. The global network of technological collaborations also grew to include a higher number of countries. It also became more integrated and denser (i.e. there are more patent co-invention links between a higher number of countries).

Another study using USPTO data (Guan/Chen 2012) reports a similarly strong growth in granted co-inventions at a higher base level: 1,23% international co-inventions in the period 1981-1985 compared to 2,41% for 1991-1995 and 4,5% for 2001-2005. The shares are similar to what Guellec and van Pottelsberghe de la Potterie (2001) found for patents filed at the European Patent Organisation: They report a share of international co-inventions of over 4% already in 1995. Interestingly, the PatVal-EU 1 Survey (Giuri et al. 2007) found that 15% of the surveyed 9.000 granted patents involved a co-inventor from outside the applicants firm (this is according to what respondents indicate, not according to patent data analysis). The share is slightly lower for firms as they tend to internalise the invention process.

The co-patenting share is not comparable with the share of co-authorship in academic articles, but it is growing.

The discussion on the reasons and exact mechanisms of this increasing techno-globalisation are ongoing. The literature points to an increasing number of countries participating in the global technological advances (Guan/Chen 2012), an increased capacity to codify and share knowledge across distances, enabling collaboration (Moreschalchi et al. 2015), increased mobility of scientists and engineers (Guellec/van Pottelsberghe de la Potterie 2001), the exploitation, decentralisation and related internationalisation of firms' R&D (Picci/Savorelli 2012; Penner-Hahn/Shaver 2005), etc. It

should be taken into account that by far the largest part of patenting activity is firm-based, most of it in large corporations (Meyer/Bhattacharya 2004, 448), and that the dominance of firm patent holders especially applies to international co-patents (Picci 2010)[23]. As also indicated above, not only do multinationals and other firms own the largest part of internationally invented patents, but international co-inventions are in fact produced/invented within the same multinational firm or among its subsidiaries (Bergek/Bruzelius 2010). Nevertheless, co-patents are an indication of knowledge exchange and collaborative inventive activity between the countries involved. We can trace this activity at an aggregate level at some level of detail. Separating firm-based "intra-mural" and extra-mural international co-inventions from each other is not possible at a national-level aggregate scale due to the fact that inventor names cannot be traced to their potential (and changing) company affiliations (this could only be done for small samples allowing for inventor and firm surveys).

Recalling that most patenting activity is firm-based, there is, indeed, some indication in patent data, which can give us additional meta-level insights into transnational activities of firms: Apart from patents with inventors from two or more countries, there are patents where the applicant is from a different country than one or several of the inventors. This indicates knowledge flow out of the country of the inventor(s) and into the country of the applicant, i.e. towards the owner of the intellectual property (IP). Guellec and van Pottelsberghe de la Potterie (2001) showed that the share of this kind of foreign ownership of patents is more frequent than co-inventions (12% already in 1995). We can thus distinguish two major forms of international collaborative patenting activity:

- **Co-inventions**: Co-inventions represent the international collaboration in the inventive process. International collaboration by researchers can take place either within a multinational corporation (with research facilities in several countries) or through co-operative research among several firms or institutions (collaboration between inventors belonging to different universities or public research organisations). In that sense, co-invention indicators also reflect international flows of knowledge.
- **Foreign ownership**: Cross-border ownership of patents reflects international flows of knowledge from the inventor country to the applicant countries and international flows of funds for research (multinational companies). In most cases, patents with inventors from abroad correspond to inventions made at the research laboratories of multinational companies and applied for at company headquarters (although in some cases national subsidiaries also may own or co-own the patents). Hence, this indicator expresses the extent to which foreign firms control domestic inventions.

Co-ownership (or co-application) would be a third kind of collaborative patenting: the presence of applicants from different countries in the same patent application. This also occurs, but it is

[23] This links to discussions of the reasons of companies to decentralise and internationalise their R&D. The research on this indicates that firms might follow a strategy of exploiting home-based R&D, leveraging existing expertise abroad, or on augmenting the home-base, i.e. on seeking knowledge available only abroad (cf. Penner-Hahn/Shaver 2005; Kuemmerle 1997; Song et al. 2011). Niosi (1999) identified three purposes multinationals might pursue with locating research facilities abroad: adapting products to local markets; monitoring new technology developments occurring in foreign countries; and developing special technology using the partner country's comparative advantages. Yet another line of research (Patel 1995) points to the simple fact that after mergers and acquisitions, the buying company ends up with R&D faci-lities abroad. Besides these motives of knowledge and technology transfer, actual collaborative knowledge generation and innovation-oriented inventive activity is also observed (Archibugi/Iammarino 1999).

considered a separate topic and is of limited interest to us here. There is literature discussing patterns of and reasons for patent co-applications (e.g. Hagedoorn 2003). It points to strong sectoral differences in co-applications that seem to be rooted in some sectors providing more legal security for firms to engage in co-applications as a kind of ex ante sharing of intellectual property.

We distinguish two relevant kinds of co-patents: Co-inventions, indicating networks engaging in collaborative invention-oriented activities, and patents where the inventors and applicants are from different countries, suggesting foreign ownership and related knowledge flow networks. In both cases, the largest share of international co-patents is owned by firms, mostly multi-nationals.

The following section will introduce in more detail how we utilise and frame co-patents as indications of relevant invention-oriented collaborative activity.

5.1.2 This study's patent data

The aim of the present study is to analyse collaborative patent output in the Danube region countries[24]. We are interested in answering questions like the following:

- What is the Danube region country's patent application output? Which major co-invention linkages exist between the Danube region countries? What are their thematic patterns? How do they compare to linkages of Danube region countries with non-Danube region countries?
- Which foreign ownership patterns can be identified in the Danube region? What is the evidence regarding patent-related knowledge flows and their geographic and thematic patterns?

The data source for the present study is the April 2014 edition of the European Patent Office's PATSTAT database. PATSTAT offers the advantage of maximised patent data coverage: Around 70m records from over 80 application authorities are indexed (including all items, also trademarks, etc.). We limit the selection to the years from 2003 to 2013[25], resulting in a base set of around 12.5m worldwide patent applications (not including trademarks) potentially including Danube region applicants or inventors.

The reference to applications is important: We retrieve and analyse all patent applications, not only granted patents. We deliberately chose to do so for conceptual reasons: Many patent applicants do not follow up the publication of their application (after a maximum of 18 months after application) with paying the fee for the patent grant. Either they have lost the interest in the invention, they cannot or do not want to pay the registration fee, or, what's particularly interesting and relevant,

[24] In the context of this study, we define the Danube region as including the countries specified in the EU Strategy for the Danube plus Albania and FYRO Macedonia.

[25] This refers to the so called ‚filing date', i.e. the time the patent application is first filed. It is different from the publication date (usually up to 18 months after the filing date) or the date of granting a patent.

they never intended to go for a granted patent. Producers of IP can aim at a patent application solely if they do not intend to commercialise (e.g. license out, sell, etc.) a patent and only aim to publish their invention in order to avoid others to patent it. This possibility exists because of the principle of novelty: As a patent can only be granted for new knowledge, other entities cannot file a patent for something that is already published (be it as an academic article, a patent application, etc.).

The numbers of patent applications that are not granted seems to be significant: EPO, for instance, the amount of annual applications received was fairly stable at 150,000 per year since 2010. The number of granted patents since 2012 (the years where the applications since 2010 would be published and granted) was also quite stable at around 65,000 patents. The share of granted patents to applications can thus be estimated at around 40-45%[26].

Due to these conceptual considerations and statistics, our raw data items are patent applications, which constitute the first disclosure of any invention filed at a given patent authority. Among the applications, different kinds have to be distinguished that depend to some degree on the patenting authority. Some authorities, for instance, use specific kind codes for different kinds of intellectual property, including trademarks, design patents, utility models, etc. Unless otherwise stated, we are analysing patent application documents of the kinds 'A' and 'W'. The former indicates patent applications to a national or regional patent authority. The W-kind applications are so-called PCT patent applications. They have been filed according to the Patent Cooperation Treaty (PCT) procedure. PCT patent applications can be filed at one patent authority (in a PCT member state) where protection in a number of PCT countries (the applicant specifies which ones) can immediately be sought. By this means, the procedure of seeking protection in a series of markets is simplified. For us, PCT patent applications are of particular relevance because of their immediate aspiration towards a more international protection. If an applicant goes for a PCT procedure and aspires protection in a number of countries, she or he must suppose that the value of the patent outweighs the costs of the process.

Regardless of the procedure, we limit the patent applications we analyse to so-called first filings. A patent is filed first with a specific patent authority (in a national authority, regional, like EPO, etc.), also when following the PCT procedure. From there, protection can be extended to other countries and, thus, authorities. The group of patents based on the same invention that is protected in a number of national or regional IP systems is referred to as the 'patent family'. We are however mainly interested in the first filings as this is the time and location where new technical knowledge is codified and published. Whether or not this application is followed up with a granted patent and with extended protection in other markets is not of concern for us, at the moment. This question might however be an interesting aspect for additional analyses, e.g. trying to extract patent applications with an orientation to international markets from purely national ones.

An advantage of using PATSTAT data is the global coverage of applications from over 80 patent authorities (cf. Picci/Savorelli 2012 and De Rassenfosse et al. 2013 who also underline this aspect). Here is an overview of PATSTAT indexed patent applications per national application authority in the Danube region in PATSTAT in general and for the time period from 2003-2013:

[26] http://www.epo.org/about-us/annual-reports-statistics/annual-report/2014/statistics.html

Application authority	Application count (all kinds, all years)	Application count (all kinds, 2003-2013)
Albania (AL)	10	3
Austria (AT)	1,161,829	196,573
Bosnia and Herzegovina (BA)	407	147
Bulgaria (BG)	54,693	4,094
Czech Republic (CZ)	77,530	21,448
Germany (DE)	7,187,602	928,294
Croatia (HR)	15,555	8,484
Hungary (HU)	140,624	10,669
Moldova (MD)	5,784	3,113
Montenegro (ME)	558	323
FYR of Macedonia (MK)	108	43
Romania (RO)	71,386	6,254
Serbia (RS)	3,682	3,522
Slovenia (SI)	28,385	15,025
Slovakia (SK)	26,078	4,024
Ukraine (UA)	52,570	43,591
SUM	**8,826,801**	**1,245,607**

Table 22: Patent applications per national application authority

We see that apart from Albania and FYROM, all other relevant patent authorities in the countries covered in this study consistently report applications to PATSTAT. This is also confirmed by the latest PATSTAT global patent data coverage catalogue (July 2011[27]) referenced in the 2014 data catalogue. How complete this picture is varies per country as does the amount of patent application handled by the authorities. It would go beyond the scope of this analysis to compare national and PATSTAT coverage of applications registered by patent authority. So far, we take away from this data the message that it will be difficult to draw conclusions on Albania and FYROM filed applications. We can still meaningfully analyse applications with inventors and applicants from these countries. The limitation applies to patents applied for (by nationals or others) in Albania and FYROM.

While the table above includes applications of all kinds, the following limits the overview to 'A' kind patent applications and 'W' kind PCT patent applications (first filings in both cases). The significant difference in the sums mostly stems from utility model applications, which make up over 200,000 records, and translations of applications (which are published separately in e.g. Germany with a 'T' kind code).

Applic. authority	A applications (2003-2013)	W applications (2003-2013)	W/A
AL	1	2	200.00%
AT	15,542	5,152	33.15%
BA	75	72	96.00%
BG	2,271	265	11.67%
CZ	7,061	1,193	16.89%
DE	558,279	22,660	4.06%
HR	4,287	449	10.47%
HU	6,900	1,312	19.01%
MD	2,845	34	1.20%
ME	323	0	0.00%

27

http://documents.epo.org/projects/babylon/eponet.nsf/0/2464E1CD907399E0C12572D50031B5DD/$File/global_patent_data_coverage_0711.pdf

MK	24	19	79.17%
RO	5,929	195	3.29%
RS	2,918	114	3.91%
SI	2,881	583	20.24%
SK	1,822	246	13.50%
UA	16,928	825	4.87%
SUM	**628,086**	**33,121**	**5.27%**

Table 23: Patent applications per national application authority and kind

On average, the number of PCT applications filed in the Danube region country's patent authorities (excluding EPO) amounts to 5.3% of nationally or regionally filed patents. The share is significantly higher in the case of Austria, Slovenia, Hungary and the Czech Republic and well as smaller countries with little national coverage.

On a side note: As stated, in our entire PATSTAT coverage for 2003-2013, there are 12.55m patent application records (of 'W' and 'A' kind). Out of this, 10.96m are national or regional ('A') patent applications, 1.59m (or 14.5%) are 'W' kind applications. The reason for this significant difference is that most PCT applications for the Danube region are not filed via the national offices, but via EPO or other authorities of global relevance.

As mentioned above, the period of analysis for our data is patents filed between 2003 and 2013. Here, it should be taken into account that national IP offices and authorities report to PATSTAT with varying time lags and backlogs that can have significant impact on the coverage in recent years. In addition, the patent application process itself has an impact on the coverage in recent years: The application process takes time. Usually, an application is published 18 months after its filing. That is, most applications filed in 2013 have not been published yet in April 2014. When a patent application first filed in 2013 is published some time in 2014, its publication date is in 2014, but its first filing date is 2013. Such an application may not be present in PATSTAT April 2014, but it will be present in PATSTAT April 2016[28], for example. We decided against excluding the 2012 and 2013 data from the analysis as it complements the general picture. We should, however, consider this limitation when looking at time series data.

We present the exemplary case of Austria to show the apparent decrease in patent output in recent years that is explained by time lags in publication and reporting to PATSTAT:

Filing year	Patent authority	Application count
2003	AT	35,170
2004	AT	34,219
2005	AT	32,096
2006	AT	29,226
2007	AT	24,826
2008	AT	19,296
2009	AT	11,516
2010	AT	5,008
2011	AT	2,868
2012	AT	1,992
2013	AT	356

Table 24: Filings per patent authority and year - Austria

[28] If the patent applications filed in 2014 are published 18 months after their filing, they will only appear in the PATSTAT 2016 versions, not in 2015 already.

The situation is similar for other countries as well, especially for Germany, but also for Hungary, Serbia and Slovenia. Several countries including Bulgaria, Croatia, the Czech Republic, Romania or Slovakia have significantly shorter time lags in reporting the data to EPO and PATSTAT, limiting coverage only for 2012 and 2013, not for 2010 and 2011. Ukraine has a severe lack of data coverage since 2008.

Filing year	Patent authority	Application count
2003	UA	9,825
2004	UA	5,380
2005	UA	8,040
2006	UA	9,348
2007	UA	8,717
2008	UA	915
2009	UA	304
2010	UA	401
2011	UA	393
2012	UA	230
2013	UA	38

Table 25: Filings per patent authority and year - Ukraine

Another relevant data limitation in PATSTAT, and all global patent data, is the quality and availability of postal address data. Address coverage for some patent authorities is fairly poor, although this does not seem to affect the authorities most relevant to our analysis. According to a presentation at the 2013 PATSTAT User Day[29], coverage is particularly good for applications filed at the EPO (almost 100% address data), the US PTO, Korean patent office, Austrian, Russian, Spanish and other patent offices (between 70 and 85% coverage); regular for the German, Chinese, and Canadian patent offices (around 60-65%); rather bad for the French and British patent offices (35-45%); and severely limited in the cases of the Japanese (12%) and Australian (5%) patent offices. According to this presentation and an EPO response at the 2014 PATSTAT User Day[30], about 1/3 of all persons do not have a country code[31].

In the PATSTAT data retrieved by us (the above-mentioned 12.5m records in the April 2014 version for the 2003-2013 period), there are 4.67m records with no country address information at all for the inventor(s) – a share of 37.2%. In another set of records, there is evidence of at least two inventors from two different countries, but country information for at least one inventor missing. The number of this kind of missing address information is relatively marginal, however: 19,678 records out of a total of 474,209 co-invented patent applications, i.e. 4.2%.

These numbers allow us to compare our base set of PATSTAT patent application records with another benchmark measure that has been indicated above: The share of internationally co-invented patent applications. In our set of 12.5m PATSTAT records, we have at least some address information for 7.88m records. 474,209 or 6.0% of these have been filed indicating inventors from a minimum of two countries. Of these 6.0% only 13% (or 0.8% of the overall amount of patent records) have been filed with inventors from three or more countries, confirming the reported dominance of small networks in collaborative patenting (Meyer/Bhattacharya 2004). These figures are somewhat in line with what

[29] http://de.slideshare.net/gianlucatarasconi/patstat7-201311riov1
[30] http://www.jpo.go.jp/torikumi_e/ibento_e/program/img/userday/4_MK_SevenSins_Response_v0.1.pdf
[31] EPO to some degree tries to improve the quality of the data retrieved by the reporting national authorities. However, if address information is missing, data cleaning would be too much of an effort in most cases.

other above cited studies find, but larger than what De Prato and Nepelski (2014) indicate for PATSTAT data.

If we limit the base set to the 10.96m patent applications of the 'A' code (national or regional, not PCT) and then again to those 6.38m 'A' patent applications with address information, we get a slightly lower share of 5.6% applications with inventors from two or more countries, 14% of this (or 0.8% of the overall amount) were filed with inventors from three or more countries. As can be expected, the share of co-invented applications is higher in PCT applications: 7.8% of the 1.51m 'W' applications (with known address information) in our dataset have inventors from at least two countries. Among the 793,934 patent applications of kind code 'A' with at least one inventor from the Danube region, the co-invention share is 11.7%, 20% of which are with inventors from three or more countries. Again, also for the Danube region specific data, PCT applications have a higher percentage of international co-invention: 16%.

In order to further contextualise the frequency of international co-inventions among patent applications, we can additionally consider the number of inventors involved in patent applications in general. This helps us compare the relevance of the phenomena of international co-inventions and co-inventions in general.

Among the 7.88m patent applications where we have country information for at least one inventor, the share of applications with two or more inventors is 61.3%[32]. Almost 40% of all applications have three or more inventors. In the 'A' applications, the percentage of applications with at least two inventors is 59.5%, in the 'W' or PCT applications 68.6%. That is, the average size of the inventor group per application is higher for PCT patents. If we combine this with the evidence on the frequency of international co-inventions, it becomes clear that most inventions are produced collaboratively (and credited to more than one inventor)[33], but only a fraction of them in an international setting. This also applies to the Danube region patent applications: 65.6% of the slightly over 1m inventions involving at least one inventor from the Danube region are produced by two or more inventors (64% of 'A' applications, 72% of 'W' applications).

With these introductory remarks regarding our dataset and the general characterisation of co-invention frequency and address coverage, we can proceed to present the results of relevance to our research question. We will begin with an overview of the thematic characterisation of the Danube region patent application portfolio. We then proceed to present the co-invention and, subsequently, the foreign ownership patterns of the Danube region, including information on thematic specialisations and major application authorities. We will also present country tables for some of the indicators in order to also ensure the availability of results beyond the countries with the highest output.

[32] If we disregard address information and take the 12.5m patent application records as the base, the share is still 60.6%.

[33] Whatever the varying role of each inventor might be – see discussion above.

5.2 Results

5.2.1 Danube region inventions and applications – topics

As stated above, between 2003 and 2013, PATSTAT (April 2014) registers 793,934 'A' kind patent applications with at least one inventor from a Danube region country, around 12.5% of all 'A' applications (with at least some address information) indexed in PATSTAT. In the PCT applications, the shares are similar: 216,412 'W' applications with inventors from at least one Danube region country stand against 1.51m applications in PATSTAT – 14%.

We can use these percentages in order to not only specify the amount of patent application output per topic, but to get an overview of the relative thematic specialisations of the Danube region. The following table shows the number of 'A' and 'W' applications by the Cooperative Patent Classification system (CPC)[34]. We use as a benchmark all thematically categorised as 'A' and 'W' applications (not only those with address information) in order to get a more reliable base (otherwise we would mix the data quality of thematic classification and geographic localization). It is important to keep in mind that it is not possible to sum up the values over all classification symbols as an application can be assigned to more than one thematic classification.

CPC	'A' DR	'A' all	'A' DR / 'A' all	'W' DR	'W' all	'W' DR / 'W' all
A	107,500	842,458	12.76%	36,697	331,964	11.05%
B	231,747	1,115,740	20.77%	58,917	308,996	19.07%
C	101,874	716,403	14.22%	44,851	329,312	13.62%
D	18,057	75,481	23.92%	5,013	25,047	20.01%
E	38,068	197,693	19.26%	8,272	56,520	14.64%
F	151,983	639,728	23.76%	39,377	164,112	23.99%
G	140,042	1,736,546	8.06%	40,444	393,446	10.28%
H	141,421	1,767,918	8.00%	44,178	421,062	10.49%
Y	59,832	656,016	9.12%	17,694	118,421	14.94%

Table 26: Thematic characterisation of the Danube region patent application portfolio

We see that the Danube region's output is relatively less specified in the two CPC sections with the highest global application output: physics (G) and electricity (H). It is significantly higher in mechanical engineering (where a Danube region inventor is involved in almost a third of all PATSTAT index patents), the smaller textiles category and the "operations and transport" class.

The specialisation patterns also show in the PCT patent applications. Three differences can be noted: First, in the "fixed constructions" section, the share of the Danube region's output in global output is lower than in 'A' applications. Secondly, while the "human necessities" section is of higher relevance in the global PCT output (compared to the national and regional 'A' applications), the Danube region's share in this category is rather low. Thirdly, in the case of the "emerging and cross-sectional technologies" section, the situation is the opposite: The section is of less relevance in global PCT patent applications output, but the Danube region's share in world output is relatively high and most notably considerably higher than in the 'A'-kind applications. In around 9% of global 'A' applications

[34] A: Human Necessities; B: Operations and Transport; C: Chemistry and Metallurgy; D: Textiles; E: Fixed Constructions; F: Mechanical Engineering; G: Physics; H: Electricity; Y: Emerging Cross-Sectional Technologies. We use this classification (instead of, for instance, the International Patent Classification) mostly because of the inclusion ‚Y' category.

in this category, there is at least one Danube region inventor. If we look at PCT patents, however, in 15% of the global applications in the emerging cross-sectional technologies section, at least one Danube region inventor is involved.

These relative specialisations also appear if we look at applicants, i.e. IP owners, from the Danube region (including the findings for the PCT kind applications). Like in the case of patent applications with inventors from the Danube region, mechanical engineering, the textiles and the "operations and transport" class show up as relative strengths. This goes both for 'A' applications as well as for PCT applications. In the PCT applications, the Danube region features stronger in the emerging cross-sectional technologies section (compared to the Danube region's relevance in the CPC section according to 'A' applications).

Hence, we can state that there is no single CPC class with large scale knowledge flow out of the Danube region. At most, this is somewhat the case in the 'A' applications in the chemistry and metallurgy class. Here, the share of the Danube region inventors in global patent application output is higher than the share of Danube region applicants (in global output indicating the applicants more often come from elsewhere and that, thus, knowledge flows out of the region).

More interestingly, however, seems the fact that in all CPC sections, the number of PCT applications with Danube region applicants is higher than the number of applications with Danube region inventors! In the case of national and regional application, the situation is the opposite: more applications with Danube region inventors than with Danube region applicants. This suggests that the region is a net recipient of knowledge registered through the PCT process.

It can be expected that the thematic specialisations reported here are dominated by the output of the largest country in the dataset, most notably Germany. This is why we also include an analysis of thematic specialisations in the sections on co-patenting relationships as well as in the country tables below.

First, however, we will introduce the phenomenon of international co-inventions and related statistics for the Danube region countries.

5.2.2 Collaborative output – co-inventions

We have seen above that literature reports that the share of internationally co-invented patents is much lower than co-authorship shares in academic literature. Our PATSTAT data set for the filing years 2003-2013 (including patent applications, but also other items like trademarks) contains 3.8% of the internationally co-invented records. If we calculate these co-invention shares for the individual Danube region countries (plus Albania and FYROM), the result is a much higher average. This mostly has to do with two issues:

- First, the 4.67m records that have no country information at all. In the calculation of the 3.8% co-invention share, we have counted them in (considering them individual-country inventions). If we exclude them from the analysis, the share of co-inventions over the entire set of records with at least one known inventor country is 6%.
- Secondly, co-invented patents are counted for each country share, but only once in the overall average share. An example can illustrate this: If we have 100 patent applications, 45

of which are filed with inventors from country A only, 45 of which by inventors from country B only and ten of which by inventors from both countries, then we have an overall co-invention share of 10%. If we look at the co-invention shares of the individual countries, however, we have 10/45 = 22%.

For these reasons, it is self-explanatory that we get higher shares for the individual country co-invention shares. It thus also becomes clear that it does not make sense to benchmark the country share against the overall global co-invention share. We need to compare between individual countries in order to get a feeling of an economy's embeddedness in techno-globalised invention networks. The following table indicates significant differences in the co-invention shares between the countries.

Country	Applications with inventor from country x	International co-inventions	Share of co-inventions
AL	37	28	75,68%
AT	54,836	15,681	28,60%
BA	244	136	55,74%
BG	2,894	890	30,75%
CZ	12,174	2,979	24,47%
DE	901,117	111,408	12,36%
HR	3,008	518	17,22%
HU	9,913	2,526	25,48%
MD	2,954	423	14,32%
ME	51	17	33,33%
MK	130	88	67,69%
RO	8,262	1,983	24,00%
RS	2,023	452	22,34%
SI	5,196	651	12,53%
SK	3,138	1,095	34,89%
UA	18,077	2,863	15,84%

Table 27: Co-invention shares per DR country

Perhaps with little surprise we see, for instance, that the smaller innovation systems in FYROM or Bosnia and Herzegovina feature a significantly higher share of co-inventions. The countries with higher numbers of patent applications (especially Germany and Ukraine) show lower co-invention shares. Parts of the differences thus seem to be a matter of the size of the home market. However, not all variation correlates with this factor. If we compare Austria and Slovenia, Austria has a five times higher number of records indexed in PATSTAT, but also has twice the share of co-inventions. Croatia and Moldova are also relative outliers with low co-invention shares.

One of the core research questions of this study is asking for evidence on regional collaboration patterns in the Danube region. In the following table, we list the major co-invention linkages between Danube region countries. We specify for each of the most relevant links both 'regular' patent applications (to national authorities or EPO), i.e. kind code 'A' applications, and patents filed according to the PCT procedure ('W' applications). We also add the most relevant patent authorities where the applications have first been filed.

Little surprisingly, the strongest co-invention linkages exist between the countries with the highest patent application output. Compared to its patent application output (the third largest in the region after Germany and Austria), Ukraine is comparatively less integrated into the Danube region co-invention network.

Apart from the linkages between Germany and other major Danube region countries, relevant co-invention relationships exist between: CZ-SK, MD-RO, AT-SK, MD-UA, AT-HU, AT-CZ. Interestingly, if we exclude Germany, Austria's co-invention linkages are not the dominating ones as one might expect given its overall application output. Other countries' inventive behaviour is more integrated. They produce comparatively higher shares of collaborative patent applications, especially taking into account their lower overall output.

The information on application authorities (those that receive the first filings of the co-invented patent applications) that is included in the table below can give us an indication of the most relevant markets of the applications we are looking at. - Germany and the EPO receive most of the patent applications with co-inventors from the Danube region. At least three aspects of this data are noteworthy, however: First, Asian patent application authorities (in particular: Korea and Taiwan) play a major role in most of the applications, especially in DE-UA and DE-RS, but also DE-RO and others. Secondly, the BG-DE co-invention link is unique in the sense that it's the only major one in the Danube region where most of the applications are first filed in the US. Finally, the CZ-SK co-inventions are most often filed in CZ (not in DE where a potential major market lies, EPO or others!), indicating their relevance for the local market (or at least the preference to seek protection in the Czech market first). Most of these patterns also apply to applications filed according to the PCT procedure, although EPO understandably plays a major role here as first filing application authority.

If we compare co-inventions filed according to the PCT procedure with those filed according to the regular national procedures, the former are more relevant in DE-HU, DE-SI and AT-HU co-inventions, among others. MD-RO, DE-RS and MD-UA co-inventions, by contrast, are almost never filed according to the PCT procedure.

Country 1	Country 2	'A' applications	Major applic. authorities	'W' applications	Major applic. authorities
AT	DE	7,705	DE 2748 US 1388 EP 1386 KR 999 TW 536 AT 181 RU 105	2,149	EP 1601 AT 199 DE 158 US 86 IB 56 CH 10
CZ	DE	615	DE 266 EP 137 US 69 KR 61 CZ 35 TW 23	191	EP 149 DE 11 CZ 10 US 9
DE	HU	605	DE 253 EP 117 KR 81 US 72 TW 33 HU 14	235	EP 193 IB 10 DE 9 DK 9 HU 7
DE	RO	303	DE 89 KR 82 TW 61 EP 27 US 25 RO 12	52	EP 42
DE	SK	269	DE 98 EP 61 US 31 KR 25 TW 21	76	EP 66
BG	DE	251	US 97 KR 59 DE 33 TW 26 EP 22 BG 10	34	EP 30
CZ	SK	243	CZ 124 US 36 EP 26 SK 22	65	CZ 37 EP 8 SK 7
DE	UA	230	KR 84 TW 75 DE 28 US 13 EP 11	30	EP 21
DE	HR	173	DE 39 EP 38 KR 36 TW 27 US 26	26	EP 19
DE	SI	131	DE 48 EP 19 KR 16	57	EP 48
MD	RO	97	MD 81	2	
AT	SK	94	DE 22 EP 19	30	EP 19 AT 10
DE	RS	88	TW 54 KR 26	7	
MD	UA	80	MD 34 RU 31	3	
AT	HU	77	EP 17 AT 16 DE 16	50	EP 26 AT 11
AT	CZ	66	EP 18	15	EP 8

Table 28: Co-invention links in the Danube region

With the information on these major Danube region co-invention linkages, we offer a thematically oriented view in the next section.

5.2.3 Co-inventions by topic

The following tables present, for 'A' and 'W' applications respectively, the number of patent applications by CPC section in major Danube region co-invention linkages. The top-3 sections (if above a threshold of 10) in each relationship as well as other particularities are highlighted to facilitate comparison. The same application can be assigned to more than one CPC class, which is the reason why the sums on the right do not match the above-mentioned numbers of co-inventions.

We do not narrow down the analysis to a more detailed CPC level for two reasons: First, we consider the fact that the number of cases per category would then be very low in most cases (almost all apart from AT-DE, CZ-DE and DE-HU); secondly, we take into account the limited scope of this exploratory study.

Sum – applns		Cooperative Patent Classification sections (CPC)[35]									
Country A	B	A	B	C	D	E	F	G	H	Y	**Total**
AT	CZ	***14***	6	**21**	3		9	2	**22**	6	83
AT	DE	1,068	**1,829**	**1,787**	340	275	1,286	1,232	**1,943**	534	10,294
AT	HU	9	**16**	**19**	1		9	9	**20**	7	90
AT	RO		5	3	3	1	1	5	**22**	9	49
AT	SI	**10**	5	**14**	2	1	9	5	**10**	1	57
AT	SK	15	15	**24**	1		6	15	**31**	1	108
BG	DE	25	24	**63**	2	1	13	***118***	**58**	21	325
CZ	DE	48	**189**	99	***42***	25	***159***	92	**118**	***78***	850
CZ	SK	15	**25**	**55**	9	1	21	**26**	23	18	193
DE	HR	18	20	**36**		1	**31**	13	**82**	6	207
DE	HU	66	***204***	**108**	9	16	***127***	**108**	**108**	47	793
DE	RO	28	**71**	50	3	1	48	***79***	**85**	21	386
DE	RS	15	**22**	**42**			1	**26**	11	12	129
DE	SI	***41***	**26**	21	1	5	9	14	**33**	5	155
DE	SK	30	**85**	**50**	***16***	2	36	12	**74**	26	331
DE	UA	14	39	**129**	1		20	**40**	**41**	***33***	317

Table 29: Number of 'A' applications by CPC class in major Danube region co-invention linkages (marked in bold green: top three sections; bold italic blue: deviations)

We see that in the 'A' applications, the classes where the strongest output is registered are electricity, "operations and transport as well as "chemistry and metallurgy". This does not entirely correspond to the CPC sections with the strongest application output in the Danube region in general (see above). These were, in addition to "operations and transport" (which dominates in the overall output more than in the co-inventions), "mechanical engineering" followed by electricity and then

[35] A: Human Necessities; B: Operations and Transport; C: Chemistry and Metallurgy; D: Textiles; E: Fixed Constructions; F: Mechanical Engineering; G: Physics; H: Electricity;
Y: Emerging Cross-Sectional Technologies

physics. Thus, mechanical engineering and physics are areas of comparatively less co-invention activity (compared to the degree of output in these areas in patent applications in general).

We also see in the above table that at co-invention level some of the country links correspond to the thematic patterns in the overall output: the "operations and transport" class is also dominant in CZ-DE and DE-HU linkages. Some co-invention links (CZ-DE, DE-HU) also have relative strengths in mechanical engineering or physics (like BG-DE or DE-RO), thus reflecting general output trends.

Other particularities are: In DE-SI co-invention relations, the human necessities class is the most important one. CZ-DE and DE-UA have a comparatively high output in the emerging cross-sectional technologies class.

Thematic patterns in the co-invented PCT applications are similar: "Operations and transport", "chemistry and metallurgy" as well as electricity dominate in most linkages. Exceptions are DE-SI with a focus on "human necessities", CZ-DE, DE-RO and BG-DE with strengths in "mechanical engineering".

Sum – applns		cpc									
inv_cty_1	inv_cty_2	A	B	C	D	E	F	G	H	Y	Total
AT	DE	313	531	565	109	60	355	347	540	171	2991
AT	HU	4	8	16	1	1	*14*	8	13	2	67
BG	DE	7	11	13			1	*14*	6	2	54
CZ	DE	20	57	42	2	3	*48*	41	40	27	280
CZ	SK	9	7	37	4		6	9	6	5	83
DE	HU	25	78	54	1	5	43	30	58	14	308
DE	RO	7	14	7		1	*15*	*19*	9	2	74
DE	SI	*25*	12	9	1	6	5	5	11	2	76
DE	SK	5	20	20	2	3	7	9	23	4	93
DE	UA	1	9	20	1		6	5	4	3	49

Table 30: Number of PCT applications by CPC class in major Danube region co-invention linkages

As indicated above, another kind of international co-patenting activity is foreign ownership, i.e. patent applications invented in one country, but owned by legal entities in another country. In the following, we analyse these numbers as indications for both international cooperation linkages as well as knowledge flows.

5.2.4 Knowledge flows – foreign ownership

Like in the case of co-inventions above, we will start with a characterisation of the relevance of the phenomenon of foreign ownership in the patent application output of the countries covered in this analysis. Concretely, we will first compare the number of patent applications with an inventor from a specific country with the exclusively foreign owned patent applications with inventors from this country. With 'exclusively foreign owned' we mean that there is no applicant from the country where the application was (also) invented in. A patent application with inventors from e.g. CZ and HU and

applicants from CZ and RO would not count as 'exclusively foreign owned' from CZ's perspective, but it would from HU's. The following table shows the resulting shares of foreign owned inventions.

Country	Records with inventor from country x ('A' applications only)	Country's own inventions ('A') – at least one inventor and one applicant from country x	Exclusively foreign owned inventions ('A')	Share of foreign-owned inv.
AL	32	7	25	78.1%
AT	40,189	26,568	13,621	33.9%
BA	149	28	121	81.2%
BG	2,494	1,853	641	25.7%
CZ	10,156	8,154	2,002	19.7%
DE	706,385	628,959	77,426	11.0%
HR	2,335	1,960	375	16.1%
HU	7,228	5,216	2,012	27.8%
MD	2,890	2,781	109	3.8%
ME	43	33	10	23.3%
MK	99	9	90	90.9%
RO	7,712	6,109	1,603	20.8%
RS	1,826	1,392	434	23.8%
SI	3,905	3,364	541	13.9%
SK	2,552	1,737	815	31.9%
UA	16,686	14,868	1,818	10.9%

Table 31: Shares of foreign-owned patent applications

The share of exclusively foreign-owned patent 'A' kind applications in the region varies considerably. On one extreme, less than 4% of Moldova's applications are exclusively foreign-owned. On the other, over 90% of FYROM's are. The prevalence of foreign ownership in these countries roughly matches the shares of international co-inventions in their patent application output, with the extremes being more pronounced in the case of foreign ownership (e.g. while 91% of FYROM's patent applications are foreign owned, 68% of the applications are internationally co-invented).

This characterisation (similar, but slightly higher foreign ownership shares compared to co-invention shares) also applies to some other countries, e.g. Austria, Hungary, Serbia and Slovenia. Most other countries, however, feature similar, but lower shares of foreign ownership compared to co-inventions. This applies to Bulgaria, the Czech Republic, Germany, Croatia, Montenegro, Romania, Slovakia and Ukraine.

Considering only the prevalence of foreign ownership, Austria's relatively high share of exclusively foreign owned patents seems noteworthy. Except for the above mentioned extremes (all of them countries with smaller output), none of the other cases show more than a third of the applications as exclusively foreign owned. Among the countries of comparable mid-range application output, Slovakia and Hungary show a fairly high share of foreign owned patents, while Croatia, Slovenia and Ukraine feature very low shares.

In the following series of tables, we scrutinise the phenomenon of foreign ownership at the level of individual country links. The identified links do not (as above) indicate exclusive foreign ownership, but exclusive OR co-ownership. To give an example: If an application is invented in Austria with applicants from the Czech Republic and Austria, this would count as a CZ (co-)owned invention. It is not exclusively foreign-owned, but there is some knowledge flow from Austria to the Czech Republic.

In this understanding of foreign ownership, we present data for both 'A' kind applications and applications filed according to the PCT scheme. We also include information on the most relevant

(for first filings) patent authorities. In order to reduce complexity, we introduce threshold levels that are adjusted according to the range of the respective values. Numbers in bold indicate particularities in the data.

We first present a table with the foreign ownership links between the countries covered in this study. We then show linkages between countries covered by this study and all other third countries. Finally, we exclude Germany from this analysis and present foreign ownership links between the countries covered in this study (excl. Germany) and third countries.

Inventor country	Applicant country	'A' applications (threshold: 25)	Application authorities	'W'/PCT applications (threshold: 15)	Application authorities
AT	DE	8,676	DE (4595) US (1359) EP (1246) KR (697) TW (311) RU (132) AT (102)	1,588	EP (1253) DE (161) AT (56)
DE	AT	3,076	DE (1059) EP (795) US (536) AT (223) KR (209) TW (87) RU (50)	996	EP (759) AT (77) US (77)
HU	DE	737	DE (384) EP (167) KR (64)	131	EP (112)
CZ	DE	604	DE (307) EP (154) KR (50)	80	EP (65)
RO	DE	279	DE (122) KR (52)	26	EP (19)
SI	DE	277	DE (149)	122	EP (114)
BG	DE	270	**US (149)**	15	EP (14)
SK	DE	262	DE (134) EP (68)	44	EP (42)
UA	DE	200	**KR (72)** **TW (70)**	<15	
SK	CZ	180	CZ (131)	25	CZ (12)
DE	CZ	118	DE (37) CZ (35)	35	EP (22)
HR	DE	98	DE (26) KR (23) EP (21)	20	EP (15)
RO	MD	75	MD (74)	<15	
HU	AT	74	DE (29)	30	EP (23)
DE	HU	67	EP (21) US (20)	47	EP (33)
SK	AT	44	EP (16)	<15	
SI	AT	31	EP (10)	<15	
UA	MD	30	MD (23)	<15	
DE	RO	29	<10	<15	
DE	SK	28	US (10)	15	EP (13)
CZ	SK	<25	SK (21)	22	CZ (5)

Table 32: Foreign ownership links in the Danube region

Little surprisingly, the strong links between Austria and Germany are also visible in foreign ownership patterns with German applicants present in over 8,500 'A' applications with Austrian inventors. Given

the difference in the size of the economy, the over 3,000 applications with German inventors that are owned or co-owned by Austrian applicants seem substantial too.

Understandably, Germany is also the major destination of knowledge flows through ownership of Danube region invented patent applications. Applications (both 'A' and PCT) from Hungary, the Czech Republic, Romania, Slovenia, Bulgaria, Slovakia and Ukraine are frequently owned or co-owned by German applicants. Other links that do not involve Germany as a destination country include

- Czech Republic-based applicants and inventors from Slovakia or Germany;
- Moldova-based applicants and Romanian or Ukrainian inventors;
- Austria-based applicants and inventors from Hungary, Slovakia or Slovenia
- Hungary-based applicants and inventors from Germany;
- Romania-based applicants and inventors from Germany;
- Slovakia-based applicants and inventors based in Germany or the Czech Republic.

Other foreign ownership links exist in the Danube region, but are too weak in order to draw any general conclusions from the evidence.

As announced, the table above also shows major foreign ownership links in PCT patents. In general, patterns are similar. However, compared to the strength of the foreign ownership links according to 'A' applications, the Romania-to-Germany and Bulgaria-to-Germany knowledge flows are limited when considering PCT patents. The Slovenia-to-Germany and Germany-to-Hungary links are stronger in PCT-terms then one would expect when looking at the relationship in 'A' patent applications. In Table 28 above we saw that the PCT procedure is also relatively more important in these countries' co-invention links.

As to the application authorities at which these patent applications are first filed, Germany and EPO stand out as expected (in PCT filings, the EPO is more relevant). They are the authorities offering protection at the largest markets in the region. Notably, as in the case of co-inventions (see Table 28), the patent authorities in Korea and Taiwan feature prominently. This is especially the case for applications by Ukraine inventors and with German applicants, most of which are first filed in Asia. Most of applications with Slovakia-based inventors and Czech Republic-based applicants are first filed in the Czech Republic (and vice versa for Czech Republic-invented applications by Slovakia-based applicants). Almost all indexed applications with Romania-based inventors and Moldova-based applicants are filed in Moldova. These cases indicate a particular relevance of the local market and reflect patterns that are also visible in co-inventions (see above). Similarly, as in the case of co-inventions, foreign owned applications with Bulgaria-based inventors and applicants from Germany are mostly filed in the US. It would require further analysis to assess whether this is the result of links of multinationals or of sector-specific market considerations.

In order to open the view to the global-level foreign ownership of Danube region inventions, the following tables provide lists of the strongest links – first for applications by inventors from all countries covered in this study, then excluding Germany.

The strongest knowledge flow, as indicated by foreign ownership patterns, points from Germany to the US. Applications with inventors based in Germany are also frequently owned or co-owned by applicants based in Switzerland, France, the Netherlands, Japan, Austria, Sweden, Liechtenstein, etc. Interestingly, also the Cayman Islands show up in the data as a very relevant location for applicants

and, thus, owners of German inventions. In terms of foreign ownership output, the only links comparable to the strong outward flows from Germany point from Austria to Germany, Switzerland, Liechtenstein or the US as well as from the Czech Republic to the US. In **Table 33**, more details for other relevant countries can be found.

Inventor country	Applicant country	'A' applications (threshold: 1000)	Application authorities	'W' applic. (threshold: 300)	Application authorities (thresh.: 50)
DE	US	33,923	US (12,837) DE (7,734) EP (4,713) KR (3,431) TW (2,468) GB (1,014)	6732	US (3,443) EP (2,392) WIPO (682) DE (71)
DE	CH	16,153	**EP (4,072)** DE (3,305) KR (2,502) US (1,874) TW (1,571)	5664	EP (4,655) WIPO (293) CH (262) US (195) DE (190)
AT	DE	8,676	DE (4595) US (1359) EP (1246) KR (697) TW (311) RU (132) AT (102)	1588	EP (1253) DE (161) AT (56)
DE	FR	6,990	EP (2,710) US (1,171) KR (1,007) DE (652)	2444	EP (2014) US (133) WIPO (132) FR (108)
DE	NL	3,896	**KR (1,265)** TW (687) US (596) EP (579)	4341	**WIPO (3007)** EP (943) US (152) GB (123)
DE	JP	3,097	**EP (1,087)** US (792) DE (588) **KR (296)** **TW (185)**	639	EP (474) JP (82)
DE	AT	3,076	DE (1059) EP (795) US (536) AT (223) KR (209)	996	EP (759) AT (77) US (77)
DE	SE	2,682	DE (1,327) EP (499) US (286) KR (251)	1387	EP (1114) SE (168)
DE	LI	2,662	DE (953) EP (712) US (487)	495	EP (464)
AT	CH	2,188	**US (466)** EP (448) **KR (392)** **TW (238)** DE (207)	685	EP (460) US (104)
AT	LI	1,526	DE (565) EP (451) US (328)	<300	
DE	BE	1,428	EP (703) DE (197) US (183)	633	EP (443) WIPO (87) US (74)
AT	US	1,410	US (725) KR (242) TW (154)	551	US (387) EP (88) WIPO (54)
DE	GB	1,354	**US (295)** EP (246) KR (231) GB (168)	933	EP (370) GB (358) US (100) WIPO (72)
DE	**KY**	**1,251**	US (839) DE (304)	<300	
DE	FI	1,199	EP (403) US (221)	1096	EP (761) WIPO (178)

					FI (95)
CZ	US	1,147	US (543) EP (137)	<300	
DE	SG	1,083	DE (394) US (305) EP (295)	<300	
DE	KR	1,068	DE (459) KR (380)	335	EP (292)
DE	LU	1,045	EP (328) DE (230)	337	EP (294)
DE	CN	<1,000		575	**WIPO (327)** EP (124) CN (100)
AT	NL	<1,000		435	**WIPO (405)**

Table 33: Foreign ownership of Danube region inventions - all applicants

Application authority-wise, the results show first of all the relevance of the large 'home' markets: most inventions with US applicants are first filed in the US, most with European applicants at EPO or in Germany. Between these two, the relevance varies: While by far the largest share of Swiss-owned applications with Germany-based inventors are filed at EPO, in the case of Germany-to-Austria, the German Patent and Trademark office is the most relevant one. For some links, exceptions to this general rule exist: applications with Germany-based inventors that are owned by Dutch applicants are most frequently first filed in Asian authorities. In the case of PCT applications, the World Intellectual Property Organisation (WIPO) plays a dominant role as first filing authority in this DE→NL link. Swiss-owned applications with Austria-based inventors as well as Great Britain- and Cayman Islands-owned applications with Germany-based inventors are most often filed first at the US Patent and Trademark Office (USPTO).

The strength of foreign ownership-indicated knowledge flows varies considerably for the countries included in this study. However, as Table 33 shows, some interesting findings can be drawn from the data.

In relation to the country's application output, the foreign ownership links pointing from Romania to the US are quite strong. Most of the applications with Romania-based inventors and US-based applicants are first filed in Asian application authorities, indicating their relevance for expert markets. As in the case of DE→NL flows, Dutch-owned applications with inventors based in Austria are first filed in Asia and, as PCT patents are concerned, through WIPO. Interestingly, most of the AT→NL applications are filed according to the PCT procedure. Another comparatively strong knowledge flow is indicated from the Ukraine to Russia, with the latter being the second most important foreign ownership country for Ukraine.

If we compare national/regional 'A' applications with those applications filed through the global PCT procedure, the later features as particularly relevant in some foreign ownership linkages. As indicated, this includes Austria-to-Netherlands applications, but also the links pointing from Hungary to the US, Sweden or Finland. The PCT procedure is thus of particular relevance for applications with Hungarian inventors.

As a last step in our analysis, we will now map the most relevant topic classes in foreign-owned Danube region patent applications.

Inventor country	Applicant country	'A' applications (threshold: 150)	Application authorities	'W' applications (threshold: 50)	Application authorities
AT	DE	8,676	DE (4595) US (1359) EP (1246) KR (697) TW (311) RU (132) AT (102)	1588	EP (1253) DE (161) AT (56)
AT	CH	2,188	US (466) EP (448) **KR (392)** **TW (238)** DE (207)	685	EP (460) US (104)
AT	LI	1,526	DE (565) EP (451) US (328)	175	EP (98) CH (34)
AT	US	1,410	US (725) KR (242) TW (154)	551	US (387) EP (88) WIPO (54)
CZ	US	1,147	US (543) EP (137)	170	US (138) WIPO (14) EP (10)
RO	US	785	**KR (298)** **TW (281)**	82	US (37) WIPO (36)
HU	DE	737	DE (384) EP (167)	131	EP (112)
HU	US	648	US (244) KR (142)	252	US (175) WIPO (44) EP (24)
UA	US	592	KR (187) US (173) TW (139)	86	US (71)
UA	RU	577	RU (539)		
AT	NL	290	**KR (140)**	435	**WIPO (405)** EP (19)
RO	DE	279	DE (122)	<50	
SI	DE	277	DE (149)	122	EP (114)
BG	US	274	**KR (110)**	<50	
BG	DE	270	**US (149)**	<50	
SK	DE	262	DE (134)	<50	
AT	FI	249	**EP (157)**	152	EP (126)
RS	US	242	**TW (127)**	<50	
UA	DE	200	**KR (72)** **TW (70)**	<50	
SK	US	188	TW (68)	<50	
SK	CZ	180	**CZ (131)**	<50	
AT	SE	159	DE (56)	50	EP (39)
HU	FR	158		58	**HU (29)** EP (13)
HU	SE	<150		198	EP (114) SE (39) WIPO (35)
HU	FI	<150		129	EP (81) WIPO (41)
CZ	DE	<150		80	EP (65)
AT	GB	<150		66	GB (26) EP (24)

Table 34: Foreign ownership of Danube region excl. German inventions - all applicants

5.2.5 Foreign ownership by topic

The following contains information on the most relevant topics (CPC sections; see above) in foreign owned applications in the Danube region. It confirms trends in thematic areas that are also visible in

co-invented patent applications with electricity (H), "operations and transport" (B) and "chemistry and metallurgy" (C) usually featuring most prominently. Particularities again include the relevance of the "human necessities" (A) section for applications with Slovenia-based inventors. Some other foreign ownership patterns including Germany-based applicants are particularly strong in "mechanical engineering" (F) (those involving inventors from the Czech Republic or Hungary). Still others feature physics-related applications (G) very prominently (those involving Austrian or Bulgarian inventors). In the case of Ukraine-based inventors and Germany-based applicants, the most frequent CPC section is "chemistry and metallurgy".These patterns are visible in both 'A' and PCT applications. However, in the case of Austrian-owned applications with German inventors, "chemistry and metallurgy" is the most important class for PCT patents, but only the third most important for 'A' applications.

If we compare the thematic specialisations in foreign ownership presented here with the thematic foci of co-inventions, we see similarities regarding the role of the "human necessities" class for Slovenia, but also in the case of "mechanical engineering" and the Czech Republic or "chemistry and metallurgy" and Ukraine. Two interpretations of this fact of the general correspondence of co-invention and foreign ownership specialisations seem possible: First, it is likely that dominant countries like Germany are present as applicants in many of the co-inventions involving German and e.g. Czech Republic or Ukraine-based inventors. The diagnosis here would be that most of the foreign owned patent applications are also co-inventions between the two countries involved. Another possible explanation is that large economies with a strong industry-base in most sectors pull in foreign invented IP from countries where the respective sector is strong. This would mean, for instance, that German companies own medicine- or pharma-related applications by inventors based in Slovenia even if there are generally no Germany-based inventors involved. Investigating the frequency of each of these cases is beyond the scope of the present study.

Inventor country	Applicant country	'A' applications (threshold: 25)	Top 3 CPC sections (threshold: 10)	'W'/PCT applications (threshold: 15)	Top 3 CPC classes (threshold: 10)
AT	DE	8,676	H (3109) **G (1668)** B (1636)	1,588	H (599) **F (314)** B (248)
DE	AT	3,076	H (951) B (891) **C (441)**	996	**C (303)** **A (261)** B (231)
HU	DE	737	**B (337)** **F (154)** H (112)	131	B (53) H (34) F (22)
CZ	DE	604	F (173) B (154) H (139)	80	F (24) B (21) G (18)
RO	DE	279	**B (87)** H (83) F (67)	26	**G (11)** F (10)
SI	DE	277	**A (143)** H (57) B (52)	122	**A (92)** B (18) F (13)
BG	DE	270	**G (158)** H (70) C (36)	15	<10
SK	DE	262	**B (93)** H (81) F (49)	44	H (16) B (14) F (12)
UA	DE	200	**C (129)**	<15	<10

			G (41) B (38)		
SK	CZ	180	C (30) B (20) A (15)	25	C (14)
DE	CZ	118	B (43) F (21) C (10)	35	B (12) A (10)
HR	DE	98	H (27) F (21) B (18)	20	H (10)
RO	MD	75	<10	<15	<10
HU	AT	74	F (23) H (21) B (13)	30	F (11)
DE	HU	67	H (16) A (12) C (12)	47	H (23)
SK	AT	44	H (12) A (11)	<15	<10
SI	AT	31	F (11)	<15	<10
UA	MD	30	<10	<15	<10
DE	RO	29	A (14)	<15	<10
DE	SK	28	B (16)	15	<10
CZ	SK	<25		22	C (10)

Table 35: Foreign ownership for major Danube region linkages - by topic

5.3 Discussion and outlook

In the preceding pages, we have presented several dimensions of the patent application data contained in PATSTAT for the Danube region, Albania and FYROM. After a conceptual introduction and a presentation of our raw data (including coverage per patent authority), we have had a look at general features of the Danube region-invented application output. We have then moved on to separately analyse co-invention and foreign-ownership linkages of and among the countries relevant to this study. In each of these two chapters, we have first shed light on the prevalence of the phenomenon in each of the countries and then moved on to analyse individual country links including information on 'A' and PCT applications as well as on main application authorities and topics. The data allowed us to identify general trends as well as some geographic and thematic particularities.

Given the limited resources of this exploratory country-level study, several questions remain unanswered at the moment. These include, for instance, a detailed analysis of all applications involving applicants from the relevant countries (not "only" foreign ownership). Additionally, it would be interesting to bring the analysis to the level of institutions. This would, however, require substantial additional resources as would an analysis at the regional level.

Other more methodological venues for developing this analysis further include the linking of the co-invention and the foreign ownership analysis. Concretely, knowing what shares of co-invented patents (involving which countries) are also foreign-owned would open room for additional findings regarding the relationship of the innovation systems of the countries involved. Another step in this direction, which is already used in parts of the literature, would be fractional counting of co-inventions. Co-invented patents would be assigned to each involved country in a way reflecting the weight of the inventors based in this country (i.e. in an application with 5 inventors based in Hungary and one in Austria, the application would be assigned to Hungary for 5/6 parts, to Austria for 1/6).

This fractional analysis still suffers from the problem that it cannot appropriately reflect the role of each of the inventors involved (*Who did which parts of the work? Who was involved in the research and development itself? Who was more in a non-R&D support role?* etc.).

Finally, also the analysis of patent families (i.e. going beyond first filings) or of the citations in patents (of patents and non-patent literature) would be additionally interesting steps to follow.

At the moment, we are confident that the data and analysis presented here supports the Danube region research and innovation policy makers and funding agency representatives to better understand the knowledge and innovation related linkages and dynamics in the region.

In order to benefit the most not only from this co-patent analysis, but also from the related bibliometric analysis of the research output and collaboration, in the executive summary of this work, comparative conclusions were drawn between co-patent and co-publication analyses.

6 Bibliography

Archibugi, Daniele / Iammarino, Simona (1999): The policy implications of the globalisation of innovation, in: Research Policy, 28, 317-336.

Archibugi, Daniele / Pianta, Mario (1996): Measuring Technological Change through patents and innovation surveys, in: Technovation, 16(9), 451-468.

Bergek, Anna / Bruzelius, Maria (2010): Are patents with multiple inventors from different countries a good indicator of international R&D collaboration? The case of ABB. Research Policy 39, 1321-1334

De Prato, Giuditta / Nepelski, Daniel (2014): Global technological collaboration network: network analysis of international co-inventions, in: Journal of Technology Transfer, 39, 358-375.

De Rassenfosse, Gaétan et al. (2013): The worldwide count of priority patents: A new indicator of inventive performance, in: Research Policy, 42(3), 720-737.

Gambardella, Alfonso et al. (2012): Report on empirical results and policy, Deliverable 8.1 of the project 'Innovative S&T indicators combining patent data and surveys: Empirical models and policy analyses', Milano: InnoS&T.

Giuri, Paola et al. (2007): Inventors and invention processes in Europe: Results from the PatVal-EU survey, in: Research Policy, 36, 1107-1127.

Glänzel, Wolfgang / Schubert, Andras (2005): Analyzing scientific networks through co-authorship, in: Handbook of Quantitative Science and Technology Research, p. 257-276, Springer Netherlands, p. 265

Guan, Jiancheng / Chen, Zifeng (2012): Patent collaboration and international knowledge flow, in: Information Processing and Management, 48, 170-181.

Guellec, Dominique / van Pottelsberghe de la Potterie, Bruno (2001): The internationalisation of technology analysed with patent data, in: Research Policy, 30, 1253-1266.

Hagedoorn, John (2003): Sharing intellectual property rights – an exploratory study of joint patenting amongst companies, in: Industrial and Corporate Change, 12(5), 1035-1050.

Kuemmerle, Walter (1997): Building Effective Capabilities Abroad, in: Harvard Business Review, March-April, 61-70.

Meyer, Martin (2006): Academic Inventiveness and Entrepreneurship: On the Importance of Start-Up Companies in Commercializing Academic Patents, in: Journal of Technology Transfer, 31, 501-510.

Meyer, Martin / Bhattacharya, Sujit (2004): Commonalities and differences between scholarly and technical collaboration, in: Scientometrics, 61(3), 443-456.

Morescalchi, Andrea et al. (2015): The evolution of networks of innovators within and across borders: Evidence from patent data, in: Research Policy, 44, 651-668.

Niosi, Jorge (1999): The internationalisation of industrial R&D: from technology transfer to the learning organisation, in: Research Policy, 28, 107-117.

OECD (2013): Glossary of Statistical Terms. Patent, online at: https://stats.oecd.org/glossary/detail.asp?ID=2023, last accessed: 22 April 2015.

Pakes, Ariel / Griliches, Zvi (1984): Patents and R&D at the Firm Level: A First Look, in: Griliches, Zvi (ed.): R&D, Patents, and Productivity, Chicago: University of Chicago Press, 55-72.

Patel, Parimal (1995): Localised production of technology for global markets, in: Cambridge Journal of Economics, 19(1), 141-154.

Penner-Hahn, Joan / Shaver, J. Myles (2005): Does international research and development increase patent output? An analysis of Japanese pharmaceutical firms, in: Strategic Management Journal, 26, 121-140.

Picci, Lucio (2010): The Internationalization of Inventive Activity: A Gravity Model using Patent Data, in: Research Policy, 39(8), 1070-1081.

Picci, Lucio / Savorelli, Luca (2012): The Structural Changes of Internationalized R&D Activities: An Analysis of Patent Data, Working Paper, SSRN Electronic Journal, 12.

Pohl, Hans / Warnan, Guillaume / BaasBaas, Jeroen (2014): Level the playing field in scientific international collaboration with the use of a new indicator: Field-Weighted Internationalization Score, in Research Trends, Issue 39, December 2014. URL: http://www.researchtrends.com/issue-39-december-2014/field-weighted-internationalization-score/ (last accessed: 27.02.2015)

Scherer, Frederic M. and Harhoff, Dietmar (2000): Technology policy for a world of skew-distributed incomes, in: Research Policy, 29, 559-566.

Song, Jaeyong / Asakawa, Kazuhiro / Chu, Youngeun (2011): What determines knowledge sourcing from host locations of overseas R&D operations? A study of global R&D activities of Japanese multinationals, in: Research Policy, 40, 380-390.

Swiss Federal Institute of Intellectual Property (2014): Patents, online at: https://www.ige.ch/en/ip4all/patents/patents.html?type=kxftokfxvjku, last accessed: 22 April 2015.Webster, Elizabeth / Jensen, Paul H. (2011): Do Patents Matter for Commercialization?, in: Journal of Law and Economics, 54(2), 431-453.

Annex I – Key definitions for co-publication analysis

Affiliation By affiliation we refer to a unique author-institution combination related to one record. The same author can be affiliated with several institutions within one single record. If this is the case, we consequently count several affiliated. Therefore, publications with one author, but two affiliations, one in one country of the Danube Region and one in another country, are included in the analysis and considered a co-publication. The number of affiliations in the Danube Region co-publications therefore shall not be confused with the number of authors.

BibTex BibTex on the one hand is a software package for creating literature references and indices in TeX or LaTeX documents (TeX is a typesetting system with integrated macro language, LaTeX is a variant of TeX). On the other hand we use the term in context of BibTeX exports from our data sources. In this case we refer to the BibTeX format which makes literature database entries available, coded in a particular way. The BibTeX format was the common denominator present to receive data from both different source databases with the same format, though slightly different in detail features.

Categories and main categories The two scientific literature databases used in this study assign the recorded books or periodicals to one or more thematic key words based on a classification system. In Elsevier's Scopus we have around 340 of these thematic keywords and around 250 in the case of Thomson Reuter's Web of Science (as listed in the annex). Only a small percentage of the scientific works is classified independently of the general classification of the periodical. To remove potential ambiguities, this study has used the Science Metrix Ontology that classifies journals on three levels of granularity: the domain, the field, and the sub-field.

Co-publication In the context of this study we refer to international scientific publications, indexed in literature databases, with the participation of at least two institutions/organisations in at least two different countries. For this study the term co-publication therefore is only used for international co-publications, unless explicitly stated otherwise.

Document types Each of the data sources used assigns a certain document type to the tracked publications to better describe them. These types reach from articles over abstracts and conference papers to editorials, errata and even music, movie or soft-ware reviews. To have comparable document types available we consolidated the two document type sets of our data sources to the following list: article, conference paper, meeting abstract, review, editorial, letter, other.

FRASCATI Manual The FRASCATI Manual is a standard methodology developed by the OECD to gather data on research and technology development activity of countries and contains a classification system of topic areas.

Impact Talking about impact in the framework of this study, we refer to the passive citations per record, i.e., the number of cases in which the respective publication was cited by a different younger publication. The data can only be punctual snapshots (summer/autumn 2014 in the case of this study). Citation counts for publications from very recent years are to be treated differently from the ones of very old publications and therefore, of course, comparison only makes sense for citation data from 3 or more years in the past. Publications that are tracked

in both data sources tend to be assigned with different passive citation counts. Internally, we work with various algorithms to level this bias (e.g. the weight factor for citation counts from Web of Science or the preferential usage of the higher citation count).

Institute/Organisation Because the scientific literature databases used in this study relate authors to different organisational entities (i.e.: in one case the university as a whole is named, in another case we have detailed description of the institute or even the research group, etc.), we agreed on the usage of the label "institute" for the more detailed, subordinate level often called "organisational unit" (university institute, department, laboratory, sub entity of a company or international organisation) and the term "organisation" as the bigger entity, for example university, academy or intergovernmental organisation, etc.

Levenshtein distance The Levenshtein distance measures the difference of two character strings. In the case of character strings we measure the minimum number of changes (insert, delete or exchange operations) to transform one string into another. The Levenshtein distance between "house" and "home" for example is 2. The distance is zero, when both strings are identical.

Overlap factor The overlap factor is a measure we used to numerically express the intersection's size of the sets of journals listed in one ASJC category in comparison to a WoS category.

Record With record we refer to an entry in our database containing the meta data of a uniquely identified publication. In case the same publication appears in both data sources (Scopus and Web of Science), it is still dealt with as one record.

Salton's measure Salton's measure S expresses the strength of a relation between two sets, and is similar to the Jaccard index. Both indices are commonly used in the analysis of co-publication activity, but they distinguish themselves by the value in their denominators. For the way of application, in our case, Salton's measure can be described as follows: S is the number of co-publications of two countries, divided by the geometric mean (the square root of the product) of the total publications numbers of both countries:

$$S = \frac{\mathrm{copub}_{A,B}}{\sqrt{\mathrm{pub}_A \cdot \mathrm{pub}_B}} \quad A \ldots \mathrm{country1}, B \ldots \mathrm{country2}$$

If all publications in both countries were co-publications between the two countries, Salton's measure would be 1.

Annex II – Data cleaning, consolidation of data sources and thematic areas

The process starts with database-specific tables, into which parsed BibTeX data are inserted. The resulting tables contain records and affiliations for Scopus and WoS separately; they are subsequently unified into one record table and an affiliation table.

On the basis of raw data tables, we created a unified data set using a series of processing steps:

- Unification of journal names: the number and set of journals that are registered by Scopus and Web of Science are different. Many records appear in both databases, but with different spelling, institution or author notation, etc. The first unification step normalises syntax and spelling of journal names detected as identical (e.g. with differing capitalisation). In a next step we use Document Object Identifiers (DOIs) of all records in our database, which are unique (disregarding typing errors in the original databases, whose rate of occurrence lies at roughly 1%) for any registered publication worldwide (but unfortunately often are missing), to identify identical journals (in different notations). If one record is available with the same DOI in both databases, the journals linked to this record must as well be identical. Remaining journal names are examined for their similarity and are suggested as merging candidates, which then are controlled and manually assigned.
- Removal of duplicates in both record tables: Of course, publications that are registered in both databases must not appear twice in our unified data set. The identification of records from both sources describing the same publication is led through by searching for conformities in the following variables:
  - DOI
  - title, year, begin page
  - ISBN and begin page
  - journal ID or ISSN and begin page, year and author , title or volume
  - begin page and author-keywords
- Unification of journal names, second round: the results of the record unification can now be used to run through another round of journal name unification; a procedure to enhance data quality once more.
- Based on the previous steps a unified record-table can be established and filled according to the queries of interest.
- A similar data cleaning procedure takes place for the affiliations (author-institution combinations) – details below. After these data cleaning steps it can be shown which benefits the consultation of both data sources can offer for the present analysis: of the 1,026,556 observed Danube Region publications, 815,812 are listed by Scopus and 779,024 are listed by Web of Science.

Each cleaned record not only contains keywords given by the author(s) but has also been assigned with the journal subject categories of the respective source database(s). Unfortunately, the two thematic classification systems of Web of Science and of Scopus not only distinguish themselves in the way of assignment, but also in the set of the used categories. Each database classifies each listed

journal with one or more journal subject categories (249 in Web of Science) or with the help of All Science Journal Classification numbers (ASJC; 334 categories in Scopus).

A third classification scheme, the Science Metrix ontology, offers the advantage of a clear attribution of a journal to a single category called sub-field. Sub-fields are aggregated into fields which again are aggregated into domains. The ZSI developed a semi-automatic system to connect the two different category systems. Web of Science categories and Scopus ASJC categories are compared and rated for their overlap in the especially designed web-interface (see screenshot below).

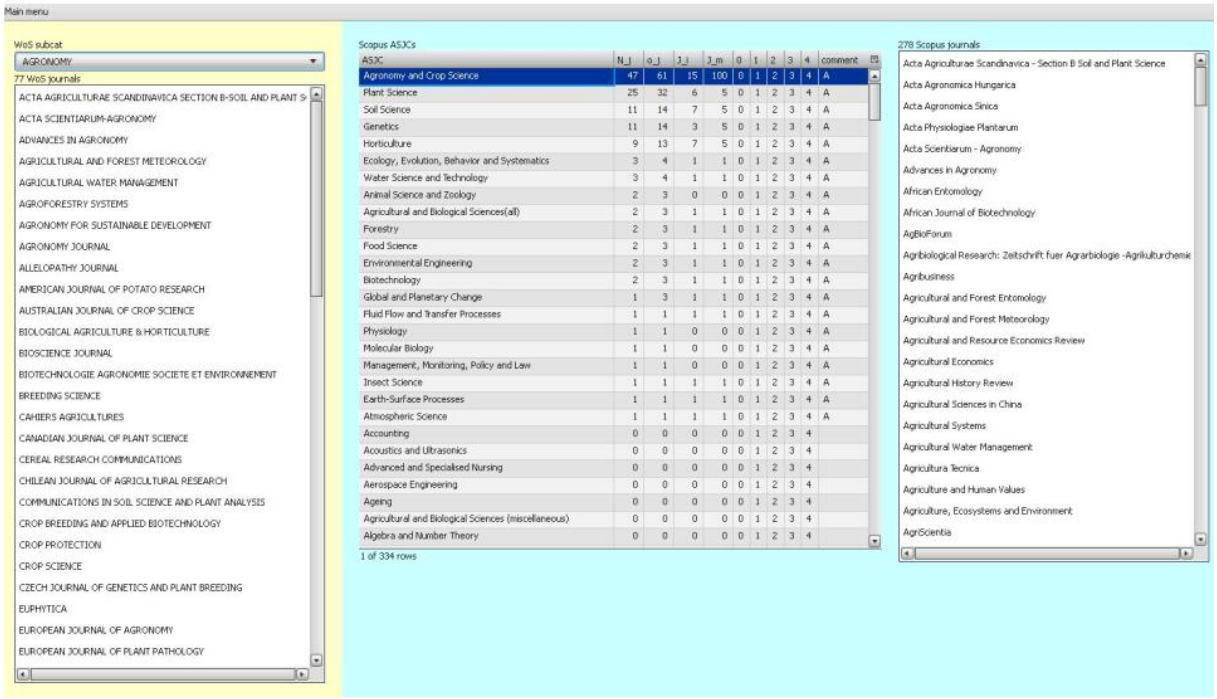

Figure 4: Web interface for the assignment journal categories, showing an exemplary assignment of Web of Science subject areas to Scopus ASJC categories, Centre for Social Innovation, 2011-2015

Annex III – Country comparison in terms of co-publications

In this section of the annex, all DR countries, apart from Kosovo and Albania, and their absolute figures in co-publication collaboration activities with the other DR partner countries + "together with average citation counts" over the time period of 2003-2013 are presented. As the figures are exhaustive and include all DR countries and their ranking from 1 – 15 regarding collaboration with the case country, one can easily draw comparisons between the charts.

To give an outlook already, here are some snapshots:

- On average, FYROM, Moldova and Montenegro belong to the weakest collaboration partners for all DR+3 countries
- As stated before already, Austria, Czech Republic, Germany and Hungary belong to the strongest collaboration partners in the Danube Region
- Looking at the citation counts of a co-publication between two DR+3 countries, one can observe an interesting fact: Not necessarily these co-publications, which result from the collaboration with the Top-3 partner countries, are also cited internationally most often. Naturally, the highest citation count could be still found in co-publications with the strongest partner country, but also **with average partner countries or even the weakest partner countries (see the examples of Serbia and FYROM).**

Each of the following seventeen tables is devoted to one DRC (the fourteen DRC as in the Danube-INCO.NET project plus Albania, FYROM, and Kosovo*). In the two left columns, one can see the case and the target country – both from the DR ("country" and "country B"). In the two right columns, the number of co-publications between the featured country and the target country as well as the average citation count[36] of a co-publication between these two countries is stated. A short description of the main findings is given for each table.

Country	Country B	Co-pubs A-B	Average cit. counts
AT	DE	41,685	13.25
AT	CZ	4,318	16.7
AT	HU	3,644	15.87
AT	SK	2,265	14.86
AT	SI	2,236	16.26
AT	RO	1,694	15.63
AT	HR	1,433	16.47
AT	RS	1,342	17.64
AT	UA	1,166	17.88
AT	BG	1,030	17.74
AT	B&H	148	8.83
AT	MK	91	7.52
AT	MD	52	9.96
AT	ME	39	4.77

[36] as a proxy for the quality or impact of the jointly created research output

AT	AL	38	14.22

Table 36: Austria's absolute co-publication figures with DR partner countries and their average citation count

Austria: Case country Austria shares the most of its co-publications in the DR with Germany (41,685). The number of co-publications between Austria and Germany is nearly ten times higher than with Austria's second most important partner the Czech Republic (4,318). The lowest amount of co-publications Austria shares with Albania; however Austria's and Albania's co-publications are cited averagely more often than Austria's higher amount of co-publications with, for instance, Bosnia and Herzegovina, FYROM, Moldova and Montenegro.

Country	Country B	Copubs A-B	Average cit. counts
BGR	**DEU**	4846	15,66
BGR	CZE	1123	17,99
BGR	HUN	1043	**20,5**
BGR	AUT	1030	17,74
BGR	ROU	951	18,38
BGR	SRB	761	16,53
BGR	UKR	630	**19,95**
BGR	HRV	603	**23,63**
BGR	SVK	522	16,28
BGR	MKD	263	6,81
BGR	SVN	244	17,01
BGR	MNE	77	16,44
BGR	BIH	49	9,51
BGR	MDA	23	3,65

Table 37: Bulgaria's absolute co-publication figures with DR partner countries and their average citation count

Bulgaria: Case country Bulgaria shares most of its co-publications in the DR with Germany (4,846). The highest number of citation counts Bulgaria has with seventh-ranked Croatia though (23.63 citations/, despite Croatia's only 7th rank in the total amount of co-publication).publications shared with Bulgaria. The lowest amount of co-publication Bulgaria shares with Moldova, which, in this case, is also reflected in the lowest number of citation counts.

Country	Country B	Co-pubs A-B	Average cit. counts
BA	**RS**	842	2.98
BA	**HR**	834	5.43
BA	SI	310	6.69
BA	DE	297	14.89
BA	AT	148	8.83
BA	MK	79	6.69

BA	RO	62	8
BA	HU	60	9.86
BA	SK	56	13.04
BA	CZ	55	17.86
BA	BG	49	9.51
BA	ME	42	2.75
BA	UA	28	10.91
BA	MD	13	7.4

Table 38: Bosnia and Herzegovina'sHerzegovinas's absolute co-publication figures with DR partner countries and their average citation count

Bosnia and Herzegovina: Case country Bosnia and Herzegovina shares the highest number of co-publications with neighbouring Serbia (842). On the contrary, Bosnia and Herzegovina has only produced 13 co-publications with Moldova during the years from 2003 to 2013, which puts Moldova at the very end of collaboration activities with Bosnia and Herzegovina. The highest number of citation counts can be found in the relation to the Czech Republic. Interestingly enough, Serbia as the top-collaboration partner for Bosnia and Herzegovina obviously cannot use this ties to boost the number of joint citation counts as it is the lowest from all collaboration partners (2.98).

Country	Country B	Co-pubs A-B	Average cit. counts
CZ	DE	13,946	**20.17**
CZ	**SK**	6,220	10.87
CZ	AT	4,318	16.7
CZ	HU	2,484	23.5
CZ	SI	1,511	18.16
CZ	RO	1,446	**20.52**
CZ	RS	1,306	**19.63**
CZ	UA	1,185	16.49
CZ	HR	1,175	**24.69**
CZ	BG	1,123	17.99
CZ	ME	79	17.43

CZ	MK	57	12.49
CZ	BA	55	17.86
CZ	MD	35	10.34

Table 39: Czech Republic's absolute co-publication figures with DR partner countries and their average citation count

Czech Republic: Case country Czech Republic finds its top-collaboration partner in Germany – a partner country, which is amongst the closest collaboration partners for the majority of the DR countries (compare with the other DR countries). The number of co-publications as well as average citation counts with Germany is around twice the number of the second-ranked Slovakia. Again, the highest number of citation counts is not to be found with the most productive (meaning the highest number of jointly produced co-publications) collaboration partner, but with an average one: The co-publications of the Czech Republic and Croatia are on average cited 24.69 times. This is the best value of all listed countries. Both the weakest collaboration ties and the lowest number of citation counts are true for the relation to Moldova. In general, Czech Republic's co-publications with all DR countries prove a certain quality, since none of the citation counts with any of the listed partner countries falls below the level of 10 citations/co-publication (also see the case of Germany and Slovakia, where the same pattern can be observed).

Country	Country B	Co-pubs A-B	Average cit. counts
DE	**AT**	41,685	13.25
DE	CZ	13,946	**20.17**
DE	**HU**	11,061	**21.45**
DE	UA	6,812	12.99
DE	RO	6,311	13.7
DE	**BG**	4,846	15.66
DE	**SK**	4,491	**19.33**
DE	SI	3,603	**20.78**
DE	HR	3,507	**23.07**
DE	RS	2,807	15.93
DE	**MD**	480	10.24
DE	MK	332	11.04

DE	BA	297	14.89
DE	ME	119	13.61

Table 40: Germany's absolute co-publication figures with DR partner countries and their average citation count

Germany: Case country Germany shares the highest amount of co-publications with Austria (as mentioned already when describing Austria, p. 83) The number accounts to 41,685 co-publications, which is roughly three times the number of co-publications with second-ranked Czech Republic. The weakest collaboration ties exist between Germany and Montenegro, resulting in a number of 119 co-publications between 2003 and 2013 only. As for the Czech Republic, also in case of Germany Croatia appears again as the "best partner to choose" for producing co-publications with a high impact, meaning being cited often (a German co-publication with Croatia is cited on average 23.07 times). In general, Germany's co-publications with all DR countries prove a certain quality, since none of the citation counts with any of the listed partner countries falls below the level of 10 citations/co-publication.

Country	Country B	Co-pubs A-B	Average cit. counts
HR	DE	3,507	**23.07**
HR	SI	2,000	8.67
HR	AT	1,433	16.47
HR	CZ	1,175	**24.69**
HR	HU	1,090	**21.45**
HR	RS	1,087	13.93
HR	**BA**	834	5.43
HR	BG	603	**23.63**
HR	RO	600	**20.25**
HR	UA	550	**23.97**
HR	SK	475	**22**
HR	MK	193	7.41
HR	ME	89	2.67
HR	MD	21	9.67

Table 41: Croatia's absolute co-publication figures with DR partner countries and their average citation count

Croatia: Case country Croatia has an overall co-publication output of 13,657 records. The most co-publications Croatia shares with the strongest of all DR collaboration partners, Germany (3,507). The lowest number of co-publications accounts to the Croatian-Moldovan scientific partnership (21). Regarding the average citation count of Croatia's co-publications within the DR, it is not Germany again whose co-publications with Croatia appear as the strongest. Ranked 4th in the number of produced co-publications, Czech Republic's co-

publications with Croatia are cited most often (24.69 times/co-publication). At the very end of this statistic one can find the citation count in Croatia's co-publications with Montenegro (2.67).

Country	Country B	Co-pubs A-B	Average cit. counts
HU	**DE**	11,061	**21.45**
HU	AT	3,644	15.87
HU	CZ	2,484	23.5
HU	RO	2,422	15.24
HU	SK	1,530	**19.44**
HU	RS	1,137	**20.66**
HU	HR	1,090	**21.45**
HU	SI	1,043	**22.45**
HU	BG	1,043	**20.5**
HU	UA	859	**26.77**
HU	BA	60	9.86
HU	MK	59	10.81
HU	MD	27	7.05
HU	ME	18	9.4

Table 42: Hungary's absolute co-publication figures with DR partner countries and their average citation count

Hungary: As so often, Germany is the strongest partner in co-publications also with the case country Hungary. Together they have produced a co-publication output of 11,061 records, which distances itself clearly from the second ranked Austria (3,644). Looking at the average citation count, Hungary's co-publications with Germany belong to the top in the list. With 21.45 citations/co-publication this cooperation is only beaten by the Hungarian-Slovenian (22.45) and Hungarian-Ukrainian citation count (26.77).

Country	Country B	Co-pubs A-B	Average cit. counts
MD	**DE**	480	10.24
MD	RO	283	4.93
MD	UA	162	6.52
MD	AT	52	9.96
MD	CZ	35	10.34
MD	RS	28	8.15
MD	HU	27	7.05
MD	BG	23	3.65
MD	HR	21	9.67
MD	SK	21	12.76
MD	SI	15	16.07
MD	BA	13	7.4
MD	MK	11	7
MD	ME	8	2.03

Table 43: Moldova's absolute co-publication figures with DR partner countries and their average citation count

Moldova: Case country Moldova is one of the least developed countries in the DR. This also affects the scientific performance of the country, which is why Moldova only has a minor output of co-publications. The top-collaboration partner is Germany, with a co-publication output of only 480 co-publications though. Together with Bosnia and Herzegovina, FYROM, and Montenegro, Moldova belongs to those countries whose highest number of jointly produced co-publications with the strongest partner country from the DR does not reach the benchmark of 1,000. Moldova's co-publications with Montenegro account to only 8 co-publications, which marks the other end. The highest number in citations can be found in the collaboration with Slovenia (16.07 citations/co-publication) – a partner with rather small amount of collaboratively produced co-publications (15 produced co-publications).

Country	Country B	Co-pubs A-B	Average cit. counts
MK	RS	465	4.38
MK	DE	332	11.04
MK	BG	263	6.81
MK	HR	193	7.41
MK	SI	171	7.35
MK	AT	91	7.52
MK	RO	79	11.85
MK	BA	79	6.69
MK	HU	59	10.81
MK	CZ	57	12.49
MK	UA	37	4.63
MK	ME	36	4.04
MK	SK	32	13.66
MK	MD	11	7

Table 44: FYROM's absolute co-publication figures with DR partner countries and their average citation count

FYROM: As stated in the description of Moldova already, FYROM has a weak co-publication output totalling to less than 1,000 co-publications in 2003-2013, putting the collaboration with Serbia on the first position with only 465 co-publications already. Close behind follows Germany with 332 collaboratively produced publications. The last position in this statistic is occupied by Moldova, which has produced only 11 co-publications with FYROM. On the other hand, a weak collaboration partner in co-publications can again be an excellent partner in producing a frequently cited output. Slovakia's scientific relation to FYROM proves that in having an average citation count of 13.66 citations per jointly produced co-publication.

Country	Country B	Co-pubs A-B	Average cit. counts
ME	RS	589	3.73
ME	DE	119	13.61
ME	HR	89	2.67
ME	RO	80	10.13
ME	CZ	79	17.43

ME	BG	77	16.44
ME	SK	76	17.3
ME	SI	50	4.78
ME	BA	42	2.75
ME	AT	39	4.77
ME	MK	36	4.04
ME	UA	25	8.85
ME	HU	18	9.4
ME	MD	8	2.03

Table 45: Montenegro's absolute co-publication figures with DR partner countries and their average citation count

Montenegro: Regarding the number of co-publications, case country Montenegro performs best with its neighbour Serbia (589 produced co-publications). The average citation count for these jointly produced co-publications, however, is rather low (3.73 citations/co-publication). For example, the citation count with second ranked Germany (119 co-publications in total) is decisively higher than the one with Serbia (13.61 vs. 3.73). The highest number in citations one can find in the co-publications between Montenegro and Czech Republic, accounting to 17.43 citations per co-publication on average.

Country	Country B	Co-pubs A-B	Average cit. counts
RO	DE	6,311	13.7
RO	HU	2,422	15.24
RO	AT	1,694	15.63
RO	CZ	1,446	**20.52**
RO	SK	955	**22.84**
RO	BG	951	18.38
RO	RS	935	17.89
RO	SI	734	19.12
RO	UA	628	**21.42**
RO	HR	600	**20.25**
RO	MD	283	4.93

RO	ME	80	10.13
RO	MK	79	11.85
RO	BA	62	8

Table 46: Romania's absolute co-publication figures with DR partner countries and their average citation count

Romania: Case country Romania shares the biggest part of its overall sum of co-publications produced with Germany (6,311). Hungary and Austria follow with 2,422 and 1,694 jointly produced co-publications. At the end of this ranking one finds the collaboration between Romania and Bosnia and Herzegovina, summing up to an output of 62 co-publications only. With 22.84 citation counts per co-publication on average, the co-publication output between Romania and Slovakia is the top-value for the case country. This value is closely followed by the citation count in Romanian-Ukrainian (21.42) and Romanian-Czech co-publications (20.52).

Country	Country B	Co-pubs A-B	Average cit. counts
RS	DE	2,807	15.93
RS	AT	1,342	17.64
RS	CZ	1,306	**19.63**
RS	SI	1,214	11.46
RS	HU	1,137	**20.66**
RS	HR	1,087	13.93
RS	RO	935	17.89
RS	**BA**	842	2.98
RS	BG	761	16.53
RS	SK	708	**19.87**
RS	ME	589	3.73
RS	ME	589	3.73
RS	UA	477	**27.78**
RS	MK	465	4.38

Table 47: Serbia's absolute co-publication figures with DR partner countries and their average citation count

Serbia: Case country has a productive cooperation with the two German-speaking countries in the DR. With Germany Serbia shares most of its produced co-publications (2,807), followed by Austria (1,342). On the other end one finds only 465 produced co-publications with FYROM and 477 with Ukraine respectively. Keeping an eye on Ukraine, the high number of citation counts is striking – with 27.78 citations per co-publication on

average this is the best value of all listed citation counts. Surprisingly, none of the two German-speaking countries can be found in the top-three of this statistic, which is concluded by 20.66 citations/co-publication with the second-ranked Hungary and 19.87 citation counts/co-publication with the third-ranked Slovakia.

Country	Country B	Copubs A-B	Average cit. counts
SK	**CZ**	6,220	10.87
SK	**DE**	4,491	**19.33**
SK	AT	2,265	14.86
SK	HU	1,530	**19.44**
SK	RO	955	**22.84**
SK	SI	788	19.4
SK	RS	708	**19.87**
SK	UA	582	11.71
SK	BG	522	16.28
SK	HR	475	**22**
SK	ME	76	17.3
SK	BA	56	13.04
SK	MK	32	13.66
SK	MD	21	12.76

Table 48: Slovakia's absolute co-publication figures with DR partner countries and their average citation count

Slovakia: Case country Slovakia finds its strongest scientific partner in neighbouring Czech Republic. Together they show a co-publication output of 6,220 records, followed by the output with Germany (4,491) and Austria (2,265). In contrast, the collaboration between Slovakia and Moldova is from smaller quantity, resulting in a co-publication output of 21 records only. Slovakian-Romanian co-publications seem from highest quality: A Slovakian-Romanian co-publication is cited 22.84 times in average, which is top of all values. In general, Slovakia's co-publications with all DR countries prove a certain quality, since none of the citation counts with any of the listed partner countries falls below the level of 10 citations/co-publication.

Country	Country B	Co-pubs A-B	Average cit. counts
SI	**DE**	**3,603**	**20.78**
SI	**AT**	**2,236**	**16.26**

SI	HR	2,000	8.67
SI	CZ	1,511	18.16
SI	RS	1,214	11.46
SI	HU	1,043	22.45
SI	SK	788	19.4
SI	RO	734	19.12
SI	BA	310	6.69
SI	UA	287	14.23
SI	BG	244	17.01
SI	MK	171	7.35
SI	ME	50	4.78
SI	MD	15	16.07

Table 49: Slovenia's absolute co-publication figures with DR partner countries and their average citation count

Slovenia: As for Serbia, also for case country Slovenia the two German-speaking countries Germany and Austria are the strongest collaboration partners in producing joint co-publications. With Germany Slovenia has produced 3,603 co-publications during 2003-2013, whereas with Austria this number accounts to 2,236 co-publications for the same time period. The lowest number of co-publications Slovenia has produced with Moldova, namely 15. Referring to the average citation count a slightly different picture comes into play: With 22.45 citations/co-publication in average Slovenian-Hungarian co-publications apparently carry a high quality with much impact subsequently. Then it is Germany again, which is second-ranked in this category (20.78 citations). The citation count for Austrian-Slovenian co-publications is to be found somewhere in the middle.

Country	Country B	Copubs A-B	Average cit. counts
UA	DE	6,812	12.,99
UA	CZ	1,185	16.49
UA	AT	1,166	17.88
UA	HU	859	26.77
UA	BG	630	19.95
UA	RO	628	21.42
UA	SK	582	11.71
UA	HR	550	23.97
UA	RS	477	27.78
UA	SI	287	14.23
UA	MD	162	6.52
UA	MK	37	4.63
UA	BA	28	10.91
UA	ME	25	8.85

Table 50: Ukraine's absolute co-publication figures with DR partner countries and their average citation count

Ukraine: The last case country in this overview is Ukraine. Ukraine, which is currently heavily affected by its internal civilian war, was an established collaboration partner for the other DR countries before this internal

crisis triggered off. As this study only covers the years from 2003 to 2013, we don't provide any figures for the year 2014, which, in fact, was totally overshadowed by the Ukrainian crisis. Hence, negative developments in the scientific output of the country could be expected. What concerns the mentioned time period, there are two main findings: First Germany is far the strongest collaboration partner for Ukraine, having produced 6,812 co-publications together. On the second place follows the Czech Republic, having produced 1,185 co-publications together with the Ukraine. At the very end we find Montenegro, having produced 25 co-publications with Ukraine over these ten years. With another country, Serbia, Ukraine shares the highest number of its average citation count per co-publication (27.78). The lowest number in this regard accounts to the co-publications between Ukraine and FYROM (4.63).

Annex IV – Growth in Scientific Fields

	Year & growth rate	Agriculture, Fisheries & Forestry	Biology	Biomedical Research	Chemistry	Clinical Medicine	Earth & Environmental Sciences	Enabling & Strategic Technologies	Engineering	General S&T	ICTs	Mathematics & Statistics	Physics & Astronomy
AL	2003	2	1	2	0	3	0	0	0	1	0	1	1
	2013	4	14	3	2	13	4	2	3	0	2	2	1
	Growth rate	100.00%	1,300.00%	50.00%	--	333.33%	--	--	--	-100.00%	--	100.00%	0.00%
AT	2003	54	72	249	167	830	111	152	101	16	90	44	442
	2013	166	243	575	313	2174	239	378	311	244	354	124	873
	Growth rate	207.41%	237.50%	130.92%	87.43%	161.93%	115.32%	148.68%	207.92%	1,425.00%	293.33%	181.82%	97.51%
BG	2003	52	117	176	306	515	103	346	173	12	173	86	530
	2013	284	230	278	391	743	105	452	268	246	248	151	614
	Growth rate	446.15%	96.58%	57.95%	27.78%	44.27%	1.94%	30.64%	54.91%	1,950.00%	43.35%	75.58%	15.85%
BA	2003	0	3	2	3	20	0	8	5	0	0	1	8
	2013	19	23	8	10	99	9	19	33	2	16	7	22
	Growth Rate	375.00%	666.67%	300.,00%	233.33%	395.00%	--	137.50%	560.00%	--	300.00%	600.00%	175.00%
	Year & growth rate	**Agriculture, Fisheries & Forestry**	**Biology**	**Biomedical Research**	**Chemistry**	**Clinical Medicine**	**Earth & Environmental Sciences**	**Enabling & Strategic Technologies**	**Engineering**	**General S&T**	**ICTs**	**Mathematics & Statistics**	**Physics & Astronomy**
CZ	2003	43	57	113	136	220	57	82	40	5	39	31	344
	2013	130	238	219	246	693	123	226	134	93	158	87	687

	Growth Rate	202.33%	317.54%	93.81%	80.88%	215.00%	115.79%	175.61%	235.00%	1,760.00%	305.13%	202.33%	99.71%
DE	2003	108	132	411	448	1122	163	335	175	21	147	124	1390
	2013	196	406	829	663	3067	338	649	456	338	500	242	2006
	Growth Rate	81.48%	207.58%	101.,70%	47.99%	173.35%	107.36%	93.73%	160.57%	1,509.52%	240.14%	95.16%	44.32%
HR	2003	22	23	30	43	55	10	31	14	2	6	9	100
	2013	71	99	82	77	231	32	76	59	26	30	18	265
	Growth rate	222.73%	330.43%	173.33%	79.07%	320.00%	220.00%	145.16%	321.43%	1,200.00%	400.00%	100.00%	165.00%
HU	2003	26	35	80	103	224	32	61	23	4	36	24	318
	2013	53	127	177	175	557	70	108	69	60	93	54	507
	Growth rate	103.85%	262.86%	121.25%	69.90%	148.66%	118.75%	77.05%	200.00%	1,400.00%	158.33%	125.00%	59.43%
MD	2003	1	2	0	19	5	0	8	1	0	2	0	29
	2013	1	3	3	28	10	3	10	8	3	3	3	42
	Growth rate	--	--	--	47.37%	100.00%	--	25.00%	700.00%	--	--	--	44.83%
	Year & growth rate	**Agriculture, Fisheries & Forestry**	**Biology**	**Biomedical Research**	**Chemistry**	**Clinical Medicine**	**Earth & Environmental Sciences**	**Enabling & Strategic Technologies**	**Engineering**	**General S&T**	**ICTs**	**Mathematics & Statistics**	**Physics & Astronomy**
MK	2003	4	6	1	14	7	0	6	2	0	3	1	15
	2013	19	13	5	11	43	14	11	10	7	20	4	19

	Growth rate	375.00%	116.67%	--	-21.43%	514.29%	--	83.33%	400.00%	--	566.67%	--	26.67%
ME	2003	0	1	0	3	2	1	0	2	0	1	0	2
	2013	9	20	5	11	37	0	11	11	0	9	6	5
	Growth rate	--	1900.00%	--	266.67%	1,750.00%	--	--	450.00%	--	800.00%	--	150.00%
RO	2003	6	7	17	82	40	15	34	15	1	12	20	162
	2013	36	71	67	144	340	63	98	89	34	79	64	433
	Growth rate	500.00%	914.29%	294.12%	75.61%	750.00%	320.00%	188.24%	493.33%	3,300.00%	558.33%	220.00%	167.28%
RS	2003	6	10	7	30	19	5	11	9	0	6	11	34
	2013	61	108	67	84	306	37	104	103	15	60	33	277
	Growth rate	916.67%	980.00%	857.14%	180.00%	1,510.53%	640.00%	845.45%	1,044.44%	--	900.00%	200.00%	714.71%
SK	2003	28	25	65	96	133	28	43	12	0	18	15	156
	2013	91	105	114	136	249	65	100	88	40	57	38	288
	Growth rate	225.00%	320.00%	75.38%	41.67%	87.22%	132.14%	132.56%	633.33%	--	216.67%	153.33%	84.62%
	Year & growth rate	**Agriculture, Fisheries & Forestry**	**Biology**	**Biomedical Research**	**Chemistry**	**Clinical Medicine**	**Earth & Environmental Sciences**	**Enabling & Strategic Technologies**	**Engineering**	**General S&T**	**ICTs**	**Mathematics & Statistics**	**Physics & Astronomy**
SI	2003	15	16	29	45	66	12	38	23	4	15	6	104

	2013	56	63	81	118	239	34	118	80	31	53	32	271
	Growthrate	273.33%	293.75%	179.31%	162.22%	262.12%	183.33%	210.53%	247.83%	675.00%	253.33%	433.33%	160.58%
UA	2003	3	12	22	88	27	21	68	18	0	3	29	367
	2013	11	28	35	117	84	23	139	45	17	35	56	577
	Growthrate	266.67%	133.33%	59.09%	32.95%	211.11%	9.52%	104.41%	150.00%	--	1,066.67%	93.10%	57.22%

Table 51: Development of Science Metrix fields in Danube Region co-publications over the years, 2003-2013 (Source: WoS+Scopus)

ANNEX V – Impact Analysis Results – Average Citations of Intra-Danube-Region Co-publications

This section contains the results of the impact analysis. As stated in the main part of the document, impact is approximated through the *average number of citations*, in the present case the average citations of the intra-DR co-publications, i.e. co-publications authored by researchers affiliated with at least two organisations in different DRC.

Per research field

Please note that the *average citations* are marked green when the *average citations* of intra-DR co-publications is greater than the *average citations* of the overall DR co-publications, within a certain research field.

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
Applied Sciences	Agriculture, Fisheries & Forestry	AL	256	51	5.02	**7.58**
		AT	16422.4	2735	6.00	
		BG	2720.6	384	7.08	
		BA	561.1	158	3.55	
		CZ	13295.5	1614	8.24	
		DE	27403.2	3230	8.48	
		HR	4418.9	769	5.75	
		HU	10935.6	1210	9.04	
		KO-	56	20	2.80	
		MD	84	21	4.00	
		MK	450.5	112	4.02	
		ME	92.9	31	3.00	
		RO	2843.3	379	7.50	
		RS	2578.9	506	5.10	
		SK	5337.3	800	6.67	
		SI	5613.4	688	8.16	
		UA	1819.4	228	7.98	
	Built Environment & Design	AL	34	9	3.78	**5.76**

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		AT	1695.7	432	3.93	
		BG	239.3	46	5.20	
		BA	14	5	2.80	
		CZ	1132.6	171	6.62	
		DE	2220.5	374	5.94	
		HR	160.4	47	3.41	
		HU	1446.1	158	9.15	
		KO-	2	1	2.00	
		MD	1	2	0.50	
		MK	12	16	0.75	
		ME	0	1	0.00	
		RO	659.1	103	6.40	
		RS	318.2	47	6.77	
		SK	391	53	7.38	
		SI	313.4	86	3.64	
		UA	187	26	7.19	
	Enabling & Strategic Technologies	AL	180	49	3.67	**8.75**
		AT	52722.3	6537	8.07	
		BG	14368.7	1967	7.30	
		BA	872	196	4.45	
		CZ	40896.2	4227	9.67	
		DE	121420.4	11353	10.70	
		HR	6519.2	917	7.11	
		HU	23820.8	2329	10.23	
		KO-	395.1	34	11.62	
		MD	2146.3	297	7.23	
		MK	1082.9	164	6.60	
		ME	174.1	56	3.11	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		RO	23200.6	3328	6.97	
		RS	7950.7	1355	5.87	
		SK	10914.7	1418	7.70	
		SI	15119.2	1641	9.21	
		UA	25097	4032	6.22	
	Engineering	AL	128	55	2.33	**5.88**
		AT	24605.9	5818	4.23	
		BG	6127.4	982	6.24	
		BA	832.8	219	3.80	
		CZ	17648.1	2577	6.85	
		DE	44560.7	6985	6.38	
		HR	3264.1	816	4.00	
		HU	11171.8	1687	6.62	
		KO-	29	24	1.21	
		MD	244.3	94	2.60	
		MK	714.8	235	3.04	
		ME	444	119	3.73	
		RO	20343.4	3125	6.51	
		RS	4881.7	967	5.05	
		SK	5441	996	5.46	
		SI	8278.2	1255	6.60	
		UA	6727	1945	3.46	
	Information & Communication Technologies	AL	119	104	1.14	**4.31**
		AT	26500.8	7148	3.71	
		BG	2240.5	891	2.51	
		BA	251.7	151	1.67	
		CZ	17237.8	3171	5.44	
		DE	29234.4	6806	4.30	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		HR	2272.9	562	4.04	
		HU	14496.7	2569	5.64	
		KO-	34	16	2.13	
		MD	333.9	97	3.44	
		MK	628.5	234	2.69	
		ME	828.2	131	6.32	
		RO	7561.5	2220	3.41	
		RS	4068.9	974	4.18	
		SK	4890.4	1011	4.84	
		SI	6737.6	1192	5.65	
		UA	2004.3	1145	1.75	
Arts & Humanities	Communication & Textual Studies	AT	342.8	244	1.40	**2.40**
		BG	39.4	16	2.46	
		BA	8.1	9	0.90	
		CZ	486.2	91	5.34	
		DE	337.6	201	1.68	
		HR	50.6	38	1.33	
		HU	381.5	110	3.47	
		KO-	2.2	3	0.73	
		MD	0	1	0.00	
		MK	0	1	0.00	
		ME	0	2	0.00	
		RO	88.7	54	1.64	
		RS	10.2	18	0.57	
		SK	13.2	28	0.47	
		SI	185.2	55	3.37	
		UA	10	7	1.43	
	Historical Studies	AL	234.2	34	6.89	**6.63**
		AT	4859.1	1005	4.83	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		BG	1359.3	158	8.60	
		BA	420.3	134	3.14	
		CZ	3621.6	554	6.54	
		DE	11695.7	1358	8.61	
		HR	2108.7	438	4.81	
		HU	2945.8	422	6.98	
		KO-	31	10	3.10	
		MD	80.3	19	4.23	
		MK	104.8	11	9.53	
		ME	34	10	3.40	
		RO	2493.7	352	7.08	
		RS	1314.3	126	10.43	
		SK	1134.6	184	6.17	
		SI	1205.6	187	6.45	
		UA	1410.8	214	6.59	
	Philosophy & Theology	AT	162.3	145	1.12	**1.90**
		BG	6.2	15	0.41	
		BA	2	2	1.00	
		CZ	44.2	41	1.08	
		DE	164.7	102	1.61	
		HR	107.1	27	3.97	
		HU	95.2	63	1.51	
		MD	1	1	1.00	
		MK	22.1	5	4.42	
		RO	104.1	50	2.08	
		RS	20.2	12	1.68	
		SK	109	13	8.38	
		SI	54	27	2.00	
		UA	66.1	14	4.72	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
	Visual & Performing Arts	AT	110.9	86	1.29	**0.80**
		BG	0	3	0.00	
		CZ	7.1	13	0.55	
		DE	23.4	60	0.39	
		HR	1.1	8	0.14	
		HU	6.3	29	0.22	
		MD	0	1	0.00	
		MK	0	1	0.00	
		RO	5.1	7	0.73	
		RS	6	22	0.27	
		SK	0	5	0.00	
		SI	5.2	14	0.37	
		UA	0	2	0.00	
Economic & Social Sciences	Economics & Business	AL	94.1	41	2.30	**5.27**
		AT	9989.3	2367	4.22	
		BG	524.3	141	3.72	
		BA	57.2	47	1.22	
		CZ	3458.1	529	6.54	
		DE	11037.9	1722	6.41	
		HR	783.4	253	3.10	
		HU	3705.5	539	6.87	
		KO-	26	10	2.60	
		MD	60	9	6.67	
		MK	56.1	47	1.19	
		ME	11.5	18	0.64	
		RO	916.2	387	2.37	
		RS	399.2	170	2.35	
		SK	1241.1	228	5.44	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		SI	2938.6	431	6.82	
		UA	611.1	145	4.21	
	Social Sciences	AL	62.2	25	2.49	**3.54**
		AT	5027.8	1557	3.23	
		BG	360.9	154	2.34	
		BA	254.2	131	1.94	
		CZ	1806.3	435	4.15	
		DE	3922.9	1319	2.97	
		HR	442.6	174	2.54	
		HU	3996.1	655	6.10	
		KO-	36.5	32	1.14	
		MD	24	15	1.60	
		MK	82.3	54	1.52	
		ME	13.2	12	1.10	
		RO	983.2	348	2.83	
		RS	508.3	247	2.06	
		SK	1084.9	235	4.62	
		SI	889.2	320	2.78	
		UA	186.5	116	1.61	
General	General Arts, Humanities & Social Sciences	AL	1	16	0.06	**1.88**
		AT	163.8	101	1.62	
		BG	16.7	12	1.39	
		CZ	86.2	23	3.75	
		DE	95.4	62	1.54	
		HR	26.2	11	2.38	
		HU	134.1	34	3.94	
		KO-	0	2	0.00	
		MD	2	1	2.00	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		MK	0	6	0.00	
		RO	5	14	0.36	
		RS	19	3	6.33	
		SK	3	7	0.43	
		SI	7.4	11	0.67	
		UA	4.3	5	0.86	
	General Science & Technology	AL	84	15	5.60	**34.20**
		AT	67799.2	2387	28.40	
		BG	5586.7	413	13.53	
		BA	62	18	3.44	
		CZ	31379.5	955	32.86	
		DE	143855.6	3133	45.92	
		HR	8140.5	214	38.04	
		HU	31853.9	808	39.42	
		KO-	0	2	0.00	
		MD	331	13	25.46	
		MK	271	41	6.61	
		ME	9	9	1.00	
		RO	5374.2	282	19.06	
		RS	1189.5	148	8.04	
		SK	6154.9	253	24.33	
		SI	7613.6	290	26.25	
		UA	4362.5	229	19.05	
Health Sciences	Biomedical Research	AL	1171.3	76	15.41	**17.99**
		AT	160167.1	9609	16.67	
		BG	18348.7	1240	14.80	
		BA	1101.5	107	10.29	
		CZ	89960.8	5432	16.56	
		DE	282612.9	12668	22.31	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		HR	27836	1348	20.65	
		HU	91086.1	4490	20.29	
		KO-	216.4	46	4.70	
		MD	274	43	6.37	
		MK	1034	134	7.72	
		ME	85	29	2.93	
		RO	16082.6	1222	13.16	
		RS	6958.8	718	9.69	
		SK	37415.8	2094	17.87	
		SI	27536.7	1476	18.66	
		UA	16120.3	1381	11.67	
	Clinical Medicine	AL	1552.5	223	6.96	**15.38**
		AT	453593.5	33980	13.35	
		BG	33090.4	2215	14.94	
		BA	4854.1	860	5.64	
		CZ	194956.5	10960	17.79	
		DE	686958.4	35713	19.24	
		HR	44208.4	3146	14.05	
		HU	219492.1	11276	19.47	
		KO-	695.9	164	4.24	
		MD	817.7	163	5.02	
		MK	5273.3	529	9.97	
		ME	545.4	234	2.33	
		RO	53599	3919	13.68	
		RS	34271.6	3579	9.58	
		SK	49390.4	3512	14.06	
		SI	42559.4	3101	13.72	
		UA	29013.8	1808	16.05	
	Psychology & Cognitive Sciences	AL	22	6	3.67	**9.79**

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		AT	12280.4	1638	7.50	
		BG	1216.2	118	10.31	
		BA	570.9	41	13.92	
		CZ	3434.4	311	11.04	
		DE	17031.5	1624	10.49	
		HR	1619.6	150	10.80	
		HU	10070.7	584	17.24	
		KO-	19.3	9	2.14	
		MD	107	4	26.75	
		MK	113	23	4.91	
		ME	0	2	0.00	
		RO	1992.6	214	9.31	
		RS	1039.9	111	9.37	
		SK	1261.9	121	10.43	
		SI	1193.1	125	9.54	
		UA	511.7	56	9.14	
	Public Health & Health Services	AL	342.1	58	5.90	**8.05**
		AT	8795	1379	6.38	
		BG	1174.7	136	8.64	
		BA	132.6	48	2.76	
		CZ	5418.8	526	10.30	
		DE	11242.1	1241	9.06	
		HR	1367.4	173	7.90	
		HU	6695	587	11.41	
		KO-	75	11	6.82	
		MD	116.2	23	5.05	
		MK	476.3	31	15.36	
		ME	32.5	15	2.17	
		RO	2364.4	254	9.31	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		RS	569.1	165	3.45	
		SK	2877	347	8.29	
		SI	3355.3	274	12.25	
		UA	942.4	126	7.48	
Natural Sciences	Biology	AL	758.3	79	9.60	**11.88**
		AT	46377.1	4257	10.89	
		BG	8612.6	978	8.81	
		BA	1077.5	178	6.05	
		CZ	53749	3954	13.59	
		DE	104454.2	7160	14.59	
		HR	6704.2	939	7.14	
		HU	28384.5	2337	12.15	
		KO-	85.4	16	5.34	
		MD	324.2	45	7.20	
		MK	991.8	138	7.19	
		ME	562.2	174	3.23	
		RO	5837.8	612	9.54	
		RS	5135.5	893	5.75	
		SK	12345.1	1128	10.94	
		SI	9726.9	835	11.65	
		UA	5422.5	705	7.69	
	Chemistry	AL	236.4	37	6.39	**11.95**
		AT	64432.5	6087	10.59	
		BG	22646	1862	12.16	
		BA	467.6	120	3.90	
		CZ	78307.3	5764	13.59	
		DE	150552.8	11828	12.73	
		HR	11990.6	1268	9.46	
		HU	52343.1	3917	13.36	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		KO-	685.7	16	42.86	
		MD	8413.2	621	13.55	
		MK	2420.4	255	9.49	
		ME	306.8	64	4.79	
		RO	34477.8	3676	9.38	
		RS	10852.6	1304	8.32	
		SK	25300.8	2345	10.79	
		SI	22427.7	1732	12.95	
		UA	29540.7	3356	8.80	
	Earth & Environmental Sciences	AL	834.9	86	9.71	**11.33**
		AT	48411.7	4886	9.91	
		BG	6846.9	711	9.63	
		BA	528.5	53	9.97	
		CZ	26612.8	2492	10.68	
		DE	95607.4	6514	14.68	
		HR	4655.1	501	9.29	
		HU	17603.7	1489	11.82	
		KO-	20	9	2.22	
		MD	168.1	24	7.00	
		MK	663.5	87	7.63	
		ME	108.4	19	5.71	
		RO	9575.7	1021	9.38	
		RS	2568.6	325	7.90	
		SK	7382.1	907	8.14	
		SI	6806.1	610	11.16	
		UA	7784.3	1025	7.59	
	Mathematics & Statistics	AL	63	21	3.00	**5.11**
		AT	13881.4	2816	4.93	
		BG	3628.4	700	5.18	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		BA	293.5	72	4.08	
		CZ	11748.5	2303	5.10	
		DE	19014.5	3565	5.33	
		HR	2762.9	620	4.46	
		HU	7878.3	1778	4.43	
		KO-	25	11	2.27	
		MD	296.3	86	3.45	
		MK	341.1	76	4.49	
		ME	198.9	48	4.14	
		RO	13581.5	2613	5.20	
		RS	9092.9	1181	7.70	
		SK	4078.6	596	6.84	
		SI	3098.6	743	4.17	
		UA	7138.9	1822	3.92	
	Physics & Astronomy	AL	153.2	35	4.38	**12.58**
		AT	169439.6	14041	12.07	
		BG	58733.2	4508	13.03	
		BA	2230.8	168	13.28	
		CZ	158545.7	12019	13.19	
		DE	589082.3	37551	15.69	
		HR	52392.2	2967	17.66	
		HU	135685.5	8171	16.61	
		KO-	153.7	9	17.08	
		MD	8414.8	786	10.71	
		MK	2004.8	272	7.37	
		ME	1598.6	149	10.73	
		RO	78497.3	7128	11.01	
		RS	33842.6	2712	12.48	
		SK	54622.8	4770	11.45	

SM Domain	SM Field	country	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		SI	63191.5	3867	16.34	
		UA	121721.6	13290	9.16	

Per country

Please note that the *average citations* are marked green when the *average citations* of intra-DR co-publications is greater than the *average citations* of the overall DR co-publications, within a certain research field.

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
AL	Applied Sciences	Agriculture, Fisheries & Forestry	256	51	5.02	**7.58**
		Built Environment & Design	34	9	3.78	**5.76**
		Enabling & Strategic Technologies	180	49	3.67	**8.75**
		Engineering	128	55	2.33	**5.88**
		Information & Communication Technologies	119	104	1.14	**4.31**
	Arts & Humanities	Historical Studies	234.2	34	6.89	**6.63**
	Economic & Social Sciences	Economics & Business	94.1	41	2.30	**5.27**
		Social Sciences	62.2	25	2.49	**3.54**
	General	General Arts, Humanities & Social Sciences	1	16	0.06	**1.88**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		General Science & Technology	84	15	5.60	**34.20**
	Health Sciences	Biomedical Research	1171.3	76	15.41	**17.99**
		Clinical Medicine	1552.5	223	6.96	**15.38**
		Psychology & Cognitive Sciences	22	6	3.67	**9.79**
		Public Health & Health Services	342.1	58	5.90	**8.05**
	Natural Sciences	Biology	758.3	79	9.60	**11.88**
		Chemistry	236.4	37	6.39	**11.95**
		Earth & Environmental Sciences	834.9	86	9.71	**11.33**
		Mathematics & Statistics	63	21	3.00	**5.11**
		Physics & Astronomy	153.2	35	4.38	**12.58**
AT	Applied Sciences	Agriculture, Fisheries & Forestry	16422.4	2735	6.00	**7.58**
		Built Environment & Design	1695.7	432	3.93	**5.76**
		Enabling & Strategic Technologies	52722.3	6537	8.07	**8.75**
		Engineering	24605.9	5818	4.23	**5.88**
		Information & Communication Technologies	26500.8	7148	3.71	**4.31**
	Arts & Humanities	Communication & Textual Studies	342.8	244	1.40	**2.40**
		Historical Studies	4859.1	1005	4.83	**6.63**
		Philosophy & Theology	162.3	145	1.12	**1.90**
		Visual & Performing Arts	110.9	86	1.29	**0.80**
	Economic & Social Sciences	Economics & Business	9989.3	2367	4.22	**5.27**
		Social Sciences	5027.8	1557	3.23	**3.54**
	General	General Arts, Humanities & Social Sciences	163.8	101	1.62	**1.88**
		General Science & Technology	67799.2	2387	28.40	**34.20**
	Health Sciences	Biomedical Research	160167.1	9609	16.67	**17.99**
		Clinical Medicine	453593.5	33980	13.35	**15.38**
		Psychology & Cognitive Sciences	12280.4	1638	7.50	**9.79**
		Public Health & Health Services	8795	1379	6.38	**8.05**
	Natural Sciences	Biology	46377.1	4257	10.89	**11.88**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		Chemistry	64432.5	6087	10.59	**11.95**
		Earth & Environmental Sciences	48411.7	4886	9.91	**11.33**
		Mathematics & Statistics	13881.4	2816	4.93	**5.11**
		Physics & Astronomy	169439.6	14041	12.07	**12.58**
BG	Applied Sciences	Agriculture, Fisheries & Forestry	2720.6	384	7.08	**7.58**
		Built Environment & Design	239.3	46	5.20	**5.76**
		Enabling & Strategic Technologies	14368.7	1967	7.30	**8.75**
		Engineering	6127.4	982	6.24	**5.88**
		Information & Communication Technologies	2240.5	891	2.51	**4.31**
	Arts & Humanities	Communication & Textual Studies	39.4	16	2.46	**2.40**
		Historical Studies	1359.3	158	8.60	**6.63**
		Philosophy & Theology	6.2	15	0.41	**1.90**
		Visual & Performing Arts	0	3	0.00	**0.80**
	Economic & Social Sciences	Economics & Business	524.3	141	3.72	**5.27**
		Social Sciences	360.9	154	2.34	**3.54**
	General	General Arts, Humanities & Social Sciences	16.7	12	1.39	**1.88**
		General Science & Technology	5586.7	413	13.53	**34.20**
	Health Sciences	Biomedical Research	18348.7	1240	14.80	**17.99**
		Clinical Medicine	33090.4	2215	14.94	**15.38**
		Psychology & Cognitive Sciences	1216.2	118	10.31	**9.79**
		Public Health & Health Services	1174.7	136	8.64	**8.05**
	Natural Sciences	Biology	8612.6	978	8.81	**11.88**
		Chemistry	22646	1862	12.16	**11.95**
		Earth & Environmental Sciences	6846.9	711	9.63	**11.33**
		Mathematics & Statistics	3628.4	700	5.18	**5.11**
		Physics & Astronomy	58733.2	4508	13.03	**12.58**
BA	Applied Sciences	Agriculture, Fisheries & Forestry	561.1	158	3.55	**7.58**
		Built Environment & Design	14	5	2.80	**5.76**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		Enabling & Strategic Technologies	872	196	4.45	**8.75**
		Engineering	832.8	219	3.80	**5.88**
		Information & Communication Technologies	251.7	151	1.67	**4.31**
	Arts & Humanities	Communication & Textual Studies	8.1	9	0.90	**2.40**
		Historical Studies	420.3	134	3.14	**6.63**
		Philosophy & Theology	2	2	1.00	**1.90**
	Economic & Social Sciences	Economics & Business	57.2	47	1.22	**5.27**
		Social Sciences	254.2	131	1.94	**3.54**
	General	General Science & Technology	62	18	3.44	**34.20**
	Health Sciences	Biomedical Research	1101.5	107	10.29	**17.99**
		Clinical Medicine	4854.1	860	5.64	**15.38**
		Psychology & Cognitive Sciences	570.9	41	13.92	**9.79**
		Public Health & Health Services	132.6	48	2.76	**8.05**
	Natural Sciences	Biology	1077.5	178	6.05	**11.88**
		Chemistry	467.6	120	3.90	**11.95**
		Earth & Environmental Sciences	528.5	53	9.97	**11.33**
		Mathematics & Statistics	293.5	72	4.08	**5.11**
		Physics & Astronomy	2230.8	168	13.28	**12.58**
CZ	Applied Sciences	Agriculture, Fisheries & Forestry	13295.5	1614	8.24	**7.58**
		Built Environment & Design	1132.6	171	6.62	**5.76**
		Enabling & Strategic Technologies	40896.2	4227	9.67	**8.75**
		Engineering	17648.1	2577	6.85	**5.88**
		Information & Communication Technologies	17237.8	3171	5.44	**4.31**
	Arts & Humanities	Communication & Textual Studies	486.2	91	5.34	**2.40**
		Historical Studies	3621.6	554	6.54	**6.63**
		Philosophy & Theology	44.2	41	1.08	**1.90**
		Visual & Performing Arts	7.1	13	0.55	**0.80**
	Economic & Social	Economics & Business	3458.1	529	6.54	**5.27**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
	Sciences	Social Sciences	1806.3	435	4.15	**3.54**
	General	General Arts, Humanities & Social Sciences	86.2	23	3.75	**1.88**
		General Science & Technology	31379.5	955	32.86	**34.20**
	Health Sciences	Biomedical Research	89960.8	5432	16.56	**17.99**
		Clinical Medicine	194956.5	10960	17.79	**15.38**
		Psychology & Cognitive Sciences	3434.4	311	11.04	**9.79**
		Public Health & Health Services	5418.8	526	10.30	**8.05**
	Natural Sciences	Biology	53749	3954	13.59	**11.88**
		Chemistry	78307.3	5764	13.59	**11.95**
		Earth & Environmental Sciences	26612.8	2492	10.68	**11.33**
		Mathematics & Statistics	11748.5	2303	5.10	**5.11**
		Physics & Astronomy	158545.7	12019	13.19	**12.58**
DE	Applied Sciences	Agriculture, Fisheries & Forestry	27403.2	3230	8.48	**7.58**
		Built Environment & Design	2220.5	374	5.94	**5.76**
		Enabling & Strategic Technologies	121420.4	11353	10.70	**8.75**
		Engineering	44560.7	6985	6.38	**5.88**
		Information & Communication Technologies	29234.4	6806	4.30	**4.31**
	Arts & Humanities	Communication & Textual Studies	337.6	201	1.68	**2.40**
		Historical Studies	11695.7	1358	8.61	**6.63**
		Philosophy & Theology	164.7	102	1.61	**1.90**
		Visual & Performing Arts	23.4	60	0.39	**0.80**
	Economic & Social Sciences	Economics & Business	11037.9	1722	6.41	**5.27**
		Social Sciences	3922.9	1319	2.97	**3.54**
	General	General Arts, Humanities & Social Sciences	95.4	62	1.54	**1.88**
		General Science & Technology	143855.6	3133	45.92	**34.20**
	Health Sciences	Biomedical Research	282612.9	12668	22.31	**17.99**
		Clinical Medicine	686958.4	35713	19.24	**15.38**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		Psychology & Cognitive Sciences	17031.5	1624	10.49	**9.79**
		Public Health & Health Services	11242.1	1241	9.06	**8.05**
	Natural Sciences	Biology	104454.2	7160	14.59	**11.88**
		Chemistry	150552.8	11828	12.73	**11.95**
		Earth & Environmental Sciences	95607.4	6514	14.68	**11.33**
		Mathematics & Statistics	19014.5	3565	5.33	**5.11**
		Physics & Astronomy	589082.3	37551	15.69	**12.58**
HR	Applied Sciences	Agriculture, Fisheries & Forestry	4418.9	769	5.75	**7.58**
		Built Environment & Design	160.4	47	3.41	**5.76**
		Enabling & Strategic Technologies	6519.2	917	7.11	**8.75**
		Engineering	3264.1	816	4.00	**5.88**
		Information & Communication Technologies	2272.9	562	4.04	**4.31**
	Arts & Humanities	Communication & Textual Studies	50.6	38	1.33	**2.40**
		Historical Studies	2108.7	438	4.81	**6.63**
		Philosophy & Theology	107.1	27	3.97	**1.90**
		Visual & Performing Arts	1.1	8	0.14	**0.80**
	Economic & Social Sciences	Economics & Business	783.4	253	3.10	**5.27**
		Social Sciences	442.6	174	2.54	**3.54**
	General	General Arts, Humanities & Social Sciences	26.2	11	2.38	**1.88**
		General Science & Technology	8140.5	214	38.04	**34.20**
	Health Sciences	Biomedical Research	27836	1348	20.65	**17.99**
		Clinical Medicine	44208.4	3146	14.05	**15.38**
		Psychology & Cognitive Sciences	1619.6	150	10.80	**9.79**
		Public Health & Health Services	1367.4	173	7.90	**8.05**
	Natural Sciences	Biology	6704.2	939	7.14	**11.88**
		Chemistry	11990.6	1268	9.46	**11.95**
		Earth & Environmental Sciences	4655.1	501	9.29	**11.33**
		Mathematics & Statistics	2762.9	620	4.46	**5.11**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		Physics & Astronomy	52392.2	2967	17.66	**12.58**
HU	Applied Sciences	Agriculture, Fisheries & Forestry	10935.6	1210	9.04	**7.58**
		Built Environment & Design	1446.1	158	9.15	**5.76**
		Enabling & Strategic Technologies	23820.8	2329	10.23	**8.75**
		Engineering	11171.8	1687	6.62	**5.88**
		Information & Communication Technologies	14496.7	2569	5.64	**4.31**
	Arts & Humanities	Communication & Textual Studies	381.5	110	3.47	**2.40**
		Historical Studies	2945.8	422	6.98	**6.63**
		Philosophy & Theology	95.2	63	1.51	**1.90**
		Visual & Performing Arts	6.3	29	0.22	**0.80**
	Economic & Social Sciences	Economics & Business	3705.5	539	6.87	**5.27**
		Social Sciences	3996.1	655	6.10	**3.54**
	General	General Arts, Humanities & Social Sciences	134.1	34	3.94	**1.88**
		General Science & Technology	31853.9	808	39.42	**34.20**
	Health Sciences	Biomedical Research	91086.1	4490	20.29	**17.99**
		Clinical Medicine	219492.1	11276	19.47	**15.38**
		Psychology & Cognitive Sciences	10070.7	584	17.24	**9.79**
		Public Health & Health Services	6695	587	11.41	**8.05**
	Natural Sciences	Biology	28384.5	2337	12.15	**11.88**
		Chemistry	52343.1	3917	13.36	**11.95**
		Earth & Environmental Sciences	17603.7	1489	11.82	**11.33**
		Mathematics & Statistics	7878.3	1778	4.43	**5.11**
		Physics & Astronomy	135685.5	8171	16.61	**12.58**
KO-	Applied Sciences	Agriculture, Fisheries & Forestry	56	20	2.80	**7.58**
		Built Environment & Design	2	1	2.00	**5.76**
		Enabling & Strategic Technologies	395.1	34	11.62	**8.75**
		Engineering	29	24	1.21	**5.88**
		Information & Communication Technologies	34	16	2.13	**4.31**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
	Arts & Humanities	Communication & Textual Studies	2.2	3	0.73	**2.40**
		Historical Studies	31	10	3.10	**6.63**
	Economic & Social Sciences	Economics & Business	26	10	2.60	**5.27**
		Social Sciences	36.5	32	1.14	**3.54**
	General	General Arts, Humanities & Social Sciences	0	2	0.00	**1.88**
		General Science & Technology	0	2	0.00	**34.20**
	Health Sciences	Biomedical Research	216.4	46	4.70	**17.99**
		Clinical Medicine	695.9	164	4.24	**15.38**
		Psychology & Cognitive Sciences	19.3	9	2.14	**9.79**
		Public Health & Health Services	75	11	6.82	**8.05**
	Natural Sciences	Biology	85.4	16	5.34	**11.88**
		Chemistry	685.7	16	42.86	**11.95**
		Earth & Environmental Sciences	20	9	2.22	**11.33**
		Mathematics & Statistics	25	11	2.27	**5.11**
		Physics & Astronomy	153.7	9	17.08	**12.58**
MD	Applied Sciences	Agriculture, Fisheries & Forestry	84	21	4.00	**7.58**
		Built Environment & Design	1	2	0.50	**5.76**
		Enabling & Strategic Technologies	2146.3	297	7.23	**8.75**
		Engineering	244.3	94	2.60	**5.88**
		Information & Communication Technologies	333.9	97	3.44	**4.31**
	Arts & Humanities	Communication & Textual Studies	0	1	0.00	**2.40**
		Historical Studies	80.3	19	4.23	**6.63**
		Philosophy & Theology	1	1	1.00	**1.90**
		Visual & Performing Arts	0	1	0.00	**0.80**
	Economic & Social Sciences	Economics & Business	60	9	6.67	**5.27**
		Social Sciences	24	15	1.60	**3.54**
	General	General Arts, Humanities & Social Sciences	2	1	2.00	**1.88**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		General Science & Technology	331	13	25.46	**34.20**
	Health Sciences	Biomedical Research	274	43	6.37	**17.99**
		Clinical Medicine	817.7	163	5.02	**15.38**
		Psychology & Cognitive Sciences	107	4	26.75	**9.79**
		Public Health & Health Services	116.2	23	5.05	**8.05**
	Natural Sciences	Biology	324.2	45	7.20	**11.88**
		Chemistry	8413.2	621	13.55	**11.95**
		Earth & Environmental Sciences	168.1	24	7.00	**11.33**
		Mathematics & Statistics	296.3	86	3.45	**5.11**
		Physics & Astronomy	8414.8	786	10.71	**12.58**
MK	Applied Sciences	Agriculture, Fisheries & Forestry	450.5	112	4.02	**7.58**
		Built Environment & Design	12	16	0.75	**5.76**
		Enabling & Strategic Technologies	1082.9	164	6.60	**8.75**
		Engineering	714.8	235	3.04	**5.88**
		Information & Communication Technologies	628.5	234	2.69	**4.31**
	Arts & Humanities	Communication & Textual Studies	0	1	0.00	**2.40**
		Historical Studies	104.8	11	9.53	**6.63**
		Philosophy & Theology	22.1	5	4.42	**1.90**
		Visual & Performing Arts	0	1	0.00	**0.80**
	Economic & Social Sciences	Economics & Business	56.1	47	1.19	**5.27**
		Social Sciences	82.3	54	1.52	**3.54**
	General	General Arts, Humanities & Social Sciences	0	6	0.00	**1.88**
		General Science & Technology	271	41	6.61	**34.20**
	Health Sciences	Biomedical Research	1034	134	7.72	**17.99**
		Clinical Medicine	5273.3	529	9.97	**15.38**
		Psychology & Cognitive Sciences	113	23	4.91	**9.79**
		Public Health & Health Services	476.3	31	15.36	**8.05**
	Natural Sciences	Biology	991.8	138	7.19	**11.88**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		Chemistry	2420.4	255	9.49	**11.95**
		Earth & Environmental Sciences	663.5	87	7.63	**11.33**
		Mathematics & Statistics	341.1	76	4.49	**5.11**
		Physics & Astronomy	2004.8	272	7.37	**12.58**
ME	Applied Sciences	Agriculture, Fisheries & Forestry	92.9	31	3.00	**7.58**
		Built Environment & Design	0	1	0.00	**5.76**
		Enabling & Strategic Technologies	174.1	56	3.11	**8.75**
		Engineering	444	119	3.73	**5.88**
		Information & Communication Technologies	828.2	131	6.32	**4.31**
	Arts & Humanities	Communication & Textual Studies	0	2	0.00	**2.40**
		Historical Studies	34	10	3.40	**6.63**
	Economic & Social Sciences	Economics & Business	11.5	18	0.64	**5.27**
		Social Sciences	13.2	12	1.10	**3.54**
	General	General Science & Technology	9	9	1.00	**34.20**
	Health Sciences	Biomedical Research	85	29	2.93	**17.99**
		Clinical Medicine	545.4	234	2.33	**15.38**
		Psychology & Cognitive Sciences	0	2	0.00	**9.79**
		Public Health & Health Services	32.5	15	2.17	**8.05**
	Natural Sciences	Biology	562.2	174	3.23	**11.88**
		Chemistry	306.8	64	4.79	**11.95**
		Earth & Environmental Sciences	108.4	19	5.71	**11.33**
		Mathematics & Statistics	198.9	48	4.14	**5.11**
		Physics & Astronomy	1598.6	149	10.73	**12.58**
RO	Applied Sciences	Agriculture, Fisheries & Forestry	2843.3	379	7.50	**7.58**
		Built Environment & Design	659.1	103	6.40	**5.76**
		Enabling & Strategic Technologies	23200.6	3328	6.97	**8.75**
		Engineering	20343.4	3125	6.51	**5.88**
		Information & Communication Technologies	7561.5	2220	3.41	**4.31**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
	Arts & Humanities	Communication & Textual Studies	88.7	54	1.64	**2.40**
		Historical Studies	2493.7	352	7.08	**6.63**
		Philosophy & Theology	104.1	50	2.08	**1.90**
		Visual & Performing Arts	5.1	7	0.73	**0.80**
	Economic & Social Sciences	Economics & Business	916.2	387	2.37	**5.27**
		Social Sciences	983.2	348	2.83	**3.54**
	General	General Arts, Humanities & Social Sciences	5	14	0.36	**1.88**
		General Science & Technology	5374.2	282	19.06	**34.20**
	Health Sciences	Biomedical Research	16082.6	1222	13.16	**17.99**
		Clinical Medicine	53599	3919	13.68	**15.38**
		Psychology & Cognitive Sciences	1992.6	214	9.31	**9.79**
		Public Health & Health Services	2364.4	254	9.31	**8.05**
	Natural Sciences	Biology	5837.8	612	9.54	**11.88**
		Chemistry	34477.8	3676	9.38	**11.95**
		Earth & Environmental Sciences	9575.7	1021	9.38	**11.33**
		Mathematics & Statistics	13581.5	2613	5.20	**5.11**
		Physics & Astronomy	78497.3	7128	11.01	**12.58**
RS	Applied Sciences	Agriculture, Fisheries & Forestry	2578.9	506	5.10	**7.58**
		Built Environment & Design	318.2	47	6.77	**5.76**
		Enabling & Strategic Technologies	7950.7	1355	5.87	**8.75**
		Engineering	4881.7	967	5.05	**5.88**
		Information & Communication Technologies	4068.9	974	4.18	**4.31**
	Arts & Humanities	Communication & Textual Studies	10.2	18	0.57	**2.40**
		Historical Studies	1314.3	126	10.43	**6.63**
		Philosophy & Theology	20.2	12	1.68	**1.90**
		Visual & Performing Arts	6	22	0.27	**0.80**
	Economic & Social Sciences	Economics & Business	399.2	170	2.35	**5.27**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		Social Sciences	508.3	247	2.06	**3.54**
	General	General Arts, Humanities & Social Sciences	19	3	6.33	**1.88**
		General Science & Technology	1189.5	148	8.04	**34.20**
	Health Sciences	Biomedical Research	6958.8	718	9.69	**17.99**
		Clinical Medicine	34271.6	3579	9.58	**15.38**
		Psychology & Cognitive Sciences	1039.9	111	9.37	**9.79**
		Public Health & Health Services	569.1	165	3.45	**8.05**
	Natural Sciences	Biology	5135.5	893	5.75	**11.88**
		Chemistry	10852.6	1304	8.32	**11.95**
		Earth & Environmental Sciences	2568.6	325	7.90	**11.33**
		Mathematics & Statistics	9092.9	1181	7.70	**5.11**
		Physics & Astronomy	33842.6	2712	12.48	**12.58**
SK	Applied Sciences	Agriculture, Fisheries & Forestry	5337.3	800	6.67	**7.58**
		Built Environment & Design	391	53	7.38	**5.76**
		Enabling & Strategic Technologies	10914.7	1418	7.70	**8.75**
		Engineering	5441	996	5.46	**5.88**
		Information & Communication Technologies	4890.4	1011	4.84	**4.31**
	Arts & Humanities	Communication & Textual Studies	13.2	28	0.47	**2.40**
		Historical Studies	1134.6	184	6.17	**6.63**
		Philosophy & Theology	109	13	8.38	**1.90**
		Visual & Performing Arts	0	5	0.00	**0.80**
	Economic & Social Sciences	Economics & Business	1241.1	228	5.44	**5.27**
		Social Sciences	1084.9	235	4.62	**3.54**
	General	General Arts, Humanities & Social Sciences	3	7	0.43	**1.88**
		General Science & Technology	6154.9	253	24.33	**34.20**
	Health Sciences	Biomedical Research	37415.8	2094	17.87	**17.99**
		Clinical Medicine	49390.4	3512	14.06	**15.38**
		Psychology & Cognitive Sciences	1261.9	121	10.43	**9.79**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
		Public Health & Health Services	2877	347	8.29	**8.05**
	Natural Sciences	Biology	12345.1	1128	10.94	**11.88**
		Chemistry	25300.8	2345	10.79	**11.95**
		Earth & Environmental Sciences	7382.1	907	8.14	**11.33**
		Mathematics & Statistics	4078.6	596	6.84	**5.11**
		Physics & Astronomy	54622.8	4770	11.45	**12.58**
SI	Applied Sciences	Agriculture, Fisheries & Forestry	5613.4	688	8.16	**7.58**
		Built Environment & Design	313.4	86	3.64	**5.76**
		Enabling & Strategic Technologies	15119.2	1641	9.21	**8.75**
		Engineering	8278.2	1255	6.60	**5.88**
		Information & Communication Technologies	6737.6	1192	5.65	**4.31**
	Arts & Humanities	Communication & Textual Studies	185.2	55	3.37	**2.40**
		Historical Studies	1205.6	187	6.45	**6.63**
		Philosophy & Theology	54	27	2.00	**1.90**
		Visual & Performing Arts	5.2	14	0.37	**0.80**
	Economic & Social Sciences	Economics & Business	2938.6	431	6.82	**5.27**
		Social Sciences	889.2	320	2.78	**3.54**
	General	General Arts, Humanities & Social Sciences	7.4	11	0.67	**1.88**
		General Science & Technology	7613.6	290	26.25	**34.20**
	Health Sciences	Biomedical Research	27536.7	1476	18.66	**17.99**
		Clinical Medicine	42559.4	3101	13.72	**15.38**
		Psychology & Cognitive Sciences	1193.1	125	9.54	**9.79**
		Public Health & Health Services	3355.3	274	12.25	**8.05**
	Natural Sciences	Biology	9726.9	835	11.65	**11.88**
		Chemistry	22427.7	1732	12.95	**11.95**
		Earth & Environmental Sciences	6806.1	610	11.16	**11.33**
		Mathematics & Statistics	3098.6	743	4.17	**5.11**
		Physics & Astronomy	63191.5	3867	16.34	**12.58**

country	SM domain	SM field	citations	records	avg. citations DR-intra copubs	avg. citations of overall DR co-publications
UA	Applied Sciences	Agriculture, Fisheries & Forestry	1819.4	228	7.98	**7.58**
		Built Environment & Design	187	26	7.19	**5.76**
		Enabling & Strategic Technologies	25097	4032	6.22	**8.75**
		Engineering	6727	1945	3.46	**5.88**
		Information & Communication Technologies	2004.3	1145	1.75	**4.31**
	Arts & Humanities	Communication & Textual Studies	10	7	1.43	**2.40**
		Historical Studies	1410.8	214	6.59	**6.63**
		Philosophy & Theology	66.1	14	4.72	**1.90**
		Visual & Performing Arts	0	2	0.00	**0.80**
	Economic & Social Sciences	Economics & Business	611.1	145	4.21	**5.27**
		Social Sciences	186.5	116	1.61	**3.54**
	General	General Arts, Humanities & Social Sciences	4.3	5	0.86	**1.88**
		General Science & Technology	4362.5	229	19.05	**34.20**
	Health Sciences	Biomedical Research	16120.3	1381	11.67	**17.99**
		Clinical Medicine	29013.8	1808	16.05	**15.38**
		Psychology & Cognitive Sciences	511.7	56	9.14	**9.79**
		Public Health & Health Services	942.4	126	7.48	**8.05**
	Natural Sciences	Biology	5422.5	705	7.69	**11.88**
		Chemistry	29540.7	3356	8.80	**11.95**
		Earth & Environmental Sciences	7784.3	1025	7.59	**11.33**
		Mathematics & Statistics	7138.9	1822	3.92	**5.11**
		Physics & Astronomy	121721.6	13290	9.16	**12.58**