# KEY TRENDS IN CO-PUBLICATION ACTIVITIES OF UKRAINIAN AND THE EU SCIENTISTS IN 2003-2013

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*The Ukrainian research community needs more active involvement into processes of international production of knowledge, and co-publication analysis opens the way for quantitative assessment of the level of internationalization. The aim of the article is to analyze level and dynamics of joint publication activity of Ukrainian scientists and scholars from the EU countries in 2003-2013. The method of this article is based on analysis of the key international databases of scientific publications and corresponding Ukrainian national data. The main result is the identification of the key sectors and dynamics of scientific co-operation in joint publications between the EU and Ukraine. Thus, the reasons for the decline in number of publications of Ukrainian scientists at the international level in the first two decades of independence are considered. We analyzed the disciplinary aspects of joint publications, trends and prospects of further cooperation between scientists of Ukraine and the EU in this area.*

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***Key words:*** *EU, Ukraine, publications, citations, international co-operation.*

*Comunitatea ştiinţifică din Ucraina ar trebui să fie implicată mai activ în procesul de internaţionalizare a cunoştinţelor realizate, iar analiza lucrărilor ştiinţifice comune permite cuantificarea nivelului de internaţionalizare. Scopul articolului este analiza nivelului şi evoluţiei activităţii de co-editare a lucrărilor ştiinţifice a savanţilor ucraineni şi a celor din Uniunea Europeană în 2003-2013. Metoda de cercetare utilizată se bazează pe analiza principalelor baze de date internaţionale şi a datelor relevante pentru Ucraina. Rezultatul principal constă în identificarea sectoarelor cheie şi a dinamicii cooperării ştiinţifice în activitatea de co-editare a lucrărilor ştiinţifice dintre UE şi Ucraina. Sunt examinate cauzele reducerii ponderii lucrărilor savanţilor ucraineni la nivel internaţional în primele două decenii de independenţă. Sunt analizate aspectele disciplinare ale lucrărilor ştiinţifice comune, identificate tendinţele şi perspectivele de cooperare în continuare a savanţilor din Ucraina şi UE în acest domeniu.*

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***Cuvinte cheie****: UE, Ucraina, lucrări ştiinţifice, citări, cooperare internaţională.*

*Украинское исследовательское сообщество должно активнее вовлекаться в процесс интернационализации производимых знаний, и анализ совместных публикаций позволяет количественно оценить уровень интернационализаци. Целью статьи является анализ уровня и динамики совместной публикационной активности украинских ученых и ученых из стран ЕС в 2003-2013 г. Использованный метод базируется на анализе ключевых международных баз данных и соответствующих данных по Украине. Основной результат состоит в выявлении ключевых секторов и динамики научного сотрудничества в сфере совместных публикаций между ЕС и Украиной. Были рассмотрены причины снижения доли публикаций украинских ученых на международном уровне в первые два десятилетия независимости. Проанализированы дисциплинарные аспекты совместных публикаций, определены тенденции и перспективы дальнейшего взаимодействия в этой сфере ученых Украины и ЕС.*

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***Ключевые слова:*** *ЕС, Украина, публикации, цитирование, международное сотрудничество.*

***JEL Classification: O3; O34; O19; O39.***

**Introduction.** Scientific publications play important role in the evaluation of scientific productivity. Co-publications, in turn, reflect the level of co-operation between the countries in different scientific disciplines.

Ukraine has chosen its pro-European vector of development, and it is useful to understand, how fast the process of its integration into European R&D structures is going. Analysis of co-publications does not answer this question completely, but it indicates important trends and it helps to understand better dynamics of the process.

The paper consists of three parts. First one contains information about specific features of publication and co-publication activities in Ukraine in recent years, the second is devoted to the quantitative parameters of co-publications, and the third are related to some conclusions and recommendations.

**Factors, which determine publication activity in Ukraine in 1990s and 2000s.** It is worth to mention that there are different aspects, which have to be taken into account, when you consider Ukrainian case. They are related to cultural and organizational aspects of functioning of scientific community of the country. That is why it is important to make some preliminary remarks on the role of publication activities in Ukraine in the years of independence. Key factors, which determined the number of publications in Ukraine in this period:

- Decline of a number of researchers in the country. It is difficult to provide correct figure of decline, because Ukrainian statistics does not use FTE (full time equivalent) according to the international standards. However, it is possible to say that the number of researchers dropped at least by 3 times since the early 1990s.

- 'Internal' incentives for publications abroad were not strong enough in 1990s-2000s (till mid-2012). In contrary, system of academic promotion was based on the calculation of number of publications in national journals from the specially established list (so-called *spisok VAK*), not international journals. Rules for obtaining scientific degrees and positions at the universities and the institutes of the state-sponsored academies of sciences. As a result, the number of publications in foreign journals stagnated in 1990s-2000s at the level of 4000-5000 per year according to Thomson-Reuters data.

Minor (secondary) factors:

- 'Inertia' of publications in Russian or Ukrainian journals. Post-Soviet 'space' has a number of places for publications. It is not Estonia or other relatively small states from the CEE, which have limited number of scientific journals. National research systems in the largest post-Soviet states, including Ukraine, are relatively isolated and not oriented on international standards of meritocracy.

- Poor knowledge of foreign languages, especially English for preparation of publications in international journals.

- Some problems are related to the publications of Ukrainian authors, who are working temporary as visiting scholars in foreign research centers. Every year approximately 1000 of Ukrainian scientist spend more than 3 months in long-term visits in foreign research organizations. They usually publish articles as representatives of these centers.

- Domination of Ukrainian language (the only state language of the country) in scientific journals. Historically, this language had lower level of utilization in Ukrainian scientific community, as almost all large Ukrainian centers of science, excluding only western city of Lviv, were predominantly Russian-speaking cities. This has created certain problems, especially for foreign readers, including Russian-speaking scholars from post-Soviet countries, who do not know Ukrainian. Number of Ukrainian scientific journals in the international databases had tendency to decline (from 13 in early 1990s to 5 in 2007, and the number has raised in recent years only due to the changes, which will be discussed later).

Productivity of Ukrainian authors was more or less stable and it even had tendency to decline in the years of independence, if relative indicators (Ukrainian share in the world publications) will be taken into account. Meanings of relative indicators are already substantially lower, than in the neighboring CEE countries.

As it was mentioned above, Ukrainian authorities have established special regulations for promotion of scholars, when the candidates for scientific degrees have to publish their articles (not less than twenty for doctors of sciences!) in Ukrainian journals, specifically mentioned in the List of the Highest State Certification Commission. This forced researchers to send articles, first of all to Ukrainian journals, which had no high international profile.

Such practice has stimulated 'strange' situation, when the 'internal' data on research productivity demonstrated positive dynamics, while the number of international publications has stagnated.

Following the Soviet practice, Ukrainian statistics operated with the information on publications, which was collected directly from research institutes and universities (see Figure 1). These figures differ substantially from the figures, which could be found in the international databases.

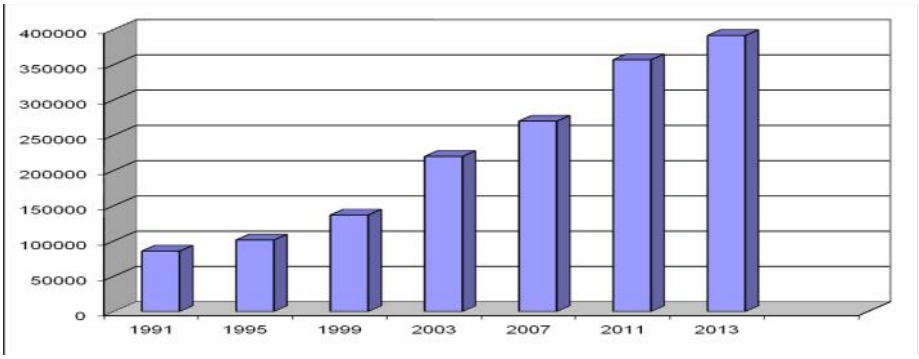


**Fig. 1. Number of scientific publications according to official Ukrainian statistics, 1991-2013, thous**

***Source: Data from the Yearbook 'Scientific and Innovation Activities in Ukraine', different issues for 1992-2014 – State Service (Committee) of Statistics, Kyiv (in Ukrainian).***

More than 60% of these publications are 'articles'. The growth of the number of articles was substantial, despite the decline in the number of scientists.

The universities are responsible for almost all growth of publications (by 15-20 thousand per year in 2003-2013). At the same time, universities have very few research projects and almost no modern equipment for applied research. In any case, approximately 2% of the printed results of Ukrainian authors are recognized internationally, if the level of internationally visible publications could be considered as a level of recognition.

The practice of taking into account 'internal' Ukrainian publications, first of all, was changed in 2011, when new rules for obtaining scientific degrees were introduced. Now, it is obligatory to have at least one publication, mentioned in the international databases for candidate of sciences and five publications for doctor of sciences. This had already positive impact on the number of Ukrainian publications abroad in recent years (since 2012).

The country still preserves positions in some areas of physics and technical sciences. But these 'islands of advancement' are relatively rare. So, approximately 10% of all internationally visible publications were written by the specialists from only one research institute in 2000s [1].

As to the international co-publications, their number is, of course, lower than the number of 'simply' international publications. Their dynamics is analyzed in second section of the paper.

**Dynamics of co-publications and citations.** Our analysis elaborates dimensions of the bi-regional S&T cooperation between EU Member States and Associated Countries to the Framework Programme 7 (EU+AC) and Ukraine, bringing one specific dimension of bi-regional cooperation into focus: co-publications between at least one author affiliated in EU or AC and one author affiliated in the Ukraine. Co-publications present a possible indicator for measuring RTD cooperation and are used as one – of many – proxies for the assessment of the current state of research cooperation.

For analysis of the co-publications special software tools were used, first of all 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.

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 334 of these thematic keywords and 249 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.

Thus, the analysis of EU-Ukrainian co-publications serves to monitor and to assess the impact of joint EU and Ukrainian RTD cooperation. It further aims at showing recent developments of academic cooperation between EU and Ukraine as well as pointing to emerging topics in RTDI cooperation. This deliverable supports the overall BILAT-UKR*AINA objective to support and provide analytical input to the institutional dialogue on STI policy between the European Commission, the EU (incl. MS, CC, and AC) and Ukraine (and the dialogue at the JSTCC) and the BILAT-UKR*AINA objective to monitor and analyse research cooperation in terms of co-publications [2].

Out of **94,135 Ukrainian publications** published between 2003 and 2013, 33.46% (31,695) publications involve at least one author from Ukraine and one from another country and are therefore international co-publications. **22.6% (**21,378) **of Ukraine's overall publications or 67,45% of all of Ukraine's international co-publications involve at least one author affiliated in an EU28/AC country**.

The annual output of Ukrainian publications, co-publications, and co-publications involving EU28/AC authors has been increasing steadily over the 11 years under examination (2003-2013), with minor drops in some years. However, comparing Ukraine's annual output of co-publications of 2013 and of 2003, international co-publications have been growing slightly faster – around 55% more international co-publications versus around 53% more Ukraine-EU28/AC co-publications, which have been in turn growing faster than the annual output of Ukraine's overall publications (around 44% more publications in 2013 than in 2003).

The partner countries most involved in Ukrainian co-publications are **Germany, Russia, USA, Poland, France, Great Britain, Italy, Spain, Japan, and Switzerland**. Out of the 20 most involved partner countries, 13 are countries from EU28/AC. Using the *Salton's Measure*[1] to assess the cooperation density between Ukraine and the most involved EU28/AC countries, it is apparent that the **relations between Ukraine and Poland, Germany, France, and the Czech Republic are comparatively strong** (each with a *Salton's Measure* of over 1%), followed by relations between Ukraine and Austria, Italy, and Great Britain (each with a *Salton's Measure* over 0.8%).

Ukraine has a strong **thematic focus on Physics & Astronomy** – 28.6% of all Ukrainian publications are published in this field. This thematic focus is even stronger for both Ukrainian overall co-publications and Ukrainian-EU28/AC co-publications: 42.03% of all Ukrainian co-publications and 44.43% of all Ukrainian EU28/AC co-publications are published in Physics & Astronomy. **Chemistry** and **Mathematics & Statistics** are research fields that are slightly more **relevant for Ukrainian EU28/AC co-publications**: 10.47% of all Ukrainian-EU28/AC co-publications are published in Chemistry and 6.48% are published in Mathematics & Statistics (compared to Ukrainian overall publications, which have a share of 9.58% in Chemistry and 6.11% in Mathematics & Statistics, respectively).

The annual output of UA-EU28/AC co-publications in **Information & Communication Technologies** is growing particularly strong: the output in 2013 is more than five times as high as in 2003. Growth in Economics & Business was even higher than that, i.e. the output grew tenfold in the same time span.

In Clinical Medicine, Biology, Engineering, and Mathematics & Statistics, the annual output roughly doubles from 2003 to 2013. For most of the other research fields, the annual growth of UA-EU28/AC co-publications is steady but rather low with yearly deviations and might be too low to be measured on a yearly basis.

[1] Salton's Measure is an indicator for the relevance of the co-publication relationship of Ukraine and partner countries

Out of the ten most involved EU28/AC partner countries, Germany has the highest share of co-publications in Chemistry (11.67%); Poland the highest share in Enabling & Strategic Technologies (10.87%) and Engineering (5.04%); Great Britain in Information & Communication Technologies (3.09%); Spain in Mathematics & Statistics (6.74%); Switzerland in Physics & Astronomy (67.71%); the Czech Republic in Biology (3.58%); and Sweden in Clinical Medicine (11.4%), Biomedical Research (8.01%), and Earth & Environmental Sciences (4.72%).

Ukrainian co-publications in the four priority areas in the observed years (2003-2013):

- **Aerospace & Aeronautics:** out of the 451 Ukrainian publications, 111 publications are international co-publications and nearly half of them, **46 co-publications, do involve authors affiliated in EU28/AC countries**. **Russia** and the **USA** are the main partner countries in this research area, **Italy**, **Great Britain**, **Germany**, **France**, **Denmark** and **Norway** are the EU28/AC countries most involved in Aerospace & Aeronautics co-publications with Ukraine with 10 or less co-publications. On the Ukrainian side, the National Academy of Science is the institution most involved in Aerospace & Aeronautics Ukraine-EU28/AC co-publications, followed by the National Taras Shevchenko University, the National Technical University of Ukraine, and the Yuzhonye State Design Office; on the EU28/AC side, the most involved organisations are the Technical University of Denmark, the University of Bergen, the Norwegian Mohn Sverdrup Center, and the Nansen Environmental & Remote Sensing Centre, both located in Bergen as well. Unmanned aerial vehicle, acoustic emission, mathematical model, fracture, and composite material are the most used keywords in Ukrainian Aerospace & Aeronautics publications; the Ukraine-EU28/AC co-publications in this field mention each keyword only once, which is why an analysis does not yield any usable results.
- **Biotechnology:** out of the 176 Ukrainian publications, 109 publications are international co-publications and three quarter of them (**82 co-publications**) **involve authors affiliated in the EU28/AC**. Compared to Aerospace & Aeronautics, the level of internationalisation in Biotechnology is much higher. **Poland** and **Israel** are the partner countries most involved in Ukraine's Biotechnology co-publications, followed by the **USA**, **Russia**, **Germany,** and **Great Britain**. The National Academy of Science is, once again, the Ukrainian institution most involved in Ukraine-EU28/AC Biotechnology co-publications, followed by the Ivan Franko National University in Lviv, the National Agricultural University in Kiev, the National University Mohyla Academy in Kiev, and the National Forestry University Ukraine in Lviv. On the EU28/AC side, the most involved institutions are the University of Haifa in Israel, the Rzeszow University in Poland, the University of Technology in Compiegne in France; and UCL in Great Britain. Medicinal Mushrooms, hansenula polymorpha, polysaccharides, and yeast are the most frequent entries of keywords both in Ukrainian Biotechnology publications and in Ukrainian-EU28/AC co-publications.
- **Nanoscience & Nanotechnology:** out of the 938 Ukrainian publications, 418 publications are international co-publications and nearly two thirds of them, **256 co-publications, are co-authored by authors affiliated in EU28/AC**. The **USA** and **Germany** are the most involved partner countries in Ukraine's Nanoscience & Nanotechnology co-publications, followed by **France**, **Russia**, **Great Britain,** and **Poland**. The National Academy of Science is, once more, the most involved Ukrainian Institution, followed by the Taras Shevchenko National University Kiev, the National Technical University in Kiev and Charkiw and the Chuiko Institute for Surface Chemistry in Kiev. On the EU28/AC side, CNRS in France is the most involved institution, followed by the German Technical University Ilmenau, the French University of Lyon, the British University of Brighton, and the Polish Academy of Sciences. Whereas carbon nanotubes, photoluminescence, fullerene, crystal structure, grapheme, magnetic field, activated carbon, and adsorption are the most frequently used author keywords for Ukraine's Nanoscience & Nanotechnology publications, the most frequently used author keywords for Ukraine's EU28/AC co-publications are slightly different, namely activated carbon, carbon nanotubes, photoluminescence, adsorption, magnetic nanoparticles, nanoparticles, raman spectroscopy, and laser radiation.
- **Information & Communication Technologies:** out of the 9,312 Ukrainian publications, 1,121 publications are international co-publications and more than half of them (**641 co-publications**) **involve authors affiliated in EU28/AC countries**. **Russia** and **Germany** are the partner countries most involved in Ukraine's ICT co-publications, followed by **France**, **USA**, **Great Britain**, and **Poland**. Not surprisingly, the National Academy of Science is the most involved Ukrainian Institution, followed by the National Aerospace University (KhAI), the Lviv National Polytechnical Institute, and the National Taras Shevchenko University in Kiev. On the EU28/AC side, the most involved institutions are the Finnish Tampere University of Technology, the French joint Institute IETR (University of Rennes I and CNRS), the German Technical

University Hamburg, the Dutch Delft University of Technology, and the Israeli Jerusalem College of Technology. The most frequently mentioned keywords of Ukraine's ICT publications are diffraction, neural networks, radar, mathematical model, antenna array, remote sensing and simulation, those of Ukraine's ICT co-publications with EU28/AC countries are rather different: neural networks, periodically correlated random processes, decomposition, support vector machines, genetic algorithm, electromagnetic fields, diffraction, optimisation, traveling salesman problem, combinatorial optimisation, and remote sensing.

Within the analysed time span of 2003 to 2013, the average citation of a publication involving at least one author from the Ukraine amounts to 3.7. Considering publications that were solely authored by authors from the Ukraine, this number is quite low: 1.39 times. It follows that works co-authored with at least one author from a foreign country are cited more often: **8.24 is the number of average citations for internationally co-authored works. Works co-authored with at least one author from EU28/AC are cited 9.48 times on average**, i.e. 15% more often than all international co-publications (again, on average).

Compared to the average citations of the overall Ukrainian co-publications in the research fields with the most co-publication output, the following countries show especially high average citation counts:

- Ukrainian co-publications in Clinical Medicine have an average citation of 16.1, Ukrainian-**Spanish** co-publications are cited 61.57 times on average, Ukrainian-**Italian** co-publications 55.81 times, Ukrainian-**Dutch** co-publications 48.93 times, Ukrainian-**Russian** co-publications 44.15 times and Ukrainian-**Belgian** co-publications 44.87 times.
- Ukrainian co-publications in Physics & Astronomy are cited 9.18 times on average, Ukrainian-**Finish** co-publications are cited 22.93 times on average, Ukrainian-**Canadian** co-publications 22.17 times, Ukrainian-**Swiss** co-publications 21.61 times and Ukrainian-**Belgian** co-publications 19.04 times.
- Ukrainian co-publications in Biomedical Research are cited 11.6 times on average, Ukrainian-**Swedish** co-publications are cited 33.74 times on average, Ukrainian-**French** co-publications 30.57 times, Ukrainian-**German** co-publications 25.9 times and Ukrainian-**Russian** co-publications 20.68 times.
- Ukrainian co-publications in Biology are cited 7.7 times on average, Ukrainian-**British** co-publications are cited 17.5 times on average and Ukainian-**German** 13.93 times.
- Ukrainian co-publications in Chemistry are cited 8.82 times on average, Ukrainian-**Italian** co-publications are cited 16.82 times on average and Ukrainian-**British** co-publications 16.31 times.
- Ukrainian co-publications in Enabling & Strategic Technologies are cited 6.2 times on average, Ukrainian-**British** co-publications are cited 12.52 times on average, Ukrainian-**Spanish** 10.71 times and Ukrainian-**Italian** 9.25 times.

**Conclusions.** Our analysis shows that Ukrainian scientific community still has not involved in the processes of internationalization to the degree, which corresponds to the size of the research potential of the country. The relatively low international visibility of Ukrainian science comes from several factors. One such factor is the high degree of separation of the Ukrainian research system from the international research community. Ukrainian researchers are not very active in international co-operation and in publishing in international journals, and the incentives for increasing the international visibility were poor in 1990s and 2000s. Situation has started to change in recent years. It is evident that in some areas Ukraine could contribute substantially into knowledge production processes and this contribution could be useful for the development of the European and the world science.

The country needs more active co-operation within the international R&D programs and more efforts from the side of the national state to stimulate participation of the Ukrainian scientists in such programs.

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