

# Scientific Cooperation in the Republics of Former Yugoslavia Before, During and After the Yugoslav Wars

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## Abstract

This paper presents an analysis of scientific research output of the republics of former Yugoslavia for the period 1970-2014. Thomson Reuters' Web of Science (WoS) database was used for data acquisition and 223 135 publications have been analyzed. The Yugoslav Wars were ethnic conflicts fought from 1991 to 1999 on the territory of former Yugoslavia, which accompanied the breakup of the country, and today, each republic of former Yugoslavia is an independent country, as well as the province of Kosovo. Results of the analysis are represented by four figures depicting cooperation networks between former Yugoslav republics and the province of Kosovo for the periods before the Yugoslav wars (from 1970 until 1990), during the wars (from 1991 until 1999), in the first decade after the wars (from 2000 until 2009), and in the last 5 years (from 2010 until 2014). The impact of the wars on scientific cooperation in the republics has been studied.

## Conference Topic

Country-level studies

## Introduction

The Socialist Federal Republic of Yugoslavia (SFRY) was established in 1946, after World War II. It was divided into six Republics (Serbia, Croatia, Slovenia, Bosnia & Herzegovina, Macedonia and Montenegro) and two autonomous provinces on the north and south of Serbia (Vojvodina and Kosovo). The Yugoslav Wars were ethnic conflicts fought from 1991 to 1999 on the territory of SFRY, which accompanied the breakup of the country. Today, each republic of former SFRY is an independent country. A Kosovo declaration of independence was adopted on 17 February 2008 by the Assembly of Kosovo, but the legality of this declaration have been disputed by the Serbian Government and other countries (e.g. the Russian Federation and China). This paper analyses the scientific cooperation in the republics of former SFRY and the province of Kosovo before, during and after the Yugoslav wars. The purpose of this analysis is to answer how the Yugoslav wars and social crises during and around those wars affected scientific productivity and scientific cooperation in these republics and whether this cooperation has recovered 15 years after the wars.

## Related work

Bibliometric analysis is a useful method for characterising scientific research (Moravcsik, 1985; Fu & Ho, 2013) and this method can be used for analysing scientific cooperation in different countries and regions (Leta & Chaimovich, 2002; Wagner & Leydesdorff, 2005; Ho et al., 2010). Citations of a publication are not a direct measure of quality and significance, but they reflect the visibility and impact of the publication on the scientific community (Furlan & Fehlings, 2006; Baltussen & Kindler, 2004). The number of times an article was cited correlates significantly with the number of authors and the number of institutions

involved in collaboration (Figg et al., 2006) and highly cited articles are usually authored by a large number of scientists, often involving international collaboration (Aksnes, 2003). Thus, scientific cooperation is important for the further development of world science and for the further economic development of a region or country.

The impact of social aspects, economic and social crises, political crises and wars on scientific cooperation in some regions has already been studied. For example, de Bruin and colleagues (1991) stated that the cooperation between the Gulf States and former western and eastern bloc has been strongly affected by political crises, which culminated in the Operation Desert Storm in 1990. There are also studies that deal with the countries of the former SFRY like Lewison and Igić (1999), Igić (2002), Lukenda (2006), Đukić et al. (2011) and Kutlača et al. (2015). Furthermore, Jovanović et al. (2010). analysed the publications and cooperation between the republics of former SFRY and the province of Kosovo is analyzed for the years from 1970 until 2007. The authors found that the Yugoslav wars had a severe impact on the cooperation networks of former SFRY republics. Furthermore, they also found that the process of recovery started with the ending of the conflicts, but that scientific cooperation recovered faster in some of those republics. The current paper revisits the data and methods of this study by analysing publications of former SFRY republics and the province of Kosovo from 1970 until 2014, thus broadly extending the database and improving the methodology. Thus, the purpose of this analysis is to answer whether scientific cooperation in all former SFRY republics is fully repaired 15 years after the Yugoslav wars or whether the interpretation of the findings of the 2010 study has to be reformulated.

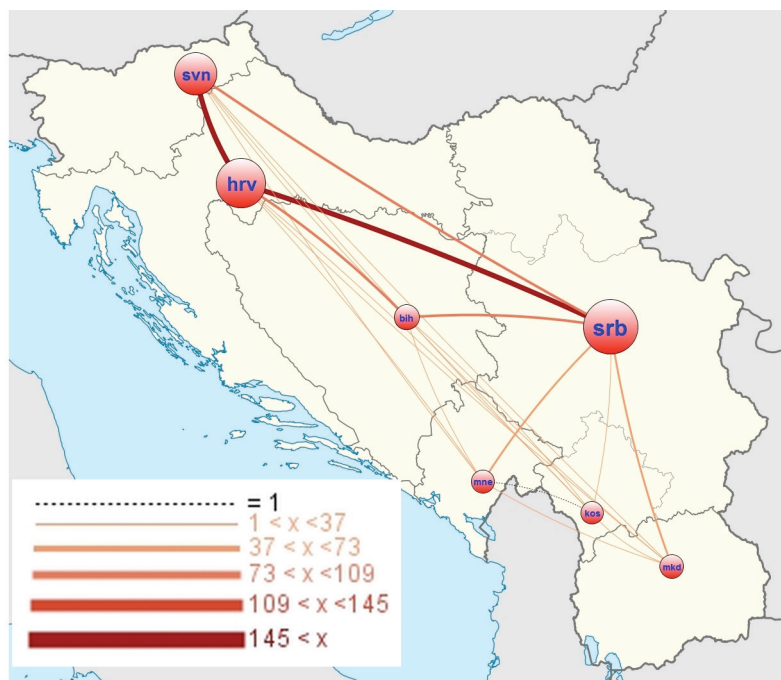
## **Methodology**

Similar to the 2010 study, Thomson Reuters' Web of Science (WoS) database was used for data acquisition. This time, however, the Arts & Humanities Citation Index Expanded was not covered, because the authors' institutions did not have access. But in addition to the Science Citation Index Expanded (SCIE) and the Social Science Citation Index (SSCI) (which were also used in 2010), both conference proceedings citation indexes (Science and Social Sciences) were covered by the search queries. This was done in order to get a more complete coverage of the publication output of the former Yugoslav countries. Again similar to 2010, the search queries consisted of the names of cities from the former Yugoslav countries, since before 1990 all successor states belonged to SFRY. In 2010, a total of 133 city and town names were used in the search queries (including synonyms of city names). For the current study, we also used search queries that consisted of the country names (Yugoslavia and all successor states) in order to find city and town names (and synonyms), which were missing in our city search queries. In addition to that, the maximum number of 50 search arguments in WoS (still existing in 2010) is no longer limited which meant that we were able to use much longer search queries for the current study. Because of this, the new search query included 769 city and town names along with synonyms, misspellings etc. This has led to a much broader database and a better allocation of publications to their respective states, in comparison to the data used in 2010. In 2010, the data set consisted of 103 963 publications (for the years 1970 to 2007), the current study has 121 602 publications for this time period (20% more) plus 101 533 publications for the years 2008 to 2014, which brings the complete data set to a total of 223 135 publications. We rechecked whether these publications were all from the correct countries by using WoS exclude tool and removing all publications from the seven Yugoslav successor states. The remaining publications consisted of around 1% of the total data set and manual checks of these publications have shown that most of these were still relevant but wrongly indexed (for example publications from Kosovo which were attributed to Albania). This leads us to believe that our data set includes all publications from the former SFRY, which can be found in the WoS.

We analysed the data set using a proprietary bibliometry toolbox (programmed at Fraunhofer INT) and the following measures and method: (1) Absolute number of publications for each state (2) Absolute number of cooperation for each state and (3) Visualization of the Yugoslav cooperation network. In our future studies, we will add measures like Salton's measure and others.

## Results

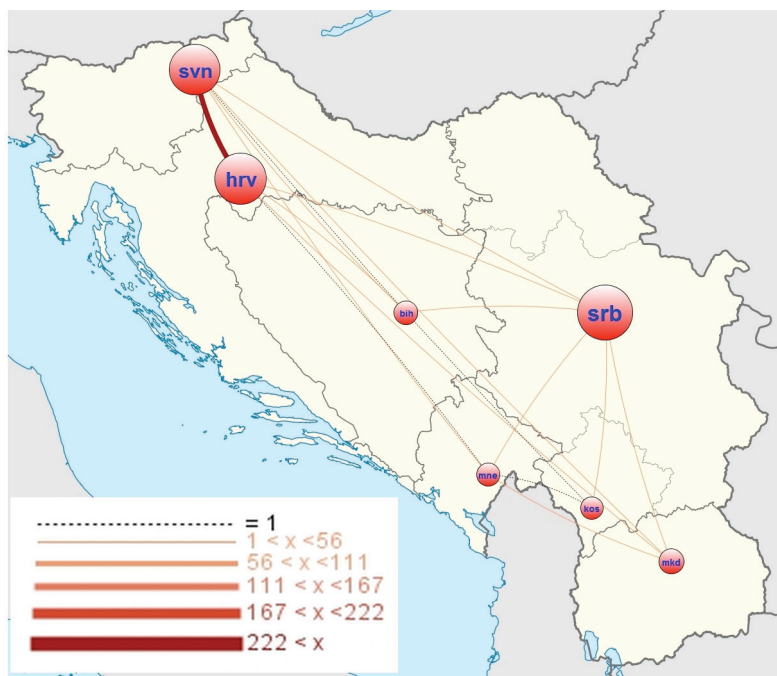
Results of the analysis are represented by four figures depicting cooperation networks between former Yugoslav republics and the province of Kosovo for the periods before the Yugoslav wars (from 1970 until 1990), during the wars (from 1991 until 1999), in the first decade after the wars (from 2000 until 2009), and in the last 5 years (from 2010 until 2014). Each republic's and the province of Kosovo's publications indexed by WoS have been represented in figures by a circle which size is proportional with the number of publications published by researchers from each respective republic. Lines between those circles represent cooperation of researchers in writing publications and line thickness is proportional with the number of collaborative publications of researchers from two republics whose circles are connected by the line. A cooperation was counted whenever more than one institution that published a paper was located on the territory of the former Yugoslavia and these institutions were not from the same republic. Cooperation between three or more republics are quite rare. These were enumerated as a set of multiple bilateral cooperation.



**Figure 1. Visualisation of the cooperation network for 1970-1990 (before Yugoslav wars).**

Figure 1 depicts the cooperation network for the period before the Yugoslav wars. Researchers from Serbia published the highest number of publications before the wars, followed by researchers from Croatia. Those two republics were the most productive republics and cooperated the most in former Yugoslavia. Slovenia, according to the productivity of its researchers and to the cooperation in this period, was in the middle between the groups of “big” republics by scientific productivity (Serbia and Croatia) and the group of “small” republics (Bosnia and Herzegovina, Macedonia, Montenegro and the province of Kosovo). Before the war, the most productive “small” republic was Bosnia and Herzegovina.

The Yugoslav wars started in 1991 and they led to a strong decrease of scientific cooperation in the republics in the 90's. Also, it affected the ratio of scientific productivity between republics during the wars. Figure 2 depicts the cooperation network for the period 1991-1999 which is the period of Yugoslav wars. Before the wars, Serbia was cooperating strongly with Croatia, Slovenia and Bosnia and Herzegovina. The cooperation triangle between Serbia, Croatia and Slovenia almost disappeared in the 90's, as well as the cooperation triangle between Serbia, Croatia and Bosnia and Herzegovina. However, scientific cooperation between Croatia and Slovenia was strengthened in this period. The reason for that is the fact that the conflict between Serbia, Croatia and Bosnia and Herzegovina during the wars was much stronger than the conflict between Croatia and Slovenia. Also, effects of the wars were much less on Slovenian economy than on the economies of other republics. War in Slovenia ended after ten days in 1991. Also, Macedonia remained at peace throughout the Yugoslav wars and declared its independence in September of 1991. Thus, the ratio of scientific productivity of Slovenian and Macedonian researchers in comparison to the other republics had been changed in favour of Slovenia and Macedonia. In this period and in the followings periods Slovenia became a member of the group of "big" republics.

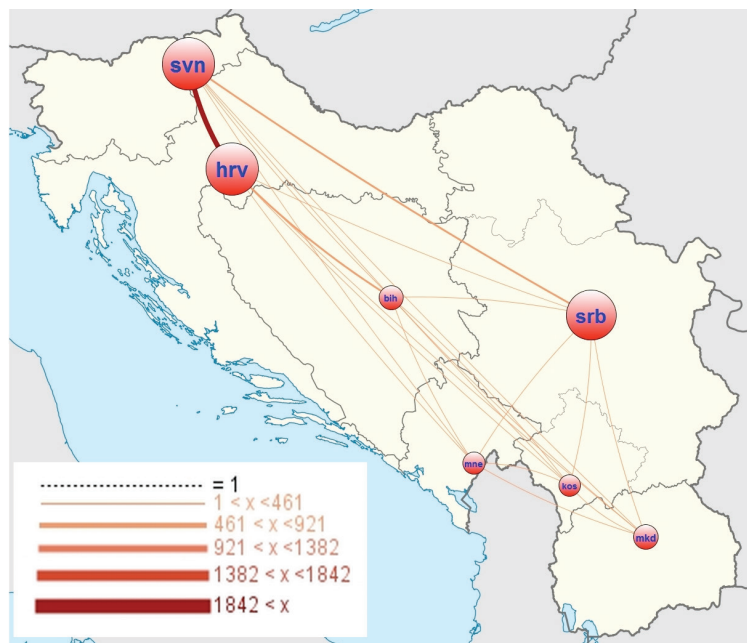


**Figure 2. Visualisation of the cooperation network for 1991-1999 (during Yugoslav wars).**

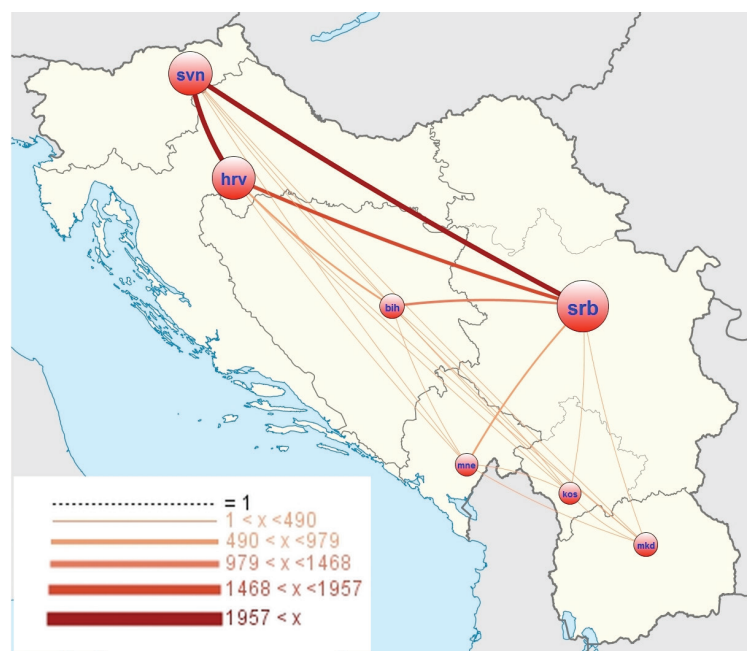
Figure 3 depicts the cooperation network for the period 2000-2009 which is the first decade after the Yugoslav wars. Scientific cooperation in this period between Serbia and Slovenia was strengthened again. The cooperation triangle between Serbia, Croatia and Slovenia was not as strong as before the wars (taking into account that the overall publication output increased), but it seems as if this cooperation triangle was resurfacing again.

Figure 4 depicts the cooperation network for the period 2009-2014. In this period Serbia has returned to having the most publications as before the Yugoslav wars. Reasons for this include introduction of a new rulebook for evaluation prescribed by the Ministry of Education, Science and Technological Development of the Republic of Serbia in 2008. That rulebook requires researchers must have articles published in journals in the Web of Science database for the promotion to scientific positions. In addition, the increase in the number of publications was influenced by the fact that several journals based in Serbia have, in recent years, started to be indexed by Web of Science: e. g. Vojnosanitetski Pregled, Archives of

Biological Sciences, Srpski Arhiv Za Celokupno Lekarstvo, Journal of the Serbian Chemical Society, etc. Those journals published a considerable number of articles written by Serbian researchers in the period 2010-2014 (Ivanović and Ho, 2014). The strengthening of the cooperation triangle between Serbia, Croatia and Slovenia started in the period 2000-2009 continues in the last five years. We conclude that this triangle is fully recovered.



**Figure 3. Visualisation of the cooperation network for 2000-2009 (1<sup>st</sup> decade after Yugoslav wars).**



**Figure 4. Visualisation of the cooperation network for 2010-2014.**

## Conclusion

The analysis of scientific-research outputs of the republics of former Yugoslavia for the period 1970-2014 has been presented in this paper. It reveals that civil Yugoslav wars affected the republics' productivities and scientific cooperation in different ways. The most



affected republics by wars and social crisis were Serbia and Bosnia and Herzegovina, while the least affected republics were Slovenia and Macedonia. However, it seems that in the last five years productivity and scientific cooperation look similar as before the Yugoslav wars. This result strengthens the results from the 2010 study. It would seem that old cooperation networks, which were disrupted during the Yugoslav wars, are in place again. However, our data cannot answer the question whether these are the same networks as before (i. e. the same researchers and/or institutions that are cooperating again) or whether new ones have taken the place of the old ones.

The presented results are the first part of our research. We are going to extend our research with following measures and methods: relative number of publications for each state and normalized cooperation score  $R_i^{(cs)}$  (as described in Jovanović et al. (2010). Also, we are going to analyse the distribution of collaborative articles per the biggest Universities based in these states.

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