Interdisciplinary Description of Complex Systems 11(2), 174-189, 2013

SCIENTIFIC PRODUCTIVITY IN TRANSITION COUNTRIES: TRENDS AND OBSTACLES

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DOI: 10.7906/indecs.11.2.1
Regular article

Received: 28 March 2013.
Accepted: 14 April 2013.

ABSTRACT

Scientific productivity is one of the engines of development in the 21st century. The most common way of its measurement is through publication in peer-review articles. Current research indicates that there is a strong connection between country's development and its share in the world publication of scientific articles. Transition countries are still catching-up with the most developed countries in terms of scientific productivity, which is especially evident in Western Balkan countries. As one of the rare attempts to assess obstacles to scientific productivity in transition countries, this study investigates different factors and their effects to the scientific productivity. The obstacles are the results of the historical reasons, inadequate systems for advancement in the scientific community, and problems with the development and/or implementation of strategies for scientific development of the particular country. In addition, without efficient measurement of scientific productivity, it is hard to analyse its behaviour. Papers written by authors from transition countries are often published in local journals that are covered insufficiently by the Web of Science. Therefore, up-to-date systems for tracking scientific publications in transition countries are of the highest importance.

KEY WORDS

scientific productivity, transition countries, obstacles, science, Web of Science

CLASSIFICATION

APA: 2960
JEL: O32, O38

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INTRODUCTION

Scientific productivity can be measured in different ways, among which the most common is to analyse the number of publications and citations of published papers – although "citation data provide only a limited and incomplete view of research quality" [1]. Such analyses are usually based on data from the Web of Science database since it covers more than 12 000 journals from all over the world and all fields of science (about 250 disciplines). Although this database does not include a large number of scientific journals, especially those not published in English and those who are more focused on national issues, it includes research publications relevant to the international level because of their "high standards of selectivity" [2], and is therefore the starting point for various analyses. Analysis based on the number of publications in Web of Science database could be extended with a variety of factors such as GERD (Gross domestic expenditure on R&D), and the number of researchers or residents in order to obtain comparable data for countries that differ in population size or level of wealth.

Scientific production is influenced by various factors that can encourage or discourage it. The most important of these factors are: (i) the system of research funding, (ii) patents, (iii) international collaboration and (iv) professional promotion system. Transition in countries of Central and Eastern Europe that began in the late 1980s was, according to some authors, "the largest natural experiment ever" [3]. The transition has, aside from the economy and politics, engulfed other social spheres such as science and research. Transformation of research (in general) in transition resulted in a reduction of institutional and financial resources of science, resulting with general backwardness in scientific and technological development [4], thus making the path to becoming a "knowledge society" significantly more difficult [5]. The transformation of the research systems also affected scientific productivity: in most countries, especially in the first few years of transition, a decline in the quantity and quality of scientific papers occurred. In our paper we shall concentrate on the causes of the fall in productivity.

In addition, research production in small countries is poorly monitored in international databases [6]. The main causes for this are the language barrier and a small scientific community, which means fewer scientists and fewer quality reviewers for local journals and this, in turn, results in lower overall quality of papers published in journals. Therefore, small countries cannot rely on international databases to gather information about their scientific productivity.

Based on the above points, we define following goals of the paper: (1) to compare the diversity of scientific productivity across countries, (2) to define obstacles to increase scientific productivity, (3) to identify obstacles to scientific productivity in transition countries, and (4) to evaluate bibliographic database usage in transition countries.

SCIENTIFIC PRODUCTIVITY AND ITS DIVERSITY ACROSS COUNTRIES

In this section, we focus on the quantitative analysis of the reported number of papers indexed in Web of Science. The qualitative analysis, which aside from the number of papers also includes citations, will be presented in the second part of this part of the paper.

In the analysis conducted for the year 2011 (shown in Table 1) we included all paper types indexed in Web of Science (article, meeting abstract, and proceedings paper). We covered 34 countries to display the characteristics of scientific production in different parts of the world. The majority of the countries included are among the most economically and scientifically advanced countries of the world: 16 countries of Western Europe, USA, Canada, Australia and Japan. We included 7 former communist countries and also the countries that are on a good way to become a scientific superpower (China and India). From Asia and Africa we listed Israel and South Africa.

Table 1. Published papers in selected countries in 2011, dased on data from Web of Science and Eurostat.

Country	Number of papers	% world	Number of papers per number of researchers (FTE)	Number of papers per population, mil	GERD per number of papers, mil €	Research area (percentage)	Country most collaborated with (percentage)
United States	509 958	28,64	0,36	1 636	0,56	Chemistry (7,34 %)	China (3,80 %)
China	172 439	9,68	0,08	127	0,35	Chemistry (19,20 %)	USA (11,27 %)
United Kingdom	141 477	7,95		2 316	0,22	Physics (5,51 %)	USA (14,50 %)
Germany	119 295	6,70	0,36	1 433	0,62	Physics (11,64 %)	USA (14,20 %)
Japan	91 515	5,14	0,14	723	1,33	Physics (13,11 %)	USA (9,23 %)
France	81 197	4,56	0,34	1 285	0,55	Physics (11,53 %)	USA (13,63 %)
Canada	74 943	4,20	0,31	2 232	0,00	Engineering (8,02 %)	USA (21,98 %)
Italy	69 454	3,90	0,65	1 182	0,28	Physics (8,76 %)	USA (13,94 %)
Spain	61 345	3,44	0,47	1 361	0,23	Chemistry (10,52 %)	USA (11,70 %)
Australia	56 905	3,19	0,41	2 584	0,00	Engineering (6,45 %)	USA (14,30 %)
India	51 707	2,90	0,13	43	0,00	Chemistry (18,49 %)	USA (7,18 %)
South Korea	51 116	2,87	0,15	1 046	0,56	Chemistry (14,21 %)	USA (14,65 %)
Netherlands	42 474	2,39	0,79	2 604	0,29	Neurosciences neurology (6,11 %)	USA (16,15 %)
Brazil	41 188	2,31	0,16	211	0,00	Agriculture (8,48 %)	USA (10,44 %)
Russia	31 261	1,76	0,04	220	0,48	Physics (26,22 %)	Germany (8,83 %)
Switzerland	30 284	1,70	0,49	4 038	0,34	Physics (10,32 %)	USA (20,64 %)
Sweden	25 464	1,43	0,56	2 801	0,51	Physics (8,21 %)	USA (16,89 %)
Poland	23 502	1,32	0,37	609	0,12	Chemistry (13,44 %)	USA (9,23 %)
Belgium	23 130	1,30	0,57	2 103	0,33	Physics (7,79 %)	USA (15,28 %)
Denmark	16 283	0,91	0,43	2 929	0,46	Chemistry (6,54 %)	USA (16,92 %)
Austria	16 232	0,91	0,44	1 989	0,51	Physics (9,27 %)	Germany (24,56 %)
Israel	14 840	0,83		1 955	0,00	Physics (8,96 %)	USA (35,75 %)
Greece	13 385	0,75	0,64	1 258	0,10	Engineering (9,46 %)	USA (13,89 %)
Portugal	12 868	0,72	0,27	1 237	0,20	Chemistry (11,54 %)	Spain (13,10 %)
Norway	12 457	0,70	0,34	2 486	0,48	Engineering (7,40 %)	USA (15,69 %)
Finland	12 193	0,68	0,30	2 368	0,59	Physics (8,86 %)	USA (15,25 %)
Singapore	11 306	0,63	0,31	2 113	0,00	Engineering (16,61 %)	USA (17,52 %)
South Africa	11 079	0,62	0,36	214	0,00	Chemistry, Plant sciences (6,00 %)	USA (16,47 %)
Ireland	9 895	0,56	0,64	2 339	0,28	Chemistry (7,68 %)	North Ireland (23,57 %)
Romania	7 853	0,44	0,49	362	0,08	Physics (15,23 %)	France (8,04 %)
Serbia	5 228	0,29	0,29	734	0,00	Engineering (12,68 %)	USA (7,08 %)
Croatia	4 392	0,25	0,64	991	0,08	Chemistry (8,33 %)	USA (9,75 %)
Slovenia	4 220	0,24	0,48	2 059	0,21	Engineering (11,89 %)	USA (9,97 %)
Bulgaria	2 482	0,14	0,21	326	0,09	Chemistry (15,26 %)	Germany (17,03 %)

The country with the largest number of papers is the USA with 28,64 % of the global scientific production. The comparison made by May [7] on a sample of 31 countries over the period 1981 to 1994 has shown that the five largest global economies were also the five countries with the largest number of papers (U.S.A. 34,6 %, UK 8 %, Japan 7,3 %, Germany had 7 % and France 5,2 % of total world production). These five countries were again in the top by the number of papers in 2011. However, the largest newcomer is China which is in the second position with 9,78 % of global production, which is, among other things, the result of strong government investment in research and development [8]. In the same time, the biggest drop in the number of papers in relation to the first half of the ‘80s and ‘90s occurred in the United States – from 34,6 % to 28,64 %. On the other side, drop in other countries it is relatively small (between 1 and 2 % in respect to the period from 1981 to 1994). The only country of the top 7 in the period from 1981 to 1994 that had an increase in publications in 2011 is Italy – its share rose from 2,7 % to 3,9 % of the world production.

The ratio of number of papers and number of researchers in full time equivalents (FTE) can give a more realistic picture of productivity than the total number of papers per country. Such approach avoids the bias created by the size of the country since, as a rule, larger countries publish a bigger number of papers. This perspective shows that the best results are achieved mainly by smaller European countries – most papers were published by the Netherlands (0,79 per researcher), Ireland, Greece and Croatia (0,64), Sweden (0,59) and Belgium (0,57). To obtain leading positions in this ranking is a dubious success, since many researchers in economically developed countries are working in the industry producing applied research, and their research efforts mostly will not result with published.

Comparison among the countries can also be made by looking at the number of papers per million inhabitants. Here the smallest proportion has the most populous countries like India and China, and the largest proportion have Switzerland and the Scandinavian countries which are relatively small countries with a large number of papers.

Alternative way to assess productivity is the ratio of governmental expenses for research and development (GERD) and the number of papers. Papers with the smallest budget are produced by poorer countries with low GERD and with a small investment in science and research, such as Croatia, Romania and Bulgaria (Table 1). One should take into account that certain countries focus more on specific areas and consequently publish a larger number of papers in these research areas. Such examples are Denmark, Sweden and Switzerland that are focused on biomedicine, while Asian countries are more focused on engineering, computer science and chemistry [7]. This focus also affects the budget of published papers because some areas of science are associated with high costs. For example, a paper in biomedicine, which includes lab work, will be more expensive to produce than, a paper in philosophy.

Research areas in which analysed countries published most papers were physics, chemistry and engineering, which is not surprising since in 2011 the largest number of papers in general were published in those categories (9,463 % in Chemistry, 7,701 % in Engineering and 7,317 % in Physics). The only surprise is Brazil with most papers (8,47 %) published in agriculture, an area in which only 1,793 % papers were published in total.

An increasing number of papers involve international collaboration. May [7] states that, for example, in 1994 only 26 % of papers whose first authors were from the UK were the result of international cooperation and today these figures are much higher. The country with which the majority of countries in this analysis had collaborated most intensively (by number of publications) were the United States, and only few countries most intensively worked mainly with geographically close countries (e.g. Austria with Germany, Portugal with Spain, and Ireland with Northern Ireland).

SCIENTIFIC PRODUCTIVITY OF TRANSITION COUNTRIES

Term transition countries refer to those countries that experienced change from the socialism to the capitalism in the early ‘90s [3], and it influenced not only economy and politics, but also science and research. Funding for the scientific research in most of the countries decreased, which resulted also in decrease of scientific publications [4]. In the following analysis we shall concentrate on the trends in the fall in productivity. First, we shall analyse the scientific productivity of selected EU countries and Central European transition countries. Second, we shall focus to selected Western Balkan countries and Russia.

Citation analysis of selected EU and Central European transitional countries for 1981-1988, 1989-96, 1997-2004 and 2005-2012 is presented in Table 2, and is based on an analysis conducted by Kutlača [9], complemented by the latest data on papers and citations from the database Web of Science. The two periods (1981-1988 and 1989-1996) were initially studied by Kutlača, and are supplemented in this paper with two additional periods (1997-2004 and 2005-2012).

Table 2 reveals following conclusions for the number of papers in Web of Science that are cited. If we compare the percentage of cited papers from the first transition period (1989-1996) and the pre-transition period, it is obvious that Poland has the lowest growth but differences in growth among countries are not very large. Considering the number of citations in all three periods comparisons, biggest growth is seen in Romania, which had significantly lower scores than other countries in the pre-transition period. All transitional countries show a rise in the number of papers, except in the first period of transition, although it is far lower than the rise in Spain and Portugal, where the number of papers published in the period of twenty years has increased by more than 7 times. Among former communist countries, in the pre-transition period best results are seen in Poland – the percentage of cited papers (74,32 %) are almost equal to Finland (75,72 %). In other categories, such as the number of citations and the number of papers, Poland also shows better results than other post-communist countries which is, partly, probably due to the fact that Poland has the largest population of all four countries (Figure 1).

In order to assess the scientific productivity of selected Western Balkan countries (mostly former Yugoslavian countries) and Russia, we firstly examined the number of papers published per year (Table 3). When analysing the data, it should be taken into account that the first period was affected by the war between Croatia, Bosnia and Herzegovina and Serbia and Montenegro, and that the second period was affected by the war between Kosovo Albanians and Serbia and military conflict between Macedonians and Albanians in Macedonia.

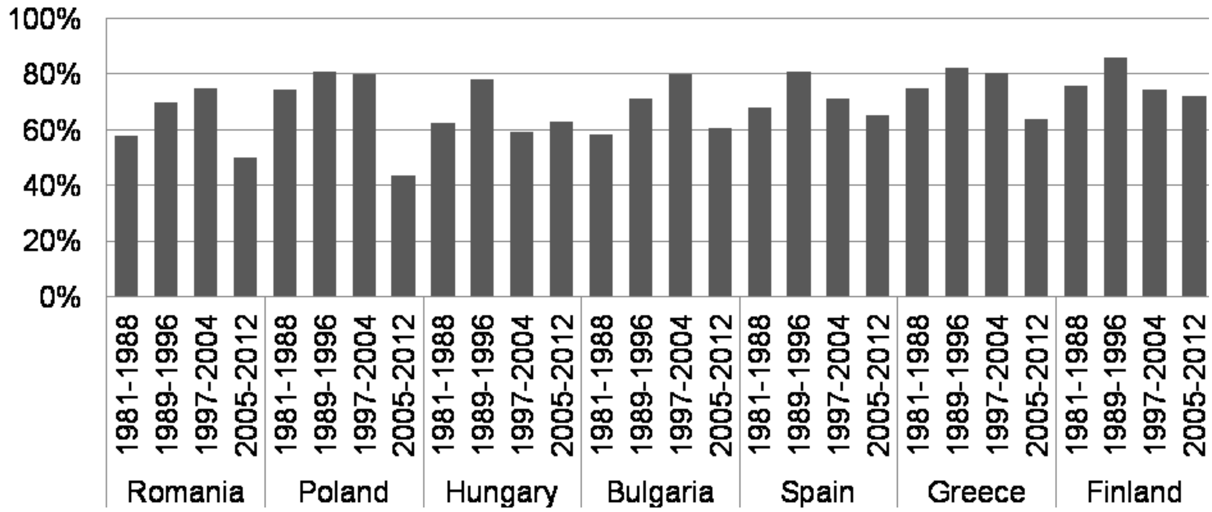

Figure 1. Percentage of papers in Web of Science that are cited of selected EU and Central European transitional countries for 1981-1988, 1989-96, 1997-2004 and 2005-2012 [9].

Table 2. Citation analysis of selected EU and Central European transitional countries for 1981-1988, 1989-96, 1997-2004 and 2005-2012 [9].

Period	Country	# of papers in WoS	Share of papers in WoS	# of cited papers	% cited papers	# of citations	Impact[(1)]	World-total number of papers in WoS
P1: 1981-1988	Finland	33 391	0,48%	25.285	75,72%	575 699	17,24	6 977 991
	Greece	13 314	0,19%	9.998	75,09%	137 280	10,31	
	Spain	56 784	0,81%	38.704	68,16%	559 153	9,85	
	Bulgaria	11 531	0,17%	6.746	58,50%	62 569	5,43	
	Hungary	29 108	0,42%	18.207	62,55%	250 098	8,59	
	Poland	45 244	0,65%	33.625	74,32%	395 403	8,74	
	Romania	8 713	0,12%	5.057	58,04%	42 484	4,88	
P2: 1989-1996	Finland	44 727	0,58%	38.514	86,11%	1120 642	25,06	7 748 178
	Greece	24 701	0,32%	20.297	82,17%	374 227	15,15	
	Spain	121 882	1,57%	98.476	80,80%	1989 284	16,32	
	Bulgaria	13 238	0,17%	9.430	71,23%	111 510	8,42	
	Hungary	26 928	0,35%	21.011	78,03%	157 682	5,86	
	Poland	54 759	0,71%	44.357	81,00%	657 610	12,01	
	Romania	8 446	0,11%	5.899	69,84%	63 229	7,49	
P3: 1997-2004	Finland	70 140	0,72%	52.160	74,37%	1560 972	22,26	9 760 789
	Greece	52 260	0,54%	42.035	80,43%	817 756	15,65	
	Spain	225 415	2,31%	160.973	71,41%	3 783 321	16,78	
	Bulgaria	13 913	0,14%	11.154	80,17%	161 993	11,64	
	Hungary	39 479	0,40%	23.363	59,18%	489 436	12,4	
	Poland	95 668	0,98%	76.670	80,14%	1214 467	12,69	
	Romania	17 399	0,18%	13.032	74,90%	175 152	10,07	
P4: 2005-2012	Finland	90 874	0,69%	65.510	72,09%	923 806	10,17	13 092 930
	Greece	101 930	0,78%	65.318	64,08%	707 999	6,95	
	Spain	413 361	3,16%	269.781	65,27%	3264 489	7,9	
	Bulgaria	19 375	0,15%	11.707	60,42%	109 651	5,66	
	Hungary	54 597	0,42%	34.278	62,78%	401 540	7,35	
	Poland	168 696	1,29%	73.548	43,60%	905 867	5,37	
	Romania	49 307	0,38%	24.725	50,15%	174 629	3,54	
Index P2/P1	Finland	1,34	1,21	1,52	1,14	1,95	1,45	1,11
	Greece	1,86	1,67	2,03	1,09	2,73	1,47	
	Spain	2,15	1,93	2,54	1,19	3,56	1,66	
	Bulgaria	1,15	1,03	1,4	1,22	1,78	1,55	
	Hungary	0,93	0,83	1,15	1,25	0,63	0,68	
	Poland	1,21	1,09	1,32	1,09	1,66	1,37	
	Romania	0,97	0,87	1,17	1,2	12,5	12,9	
Index P3/P1	Finland	2,1	1,5	2,06	0,98	2,71	1,29	1,40
	Greece	3,93	2,81	4,2	1,07	5,96	1,52	
	Spain	3,97	2,84	4,16	1,05	6,77	1,7	
	Bulgaria	1,21	0,86	1,65	1,37	2,59	2,15	
	Hungary	1,36	0,97	1,28	0,95	1,96	1,44	
	Poland	2,11	1,51	2,28	1,08	3,07	1,45	
	Romania	2	1,43	2,58	1,29	34,64	17,34	
Index P4/P1	Finland	2,72	1,45	2,59	0,95	1,6	0,59	1,88
	Greece	7,66	4,08	6,53	0,85	5,16	0,67	
	Spain	7,28	3,88	6,97	0,96	5,84	0,8	
	Bulgaria	1,68	0,9	1,74	1,03	1,75	1,04	
	Hungary	1,88	1	1,88	1	1,61	0,86	
	Poland	3,73	1,99	2,19	0,59	2,29	0,61	
	Romania	5,66	3,02	4,89	0,86	34,53	6,1	

[(1)]Impact is number of citations divided by number of papers.

Table 3. Number of published papers per year for countries of selected Western Balkan Countries and Russia, from 1993 to 2010. Source: Web of Science.

Year	Croatia	Bosnia and Herzegovina	Slovenia	Macedonia	Albania	Yugoslavia/Serbia			Russia
							Kosovo	Montenegro	
1993	931	28	693	62	29	837			25 830
1994	904	28	837	60	44	854			26 671
1995	1085	24	887	82	41	979			28 317
1996	1164	30	1010	94	49	1232			28 848
1997	1148	27	1189	109	37	1146			29 854
1998	1315	29	1201	116	42	1564			29 408
1993-1998	**6 547**	**166**	**5 817**	**523**	**242**	**6 612**			**168 928**
1999	1379	37	1457	115	40	1285			29 020
2000	1451	35	1723	156	40	1219			28 962
2001	1466	61	1708	153	32	1175			26 884
2002	1606	61	1849	171	58	1335			27 809
2003	1731	75	2 017	156	52	1428			26 758
2004	1975	98	2 120	203	45	1948			27 276
1999-2004	**9 608**	**367**	**10 874**	**954**	**267**	**8 390**			**166 709**
2005	2 262	139	2 398	216	68	2.223			27 125
2006	2 427	165	2 490	281	81	2 315		55	26 576
2007	2 994	365	3 070	309	101	3 025		77	28 018
2008	3 586	427	3 597	364	113	3 608	24	125	30 257
2009	4 073	469	3 678	390	133	4 247	21	140	30 743
2010	4 131	601	3 812	437	188	4 798	43	174	30 086
2005-2010	**19 473**	**2 166**	**19 045**	**1.997**	**684**	**20 216**	**88**	**571**	**172 805**
1993-2010	**35 628**	**2 699**	**35 736**	**3.474**	**1.193**	**35 218**	**88**	**571**	**508 442**

During the observed period of 18 years, Croatia and Slovenia show a continuous increase in the number of papers. Serbia (together with Montenegro) showed continued growth until 1998, which was followed by a 5 year period of stagnation. In Russia, the situation is even more serious – a stagnation period lasted from 1997 up until 2008. Looking at the three most developed countries of former Yugoslavia (Slovenia, Croatia and Serbia), we notice that in the period of 1993-2010 years all three countries published a roughly similar number of papers (about 35 000). If we consider the ratio of papers and population size, Slovenia would have the best result since Slovenia's population is about half of Croatia, and Croatia's is almost half as large as Serbia's. However, the analysis will be more accurate when we take quality into account, which is presented through a number of citations and cited papers (Table 4).

In Table 4, we have also used Kutlača's [9] approach, but we have changed the structure of the periods observed, since Web of Science does not distinguish papers published in selected Western Balkan countries (mostly former Yugoslavian countries) and Russia before 1993. Thus, we looked at three periods: 1993-1998, 1999-2004 and 2005-2010.

Comparing the two later periods with the first transition period, almost all countries had continuous growth in the number of citations and papers - with the exception of countries that started with modest results (e.g. Bosnia and Herzegovina). In the second, but especially the third period, the largest increase in the number of papers and citations occured in Slovenia. Russia showed a significant decline in the third period, especially in the number of citations which has decreased by almost a third from the second to the third period, regardless of the number of published papers being approximately the same.

Former Yugoslavia, consisting of Serbia, Montenegro and Kosovo in the 1990s, had the largest production in the first transition period, while Croatia's production was slightly smaller.

Table 4. Citation analysis of selected Western-Balkan transitional countries and Russia in 1993-1998, 1999-2004, and 2005-2010. Source: Web of Science.

Period	Country	Number of papers in WoS	Share of papers in WoS, %	Number of cited papers	Cited papers, %	Number of citations	Impact[(1)]
P1:1993-1998	Croatia	6 547	0,10	5.156	78,75	73 128	11,17
	Bosnia and Herzegovina	166	0,00	121	72,89	1743	10,50
	Slovenia	5 817	0,09	4.665	80,20	86 310	14,84
	Macedonia	523	0,01	362	69,22	6 059	11,59
	Albania	242	0,00	181	74,79	2 210	9,13
	Federal republic of Yugoslavia	6 612	0,10	4.708	71,20	56 726	8,58
	Russia	168 930	2,59	104.602	61,92	1276 478	7,56
P2:1999-2004	Croatia	9 608	0,13	7.400	77,02	101 961	10,61
	Bosnia and Herzegovina	367	0,00	239	65,12	3 884	10,58
	Slovenia	10 874	0,15	8.863	81,51	151 128	13,90
	Macedonia	954	0,01	615	64,47	7 942	8,32
	Albania	267	0,00	190	71,16	2 561	9,59
	Federal republic of Yugoslavia/ Serbia and Montenegro	8 390	0,11	5.955	70,98	70197	8,37
	Russia	166 707	2,24	113.928	68,34	1448 673	8,69
P3:2005-2010	Croatia	19 473	0,20	12.237	62,84	116 825	6,00
	Bosnia and Herzegovina	2 168	0,02	1.087	50,14	7 670	3,54
	Slovenia	19 045	0,20	13.865	72,80	153 627	8,07
	Macedonia	1 997	0,02	882	44,17	7 471	3,74
	Albania	684	0,01	252	36,84	2 129	3,11
	Serbia and Montenegro/Serbia/ Montenegro/Kosovo	20 227	0,21	12.663	62,60	99 690	4,93
	Russia	172 805	1,81	108.011	62,50	919 279	5,32
Index P2/P1	Croatia	1,47	1,28	1,44	0,98	1,39	0,95
	Bosnia and Herzegovina	2,21	1,93	1,98	0,89	2,23	1,01
	Slovenia	1,87	1,64	1,9	1,02	1,75	0,94
	Macedonia	1,82	1,6	1,7	0,93	1,31	0,72
	Albania	1,10	0,97	1,05	0,95	1,16	1,05
	Federal republic of Yugoslavia/ Serbia and Montenegro	1,27	1,11	1,26	0,99	1,24	0,98
	Russia	0,99	0,86	1,09	1,10	1,13	1,15
Index P3/P1	Croatia	2,97	2,03	2,37	0,80	1,6	0,54
	Bosnia and Herzegovina	13,06	8,9	8,98	0,69	4,4	0,34
	Slovenia	3,27	2,23	2,97	0,91	1,78	0,54
	Macedonia	3,82	2,6	2,44	0,64	1,23	0,32
	Albania	2,83	1,93	1,39	0,49	0,96	0,34
	Serbia and Montenegro/Serbia/ Montenegro/Kosovo	3,06	2,08	2,69	0,88	1,76	0,57
	Russia	1,02	0,7	1,03	1,01	0,72	0,71

[(1)]Impact is number of citations divided by number of papers

However, despite the small number of papers, Slovenia had the largest number of citations (Figure 2). In the second period, Slovenia published the highest number of papers and also had the largest number of citations. It is interesting that Slovenia has 80 000 citations more than Yugoslavia but only 2 500 more published papers. In the third period, Serbia had again published the largest number of papers, but Slovenia had 54 000 more citations than Serbia, even though its researchers published 1000 papers less.

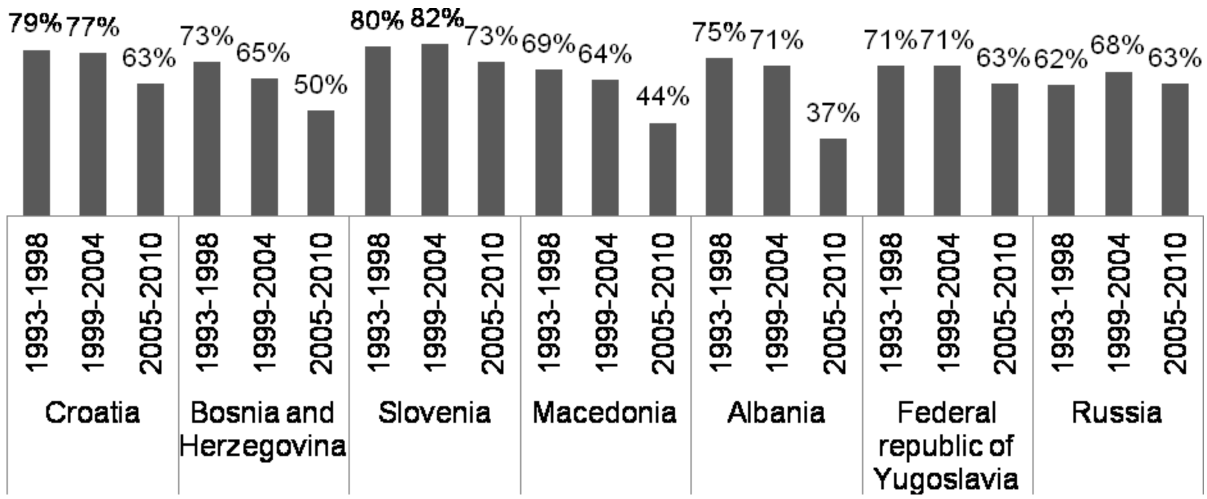

Figure 2. Percentage of papers in Web of Science that are cited or of selected Western-Balkan transitional countries and Russia during 1993-1998, 1999-2004, and 2005-2010. Source: Web of Science.

OBSTACLES TO DEVELOPMENT OF SCIENTIFIC PRODUCTIVITY

Economic development of a given country that has the strongest impact on the scientific productivity of a given country. By analysing 95 countries and observing various factors and their impact on scientific production, Cole and Phelan [10] demonstrated that GDP is moderate to strongly correlated with the production of "high-quality science", and this title was given to articles with more than 40 citations. Schofer [11] observed the scientific production in the period from 1970 to 1990 and found that the number of papers on a global level doubled in that period, with the highest level of growth in the industrialised West, but also in the other parts of the world. The most important factor that contributed to this growth is again GDP [11]. Therefore, we can conclude that economic development is the strongest incentive, but at the same time obstacle to the development of scientific productivity.

The reason for the strongest impact of economic development is the fact that in most countries the government is the main funding source for scientific inquiry, especially for basic research since the results of basic research is often unpredictable and unknowable [12]. Therefore, it cannot be expected that the market will be a "vehicle for capturing the value of innovation" generated as the result of basic research [13]. Although richer countries generally spend more budget funds on scientific research, spending trends are changing over time. In the early 1990s Japan and Sweden were the countries with the largest investment in science (compared to GDP), outpacing the US and Germany. Since a significant portion of research funds was spent on defence purposes, with the end of the Cold War, but also the budgetary cut policies of Ronald Reagan and Margaret Thatcher, USA and United Kingdom significantly reduced public funding of research in the early '90s [12].

Private investment in scientific research sector significantly increased since 1985 [14]. At the turn of '80s to '90s the largest private sector investments in science were made in Japan, the United Kingdom and Sweden [12]. At the turn of '90s to the 21st century, Japan remains in the lead with private funds invested in public research, followed by the US, Germany and France [15]. The largest increase in private investment had the countries that introduced tax credits during the '90s [12].

It could be expected that this increase in investment will have a negative or neutral effect on scientific productivity measured in terms of scientific articles since the reward system is very different in the industry than in the academic community for each of these sectors has different goals, i.e. different expectations of the conducted research [14]. While in the academic community, in addition to the new discoveries, it is expected that the final result will be a published paper, the business sector expects new solutions that will be marketable and thus gain profits. However, various studies (e.g., [12, 16]) have shown that intensive research collaboration with industry, in addition to applicable solutions such as patents, results in high scientific production. Indeed, Van Looy [16] argues that "both publication and patenting activities are not very different in terms of their intellectual challenge and nature. In both instances, creativity, originality and novelty are key factors contributing to effectiveness".

Of course, there are some limitations. Based on an analysis of Canadian publications in the field of nanotechnology in the period 1985-2005, Beaudry and Allaoui [14] concluded that patenting has a positive and significant effect on the number of published articles. The first patents intensify scientific production and strengthen the reputation of the researchers. However, the reversal occurs at about 30 patents in three years – for those researchers who have more than 20 to 40 patents in 3 years, a decline occurs in the number of papers, as researchers are giving priority to applied research and patenting, and that, in a way, becomes their career choice. Thus, it could be concluded that moderate cooperation with the economy leads to increase in productivity measured in terms of published papers, while orientation towards patenting (more than 30 patents in 3 years) reduces productivity.

Collaboration and networking also have a strong effect on scientific productivity [17]. The probability that a scientist will get involved in new cooperation increases with the number of his previous collaborations. Also, the likelihood that a pair of scientists will start collaborating depends on the number of common collaborators they have [14]. Future cooperation will be easier for scientists who come from the networks with similar views that overlap intellectually, although this would partly limit the breadth of knowledge within the network [18]. DeFazio et al. [17] analysed the impact of funding on the relationships within the collaborative networks and scientific productivity, on a sample of 296 researchers who participated in research networks within the EU funded projects from the Fourth Framework Programme. Based on the analysis, it was concluded that financing has a stronger effect on productivity than cooperation within the network and that the effect of collaboration within the network is positively related to productivity in the period after the stop of funding. The authors summarize that "although the structure of collaboration changes in relation to the funding, it requires time to develop structures of collaboration that are effective in enhancing researcher productivity" [17]. We could conclude that funding is important because it allows the creation of new collaborations, but cannot, by itself, create effective cooperation.

Legislation that defines the criteria for professional promotion has a direct impact on the productivity of scientists [4], but it can be both positive and negative. For example, publishing in international journals with higher impact factor is currently strongly encouraged in Croatia [2]. However, although quality is stimulated, researcher structure shows that the overall criteria are too weak. A study conducted at the University of Zagreb (largest scientific institution in Croatia) showed that the majority of scientists advance from title to title within five years of previous advancement, with the result that most scientists spend more than 10 years in tenure, i.e. more than 15 years of service as a full professor. This is confirmed on a national level by the analysis in the draft amendments to the Law on Higher Education and Scientific Research [19]. The study showed that currently the largest proportion of scientists in Croatia is in the position of scientific adviser and at the same time the above-average number of scientific advisers had not resulted with outstanding productivity.

OBSTACLES TO DEVELOPMENT OF SCIENTIFIC PRODUCTIVITY IN TRANSITION COUNTRIES

Scientists from Eastern European (EE) countries, especially those from the social sciences and humanities, face a number of barriers towards publication [20].

First, social sciences and humanities research in capitalist and communist/socialist societies was different due to ideological reasons up in the early '90s when the perestroika caused the breakup of the former Soviet Union, uprisings in EE countries, and termination of the Cold War [21]. However, even in these systems there were prominent individuals such as the Croatian economic theorists Branko Horvat, who was a guest lecturer at a number of scientific institutions around the world, and a candidate for the Nobel prize in economics in 1983. However, such examples were more an exception than a rule. In addition, researchers from EE countries had a hard time catching up with their colleagues from developed countries, due to the diverse institutional milieu of scientific research [22] and to the fact that authoritarian regimes do not represent an enticing environments for scientific production [23].

Second, language issues are important barriers for authors from non-English speaking countries, especially in the social sciences [24]. For example, people whose first language is Russian are sometimes perceived as hyperbolic when they write in English. People whose first language is Spanish seem to be reluctant to be sufficiently critical of other people's work and with their own contribution is not always clear enough [25]. Journals that publish articles in local languages have undeniable necessity and importance but most of the best journals are published in English [6]. To avoid the language barrier, reach a wider audience and achieve recognition of global scientific community mainstream, many smaller national journals began to publish papers in English [26].

Third, future professionals are rarely instructed in scientific writing and manuscript preparation [27]. In Croatia, for example, one of the few positive examples is the course "Principles of Scientific Research in Medicine" that has been taught at the University of Zagreb Medical School [28] since 1995. Others, who do not have access to such a systematic introduction to the basics of scientific work, learn "only through the painstaking process of trials and errors" on four important issues: (1) choice of the relevant topic for publication, (2) choice of the journal for possible publication, (3) organization of the paper according to IMRAD outline, and (4) writing a paper with a high level of proficiency.

Fourth, scientific productivity is usually measured by the use of Web of Science and Scopus. Bibliographic databases are essential for searching relevant scientific results in the field of interest of scientists. They contain a detailed description of the work, information about the authors, their home institutions and the journal in which the paper is published. Most databases specialise in a particular field of science, whereas research on general scientific productivity is possible by using databases like Web of Science and Scopus which, as well as covering all fields of science, also index the citations, which further distinguish significant results and also makes large-scale citation analyses possible. This, and the aforementioned high standards of selectivity, gives them the status of most relevant scientific databases. New to the world of citation databases is Google Scholar, which indexes all papers whose bibliographic information is available on the Internet, without question of selectivity. Each author and/or journal publisher has the ability to tailor its website in a way that it is recognised by Google Scholar as a source of scientific material. On the other hand, Google Scholar excludes some types of papers that are typically included in Web of Science (e.g. book reviews, editorials etc.). However, although the Google Scholar is basically a citation database, it is not suitable for general research productivity at the level of an institution or a country [29], allowing Web of Science to retain a leading position in the area of measuring scientific productivity with the Scopus is catching-up. At the moment (March 2013), 57 Croatian journals are indexed in Web of Science, which is 17,6 % of all Croatian journals (indexed in the Portal of Scientific Journals of Croatia http://hrcak.srce.hr). Analysis of papers in Croatian language indexed in Web of Science shows a significant rise since year 2007, which coincides with the expansion of Web of Science with regional materials during the period 2007-2009, when about 1600 journals of regional type was added to Web of Science, after having the same rigorous quality evaluation like all other journals indexed in Web of Science [30].

Fifth, systems of tracking scientific publications in transition countries are still developing. In Croatia, published scientific papers are recorded in the Croatian Scientific Bibliography (CROSBI), part of the Croatian Science Portal (www.znanstvenici.hr) under the patronage of the Ministry of Science, Education and Sports (MSES), in which scientists who are registered in the Register of Scientists of MSES should enter bibliographic data about their published papers by themselves using their electronic academic identity. Therefore, CROSBI is the official source of information on the scientific productivity of Croatian scientists. . It is possible to search according to scientist, institution, project and field of science, and access to all the data is free. Most publications in Croatian journals are available in the sister service "Portal of scientific journals of Croatia" (hrcak.srce.hr), where the full text of 89,000 papers from 326 Croatian scientific journals are available. The main drawback of CROSBI is the fact that the data in the database are entered by the authors themselves, so errors such as repeated or incomplete entries are possible. Except for Croatia, among the countries of former Yugoslavia, Slovenia and Bosna and Herzegovina also have a national virtual library. Both countries use a system called COBISS (Cooperative Online Bibliographic System and Services – cobiss.si and cobiss.ba), which links all the libraries at the national level. Scientific papers are recorded in "Current Research Information System" (CRIS), which is a service within Cobiss. In Bosnia and Herzegovina CRIS is still in an experimental phase, while in Slovenia there are precise information on scientific institutions, projects and researchers, but without a broad overview of annual scientific publications and relevant statistics. CROSBI contains bibliographic data on nearly 300 000 publications of Croatian scientists.

CONCLUDING REMARKS

The goals of our paper were to investigate current trends in scientific productivity in transition countries and to discuss obstacles to its development. The main conclusion is that scientific productivity exhibits different patterns in Central European countries compared to Western Balkan countries and Russia. Scientific production is substantially higher in Central European countries, which is probably the result of diffent factors ranging from the level of economic development, criteria for scientific advancement and the war that occurred in the number of Western Balkan countries, slowing down scientific productivity.

However, if we take a closer look at publication trends Croatia, some positive trends are present (Figure 3). Throughout the last 10 years, percentage of Croatian publications included in the Web of Science continues to grow so far, reaching a record of 26 % in 2012. During the same period, the Croatian share in the total contents of the Web of Science rises, although it is still at the very low level, ranging from 0,10 % in 1996 to 0,25 % in 2011. Such increase is probably the result of a Croatian promotion system where scientists from the fields other than social and human sciences are obliged to publish in journals with an impact factor [4].

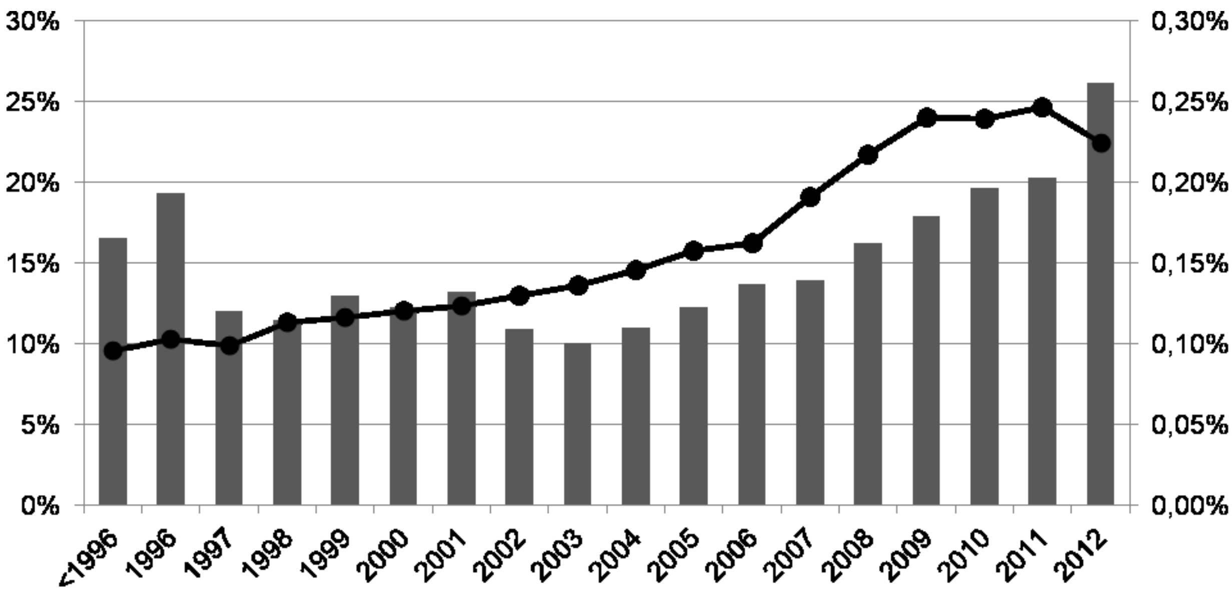

Figure 3. Percentage of Croatian publications included in Web of Science (histogram) and Croatian share of total papers in Web of Science (solid line), based on data from Web of Science.

Our research has also some limitations. We have focused only on selected transition countries, papers published in journals covered by the Web of Science and secondary data available in public databases. Deeper understanding would have been attained by the analysis of the large number of transition countries, based also on the national journals, and with the support of primary research, that would collect the perceptions of individual researchers.

Future research should also be devoted to incentives of scientific productivity in transition countries, that should embrace not only increase in governmental investments in scientific research, but also to more sophisticated instruments that are present in leading institutions and countries. Such instruments range from the direct financial support to individuals that publish heavily in leading journals to breading of research-supported environment within universities. McGrail et al. [31] found out also following interventions to be effective: writing courses, writing support groups and writing coaches.

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PREPREKE RAZVOJU ZNANSTVENE PRODUKTIVNOSTI TRANZICIJSKIH ZEMALJA

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SAŽETAK

Znanstvena produktivnost je jedan od glavnih pokretača razvoja u 21. stoljeću. Najčešći način mjerenja znanstvene produktivnosti je kroz publiciranje u obliku recenziranih članaka. Tekuća istraživanja ukazuju kako postoji jaka povezanost između razvijenosti zemlje i njezinog udjela u svjetskom publiciranju znanstvenih članaka. Tranzicijske zemlje još uvijek hvataju korak sa najrazvijenijim zemljama u području znanstvene produktivnosti, što je posebno razvidno za zemlje Zapadnog Balkana. Ovaj rad je jedan od rijetkih pokušaja analize prepreka znanstvenoj produktivnosti u tranzicijskim zemljama, te istražuje različite čimbenike i njihov utjecaj na znanstvenu produktivnosti. Prepreke proizlaze iz povijesnih razloga, ciljeva koji se postavljaju pred znanstvenike kao uvjeta za napredovanja, te postojanja i implementacija strategija razvoja znanosti. Također, bez efikasnog mjerenja znanstvene produktivnosti, teško se može analizirati njezino kretanje. Dio prepreka također proizlazi iz nedostataka u evidenciji znanstvenih publikacija. Autori iz tranzicijskih zemalja često objavljuju svoje radove u lokalnim časopisima, koji nisu dovoljno zastupljeni u znanstvenoj bazi *Web of Science*. Prema tome, ažurni sustavi za praćenje znanstvenih publikacija u tranzicijskim zemljama su od najveće važnosti.

KLJUČNE RIJEČI

znanstvena produktivnost,tranzicijske zemlje, prepreke, znanost, *Web of Science*