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Cristian Mihai Dragos[a], Vasile Dinu[b], Ciprian Marcel Pop[a] & Dan Cristian Dabija[a]

[a] Faculty of Economics and Business Administration, Babes-Bolyai University, Cluj Napoca, Romania

[b] Faculty of Commerce, Bucharest University of Economic Studies, Bucharest, Romania

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Cristian Mihai Dragos[a]*, Vasile Dinu[b], Ciprian Marcel Pop[a] and Dan Cristian Dabija[a]

[a]*Faculty of Economics and Business Administration, Babes-Bolyai University, Cluj Napoca, Romania;* [b]*Faculty of Commerce, Bucharest University of Economic Studies, Bucharest, Romania*

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Some scientometric studies attempt to explain the factors affecting a country's scientific output, which is usually measured by proxy variables such as the number of articles and citations in internationally-renowned journals. This paper highlights the main drivers for scientific output in economics and business, namely, financing of education and research, population size, the number of scholarly journals and English as the official language. We use multiple OLS regressions and data provided by *Web of Knowledge* and the *World Bank* covering 56 nations. The study also highlights the relationship between scientific output and the efficiency in using the research funding. The rankings of sample countries show that there is a learning process at national level, the output being doubled by efficiency.

Keywords: scientific productivity; R&D financing; bibliometric analysis; OLS regression

JEL classification: C21, O31, O32

1. Introduction

For centuries, economic competitiveness has been maintained mainly by social organisation through the division of labour, access to resources and the qualifications of the workforce. In the second half of the twentieth century, technological advancement and capital began to act as powerful engines of economic competitiveness. However, the levels of R&D activity vary considerably across countries, and harnessing the available human and financial resources for this purpose is not that simple (Sharma & Thomas, 2008). In order to assess the results produced by the R&D activity, a new instrument has been developed, namely, scientometrics. Its main goal is to provide, in the form of various statistical approaches, synthetic indicators of the quantifiable scientific output: published articles, citations, patents, etc. Although initially developed just as a statistical tool, scientometrics has increasingly acquired economic connotations. Even some economic methods have been introduced, such as inter-industry relations analysis into studies of autopoietic systems of citations (Shirabe & Fujigaki, 2000). Output as well as labour and capital resources efficiency is assessed by employing constantly developing methods (for a history of changes undergone by this science, see Van Bochove, 2013). However, there is some criticism of scientometrics (Balaram, 2008) mainly with regard to the danger of conducting quantitative assessments of scientific output to the detriment

*Corresponding author. Email: cristian.dragos@econ.ubbcluj.ro

of qualitative ones. Bibliometric rankings of institutions and researchers have produced important effects in terms of policy implications. Research strategies and methods are often changed to a significant degree by the proposed indicators (Nederhof, 2008).

According to the level at which the assessment is performed, scientometrics may fall into two categories. The first category is microscientometrics, which assesses individuals, journals and institutions. The second category is macroscientometrics, which assesses scientific output at national and regional levels. This division is further reflected in the assessment methods. Indicators such as the impact factor, H-index (Hirsch, 2005) or article influence score are not suitable at national level. At this level, on the basis of the law of large numbers, only the indicators showing the number of articles (published in reputed journals or presented at international conferences) and the number of citations are considered acceptable.

One of the main goals of scientometrics at country level is to highlight the mechanisms that generate more or less scientific output. One important issue is finding some national or local *right incentives* mechanisms that should stimulate R&D activities both quantitatively and qualitatively. A comprehensive study on the factors affecting the countries' scientific output was recently conducted by Gantman (2012). With the aid of the *Scopus* database and a Poisson model of econometric estimation, Gantman analyses output in the following fields: Agricultural and Biological Sciences, Neurosciences, Medicine, Mathematics, Chemistry, Physics and Astronomy, Sociology and Political Science, Economics, Econometrics and Finance. The study fails to show the statistical significance of all factors proposed by the working hypotheses. However, Gantman's most important result shows that motivational factors vary across fields. Naturally, there are general factors such as financing of education and research. Field-specific factors, however, are the most difficult to identify and highlight. For instance, in Agricultural Sciences, research demand may be affected by both extensive and intensive factors and also by a nation's need and desire to promote its agriculture. The extensive factors relate to the area of cultivated land and the intensive ones to the technologies involved. Consequently, despite the high level of household income and financing for education, the level of research into Agricultural Sciences is low in countries such as Saudi Arabia, the United Arab Emirates, Kuwait or Qatar.

Attempts have been made in the scholarly literature to highlight motivational factors in specific areas such as Medicine (Masic, 2013), Chemistry (Kato & Ando, 2013), Physics (Zheng, Yuan, Pan, & Zhao, 2011), Agricultural Sciences (Dinu, Schileru, & Atanase, 2012; Nederhof, Meijer, Moed, & Vanraan, 1993), Mathematics (Bensman, Smolinsky, & Pudovkin, 2010; Wagner-Dobler & Berg, 1996), Environmental Sciences and Ecology (Dragos & Dragos, 2013) and Engineering (Jesiek et al., 2011). Using a Poisson model and data from important international conferences, Gantman (2009) assesses the effect of economic and non-economic variables on scientific output in the field of management. He only uses general factors, placing no emphasis on specific factors.

Apparently, there are no specific motivations for research into economics and business or into agricultural sciences, environmental sciences or chemistry. However, general factors may have unique characteristics that one can take advantage of in order to make as accurate assessments as possible.

There are concerns regarding specific factors influencing the scientific output from different branches in economics and business. Chung and Cox (1990, 1991) study the concentration of the number of authors in the most important journals in finance. Such a mechanism can be extended, if we take into consideration the resident countries of the authors. The present study reveals the impact of economic and non-economic factors on scientific output in the fields of economics and business. Moreover, emphasis is placed on the relationship between scientific productivity and efficiency of R&D financing.

2. Hypotheses, data and methodology

The factors affecting scientific output can be measured approximately by means of proxy variables available in databases. While some factors are very explicit about how they affect scientific output, there is an element of ambiguity about the influence of other factors.

Hypothesis 1: *The economic development of a country influences, positively and significantly, the scientific output in E&B (economics and business).*

Academic research on economics is mainly conducted by universities. Companies and other research institutions conduct considerably less research into this field than into other fields such as Engineering. The research financing falls less on material expenses and more on the available human resources. Therefore, we believe the most relevant factor is the financing of education and research. Several comparative studies show the process of scientific and technological development in less-developed countries (Shrum & Shenhav, 1995) and the effect of economic development on the scientific output in the 'business' field (Gantman, 2009). We believe the level of economic development is not fully relevant unless it is reflected in the research funding. A comparative test on the effect of actual economic development (GDP) and the financing of education and research (public spending in education), respectively, shall be conducted.

Hypothesis 2: *The number of inhabitants of a country influences the scientific output.*

It is expected that population size has an inversely proportional effect on scientific output. There are many application studies in economics and business dealing with the characteristics of a country's economy. The number of such studies that are necessary for an economy may increase slightly according to the size of the economy, but under no circumstances is it proportionate to the population size. To better understand the argument, an example from public administration is provided here. Internationally, the number of members of Parliament has been found to be larger in highly populated countries but no direct proportionality has been established to this effect. A similar phenomenon is expected to be found with scientific output and a negative regression to be obtained for population. Another argument is the fact that the percentage of researchers out of the overall population is low in highly populated countries such as China, India, Pakistan, Bangladesh etc.

Hypothesis 3: *Scientific output is positively influenced by the number of scholarly journals published on the national territory.*

There are fields, such as mathematics, in which the scientific findings have worldwide application. However, in social sciences there are many local, national and regional peculiarities. These are often covered by studies published in journals of economics edited on a particular national territory. Thus, a national journal serves as an opportunity for promoting indirectly the research conducted by the inhabitants of the country since they know best the characteristics of the country's economy. In general, the correlation between the number of journals and the national scientific output is not linear. The greater the number of edited journals, the greater the number of articles published by researchers from abroad.

Hypothesis 4: *Civil and political rights have effects over scientific productivity.*

In the field of natural sciences, the involvement of political decision-makers in the research activity is almost non-existent, regardless of the country. In social sciences, however, many topics are not approved of by the authorities. In economics in particular, many opinions about the mechanisms of the economy were forbidden in the communist countries or in countries with a centrally planned economy. Some studies investigate at regional level the changes in scope and content of R&D activities following the replacement of a political regime (for an analysis of former communist countries in Central and Eastern Europe, see Schlemmer, 2005).

Hypothesis 5: *English as an official language has an effect over the number of publications in international journals of Economics and Business.*

Social science articles are generally longer than natural science articles. Writing them in English can be a real challenge for researchers who are not native speakers. Figures 1, 2 and 3 present an informative comparison of international scientific output quantified by the number of articles (and citations) published in journals indexed by the

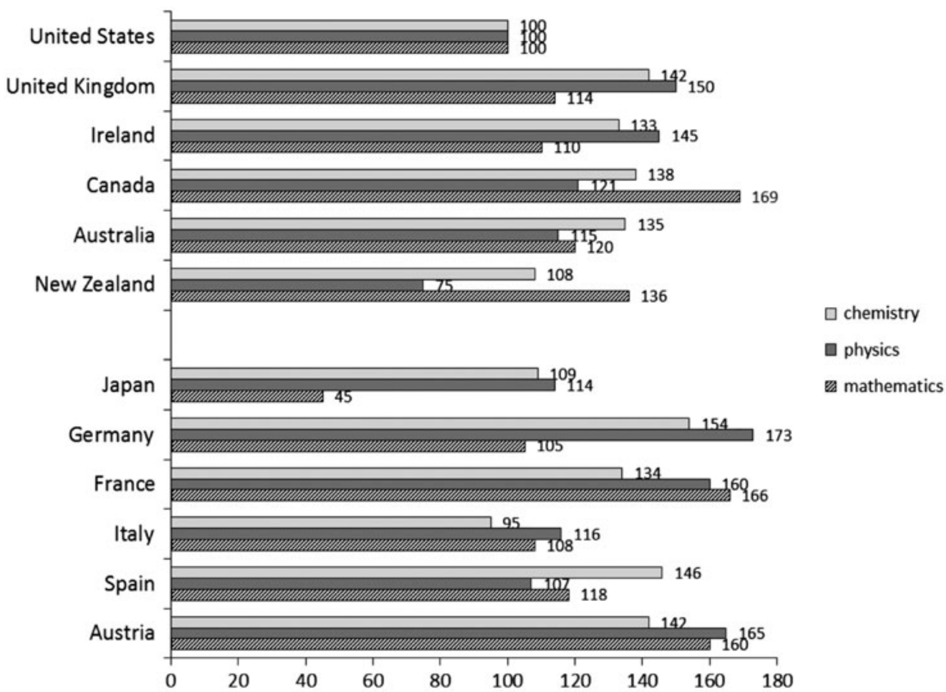

Figure 1. Comparison of *PPP* index in countries having English as the official language versus countries having other official language (fixed base index, USA = 100).
Source: Authors' computations.

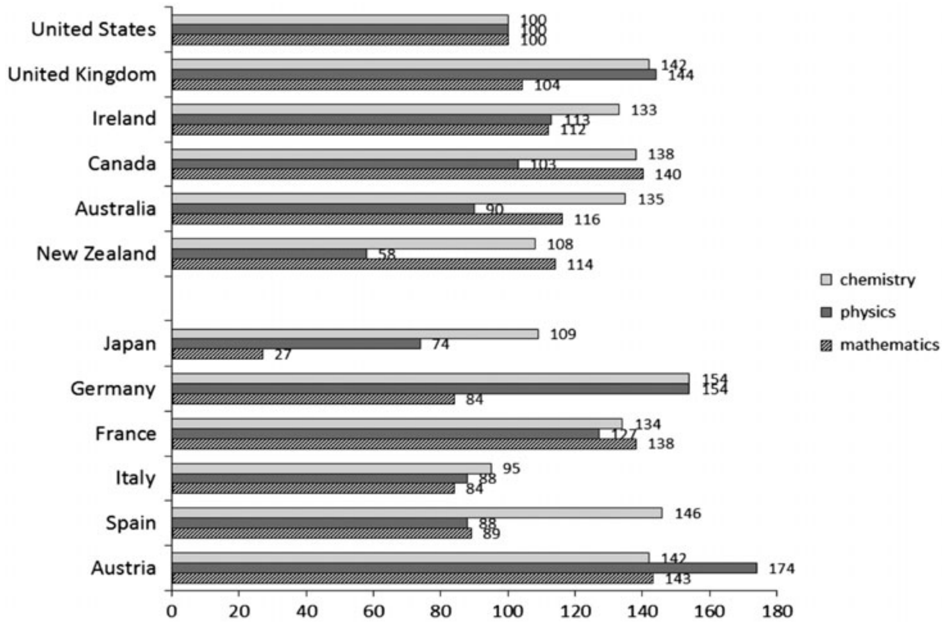

Figure 2. Comparison of *CPP* index in countries having English as the official language versus countries having other official language (fixed base index, USA = 100).
Source: Authors' computations using STATA 9.1 software.

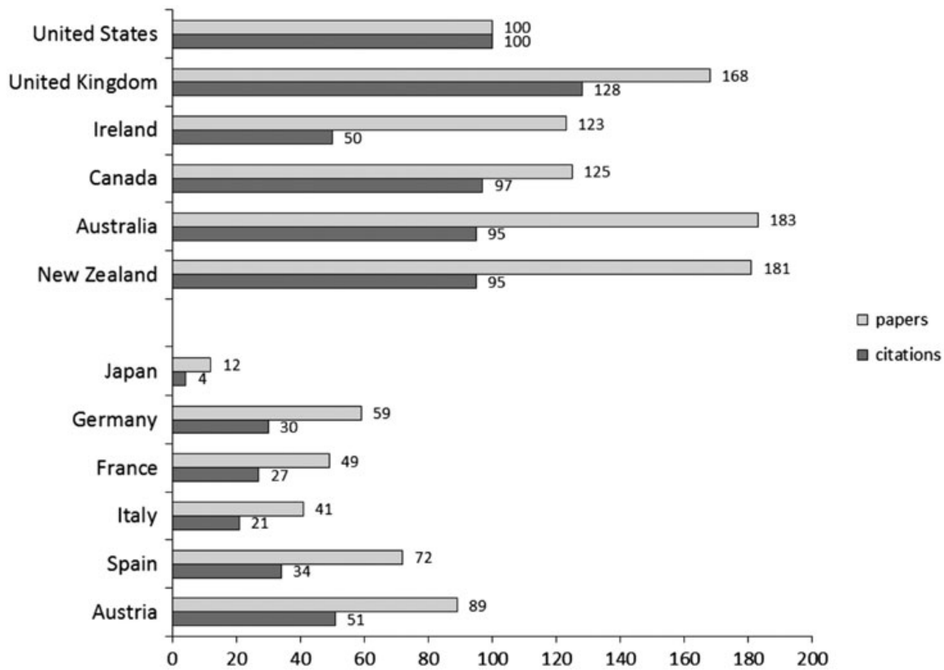

Figure 3. Comparison of *PPP* and *CPP* indices in economics and business in countries having English as the official language versus countries having other official language (fixed base index, USA = 100).
Source: Authors' computations.

Table 1. Descriptive statistics of the used variables.

Variable	Mean	Median	St. dev.	Min	Max
PPP	153.5	62.6	169.2	0.7	500.5
CPP	901.5	160.2	1,174	1.2	3,962
POPULATION	91.9	30.9	230	0.49	1,320,555
GDP_cap	23,068	15,362	21,105	257	94,574
Exp_EDU ($)	1,253	703	1,262	13	5,468
CIVIL_POLITICAL	4.41	3	3.26	2	13
DOM_JOURN	11.1	1.00	40.9	0	238
ENGL	0.143	–	0.337	0	1

Source: Authors' computations using STATA 9.1 software.

Thomson ISI database. The PPP (publications per population) indicator varies greatly from one field to another. In order to make comparisons, a USA = 100 base index was used. In Table 1, a comparison was made between the scientific output of countries with English as the official language versus that of countries having another official language. The two groups of countries have a closely comparable level of economic development. One can notice there is a balance between the two groups of countries in terms of productivity in the three fields considered: mathematics, physics and chemistry. The same result was obtained in Table 2 where citations (CPP-citations per population) were considered. A balance between the two groups of countries was also noticed with regard to the quality or visibility of articles. On the other hand, if the *economics and business* field is considered, the overwhelming number of articles and citations goes to countries having English as the official language (Figure 3). By comparison with these countries, the group of countries having other official languages shares only 36.6% of published articles and 29.6% of citations.

3. Data and methodology

In order to test the above-mentioned hypotheses, we use data collected from journals indexed by Thomson ISI in the subfields of Economics, Business, Business & Finance, and Management. The sample comprises the most productive countries in the world, in which more than 100 articles in these subfields have been published over the last 10 years. Countries whose total number of articles is very small are not included in the survey because their scientific output is irrelevant at international level since an extra article produces minor percentage variations with no significant impact on statistical calculation. The final sample comprises 56 countries with a total output of over 100 published articles and for which data are available for all variables.

Data are collected from:

- Essential Science Indicators (Web of Knowledge, 2013) – the number of articles and citations in journals indexed by Thomson ISI for each country;
- World Development Indicators (World Bank, 2013).

We use the following variables:

i = country index.

PPP_i = publication per population – the number of articles in the fields of Economics, Business, Business & Finance and Management published by country i in journals

Table 2. Coefficients of OLS regressions (*t*-values).

	Endog. var. : *PPP*		Endog. var. : *CPP*	
	Equation (1)	Equation (2)	Equation (3)	Equation (4)
ln(*POPULATION*)	−17.24** (−2.30)	−22.74** (−2.66)	5.920 (0.10)	−42.99 (−0.64)
sqrt(*GDP_cap*)		1.437*** (6.44)		10.03*** (5.69)
sqrt(*ExpEDU*)	6.496*** (8.51)		47.83*** (8.16)	
sqrt(*DOM_JOURN*)	79.96** (2.60)	82.03** (2.29)	864.5*** (3.67)	904.2***9 (3.20)
ENGLISH	78.91** (2.42)	87.02** (2.31)	510.6** (2.04)	575.5* (1.93)
CIVIL_POLITICAL	1.241 (0.32)	0.721 (0.16)	30.60 (1.02)	22.28 (0.61)
Constant	91.08 (1.05)	153.2 (1.53)	−1,065 (−1.60)	−436.5 (−0.55)
	R^2 = 0.848	R^2 = 0.797	R^2 = 0.815	R^2 = 0.738
	N = 56	N = 56	N = 56	N = 56

Note: ***, **, * significant at 1, 5 and 10% level.
Source: Authors' computations using STATA 9.1 software.

indexed by Thomson ISI, between 1 January 2003 and 30 June 2013, with reference to 1 million inhabitants.

CPP_i = citation per population – the number of citations in the fields of Economics, Business, Business & Finance and Management published by the country *i* registered in ISI journals by the researchers in a country, between 1 January 2003 and 30 June 2013, with reference to 1 million inhabitants.

We must note that in the field literature there are some critical positions regarding the use of PPP and CPP as indicators, because they are not in agreement with Superstardom Theory (Chung & Cox, 1994).

$POPULATION_i$ = population of country *i* (millions) – average values between 2002 and 2011.

GDP_cap_i = gross domestic product (in $) per capita – average values between 2002 and 2011.

$ExpEDU_i$ = expenditure on education per capita ($) – average values between 2002 and 2011.

$CIVIL\_POLITICAL_i = DEMOCRACY_i + POLITICAL\_FREEDOM_i$

DEMOCRACY and *POLITICAL_FREEDOM* are annual scores representing the levels of political rights and civil liberties in each state and territory, on a scale from 1 (most free) to 7 (least free). Depending on the ratings, the nations are then classified as 'Free', 'Partly Free', or 'Not Free' (Freedom House, 2013).

DOM_JOURN_i = domestic journals. Number of journals published during the period of 2009–2013 in country *i* related to 1000 thousand inhabitants. All the journals indexed by Thomson ISI in the fields *Economics, Business, Business & Finance and Management* were taken into consideration. $ENGL_i$ = dummy variable; $ENGL_i = 1$ if English is the official language of country *i*; $ENGL_i = 0$ if otherwise. In some countries in which English coexists as an official language or is employed in the educational system we use $ENGL_i = 0.5$

The methodology uses OLS Multiple Regression with PPP and CPP as endogenous variables.

4. Results and discussion

Descriptive statistics (Table 1) show that the used variables varied enough from one country to another. Considerations of the mean, median and variance show asymmetrical distributions of the variables, suggesting the necessity of some transformations for linearising the correlations.

The regression results are presented in Table 2. Several regression analysis methods have been tested but only the best versions are presented. The logarithm and square root transformations were applied to variables having nonlinear correlations with endogenous variables. Through these transformations the correlations have become linear.

The hypotheses are to a great extent confirmed by the estimation results. The *H1*, *H3* and *H5* hypotheses are completely accepted, *H2* is partly accepted and *H4* is rejected. According to the logic of the stated mechanism, a country's population size has a negative effect on the number of published articles. However, the relationship cannot be demonstrated with respect to citations. The effect could be offset by the fact that in a highly populated country there are many researchers likely interested in some regional studies published by co-national fellows. Consequently, the number of cross citations from authors in the same country is likely to increase. This mechanism cannot be verified with data in the present study. The money spent on education and research represents a variable even more significant than GDP. The phenomenon can be explained by allocating different funds for education and research expenses, respectively, expressed as a percentage of GDP (between 2.45% and 8.18% for sample countries). The number of domestic journals and English as the official language are also significant factors affecting the scientific output. This further confirms the formulated hypotheses and the observations of descriptive statistics. Political and civil rights have proven to be insignificant. This phenomenon should, however, be studied more carefully. A great number of countries where these rights are obviously violated are missing from the sample.

Naturally, some results yielded by the study may appear obvious. The essential factors affecting the scientific output have been clearly highlighted. A question arises, however: do countries with a high scientific output efficiently use the allocated funds? The allocation of substantial funds for R&D activities yields a high scientific output. But is there an efficient connection between this output and the allocated funds? To answer these questions, sample countries are assessed according to four criteria. The former two quantify the scientific output while the latter two quantify the efficiency expressed as the ratio between output and allocated funds.

C1: *PPP* = publication per population – the number of articles with reference to 1 million inhabitants;

C2: *CPP* = citation per population – the number of citations with reference to 1 million inhabitants;

C3: *PUB/sqrt(TOTEXPEDU)* = total number of publications in a country with reference to total education and research expenses;

C4: *CIT/sqrt(TOTEXPEDU)* = total number of citations in a country with reference to total education and research expenses.

The regression analysis revealed a nonlinear relationship between the number of publications (or citations) and financing. This aspect was taken into account when developing the efficiency indicators.

A figure-based analysis of the correlation between productivity and efficiency is provided for publications (Figure 4) and citations (Figure 5), respectively.

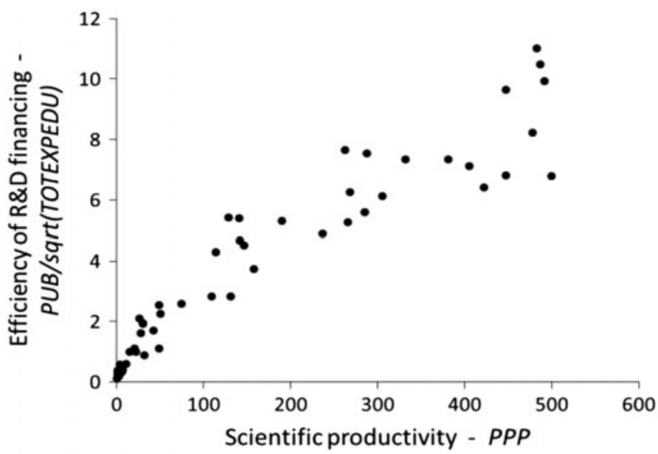

Figure 4. Distribution of countries according to productivity and efficiency (publications).
Source: Authors' computations.

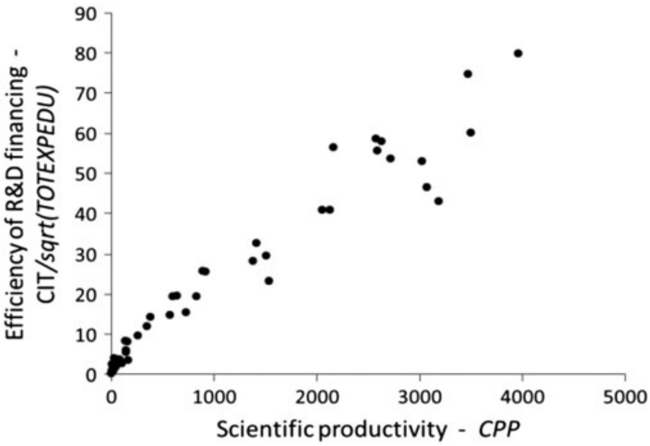

Figure 5. Distribution of countries according to productivity and efficiency (citations).
Source: Authors' computations.

Table 3. Ranks of countries by the intensity of their scientific contribution in economics and business.

R	Country	R_{C1}	R_{C2}	R_{C3}	R_{C4}	R	Country	R_{C1}	R_{C2}	R_{C3}	R_{C4}
1	Netherlands	2	1	3	1	29	Chile	30	29	29	29
2	Switzerland	5	2	5	3	30	Turkey	34	32	32	28
3	UK	7	3	4	2	31	Croatia	29	34	30	34
3	N Zealand	4	10	1	4	32	Hungary	32	31	34	31
5	Australia	3	9	2	7	33	UA Emirates	30	28	36	35
6	Norway	1	4	12	11	34	South Africa	36	35	35	33
7	Denmark	6	5	11	10	35	Japan	33	33	40	37
8	Canada	11	8	9	5	36	Romania	35	40	33	41
9	Sweden	9	6	10	9	37	Malaysia	39	36	37	38
10	Israel	13	11	7	6	38	Poland	38	37	39	42
11	Finland	10	12	8	13	39	Argentina	41	38	41	40
12	USA	16	7	20	8	40	China	44	39	43	36
13	Belgium	12	13	15	12	41	Tunisia	40	41	38	43
14	Luxembourg	8	14	13	19	42	Kenya	48	42	42	32
15	Cyprus	15	16	14	14	43	Ukraine	37	50	31	51
16	Slovenia	17	19	6	17	44	Brazil	42	43	47	47
17	Ireland	14	15	16	15	45	Thailand	46	45	44	44
18	Austria	18	17	21	16	46	Colombia	44	46	45	45
19	Spain	19	18	19	18	47	Mexico	43	44	51	48
20	Portugal	21	22	23	20	48	Peru	47	49	46	49
21	Germany	20	20	25	22	49	Ethiopia	54	52	48	39
22	Greece	22	23	22	21	50	Philippines	51	48	49	46
23	France	24	21	26	23	51	Iran	49	51	52	52
24	Czech Rep.	23	27	18	27	52	Russian Fed.	50	47	54	53
25	Estonia	26	25	24	25	53	India	54	53	53	50
26	Italy	27	24	26	24	54	Pakistan	52	56	50	56
27	Slovakia	25	30	17	30	55	Vietnam	52	54	54	54
28	Korea Rep.	28	26	28	26	56	Indonesia	56	55	56	55

Source: Authors' computations.

The correlation between productivity and efficiency is surprisingly high. Spearman's coefficient is 0.970 for published articles and 0.976 for citations. There are virtually no countries in the sample that could be viewed as outliers. It may be stated that a learning process exists wherein countries attaining a high level of productivity become important players in the R&D field and manage to use efficiently the available financial resources.

Table 3 presents a ranking of the 56 sample countries according to the intensity of their scientific contribution in economics and business. R_{C1}, R_{C2}, R_{C3} and R_{C4} are the ranks held by countries according to the criteria C1, C2, C3 and C4. The rank of each country (R) equally takes into consideration R_{C1}, R_{C2}, R_{C3} and R_{C4}.

Significant gaps can be noticed between the countries at the top and those at the bottom of the ranking. Throughout the analysed period (between 2002 and 2011), the first ten countries had an average GDP per capita of $ 44,019 while the last ten countries only recorded an average GDP per capita of $1931. This huge gap is also recorded with respect to population size, from 8.42 million inhabitants (the median of top ten countries) to 102 million inhabitants (the median of the last ten countries). The latter factor prevents countries such as the USA, Germany and France from holding top ten positions, despite their traditional schools of economic thought, high total scientific output and significant funds allocated for R&D activities. Japan's position is also surprising since it holds top positions in other fields, mainly the technical ones.

5. Conclusion

In dealing with the topic of scientific output in economics and business, the present study confirms several results published in previous articles concerning relevant explanatory variables such as financing of education and the English language. The study also highlights the effect of some factors that have not been studied yet, such as the publishing of domestic journals. The negative effect of population size on productivity has also been demonstrated. The most important result lies in identifying the relationship between the scientific output and the efficient use of funding for education.

Without a study of this kind, the countries leading the field of research into economics and business are apparently the USA, the UK and China. This dominance is mainly reflected in the volume of research. If the intensity of the phenomenon is taken into account by reference to population and the level of financing, the top positions are held by small but well-developed countries. These conclusions can only be viewed as an intermediate stage. Subsequent studies may research the impact of the intensity of scientific output in economics and business on the way the countries manage their economy.

It is difficult to make recommendations at national level as a result of this study. Some factors that influence the scientific productivity in economics and business (economic development, number of inhabitants, official language) are hard to handle through governmental politics, especially on short terms. Fortunately for developing countries, scientific developments from the fields of economics and business are accessible at a global level, not being protected by licensed inventions. It is rather advisable for developing countries to focus on applying the economic theories and trends that came from first-class economic literature.

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