LIFE STANDARD, SCIENCE AND ASTRONOMY

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Abstract.
The bibliometrc data published by Sanches & Benn (2004, arXiv:astro-ph/0401228) are analized. The proprotionality in log-log coordinates between the population and annual gross domestic product (GDP) with coefficient equal to unit is used for selection of "developed" countries and for futher reveal of dependances through them. The proportionality coefficients between the GDP and the citation of all-science or only of the 1000 astronomy top-articles in 1991-98 occur 0.75 and 0.93, respectivelly. The fact that coefficients are less then 1 gives evidence that when the wealth of the community grows up the citation (i.e. the quality) of the articles increases with a less speed. Correlations between the "cost" of 1% citation as part of the GDP or as a part of the GDP per person for all-science and for the 1000 astronomy top-articles only are found. They show that the scientific papers are relatively more "cheap" for the big scientific communities (USA, EU), but in the same time the most cited astronomical articles are relatively more "expensive", up to 2 times. Generally, the astronomy seems to be more interesting, but also more expensive than the science on average.
Key words: *scienciometric, bibliometric, productivity in science*
PACS No.

Till July 1, 2004, the ADS archive (Abstract Service of the Harvard-Smithsonian Center for Astrophysics; http://adswww.harvard.edu/ads_-abstracts.html) already contains more than 1 000 000 records for papers in Astronomy & Astrophysics and more than 1 770 000 in Physics and Geophysics. It is considered, that the astronomical papers sample published after 1970 is well enough complete. It comprises of the most representative journals with a small exception of the hardly accessible ones. Another usual source of information to date used for bibliometric studies is the Institute of Scientific Information (ISI, see for instance Abt (2003) for details). Different investigations could be made based on the information from ADS and ISI. Here we reanalyze the data of one such recent article.

The impact of astronomical research carried out by different countries has been compared in the paper of Sanches & Benn (2004) based on analysis of the 1000 most citated astronomy papers published 1991-98 (125 such per year). The data about 22 countries and 2 comunities (EU, presented by 9 countries – BE, DK, FR, DE, IT, NL, ES, SE, UK, and ESO, presented by 8 countries – BE, DK, FR, DE, IT, NL, SE, CH), prodused at least 2 such top papers, are collected in Table 1. The Table 1 columns contain the following data: 1 – 2 – name of the country and ISI code used in Fig.1-3; 3 – 4 – the number of the top-cited 1000 articles N_A with first author hosted by the given country or community and the respective citation fraction C_A; 5 – the *all-science* citation fraction C_S (from ISI, 1995); 6 – total population N_P (1999); 7 - annual gross domestic product (GDP) per head of population $\$/N_P$; 8 – 9 – GDP per percent of astronomy (top 1000) citation $\$/C_A$ or per all-science citation $\$/C_S$; 10 – 11 – GDP per head of population per percent astronomical $\$/N_P/C_A$ or all-sceince $\$/N_P/C_S$ citation.

Language bias against both publication and citation need to be considered when comparing citation counts for different countries, because of: (i) the favorization of the english-speaking scientists, which write naturally in english and tend not to read papers in other languages; (ii) citation databases provide uneven coverage of foreign-language journals; (iii) the big comunities (f. i. USA, UK) tend to over-cite their own results, e.g. through preferentially reading and citing national journals (Sanches & Benn, 2004). We can add that many scientists are leaving their countries and work mainly in the USA, thus the results of the statistics is more favorable for the smaller countries. Another source of biases is the insufficient statistics and by this reason we exclude 4 countries (Austria, Estonia, Finland and S. Korea), these are presented in the current investigation with only one astronomical top-cited paper.

Table 1. The data about the countries and the citations

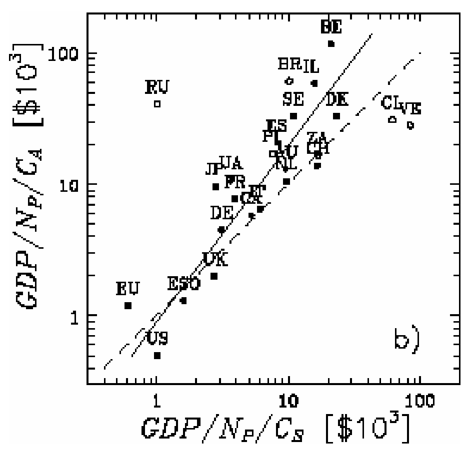
Country	Code	N_A	C_A [%]	C_S [%]	N_P [10^6]	$\$/N_P$ [$\$10^6$]	$\$/C_A$ [$\$10^9$]	$\$/C_S$ [$\$10^9$]	$\$/N_P/C_A$ [$\$10^3$]	$\$/N_P/C_S$ [$\$10^3$]
1	2	3	4	5	6	7	8	9	10	11
Australia	AU	18	1.6	2.2	18.8	20.9	246	179	13.1	9.5
Belgium	BE	2	0.2	1.1	10.2	23.1	1180	214	115.7	21.0
Canada	CA	40	3.8	4.3	31.0	22.2	181	160	5.8	5.2
Denmark	DK	6	0.7	1.0	5.4	23.0	177	124	32.8	23.0
France	FR	35	2.9	5.7	59.0	22.4	455	232	7.7	3.9
Germany	DE	56	4.9	7.2	82.1	22.1	370	252	4.5	3.1
Israel	IL	3	0.3	1.1	5.8	17.4	337	92	58.0	15.8
Italy	IT	31	3.2	3.4	56.7	20.8	369	347	6.5	
6.1□Japan	JP	23	2.4	8.2	126.2	23.0	1210	354	9.6	2.8
Netherlands	NL	23	2.1	2.3	15.8	22.0	166	151	10.5	9.6
Spain	ES	7	0.8	2.0	39.2	16.5	806	322	20.6	8.2
Sweden	SE	4	0.6	1.8	8.9	19.7	292	97	32.8	10.9
Switzerland	CH	14	1.9	1.6	7.3	26.2	100	119	13.8	16.4
UK	UK	101	10.7	7.9	59.1	21.2	117	158	2.0	2.7
USA	US	599	60.6	30.8	272.6	31.2	140	276	0.5	1.0
ESO	ESO	171	16.5	14.1	245.4	22.0	326	382	1.3	1.6
Europe	EU	265	17.1	32.5	336.4	21.1	415	218	1.2	0.6
Brazil	BR	2	0.1	0.6	171.1	6.0	10350	1725	60.5	10.1
Chile	CL	5	0.4	0.2	15.0	12.3	460	920	30.7	61.3
Poland	Pl	4	0.4	0.9	38.6	6.8	658	292	17.0	7.6
Russia	RU	2	0.1	4.1	146.4	4.1	5930	145	40.5	1.0
S.Africa	ZA	3	0.4	0.4	43.4	6.7	725	725	16.7	16.7
Ukraine	UA	2	0.2	0.6	49.8	2.2	540	180	10.8	3.6
Venezuella	VE	2	0.3	0.1	23.2	8.4	647	1940	27.9	83.6

In spite of the disadvantages of such kind of data, Sanches & Benn (2004) show in log-log coordinates the proportionalities between the citation fraction of the 1000 top-papers and the population, GDP per head of population, IAU numbers and percent of all-science citation for considered countries and communities. Generally, the phenomenon seems to have fractal nature. The most cited astronomical authors are hosted in USA, EU, ESO and UK, but in all-science case the USA and EU changes their positions. One special case is Russia, having significant all-science impact but low contribution to the 1000 astronomical top-cited articles. Further we emphasizes on the citation "cost" in comparison with the GDP and GDP per head of population.

The narrow dependence between the population and the annual GDP of 15 well developed countries and communities, which are involved in deriving the dependence in the next figures in Fig. 1 is conspicuous. These countries well contribute the coefficient equal to 1. This means that they are approximately equally developed in sense of life standard, corresponding to $ 20 000 per year per person (in 1999). The other 7 countries which do not support this proportionality are collected in the bottom of Table 1.

Figure 2 shows the approximate proportionality between the annual GDP and the citation of the all-science and the 1000 top-cited astronomy articles. Having in mind the dependence presented in Fig.1, one can expect regression coefficients close to 1. However, the phenomenon is more interesting – the coefficients are less than 1 and are different. The dependence of all-science citation on the GDP (build on other, large and may be full "observing material") is characterized by coefficient 0.75. Therefore, the richer the scientific community, the more scientific quality, but not so fast with respect to Fig. 1. Obviously, we find some decreasing of the interest in the all-science investigations in the rich communities and we claim for the existence of the "3/4 law" in this field. However, the dependence of the astronomical citation on the richness of the community (build on a limited "observing material") is stepper – 0.93. This fact shows in general that the interest in the astronomy is more strong and resistant against the wealth then in the all-science case.

Figure 3 compires the relative "costs" of the all-science and the 1000 top-citated astronomy articles, expressed as parts of the GDP and as parts of GDP per person.The correlation in Fig.3a is poor prominent, but it gives evidence that in comparison with the high quality astronomical articles the all-science citation is "cheaper" up to 2 times. The correlation in Fig. 3b is more prominent and it shows that the efficiency (i.e. low cost in comparison with the life standard) of all-science or astronomy investigations is most efficient in the large and rich communities (USA,EU,ESO,UK), decreasing when the community population decreases. This tendency is more strong for the astronomy, where the citation of the top articles seem to be up to 1.5 times more expensive.



. Fig.2. Proportionality between the GDP and the citation percentage C of all-science (dots, solid line) and 1000 astronomy articles (asterisks, dashed line), with regression coefficients 0.75 and 0.93. The dotted line represents the slope coefficient of 1.0. The last 7 countries, found at the bottom of in Table 1, which are not used for the regression, are denoted either with small dots or asterisks

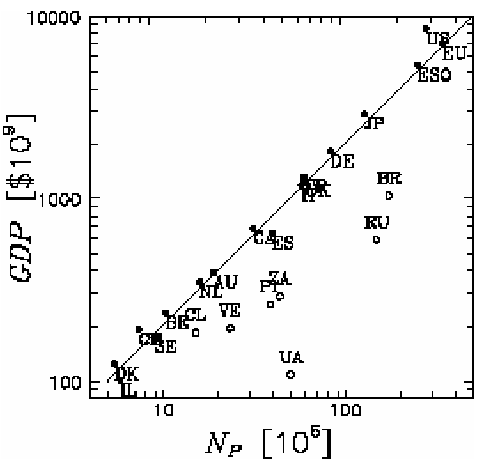


Fig.1. Proportionality between the population N_P and the annual GDP for 15 developed countries and 2 communities, presented by dots. The coefficient of the line is equal to 1, and the vertical shift corresponds to life standard of $ 20 000 per year per head of population. The other 7 countries, found at the bottom of Table 1, which do not follow such a proportionality, are shown by circles

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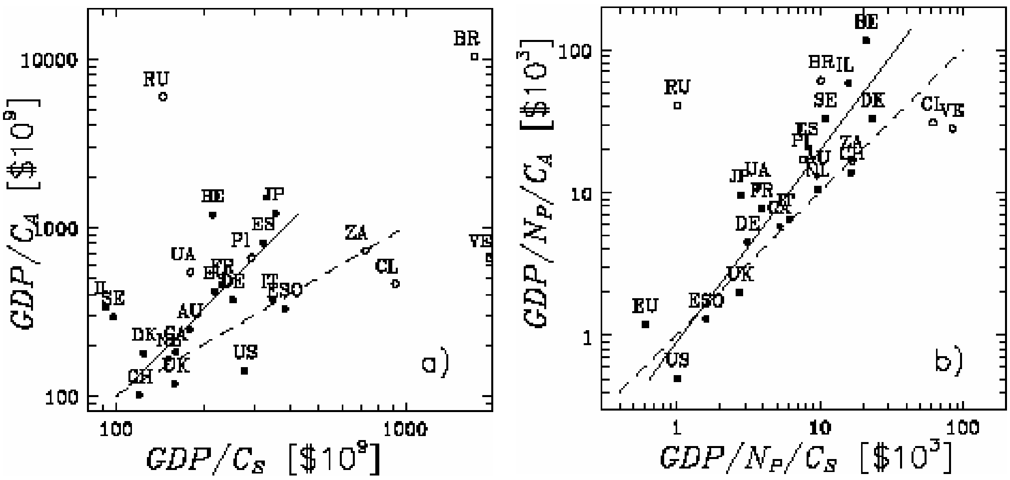

Fig. 3. Correlation between the “cost” of the citations of the all-science papers (C_S) and the 1000 astronomical top-articles (C_A) with respect to the GDP (a) and GDP/N_P (b). The solid lines represent the orthogonal regressions and the dashed lines represent the dependences with coefficients equal to 1. The last 7 countries, found at the bottom in Table 1, which are not used for the regressions, are presented by circles.

Generally, the astronomy seems to be more interesting (Fig.2) and more expensive (Fig.3) than the science on average.

The author is gratefull to R. Kurtev, V. Golev and P. Nedialkov for the valuable discussions.

R e f e r e n c e

A b t H., in Organizations and Strategies in Astronomy, Vol. 4, 197, 2004

S a n c h e z S. F., C. R. B e n n, 2004, arXiv:astro-ph/0401228; Astr. Nachr. (in print)