Scientometrics (2010) 82:507–516
DOI 10.1007/s11192-010-0186-8

Does a country's scientific 'productivity' depend critically on the number of country journals indexed?

Aparna Basu

Received: 11 May 2009 / Published online: 10 February 2010

Abstract In this paper, we examine the question whether it is meaningful to talk about the scientific productivity of nations based on indexes like the Science Citation Index or Scopus, when the journal set covered by them keeps changing with time. We hypothesize from the illustrative case of India's declining productivity in the 1980s which correlated with a fall in its journals indexed, that an apparent increase/decrease in productivity for any country, based on observed change in its share of papers could, in fact, be an effect resulting from the inclusion of more/less journals from the country. To verify our hypothesis we have used SCIMAGO data. We found that for a set of 90 countries, the share of journals regressed on the share of papers gave a linear relationship that explained 80% of the variance. However, we also show that in the case of China's unusual rise in world scientific productivity (to second rank crossing several other countries), there is yet another factor that needs to be taken into account. We define a new indicator—the JOURNAL PACKING DENSITY (JPD) or average number of papers in journals from a given country. We show that the packing density of Chinese journals has steadily increased over the last few years. Currently, Chinese journals have the highest 'packing density' in the world, almost twice the world average which is about 100 papers per journal per annum. The deviation of the JPD from the world average is another indicator which will affect so called 'national productivities' in addition to the number of national journals indexed. We conclude that in the context of a five fold increase in the number of journals indexed over 20 years, the simplistic notion of 'scientific productivity' as equivalent to papers indexed needs to be re-examined.

Keywords Bibliometrics · Publications · Country share · Journals · Scopus · SCImago · Web of Science · China · India

A. Basu (✉)
CSIR, Rafi Marg, New Delhi 110001, India
e-mail: aparnabasu.dr@gmail.com

Introduction

The Science Citation Index, which was initially developed by Eugene Garfield in the nineteen sixties as a research aid, came to be used extensively after the seventies as a source for bibliometric studies. At the time of starting, the Science Citation Index included less than a thousand international journals from several fields of science. Some criteria were set for the inclusion of journals, such as quality (reputation and acceptance among scientists), timeliness of publications, etc. In fact inclusion in the Science Citation Index was synonymous with high quality. The average citedness of a journal gave a quantitative indicator, the Impact Factor, which is now widely accepted as indicating journal quality. The country share of papers is also routinely used as a measure of the scientific productivity of nations.

Over the years, the number of journals included in the SCI has steadily increased, partly due to editors' continued endeavour to ensure that more journals, both old and new, are included by SCI, and partly due to ISI's (now Thomson Reuters) own need to widen its coverage of scientific journals. The proportion of internationally authored articles in some of these journals can be quite low, with most papers being authored by scientists from within the country of publication (Moed 2002). This in turn could produce a disproportionately high figure for the number of articles published from the country, leading to the conclusion that the country's productivity has increased, while in fact what has happened is that an additional set of papers from the country have acquired visibility simply on account of the inclusion of some journals in the SCI. This raises two related questions, (i) how valid is it to look for temporal changes in the productivity of countries if the journal mix and country share of journals indexed has changed, and (ii) how valid is it to compare the productivity of countries when the country shares of journals are different, and the journal mix is not constant over time (see for example Fig. 1 for the Scopus database). The figure clearly shows that the changes in journals indexed, varies significantly between countries.

While it is difficult to disentangle a real change in productivity from a change resulting from the induction of certain journals, one could look for a correlation between a country's

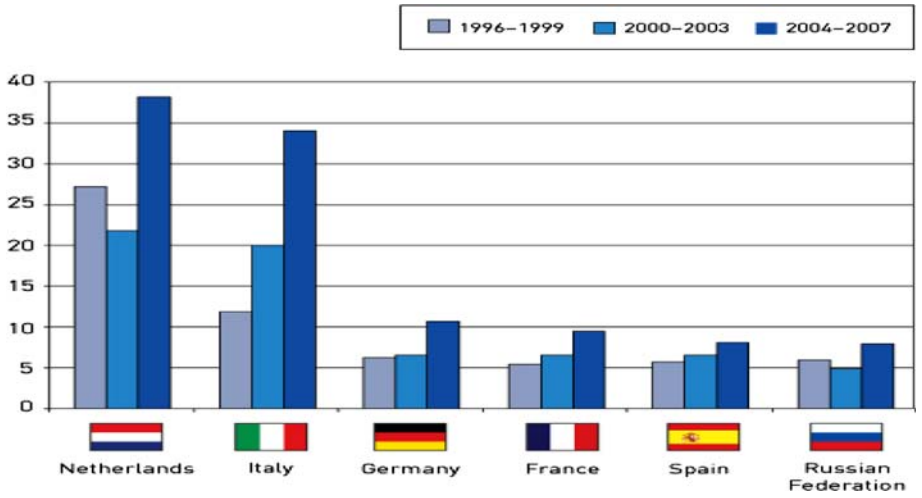

Fig. 1 Changes in the number of Journals indexed by Scopus over different time periods for a few countries: *reproduced from Research Trends2007*

share of journals and its share of papers. This would support the hypothesis that in spite of the projected international nature of science, in general, the major contribution to a country's papers comes from its own journals. While this is to be expected, it nevertheless raises questions about bibliometric inferences drawn.

Background: India's declining productivity in the 1980s

In 1996, a Nature paper Raghuram and Madhavi commented upon India's declining ranking in terms of share of papers in SCI. It also pointed out that not only the share but the annual output of papers fell in absolute terms during the 1980s. This was attributed to the falling productivity of Indian scientists, and it became a subject of debate among scientists and science managers. All policy prescriptions were aligned towards creating conditions for raising productivity levels, and the entire discussion centred on poor research conditions in laboratories, need to change strategies, improving funding in universities, etc.

A closer look at the SCI data revealed that the number of journals from India indexed in SCI grew from less than 10 journals to 40 gradually in the 20 year period 1960–1980 and thereafter fell from 40 to about 10–11. The fall in papers coincided approximately with the fall in the number of journals indexed. In several papers refuting the inferences on falling productivity in the Nature paper, we argued that India's share of scientific publications fell from close to 3% of world publications to less than 1.5% in the given time period, not because of causes internal to the science system as had been claimed, but possibly due to a fall in the journals indexed (Basu 1999a, b). It was shown that India's share of scientific papers declined over the 1980s when the number of journals indexed fell by more than half. In the 1990s, the number of Indian journals indexed remained fairly constant and the Indian output which rose marginally was described as 'stagnating' (Fig. 2).

Throughout this period of 18 years, 1980–1998, we found that the India's share of scientific papers in SCI was well correlated with its share of journals indexed (Fig. 3 reproduced with data from Basu et al. 2000). Even in the humanities and social sciences, it has been noted in a recent paper that 'the massive decline of Vienna is due probably to the drop out of an Austria Journal of SSCI' (Gorraiz et al. 2008). Based on the fact that for a single country, rising or falling productivity in time could be an artifact arising from

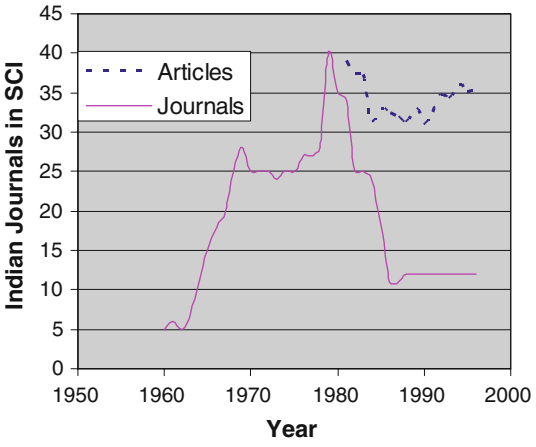

Fig. 2 Indian papers (scaled by a factor of .003) and journals in Science Citation Index, 1980–1998; *reproduced using data from* Basu et al. (1999a, b) *Scientific Productivity, where do we stand?* Brochure prepared for *Indian Science Congress*, Chennai, Jan 3, 1999 (*Number of articles have been scaled by a factor of .003 to enable both journals and articles to be shown on the same graph.*)

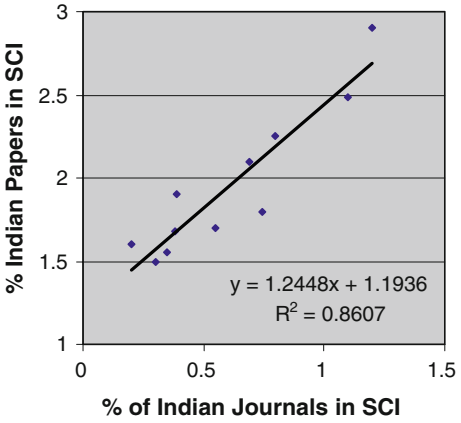

Fig. 3 Percentage of Indian Journals and papers in Science Citation Index, 1980–1998, *reproduced using data from* Basu et al. (2000) *Scientific Productivity, where do we stand?* Brochure prepared for *Indian Science Congress*, Pune, Jan 3, 2000

changes in journals indexed, we hypothesize here that this could be the same for other countries as well.

The study could not be easily generalized at the time to other countries, as the country of publication of journals did not form part of the data indexed by SCI, and this would need to be found manually from other sources. SCImago, based on Scopus, provides this information, and moreover Scopus indexes a larger number of journals than SCI or Web of Science. SCImago thus provides a good platform for the current study.

Hypothesis 1 A country's share of papers, and hence rank in terms of scientific productivity, depends critically on the share of journals from that country that find a place in the index.

Data and methodology

We have used Scopus data as analyzed by SCImago for the years 1996–2006, to check for country journals and country papers. For the earlier study on India, SCI data covering the years 1980–1997 was used. To show China's rapid rise, Scopus data for 2007 has been used. Simple linear regression was used to establish correlation between share of journals and share of papers for 90 countries.

Outcome/findings/results

A simple regression relating the number of country papers to the number of journals indexed in Scopus aggregated over the years 1996–2006 shows that a country's papers varies linearly with journals from that country, with more than 80% of the variance explained by this relationship $y = 0.67x$ (y = number of papers, x = number of journals; $R^2 = 0.8$; Fig. 4).

We note that countries like the United Kingdom and the Netherlands which lie below the line, are net producers of journals, and produce more journals than would be expected by the linear regression. This possibly indicates a larger number of commercial journals in these countries as opposed to those run by learned societies, which would cater to the requirements of scientists within a discipline and country.

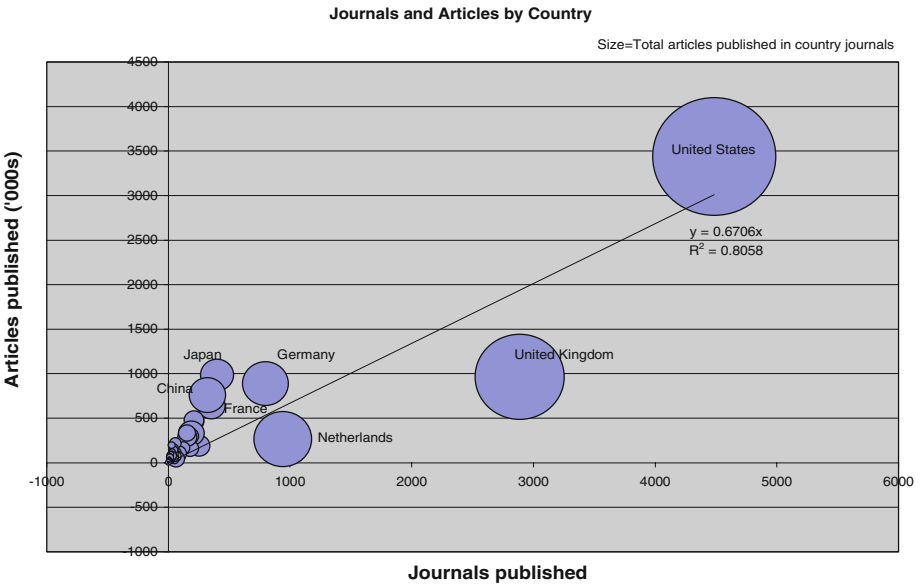

Fig. 4 Regression line between journals and papers indexed in Scopus for different countries (data SCIMago 1996–2006); size of bubble = number of papers in journals of the same country

If the top four countries (in terms of numbers of their country journals) namely, USA, UK, Germany and the Netherlands are removed, the remaining countries show an even stronger relationship between the number of papers and journals published (Fig. 5). More than 87% of the variance is explained by a linear regression line $y = 1.192x$ ($R^2 = 0.87$). Note that in these figures (bubble chart), the size of the 'bubble' is determined by the number of papers in the journals published in the same country. In Fig. 5, the countries with a large number of journals and large contributions arising from them are Japan, China and France. For all three countries, the likelihood of journals being in a language other than English is high, together with probability of the contributions being from the parent countries.

Year 2007: The race ahead: China

The SCImago data for the year 2007 shows one country well ahead of its position in the earlier decade in terms of published papers (see Fig. 6). This country is China. The rapid rise of China as evidenced by the number of papers in publication indexes in the 21st century has been commented upon by various authors (Moed 2002; Leydesdorff and Zhou 2005, 2006, 2008; Jin et al. 2005). Shelton (2008) predicts that China will overtake the USA in 2016 in terms of papers published. The prediction is made on the basis a model linking expenditure in research (GERD) to publication output (Shelton 2008; Shelton and Foland 2008).

We note from Fig. 6 that in 2007 China, at close to 200,000 papers, deviates considerably from the approximately linear relationship that has been shown to connect papers published from a country and the number of country journals indexed. This was not true in

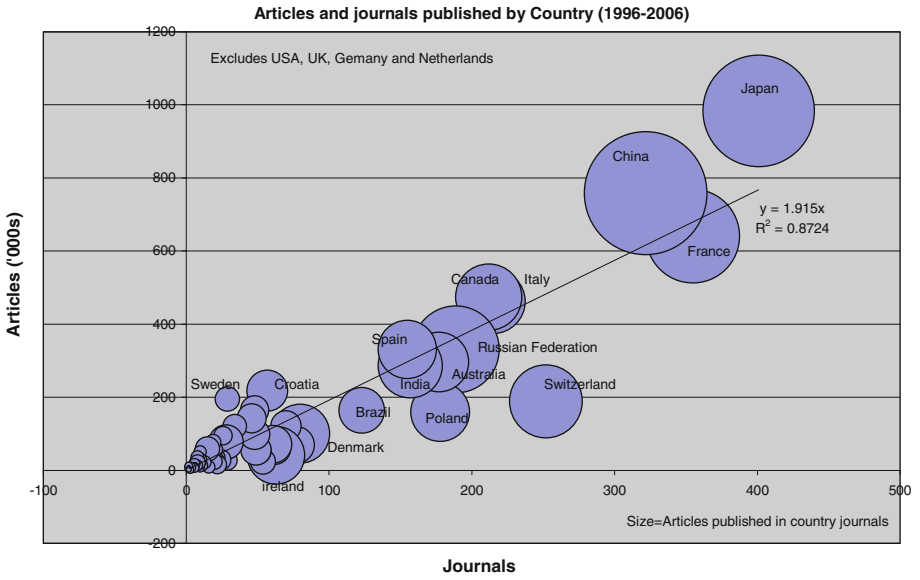

Fig. 5 Regression line for journals and papers indexed in Scopus for different countries excluding USA, UK, Germany and Netherlands (data SCIMago 1996–2006); size of bubble = number of papers in journals of the same country

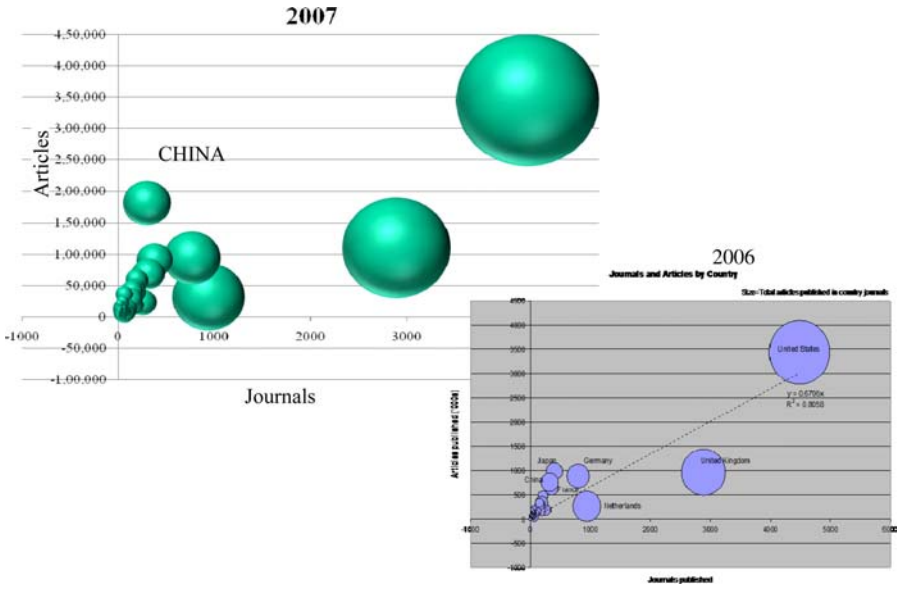

Fig. 6 Journals and papers indexed in Scopus for different countries (data 2007 and 1996–2006 for comparison—*inset*; please refer to Fig. 4 for details); X = number of journals, Y = number of papers, size of bubble = number of papers in journals of the same country. *Note the rapid rise of one country (China) in 2007 as compared to the average for the decade*. In the case of China, its position on the X-axis, i.e. Chinese journals remain virtually unchanged, but size of the bubble, i.e. papers in Chinese journals, has increased. This is explained by increased Journal Packing Density

the earlier years (Figs. 4, 5). In other words, the number of Chinese journals indexed appears to be far less than would be expected from the number of papers from China, or conversely the number of papers appears to be far more than expected considering the Chinese journals indexed. Does this mean that our hypothesis is incorrect, and that China is publishing much more in journals from other countries or is there yet another reason?

To answer this question we took a closer look at the average number of papers published in journals by country. The results are given in Table 1 for the years 2000, 2004 and 2007. In the table, the first two columns give the number of journals published by a country and the number of papers in these journals. Countries are ordered in decreasing order of what we call the JOURNAL PACKING DENSITY or JPD for a country shown in Column 4 (Column 4 = Column 3/Column 2).

Definition The JPD or JOURNAL PACKING DENSITY for a country is defined as the ratio of the number of papers published in a country's own journals to the number of journals published.

In 2000 the JPD for world journals (*ratio of world papers to world journals*) was on average about 100 articles per journal per year. In the last column in Table 1, we see the percentage deviation of the JPD for a country from the world average. In 2000 there are four countries whose JPD is higher than the world average, namely the Russian Federation, China, Netherlands and the United States. The maximum deviation of the journal packing density from the world average in 2000 was 34.8% for the Russian Federation, followed by China at 31.8%. In other words Russian and Chinese journals contained on average approximately 135 and 132 papers against the world average of 100. Clearly a JPD for a country that is higher than the world average gives a higher likelihood of papers to that country as compared to expected values from the number of journals indexed. The percentage deviation is a measure of the extent to which this is so.

By 2004, China's JPD had the highest value at almost 180 papers per journal-a 72% deviation over the world average. This trend continued into 2007 with about 194 papers per Chinese journal, a deviation of 79% over the world average. Note that in the same period the world average has hardly shifted from 100 papers in 2000 to 108 papers per journal in 2007.

Returning briefly to India

Returning briefly to India, we quote from a recent article on India in Science Watch (King and Christopher 2008).

"… In 1985, the number (of papers) was approximately **12,500**, and for the next 15 years the total never much exceeded **14,000**. Around the year 2000, however, the number began to tick upwards, rising to nearly **17,000** in 2001, reaching **20,000**-plus in 2003, and winding up at more than **27,000** in 2007. "The data cited here are based on the Web of Science or SCI-Expanded.

What is not mentioned in the article is the number of new journals added. In the 1990s the number of Indian journals was static at about 10–11 journals. 21 Indian journals were added to the journals in the SCI list in 2006 (Pratt, Thompson Reuters, personal communication). In view of our results the numbers quoted above are hardly surprising. The question is do the numbers reflect India's scientific productivity?

Table 1 Number of journals indexed from a country and the papers contained therein; average, 'journal packing density' JPD and % deviation of JPD from the world average (2000, 2004, 2007)

Country	Journals	Papers in country journals	Average papers per country journal	Percentage deviation from world average
2000				
Russian Federation	114	15369	134.82	34.5
China	117	15418	131.78	31.5
Netherlands	713	91742	128.67	28.4
United States	3362	387301	115.2	14.9
WORLD	*9268*	*928979*	*100.24*	*0.0*
United Kingdom	2034	191247	93.98	−6.2
Japan	333	30766	92.39	−7.8
Germany	545	50317	92.32	−7.9
France	228	19851	87.07	−13.1
India	107	9028	84.37	−15.8
Switzerland	148	12001	81.09	−19.1
2004				
China	226	40651	179.87	72.3
Netherland	808	107291	132.79	27.2
Russian Federation	124	14903	120.19	15.1
United States	3832	457259	119.33	14.3
WORLD	*10969*	*1144947*	*104.38*	*0.0*
Japan	364	36175	99.38	−4.8
United Kingdom	2432	239812	98.61	−5.5
Germany	660	61894	93.78	−10.2
France	270	23601	87.41	−16.3
India	132	11436	86.64	−17.0
Switzerland	191	15207	79.62	−23.7
Spain	131	9643	73.61	−29.5
Poland	142	10124	71.3	−31.7
Australia	140	9893	70.66	−32.3
Canada	190	11509	60.57	−42.0
Italy	177	10435	58.95	−43.5
2007				
China	304	58920	193.82	78.8
Netherlands	944	133691	141.62	30.7
United States	4259	527057	123.75	14.2
WORLD	*12751*	*1382129*	*108.39*	*0.0*
Germany	771	82508	107.01	−1.3
United Kingdom	2895	299919	103.60	−4.4
Russian Federation	137	13443	98.12	−9.5
France	317	27550	86.91	−19.8
Japan	383	33028	86.23	−20.4
India	147	12443	84.65	−21.9
Switzerland	255	20633	80.91	−25.4
Australia	169	13503	79.90	−26.3

Table 1 continued

Country	Journals	Papers in country journals	Average papers per country journal	Percentage deviation from world average
Brazil	147	11713	79.68	−26.5
Spain	171	11109	64.96	−40.1
Canada	193	12030	62.33	−42.5
Italy	205	12609	61.51	−43.3

Conclusions

In this paper we asked if, in general, a country's share of papers depends on the number of journals indexed from that country. We believed this to be so because the journals from a country are expected to be its core journals (in the Bradfordian sense). We conclude that our hypothesis, namely, that the world share of papers for a country as seen from any index such as SCI-E or Scopus will depend critically on the number of journals indexed from that country, was certainly true in the last decade, but in recent years a caveat has to be added. We had assumed that journals from different countries were all, in some sense, equivalent in terms of the number of papers they carried. It has been shown here that that is not a valid assumption, and some countries have much higher journal packing density, i.e. carry overwhelmingly more papers in their journals on average. Accordingly we defined a new indicator, the JOURNAL PACKING DENSITY or JPD. It is our belief that this is a new trend and needs to be discussed in the context of national productivity as this implies that a country can autonomously improve its rank in terms of papers published without either publishing more in other international journals, or trying to ensure the inclusion of more of its own journals in the indexes. Earlier there was an effort of the part of journal editors and countries to try to ensure that their papers got coverage by trying to get their journals indexed by the (then) Science Citation Index. SCI journals were regarded as quality journals. If increasing the packing density becomes the norm, then this may no longer hold.

Summary and discussion

In an earlier study using SCI data from 1980 to 1998, it had been found that, for a single country, India, the share of scientific papers varied quite strongly over the years, the changes being well correlated with the share of journals indexed (Basu 1999, 2000). It was suggested there that India's share of scientific publications in SCI fell from close to 3% of world publications to <1.5% in the 1980s, not because of decline in real productivity, but possibly as a direct consequence of the fact that the number of Indian journals indexed in SCI fell by more than half in the same period. The present study includes data from a large number of countries over the period 1996–2006, and, using regression, confirms that the publication output varies linearly with the number of country journals indexed ($\sim$80% of variance explained). The relationship appeared to be stronger (87% of variance explained) if the most productive countries that form the core of the research system are excluded. It may be noted that the three most prominent countries in this truncated list of countries, namely China, Japan and France are more likely to publish journals in languages other than English, and the share of country journals would be expected to have a stronger effect on their apparent productivity. The data for 2007 showed that China deviated considerably

from the proposed linear relationship with many more papers than expected given the number of Chinese journals indexed. This was attributed to increasing JOURNAL PACKING DENSITY (JPD) whereby Chinese journals appeared to have continuously increased in size in successive time periods in recent years.

Having said this, we are now faced with the question as to whether scientific productivity at the national level, as it is currently defined, is indeed a meaningful indicator of a country's performance, or is it merely an artifact of policies governing the data sources, journals indexed and publication practices in journals (such as increasing packing density)? The databases are designed primarily to cater to the needs of researchers/scientists and will need to increase their coverage. Other commercial reasons can influence the decisions of inclusion/exclusion of journals. As long as there was only a single data source, the ISI, this question was tautological, but now with multiple sources, this question needs to be discussed. Clearly, in the context of a five fold increase in the number of journals indexed over 20 years, the simplistic notion of 'scientific productivity' as equivalent to papers indexed needs to be re-examined.

References

Basu, A. (1999a). Are Indian scientist's losing in the world publishing race? A refutation. In P. S. Nagpaul, et al. (Eds.), *Emerging trends in scientometrics*. New Delhi: Allied Publishers.

Basu, A. (1999b). Science publication indicators for India: Questions of interpretation. *Scientometrics, 44*, 347–360.

Basu, A. et al. (1999, 2000). Scientific Productivity, where do we stand?, Brief reports on Indian science based on bibliometric indicators, prepared for *Indian Science Congress*, Chennai Jan 1999 and Pune, Jan 2000 (reprinted in Information Today and Tommrrow, 1999).

Gorraiz, J., Greil, M., Mayer, W., Reimann, R., Sturn, D., & Schiebel, E. (2008). International publication output and research impact in the social sciences: Comparison of the universities of Vienna, Zurich and Oslo in Excellence and Emergence: A new challenge for the combination of quantitative and qualitative approaches, Book of Abstracts, tenth international conference on science and technology indicators, Vienna, p. 236.

Jin, B., & Rousseau, R. (2005). China's quantitative expansion phase: Exponential growth, but low impact. Proceedings of the 10th international conference on scientometrics and informetrics, Stockholm.

King, C. (2008). India's new millennium in science, Science Watch, Sep–Oct 2008.

Leydesdorff, L., & Zhou, P. (2005). Are the contributions of China and Korea upsetting the world system of science? *Scientometrics, 63*, 617–630.

Moed, H. (2002). Measuring China's research performance using the science citation index. *Scientometrics, 53*, 281–296.

Raghuram, N., & Madhavi, Y. (1996). India's declining ranking. *Nature, 383*, 572.

SCImago. (2007). SJR—SCImago journal and country rank. Retrieved April 23, 2008 from http://www.scimagojr.com.

Shelton, R. D. (2008). China forecast to lead the U.S. in scientific publications within ten years, poster, tenth international conference on science and technology indicators, Vienna, Sept. 2008. Working Paper: CpaperSummary9.12.8.doc.

Shelton, R. D., & Foland, P. (2008). National efficiencies in publishing scientific papers, in excellence and emergence: A new challenge for the combination of quantitative and qualitative approaches, Book of Abstracts, tenth international conference on science and technology indicators, Vienna.

Scopus. http://www.scopus.com/scopus/home.url (Retrieved April 23, 2008).

Science Citation Index. http://www.scientific.thomsonreuters.com/products/sci/.

Thomson Scientific. (2007). Scientific output in china is growing. http://scientific.thomson.com/press/2007/8423909/.

Web of Science. http://www.scientific.thomson.com/products/wos/.

Zhou, P., & Leydesdorff, P. (2000). China Ranks Second In Scientific Publications Since 2006, *ISSI Newsletter* March 2000.

Zhou, P., & Leydesdorff, L. (2006). The emergence of China as a leading nation in science. *Research Policy, 35*(1), 83–104.