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A new indicator for international visibility: exploring Brazilian scientific community

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Abstract Brazilian science has increased fast during the last decades. An example is the increasing in the country's share in the world's scientific publication within the main international databases. But what is the actual weight of international publications to the whole Brazilian productivity? In order to respond this question, we have elaborated a new indicator, the International Publication Ratio (IPR). The data source was Lattes Database, a database organized by one of the main Brazilian S&T funding agency, which encompasses publication data from 1997 to 2004 of about 51,000 Brazilian researchers. Influences of distinct parameters, such as sectors, fields, career age and gender, are analyzed. We hope the data presented may help S&T managers and other S&T interests to better understand the complexity under the concept scientific productivity, especially in peripheral countries in science, such as Brazil.

Keywords Brazilian science · Scientific publications · International publication ratio

Introduction

The consolidation of Brazilian science and technology system as well as the expansion of Brazilian scientific community has its origins during the 1950 s when some governmental initiatives and acts started guiding the sector. As for the following decades, public policies were orientated to the establishment of a complex and huge national program for training human resources to scientific activities in the country (Guimaraes and Humann 1995). After strong supports by the military govern, the sector faced a remarkable drop in terms of federal investments in 1990 s. Nevertheless, there has been a continuous growth of the scientific and technological park as well as of the number of masters and PhDs in the

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country. In 2008, for example, 118,015 researchers, among these 78,783 had a PhD degree, were enrolled in the base Directory of Research Groups organized by the Brazilian National Council for Science and Technology.

The investment in graduate courses was accompanied by the growth of Brazilian contribution in technical and scientific publications indexed by the Institute for Scientific Information (ISI/Thomson). Brazilian's share of world's total publications increased from 0.16%, in 1967, to 0.31% in 1974 (Morel and Morei 1977), 0.46% in 1993 (Sikka 1997), 1.11% in 2000 (Pinheiro-Machado and Oliveira 2001) and 1.75% in 2005 (BritoCruz 2007). Considering a more recent period, it is possible to note even a stronger increase in these publications: Brazilian's share has surpassed 2.5% (Regalado 2010).

The noteworthy increase of Brazilian scientific output has gained publicity not only among the country's scientific community but also among national and international media.[1] In all cases, journalists have celebrated the better Brazilian performance in terms of number of publications catalogued in the database ISI/Thomson Reuters which has led the country to occupy the 13th position worldwide, ahead of Holland, Israel and Switzerland. But what factors are related to this recent increase?

There is no doubt that the national evaluation system carried out by one of the main Brazilian S&T funding agency, named CAPES, responsible for assessing the performance of Brazilian graduate programs, is pushing the whole Brazilian scientific community to a publishing routine. This evaluation, carried out every 3 years, forces researchers and their PhD students, and so the graduate courses they are affiliated, to some quantitative criteria, such as the number of publications in international journals. Also, other factors may also be contributing to this recent scenario of Brazilian science, including personal or academic factors associated with the scientific productivity of a country, a region, a community or even a single scientist worldwide (Basu 2010; Hirsch 2005; Cohen 1991; Fox 1983; Allison and Stewart 1974). Whatever the explanation for such recent growth is, the fact is that Brazilian science has gained more visibility within the international audience. Hence, what is the actual weight of international publications to the whole Brazilian productivity?

In order to get a response for this question, we have elaborated a new indicator, the International Publication Ratio (IPR), which was already applied to the Brazilian scientific community in a previous publication (Leite et al. 2009). The present study aims presenting additional evidences of the weight of international publications to the recent performance of Brazilian researchers. We believe our findings may be useful to better understand some of the aspects that may influence the dynamics of a country's, region's, institution's or even a group of scientists' publications in a moment that has been characterized by a large competition within Brazilian scientific arena.

Methods

Data on Brazilian scientific community (all having a PhD degree) were retrieved from a subset of CNPq[2] database, including information about 51,223 Brazilian researchers,

[1] Examples: BBC/Brasil (2010) Produção científica do Brasil ultrapassa a da Rússia, indice levantamento. Available at: http://www.bbc.co.uk/portuguese/ciencia/2010/01/100127_brasil_russia_ciencia_rw.shtml; Folha de São Paulo (2009) Produção científica cresce 56% no Brasil. Available at: http://www1.folha.uol.com.br/folha/ciencia/ult306u561181.shtml; KING C. (2009) Brazilian Science on the Rise. ScienceWatch. Available at: http://sciencewatch.com/ana/fea/09julaugFea/.

[2] CNPq is the short name for National Council for Scientific and Technological Development.

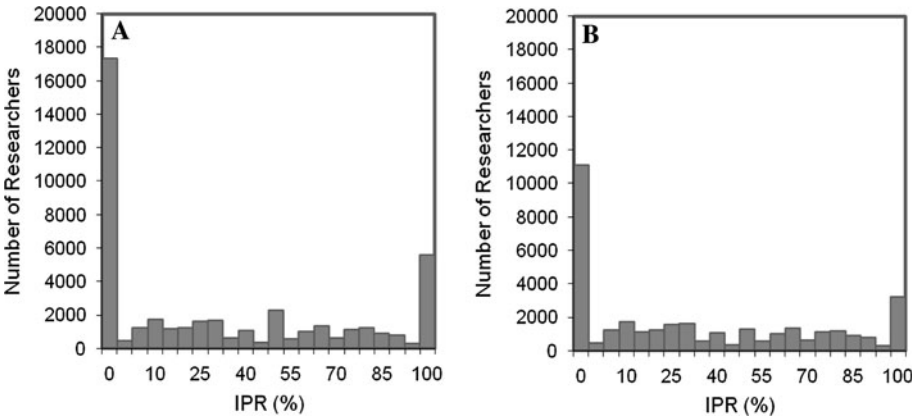

Fig. 1 International Publication Ratio (IPR) among the whole Brazilian scientific community (**a**) and among people with three or more publications (**b**), 1997–2004. *N*(a) = 44,003. *N*(b) = 34,390

which were registered in Research Groups Directory by the time of sampling. The data source was the Lattes Database[3] referred as "one of the cleanest researcher databases in existence", in the words of Lane (2010).

Information retrieved for each researcher included: name, gender, science field, graduation year, subfield, institution, whether or not the researcher was the leader of a research team, whether or not the researcher was awarded with productivity fellowship and which kind of it, proficiency data, and publication data. From the whole sample, 24 had double entrance, being discarded the older ones. Homonyms, comprising 119, were also excluded. At the end, the sample was reduced to 51,080 researchers.

The affiliation institutions listed in the database were checked in the Directory of Institution organized by CNPq in order to determine the sector and the type of institution as well as its geographical location.

Publication data encompass the period of 1997–2004 and refer to publications published in specialized journals of national circulation (published only in Portuguese) and international circulation (published in other languages rather than Portuguese). Data also include publications published in scientific, technological or artistic conference proceedings.

Among the whole sample, 7,076 researchers did not publish either in national or in international journals in the 8 year period. As for the 1997–2000 and 2001–2004 periods, this set is higher but it has been reduced from 15,000 to 11,759.

In order to estimate the weight of international publications to the whole scientific publications published by Brazilian community, we have elaborated the International Publication Ratio that is defined as: IPR = number of international publication/total number of publications. For each of the 51,080 names of our sample, with at least one publication in the whole period, an IPR value was assigned and its distribution is presented in Fig. 1a. The peaks suggest a non-homogeneous group. To avoid bias, we excluded researchers that have published less than three publications in the whole period (Fig. 1b). For this new sample, that encompasses 34,390 names, we observed that the peak of 50% IPR disappears.

[3] http://lattes.cnpq.br/english/conteudo/aplataforma.htm.

Hence, all analysis present in this work took into account only Brazilian researchers with three or more publications. They were classified into five groups according to their IPR: (1) highly international (with 80.1–100% of international publications), (2) mostly international (with 60.1–80%), (3) intermediary (with 40.1–60%), (4) mostly national (with 20.1–40%) and (5) highly national (with 0–20%).

Results and discussion

In the following, results on the effect of different factors on the international performance of Brazilian researchers and about differences among those classified as highly international and highly national productive are presented.

IPR and the effect of distinct sectors and fields

During the 19th century, the main role of military organizations within the institutional structure of contemporary societies started to be replaced by academic organizations. Since then, the relationship between the university, industry and government have been transformed (Etzkowitz and Leydesdorff 2000).

Within this new institutional model, it can be observed that private institutions and industries play a major role in research and development activities in developed countries while laboratories and universities are responsible for about 10–20% of R&D activity (UNESCO 2001). As for developing countries, public institutions, especially universities, are the main R&D producers, following the "western model" (Glanzel et al. 2006).

In order to check whether this assumption is available to the Brazilian community we have adapted the concept of University-Industry-Government triad to other that better

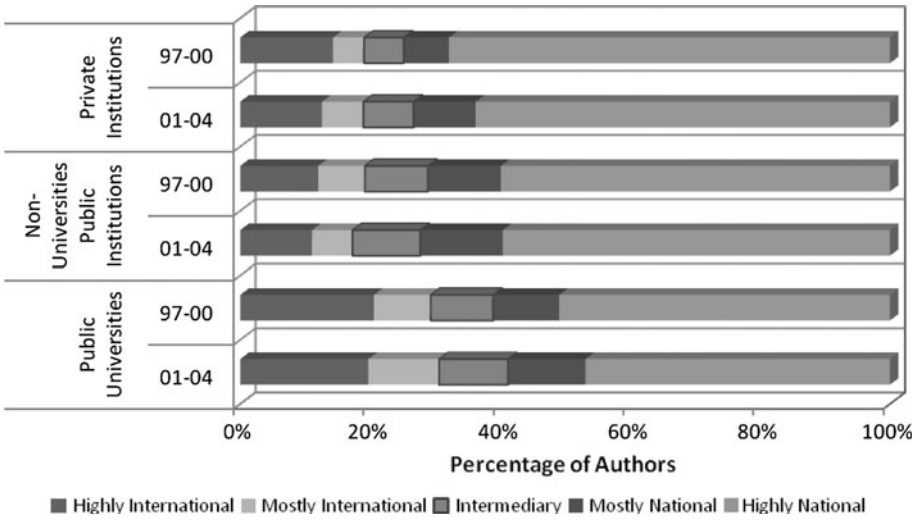

Fig. 2 The distribution of Brazilian researchers among different groups of IPR and the effect of researchers' affiliation category in 1997–2000 and 2001–2004. $N = 22{,}114$ (1997–2000) and 23,011 (2001–2004). Only researchers with three or more publications between 1997 and 2004 were considered and 18,148 researchers hadn't specified institution

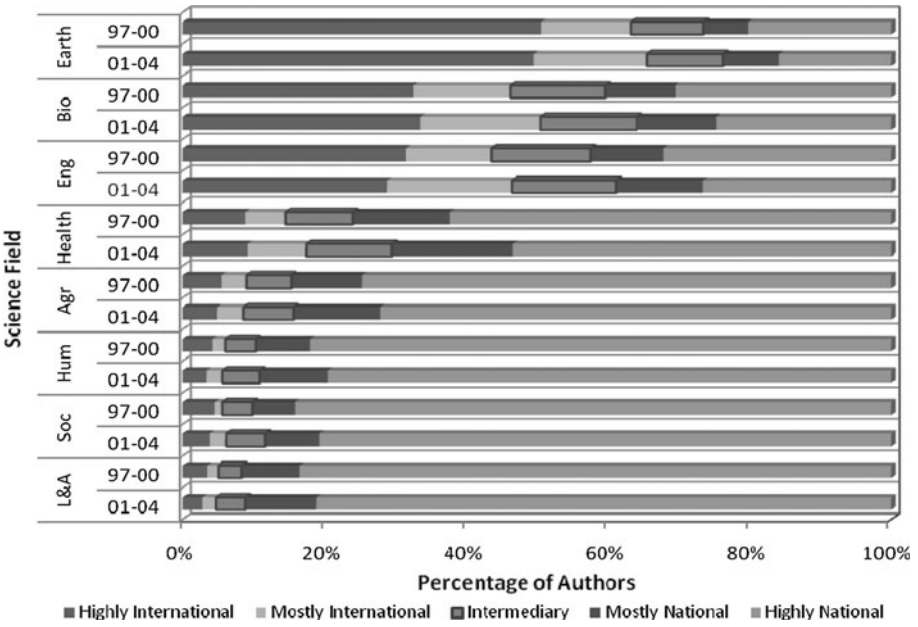

Fig. 3 Distribution of Brazilian researchers among different groups of IPR and the effect of fields in 1997–2000 and 2001–2004. $N = 31{,}073$ (1997–2000) and 33,006 (2001–2004). Only researchers with three or more publications between 1997 and 2004 were considered. *Agr* Agriculture, *Bio* Biology, *Eng* Engineering, *Earth* Earth and Exact Sciences, *Hum* Humanities, *L&A* Linguistics and Arts, *Health* Health Sciences, *Soc* Social Sciences

expresses Brazilian's reality. Hence, the affiliations of Brazilian researchers were categorized into Private Institutions, Public Universities and Non-Universities Public Institutions. These categories were already used by Leta et al. (2006). Figure 2 shows the effect of affiliation category on the distribution of researchers among different groups of IPR in two different periods (1997–2000 and 2001–2004).

Brazilian public universities, which are fully supported by state and federal governs, present the largest proportion of researchers with highly international profile. It is noteworthy pointing out that public universities concentrate the major part of Brazilian scientific community and they account for more than 80% of the total publications (Leta et al. 2006). Thus, considering the key role of public universities in the Brazilian S&T system, it would be expected that public universities hold researchers with higher IPR.

Comparing the two periods, the results also show that the proportion of researchers with highly international profile is increasing over time whereas the proportion of those with highly national profile is being reduced.

Another factor investigated was the main field in which Brazilians researchers carried out their projects. It is widely discussed that the field of research has a major influence in the publication profile (Glanzel and Moed 2002; Batista et al. 2006; Hu et al. 2010). For our sample it is clear that IPR is extremely sensible to this variable (Fig. 3).

The more experimental and/or technological is the field, the larger is the fraction of researchers with highly international profile. Earth and Exact Sciences, Biology and Engineering are the fields with highest international publication profile, with more than 50% of researchers presenting an IPR at least intermediary. Linguistic and Arts, Social

Sciences and Humanities are the fields with a predominantly national profile, with around 80% of researchers presenting highly national profile. Despite of the publishing culture of the field, from the first period to the second one, all fields presented an increase of international publication proportion.

IPR and the effect of years since PhD and gender

It is well known that aging affects the productivity of researchers (Wallner et al. 2003; Allison and Stewart 1974). In general, youngest and oldest researchers tend to have low rates of productivity. Does the Brazilian community follow this trend? Figure 4 shows the distinct IPR groups according to the difference between the year of 2005, when the data was collected, and the conclusion year of the PhD.

It can be seen that the distribution profile is similar among the different IPR groups, although youngest tend to have a larger proportion of highly national publication pattern. Among those researchers with less than 6 years since PhD, 51% do have a profile of highly national publication, while for those with more than 15 years, this proportion drops to 42%.

As a final aspect investigated in this set of analysis, we have checked whether the gender of the researcher affects the IPR (Fig. 5).

International literature points out that woman still struggle for equal conditions in relation to man to get a position in labour market in most social activities, including science (Schiebinger 2002). In science, productivity may count a lot in this process. In the case of Brazilian community, men seem to have relatively more international publications than women because of larger proportion of highly international group and smaller proportion of highly national group. However, it is clear that both woman and man have increased their share of international publications from one period to the other, revealed by the decrease of highly national proportion.

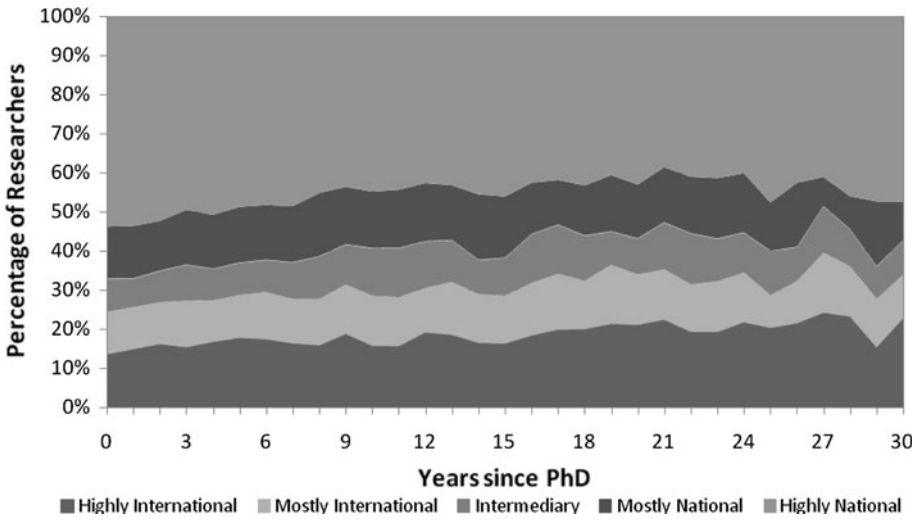

Fig. 4 Distribution of Brazilian researchers among different groups of IPR and the effect of years since PhD in 1997–2000 and 2001–2004. $N = 33{,}600$. Only researchers with three or more publications between 1997 and 2004 and 30 years or more since PhD were considered

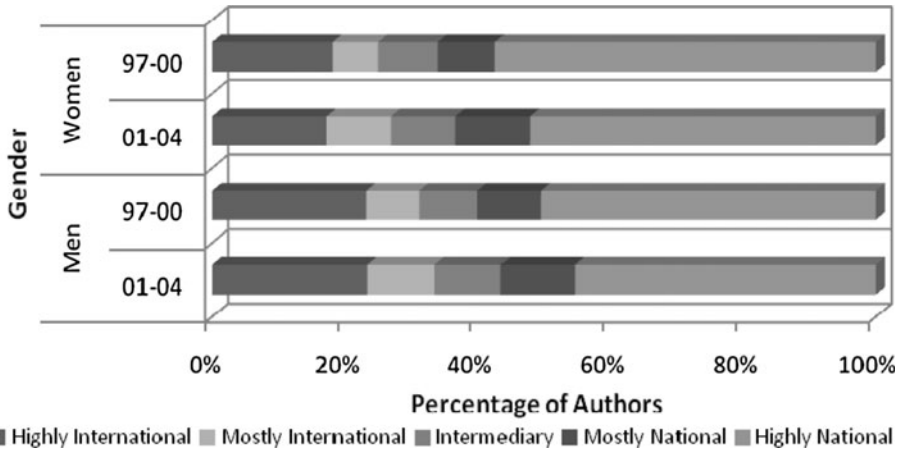

Fig. 5 Distribution of Brazilian researchers among different groups of IPR and the effect of gender in 1997–2000 and 2001–2004. $N = 31{,}033$ (1997–2000) and 32,963 (2001–2004). Only researchers with three or more publications between 1997 and 2004 were considered and 175 researchers hadn't specified the gender

National productivity × International productivity

In order to compare researchers with distinct publication behaviour in terms of audience or visibility, different parameters were associated with those with highly international profile (IPR > 80%) and those with highly national profile (IPR ≤ 20%) (Table 1).

Considering the parameter gender, we have found that the group of highly international profile encompasses proportionally more men than the other one. We also observed a higher proportion of researchers with more years of degree and affiliated at public universities in the former group.

We have also found that Agriculture, Humanities, Linguistic and Arts, Health Sciences and Social Sciences are stronger fields among researchers with national productivity. On

Table 1 Personal and academic parameters between the researchers with highly national and highly international profiles

Parameters	Highly international profile	Highly national profile
Ratio men/women	2,26	1,37
Years since PhD ≥ 5 years	69%	63%
Public universities	86%	74%
Science field		
Agriculture	2%	21%
Biology	25%	7%
Engineering	13%	5%
Earth and exact sciences	52%	6%
Humanities	1%	22%
Linguistic and arts	0%	7%
Health sciences	5%	18%
Social sciences	1%	14%

the other hand, Biology, Engineering and Earth and Exacts Sciences are more representative among those with international productivity.

It is important to note that Agriculture is an important field within Brazilian science, with a particular publication pattern, which has a strong local research interest. It has a massive influence of a specific non-university public institution named EMBRAPA and the share of researchers working in public universities is lower for the group of national productivity.

Despite the research interest (global or local), among some personal and academic factors, to reach the international audience any researcher has to have the proficiency in writing their studies in the *lingua franca* of science, the English. Hence our results are maybe pointing to a proficiency issue, that would take more time to the non experienced researcher be ready to publish in other idioms (Vasconcelos et al. 2008).

Conclusion

In this study we proposed a new approach to investigate scientific productivity. The International Publication Ratio (IPR) was developed to allow distinction between groups with different publication trends. The methodology was possible due to Lattes database infra-structure that presents complete curriculum of Brazilian researchers and is available at the internet.

We have found evidences that the international performance is a field dependent variable. Fields devoted to issues with international interests, such as Biology, Engineering and Earth and Exact sciences, present a large fraction of researchers with a higher IPR. But this is not true to fields primarily devoted to issues with local and national interests. The use of IPR gave us a good example of the importance of each field's idiosyncrasies as critical factors to be considered while comparing performances in different areas, within a scenario where general evaluation determines resources destination.

IPR also allowed the demonstration of aging influence in international publication. It takes career time for researchers to get to know the paths for publishing in international vehicles, to establish their nets and to get recognition.

The pattern found for gender of researchers can be a result, for example, of the choice of scientific field, which is widely known as a phenomenon influenced by culture and social relations (Costas 2002). Observing Fig. 3, where Humanities, Social Sciences and Linguistic and Arts, which are historically female disciplines, show an essentially national publication profile, one should expect a female representativeness to increase in the group of national productivity. Another aspect to be considered is the recent incorporation of women in the scientific community. It was shown that younger researchers tend to present larger proportion of national publication and it is exactly among the younger researchers that women prevail.

Finally, we believe the data presented in this work may help S&T managers and other S&T interests to better understand the complexity under the concept productivity.

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