Growth of Brazilian science: a real internationalization or a matter of databases' coverage?

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Abstract

Brazilian science and technology system has been expanding since the 1950s. As a result of this expansion Brazil has increased its contribution to the world's scientific production indexed in international databases. In more recent period, a stronger increase was observed and gained repercussion in national and international media. The aim of the present study is to investigate whether the recent growth of scientific production means a true insertion of Brazilian science in international scenario or a result of a larger inclusion of Brazilian journals in informational databases.

Introduction

The consolidation of Brazilian science and technology system as well as the expansion of Brazilian scientific community started formally in the 1950s. As for the following decades, public policies were oriented towards the establishment of a complex and huge national program for training human resources to science activities in the country (Guimarães & Humann, 1995).

The investment in graduate courses was accompanied by a growth of Brazil's contribution in technical and scientific publications in journals indexed by the Institute for Scientific Information (ISI/Thompson). Brazilian's share of world's production increased from 0.16%, in 1967, to 0.31%, in 1974 (Morel & Morel, 1977), 0.46%, in 1993 (Leta & de Meis, 1996), 1.11%, in 2000 (Pinheiro-Machado & de Oliveira, 2001) and 1.75%, in 2005 (de Meis, Arruda & Guimarães, 2007). Regarding a more recent period, a stronger increase in these publications was observed: Brazilian's share in the world's scientific production reached 2.7%. (Regalado, 2010). This performance, according to the author, led Brazil to occupy the 13th position in the worldwide ranking of scientific production, ahead of Holland, Israel and Switzerland.

According to some Brazilians, this performance is as a result of a national evaluation on Brazilian researchers, carried out in the last two decades by the Brazilian Agency for Higher Education (short name CAPES). Such evaluation tends to prioritize the implementation of international standards, stimulating and enhancing the scientific communication published in high-impact journals with international visibility. On the other hand, it is also important to consider that this growth may be a reflection of the dynamics of inclusion and exclusion of journals within the main informational databases. This is continuous and permanent mechanism of databases' indexing system, which aims equalizing the relationship between multiple factors, including the increasing demand for the inclusion of new journals, the performance of journals already included in the database and physical limitations of the bases (Garfield, 1990; Testa, 1998). Thus, considering these factors and a range of other interests, this relationship will hardly occur in favor of a more balanced coverage of journals in terms of country, language and area.

Taking into account the coverage of the main informational databases responsible for indexing international scientific literature, the aim of this paper is to present evidences to better understand whether the recent growth of Brazilian scientific production was a true insertion of country within the international science arena or a result of a larger inclusion of Brazilian national journals in databases.

Methodology

Information about Brazilian scientific publications published in nine different biennials was collected through Web of Science's (WoS) and SCOPUS' websites, http://apps.isiknowledge.com/WOS_GeneralSearch_input.do?highlighted_tab=WOS&product=WOS&last_prod=WOS&SID=4Dchb6aaemDjGEKIb96&search_mode=GeneralSearch and http://www.scopus.com/home.url. The searches used a filter "Brasil" OR "Brazil" in the field *address* and were applied to the all parts of the databases.

The sums of all biennials were 168,005 and 176,964 in SCOPUS and WoS, respectively. The number of total publications in each of the nine biennials as well as their respective information on type, language and main field of publication were collected manually, directed from the databases' websites in the 1st of December, 2010.

Part of the data presented here is included in an invited full paper, "*Indicadores de desempenho, ciência brasileira e a cobertura das bases informacionais*" (in English: "Indicators of performance, Brazilian science and database coverage"), to be published by Revista USP, in March 2011.

Results and discussion

Figure 1 shows time changing in the number of Brazilian publications along the nine biennials. A similar growth trend is observed for both databases. However, it can be noted a reversal between the two databases in terms of coverage: WoS covered a larger number of Brazilian publications until the 1990s, after which SCOPUS assumes this role.

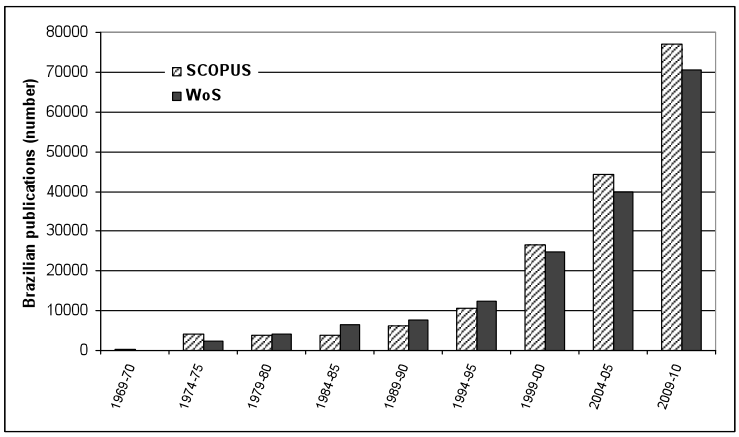

Figure 1: Time trend of Brazilian publications catalogued by SCOPUS and WoS, along nine biennials.

Based on Figure 1, three criteria were investigated in detail: the type, language and main field of publication. In addition, other aspect was also analyzed: the weight of national and international journal within the set of core (or nucleus) journals, according to Bradford's definition (Bradford, 1934). All these criteria were investigated along the nine biennials.

Type, language and main fields of Brazilian publications

Written communication among scientists has continuously been updated and changed. However, after the 2nd world war scientific journals have spread all of the world and original papers, or articles, turned to be the most important format for disseminating the new scientific knowledge (Meadows, 1974). As for the Brazilian scientific publications, Table 1 shows that articles represent the largest share of publications indexed in both databases. For the period 2004-05, articles represent about 80% of Brazilian output. But this is a fraction that varies notably, especially at the SCOPUS database.

Table 1: Brazilian total publications and the share of articles and publications written in English, in SCOPUS and WoS databases along nine biennials.

Period	Brazilian publications		Publication in the format article (%)		Publication written in English (%)	
	SCOPUS	WoS	SCOPUS	WoS	SCOPUS	WoS
1969-70	336	98	93.8	88.8	97.3	44.9
1974-75	4,154	2,342	30.7	69.6	34.1	78.5
1979-80	3,821	4,254	49.8	72.7	55.2	79.1
1984-85	3,748	6,403	65.6	70.6	76.6	79.5
1989-90	6,326	7,538	80.5	77.7	83.0	83.5
1994-95	10,506	12,277	83.0	69.7	87.7	91.7
1999-00	26,565	24,715	87.9	72.2	85.3	92.0
2004-05	44,386	39,755	74.1	69.4	88.1	92.9
2009-10	77,122	70,623	79.5	79.1	76.5	79.4
Total	176,964	168,005	-	-	-	-

It is well known that English has become the *lingua franca* of science since the 2nd world war. It is unquestionable the role of English as a key component in global science. So, having proficiency in this language is a universal requirement to be part of global science. One evidence is the hegemony of journals written in English indexed in informational databases, as Thomson / ISI (Van Leeuwen *et al*, 2001). As for the Brazilian publications, it can be observed that about 80% are written in English. It is not clear, however, whether this is an increasing feature.

As a third aspect investigated in this set of analysis, Table 2 presents the three top fields where Brazilian publications are classified.

Table 2: Top fields of Brazilian publications catalogued in SCOPUS and WoS databases, **along nine biennials**.

Period	SCOPUS	WoS
1969-1970	Physics And Astronomy (114); Biochemistry, Genetics&Molecular Biology (89); Medicine (88)	Psychology (43); Psychology, Applied (42); Economics (14)
1974-1975	Medicine (3.233); Biochemistry, Genetics & Molecular Biology (308); Physics & Astronomy (280)	Multidisciplinary Sciences (268); Medicine, General & Internal (150); Biochemistry & Molecular Biology (132)
1979-1980	Medicine (2.338); Physics & Astronomy (504); Biochemistry, Genetics&Molecular Biology (442)	Multidisciplinary Sciences (403); Medicine, General & Internal (366); Biology (220)
1984-1985	Medicine (1.519), Physics & Astronomy (739), Biochemistry, Genetics&Molecular Biology (525)	Biology (944); Medicine, Research & Experimental (833); Agriculture, Multidisciplinary (376)
1989-1990	Medicine (2.422); Physics & Astronomy (1.116), Biochemistry, Genetics&Molecular Biology (925)	Biology (540); Medicine, Research & Experimental (451); Tropical Medicine (434)
1994-1995	Medicine (3.539); Physics&Astronomy (2.100); Biochemistry, Genetics&Molecular Biology (1.521)	Biology (674); Biochemistry & Molecular Biology (572); Physics, Condensed Matter (568)
1999-2000	Medicine (7.085); Physics & Astronomy (4.529); Agricultural & Biological Sciences (4.075)	Dentistry, Oral Surgery & Medicine (1,734); Biochemistry & Molecular Biology (1,381); Physics, Condensed Matter (918)
2004-2005	Medicine (12.343); Physics & Astronomy (6.246); Biochemistry, Genetics&Molecular Biology (6.031)	Dentistry, Oral Surgery & Medicine (2,142); Biochemistry & Molecular Biology (1,968); Neurosciences (1,579)
2009-2010	Medicine (24.199); Agricultural & Biological Sciences (14.461); Biochemistry, Genetics & Molecular Biology (9.206)	Veterinary Sciences (2,698); Public, Environmental & Occupational Health (2,667); Biochemistry & Molecular Biology (2,445)

It calls attention to the fact that, despite the differences between the two databases in terms of fields' name and coverage, a large fraction of Brazilian publication is published in journals devoted to international themes, especially those related to biology, biomedicine and physics. This is a typical example of the bio-environmental model described in 2nd European Report on S&T Indicators (REIST-2, 1997). Also important is to note that these fields that appear as the top performers were the basis for the rising of Brazilian science.

Core journals of Brazilian publications

As a final attempt to investigate the level of internationalization of Brazilian scientific production, especially in recent times, an analysis of the core journals was performed. Following Bradford (1934), core journals are defined as the set of journals that contributes to one-third of all publications. For a given field of knowledge, publications in this set of journals express the nucleus of the field. For an institution or a country, they also express the central pathways through which their scientific efforts are been conducted.

Considering this premise, Brazilian publications in WoS and Scopus were analyzed (Table 3). It is possible to observe an amazing increase in the number of total core journals along the biennials: increasing by 14-fold and 97-fold in WoS and SCOPUS, respectively. So, as a first conclusion: Brazilian central science, over the years, ceased to be concentrated, gaining new spaces and new audiences worldwide. In this respect, it can be inferred that such new spaces seem to be old acquaintances of Brazilian researchers. Throughout the biennials, the fraction of core journals that are edited in Brazil is sometimes greater than the fraction edited abroad. For the last biennium, for example, core journals edited in Brazil represented 63.1% and 63.9% of total core journal indexed by SCOPUS and WoS, respectively.

Table 3: Core journals in which Brazilian publications are published, SCOPUS and WoS, along nine biennials.

Biênio	Total of Core Journals		Core Journals edited in Brazil			
	Scopus	WoS	Scopus (n)	WoS (n)	Scopus (%)	WoS (%)
1969-70	11	1	0	1	0,0	100.0
1974-75	10	22	10	4	100.0	18.2
1979-80	10	17	9	8	90.0	47.1
1984-85	26	11	14	9	53.8	81.8
1989-90	34	23	19	10	55.9	43.5
1994-95	50	42	21	10	42.0	23.8
1999-00	75	50	30	13	40.0	26.0
2004-05	110	71	46	20	41.8	28.2
2009-10	160	97	101	62	63.1	63.9

The fraction of Brazilian publications in core journals edited in Brazil swings in both databases, especially in WoS. The higher predominance of central journals edited in Brazil in the last biennium is accompanied by an increasing of the number of publications published in this set of journals, which reached 71% and 73% of SCOPUS and WoS, respectively (data not shown). Thus, besides the fact of the core journals set is composed by an increasing number of journals edited in Brazil, this set also concentrates the majority of Brazilian publications.

The high prevalence of Brazilian journal within the set of core journals can be also visualized by the top-three ranked core journals listed in Table 4. International journals (in bold letters) sum only seven in this selective group of journals.

Comparing both databases, the list of top-three core journals differs a lot, especially after the 1989-90 biennium. Since then, some Brazilian journals appear in both databases as top central journals, they are: Brazilian Journal of Medical and Biological Research; Arquivos de Neuro

Psiquiatria; Memorias Instituto Oswaldo Cruz and Pesquisa Agropecuaria Brasileira. In the most recent biennium, Ciencia Rural and Quimica Nova are found in both databases too. In the end, the general profile of all these journals reflected in the main fields of Brazilian publications (Table 2). This observation leads to another conclusion: the new and recent spaces in international audience conquered by the Brazilian science are not so new. These paths are known internally, but gained recent international visibility as they were indexed by these two informational databases.

Table 4: Top-three ranked core journals in which Brazilian publications are published, SCOPUS and WoS, along nine biennials.

Period	SCOPUS	WoS
1969-70	**Experientia** (17); **J. Chem. Phys** (13); **Comp. Biochem. Physiol** (13)	Arq. Bras. Psicol (39); Rev. Bras. Econ (9).
1974-75	Folha Medica (320); Rev. Hosp. Clín. (150); Rev. Bras. Clin. Terap.(132)	An. Acad. Bras. Ciênc. (205); Rev. Bras. Med. (114); **Acta Physiol. Latinoam** (85)
1979-80	Arq. Bras. Cardiol. (275); Folha Medica (201); Rev. Bras. Clin. Terap. (121)	An. Acad. Bras. Ciênc. (347); Rev. Bras. Med. (161); Braz J Med Biol Res (141)
1984-85	Folha Medica (111); **Phys. Rev. B** (93); Braz. J.Gen. (76)	Braz J Med Biol Res (778); Pesq. Agropec. Bras. (360); An.. Acad. Bras. Ciênc (218).
1989-90	Braz J Med Biol Res (408); Arq. Neuro-Psiquiatr. (129); Mem. Inst. Oswaldo Cruz (113).	Pesq. Agropec. Bras. (407); Braz J Med Biol Res (405); Mem. Inst. Oswaldo Cruz (222)
1994-95	Braz J Med Biol Res (296); Arq. Neuro-Psiquiatr. (195); **Phys. Rev.B** (189)	Pesq. Agropec. Bras. (399); Braz J Med Biol Res (378); **J. Dent. Res.** (357)
1999-00	Pesq. Agropec. Bras. (569); Arq. Neuro-Psiquiatr. (336); Mem. Inst. Oswaldo Cruz (305).	**J. Dent. Res.** (1492); Pesq. Agropec. Bras. (548); Arq. Neuro-Psiquiatr. (324)
2004-05	**Lect. Notes Comput. Sc.** (502); Arq. Neuro-Psiquiatr. (412); Cad. Saúde Pública (408)	**J. Dent. Res** (1337); **Lect. Notes Comput. Sc.** (643); Rev. Bras. Zootec.(561)
2009-10	Ciencia Rural (781); Quimica Nova (637); Rev. Bras. Zootec. (582)	Ciencia Rural (810); Ciencia & Saude Coletiva (748); Quimica Nova (707)

Conclusion

The unquestionable growth in Brazilian publications in various formats and vehicles is a natural consequence of the growing of Brazilian science during the last decades as well as a result of the evaluation process of graduate courses that started in the 1990`s. Regarding this last factor, graduate courses concentrate most of Brazilian researchers and PhD students and impose strict criteria of productivity. Consequently, Brazilian researchers (and their PhD students) are pushed to follow an internationalized model of science, in which the internationality of the research focus and journals is the main requisite. In this context, journals edited in Brazil assume a marginal role for disseminating Brazilian science. However, the data shown here reveal that much of the Brazilian scientific production, recognized as international, is published, in fact, national journals, recently indexed by these bases.

Rethinking the role of national journals as main sources to spreading and diffusing the scientific output of a peripheral country in science is a challenge for any S&T manager. Nevertheless, such role is not easily perceived as well as the complexity beyond the process of inclusion or exclusion of a journal within an international database. This seems to be the

case of some Brazilian authorities and media when announced the reasons for the recent growth of Brazilian publications in international databases. The weight of national journals was not considered.

Hence, strengthening and investing in the quality of national journals are requisites for pursuing their inclusion within the international arena of scientific communication databases. In Brazil, one important initiative towards this goal is the Scientific Eletronic Library On-line (http://www.scielo.br/). Founded in the mid 1990's, SciELO is been carried out by the Latin American and Caribbean Center on Health Sciences Information and aims increasing the visibility as well as the impact of Brazilian national publications, in other words, making Brazilian science visible. Such initiatives increase the accessibility of scientific knowledge produced in the country as well as give national journals more credibility and recognition.

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