Some trends in higher education and research in BRICS countries

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This paper discusses two aspects of education, research and skills in BRICS countries: 1) whether higher education systems in these countries are likely to be prepared to produce highly skilled, especially technical, graduates in quantity and quality; 2) what is the relevance and which is the specialization of each of these countries in terms of science production (measured as number of published articles and received citations). Secondary data are gathered from varied sources to build the analysis. Potential mechanisms to enhance collaboration among these countries in higher education and research are briefly discussed. The objective is to highlight the BRICS nations capacity to produce highly-skilled labor force and influential research, as well as to identify possible channels for collaboration on education and science-related enterprises. Results suggest that BRICS nations already play an important role in both labor supply and scientific output. However, this rise is mostly numerical and the relevance of BRICS countries is not as clear in terms of quality.

1. Introduction

This paper discusses two aspects of education, research and skills in BRICS countries: 1) whether higher education systems in these countries are likely to be prepared to produce highly skilled, especially technical, graduates in quantity and quality; 2) what is the relevance and which is the specialization of each of these countries in terms of science production (measured as number of published articles and received citations). Secondary data are gathered from varied sources to build the analysis. Potential mechanisms to enhance collaboration among these countries in higher education and research are briefly discussed. The objective is to highlight the BRICS nations capacity to produce highly-skilled labor force and influential research, as well as to identify possible channels for collaboration on education and science-related enterprises.

The paper is organized in five sections. After this initial introduction, section 2 presents trends in tertiary education in the BRICS countries. Section 3 discusses BRICS' capacity to produce technical graduates, particularly engineers. Section 4 presents and discusses trends in BRICS' scientific output.Section 5 brings final remarks and conclusions.

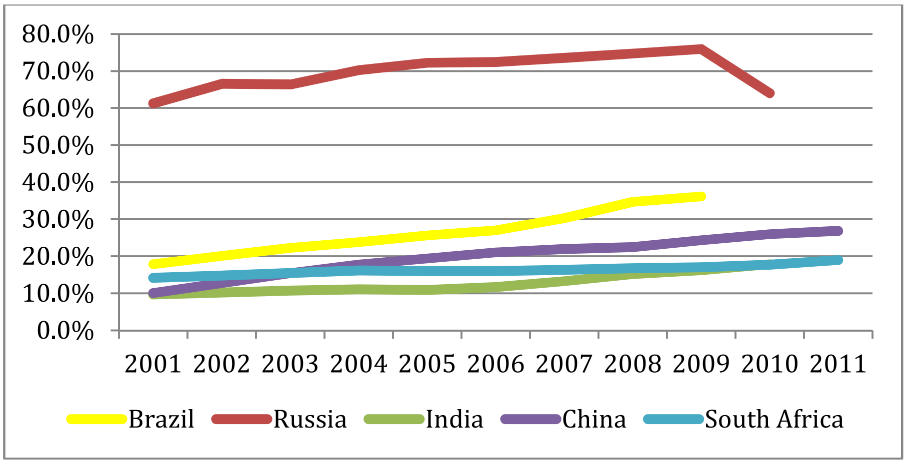
2. Trends in Tertiary Education in the BRICS

A century ago, pursuing a university degree would be a differential that very few could reach. Elementary education and literacy would then suffice as basic requirements to succeed in a modern society. Higher education now plays such a role (OECD 1998).

As a consequence, tertiary education has expanded significantly in most developed and developing countries. The scenario is not different in the BRICS nations. Their higher education system share some common characteristics with many developed countries under the same pressures to enhance education indicators: rapid expansion, the search for new sources of funding, and the consolidation of a limited number of elite ("flagship") universities (Balzer 2011).

The last decade was markedly the decade of mass tertiary education in the BRICS. Enrolments have mostly increased in Brazil, Russia, India, China and South Africa. This is shown in Figure 1, which depicts the trends for tertiary gross enrolment ratio in these countries between 2003 and 2010.

Figure 1: Gross enrolment ratios on tertiary education. Brazil, Russia, India, China and South Africa, 2001-2010.



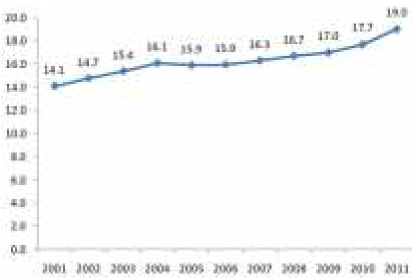
Source: Calculations using data from the Unesco Institute for Statistics (UIS). For Russia (2010 only) and for South Africa (all years), Menon (2012).

We can see from Figure 1 that Brazil, India and China have experienced the greatest expansion rates in the period, particularly from mid-2000s. Although we cannot draw causal links solely on these data, this trend is certainly associated with two other facts regarding these countries: (i) economy booming in the period; (ii) increasing number of secondary school graduates.

Russia, in its turn, may possibly be reaching its limit for further expansion. Among the BRICS, Russia is historically the most advanced in terms of educational indicators. Russia's tertiary gross enrolment ratio is high even for developed countries. In 2009, it was 75%, while in the US it was 45% (Loyalka et al. 2012). The tertiary gross enrolment ratio gives the total number of enrolments in higher education as a proportion of the population in the official age group corresponding to this level of education. Even with a high figure since the beginning of the decade, Russia's tertiary gross enrolment ratio continued to increase up to 2009. The decrease in 2010 does not necessarily mean a change in such an upward tendency, but one should take into account the demographic decline that is expected to reduce enrolments in Russia over the decade 2010-2020 (Balzer 2011).

In South Africa the concerns are of different type. Its higher education system is massified only for white citizens, whose participation rates among 18-24-years-olds is close to 60% - comparable with the developed world (Bawa 2012). University access for young African South Africans remains limited, though. The rate is 13% for this group (Bawa 2012). Hence massive expansion of tertiary education in South Africa depends on how successful are future policies to enlarge participation of African South Africans. Nonetheless, South African higher education system has been also expanding. Albeit in lower speed during some years, its gross enrolment ratio has been accelerating, particularly after 2007, as Figure 2 shows.

Figure 2: Gross enrolment ratio on tertiary education. South Africa, 2001-2011.

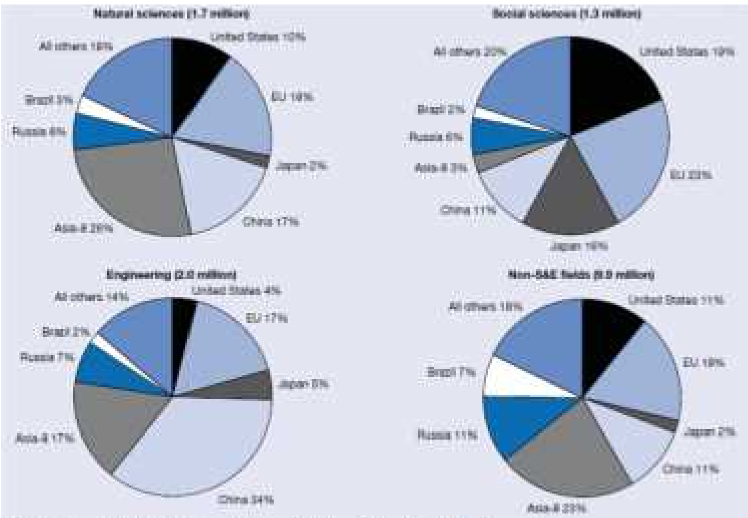


Source: Menon (2012).

3. BRICS’ capacity to produce technical graduates, particularly engineers

Competitiveness in a global economy based on innovation and knowledge demands advanced capacity to produce highly-skilled, particularly technical, workforce. Skills shortage is often seen as a potential constrain for sustaining economic growth in the BRICS (Bawa 2012; Farrell e Grant 2005; Saboia e Salm 2010). However, BRICS nations already play a central role in the global supply of technical labor. Brazil, Russia, India and China together produce more than half of the world’s engineering graduates each year (Loyalka et al. 2012). Figure 3 highlights that the relative importance of the BRICS in engineering education is greater than in other areas.

Figure 3: Distribution of first university degrees by selected regions/countries (2008).



Source: Zha e Hayhoe (2012).

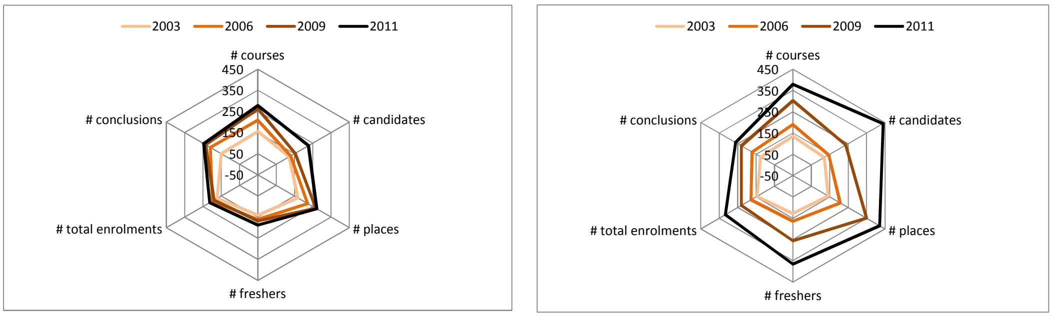
Asia-8: India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand.

EU: European Union.

Even considering that China alone provided more than 1/3 of all new engineers that entered the labor market in 2008, the relevance of BRICS countries as a whole in the global supply of this kind of labor is clear in terms of quantity. In Brazil, for example, the relative expansion of engineering education in the last decade outperforms the already significant growth of the entire tertiary education, as we can see in Figure 4.

Figure 4: Evolution of tertiary education indicators. Brazil, 2003, 2006, 2009 and 2011. All areas, and engineering, manufacturing and construction separately.

(A) All areas (B) Engineering, manufacturing and construction



Source: adapted from Gusso and Nascimento (in press).

Note: Each indicator is expressed in index numbers. Values for year 2000 = 100. The distance from the origin to the data point is proportion to the variation on the respective indicator.

Carnoy (2012) points out that Brazil, Russia, India and China produce massive numbers of university graduates, and massive numbers of engineering and computer science graduates. The author argues that this number should increase rapidly in the coming years as higher percentages of the age cohort enter university in response to high rates of return to private investment in higher education, especially in engineering education. Carnoy concludes that tertiary education is likely to continuing expand in Brazil, India and China in the next ten years, particularly in engineering education. In Russia, as we saw earlier, demographic changes and an already high baseline should constrain similar trends.

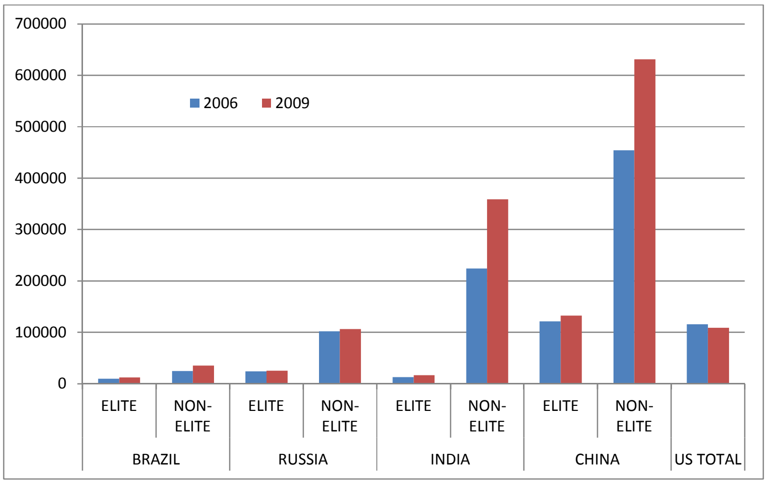
Even playing a central role in the global provision of technical labor, the quality of the BRICS graduates is dubious. Carnoy (2012) argues that the quality of 4/5 of the engineering graduates in Brazil Russia, India and China is expected to be much lower than in the developed countries – and this may impact future domestic development. This perception comes from some initial findings reported by the BRIC Higher Education Project, coordinated by Professor Martin Carnoy at Stanford University.

In spite of Professor Carnoy first conclusions, the future prospectus might be better. In a more recent study of the same project, Loyalka et al. (2012) try to estimate the number of potential highly-skilled engineers whose degrees were obtained in one of the BRIC countries. They classify higher education institutions from these countries as “elite” and “non-elite” and consider as “quality engineers” those graduating in the former ones. Although the majority of students are enrolled in “non-elite” institutions, the authors state that:

> Overall, the BRIC countries have made significant strides in improving the quality of engineering education over the last decade. Each country’s elite engineering programs benefit, albeit to different degrees, from a combination of factors, including: a competitive process by which a select group of high-ability students are admitted, relatively high per student expenditure, and relatively high qualified faculty. Policymakers in each country not only play a large role in managing these factors, but also help elite institutions (again to varying degrees) by providing substantial funding, mandating improvements in curricula and instructional practices, and encouraging faculty to concentrate more on research activities (Loyalka et al. 2012, p. 24-25).
>
> (…) Given the resources and attention the BRIC governments have lavished on their elite institutions in recent years, we speculate that, at the very least, the top half of engineering graduates of elite universities in the BRICs are probably as well-prepared technically as the top half of the engineering graduates in developed countries. More specifically, the close to 100,000 engineering graduates of elite universities in the BRIC countries each year are comparable to the top 50,000 engineers receiving bachelor’s degrees from US colleges and universities, the top 150,000 engineering first degree annually in the European Union, and the top 50,0000 engineering first degrees annually in Japan (Loyalka et al. 2012, p. 27-28).

In fact, engineering graduates from Chinese elite institutions already outnumber counterparts from all US institutions together. Figure 5 presents the evolution of the number of engineering graduates from the BRIC countries in two points of time (2006 and 2009), separating the output from elite and non-elite institutions and comparing it with the total number of engineering graduates in the US.

Figure 5: Number of Engineering graduates from the BRIC countries, 2006 and 2009, Elite vs Non-elite institutions.

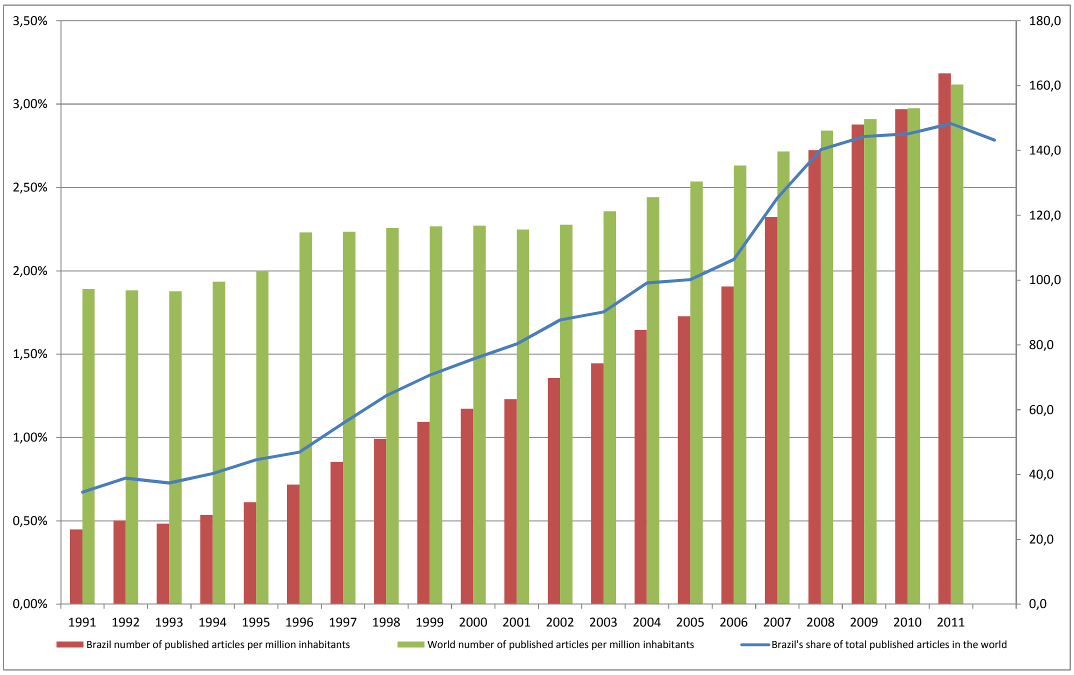


Source: Loyalka et al (2012).

4. Trends in research performance

BRICS countries accounted for 15.5% of all articles published between 2008 and 2011, according to the Thomson Reuters Web of Science database. Scientists based in the five BRICS countries are publishing growing number of papers. Figure 6 shows that for Brazil.

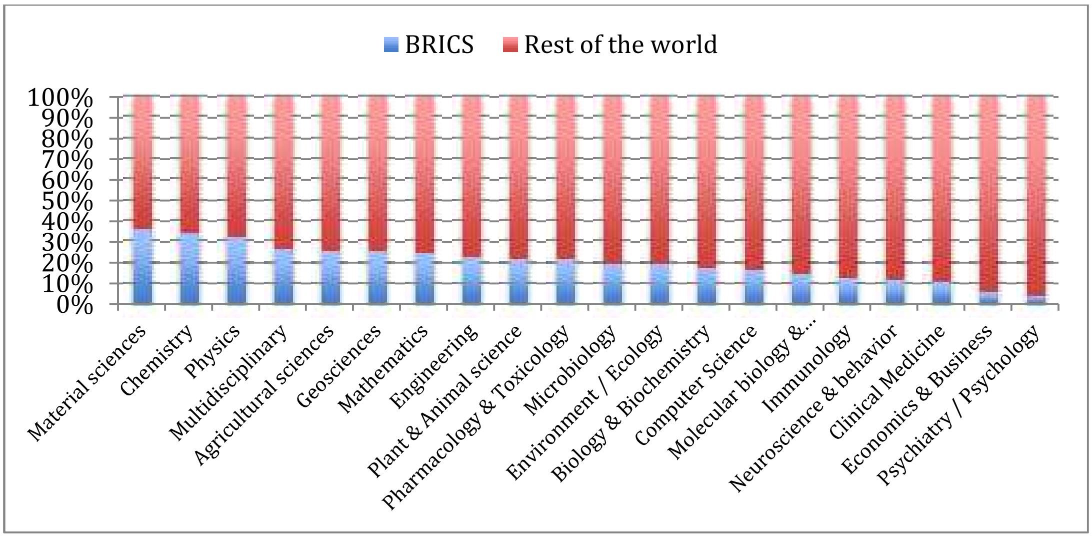
Figure 6: Brazil's evolution in terms of selected quatitative indicators of research output – 1991-2011.



Source: Own calculations using Thomson Reuters and World Bank data.

Figure 7 below shows the share of papers of the BRICS in 20 major areas.

Figure 7: Share of total number of articles published in 20 major areas between 2008 and 2011 – BRICS x the rest of the world.

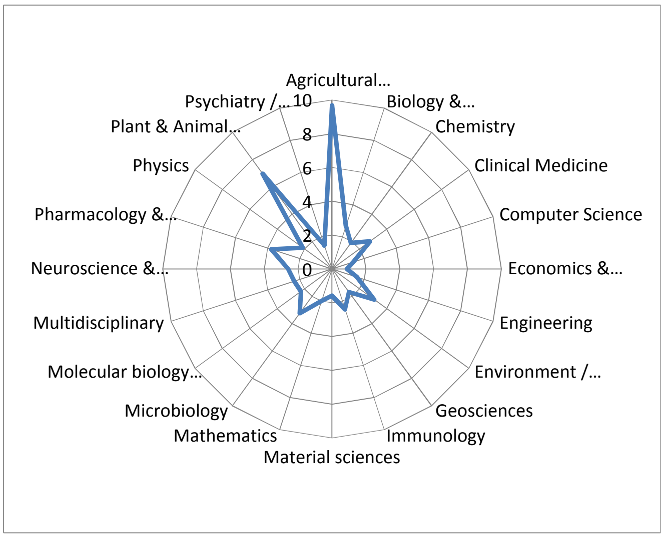


Source: Own calculations using Thomson Reuters data.

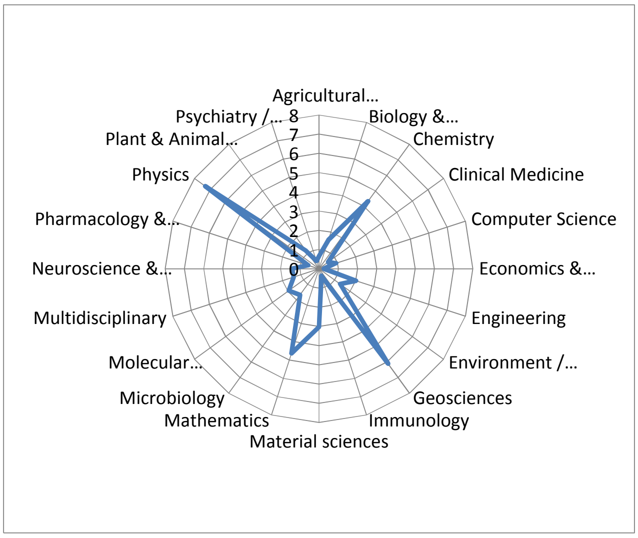
If we consider a share of 20% as a good joint performance for the BRICS researchers, ten are the areas in which they collectively appear as global players: Material Sciences, Chemistry, Physics, Multidisciplinary, Agricultural Sciences, Geosciences, Mathematics, Engineering, Plant & Animal Science and Pharmacology & Toxicology. Each of the BRICS countries presents different individual profiles, though. Figure 8 show in which areas are concentrated the research output of each of the five BRICS countries.

Figure 8: Distribution of the research output of each of the BRICS in 20 major areas between 2008 and 2011.

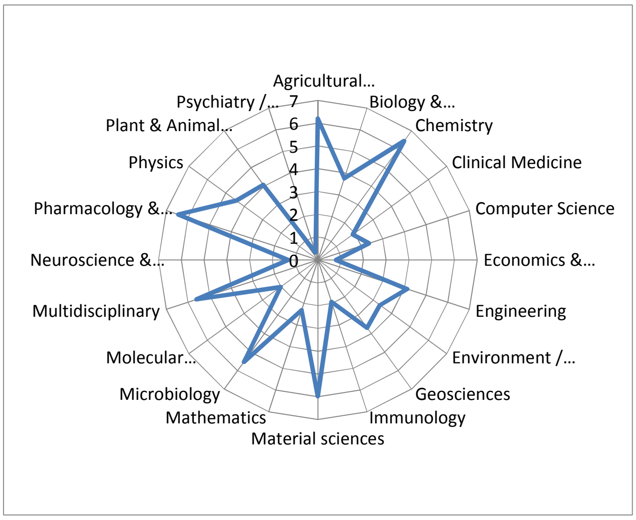
(A) Brazil



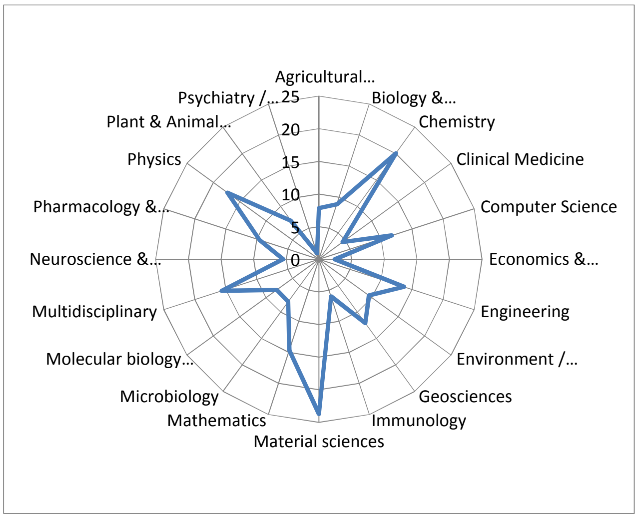
(B) Russia



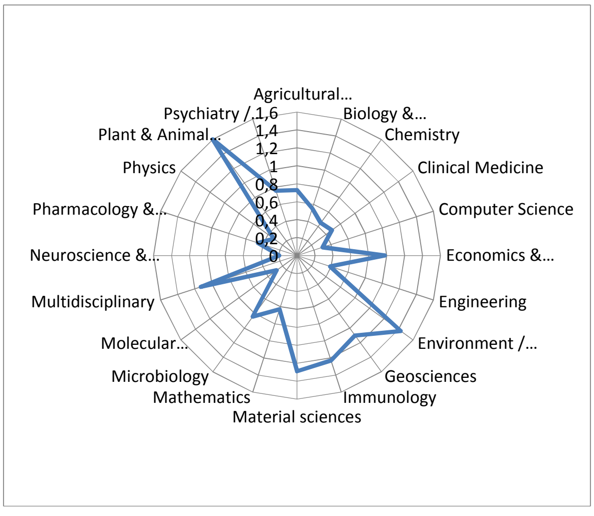
(C) India



(D) China



(E) South Africa



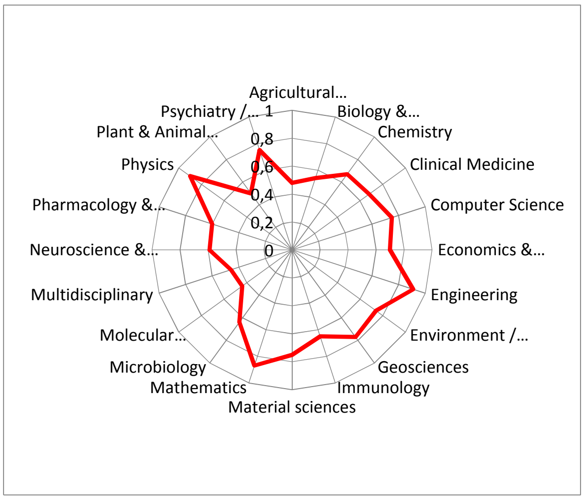
Source: Own calculations using Thomson Reuters data.

As we can see in Figure 8, in relative terms Brazil concentrates its research output in Agricultural and in Plant & Animal Sciences. The majority of Russian's articles are in Physics, Geosciences, Mathematics and Chemistry. In India, the areas that concentrate the research output are Pharmacology & Toxicology, Agricultural Sciences, Chemistry and Material Sciences, while in China these are Material Sciences, Chemistry and Physics. South African papers are concentrated in Plant & Animal Sciences, Immunology, Environment/Ecology and in Multidisciplinary studies.

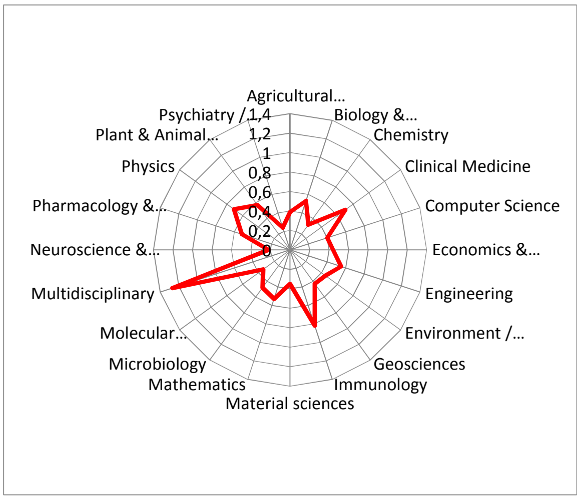
The scales of the graphs show that China is the major producer of science in quantitative terms, whereas South Africa is the smallest of the five BRICS. This reflects, obviously, the size of the countries and of their number of scientists. But an important number to look at is the citation per document relative to the average of this indicator in the respective subject area. This is an useful indicator of the impact of a nation's scientific output in a time that the "publish or perish" statement is being replaced by "be cited or perish" (Aebi 2002; Harzing 2010; King 2004). Figure 9 below presents this impact indicator for each of the five BRICS countries in 20 major areas.

Figure 9: Impact (citation per document) relative to the subject area – BRICS – 2008-2011.

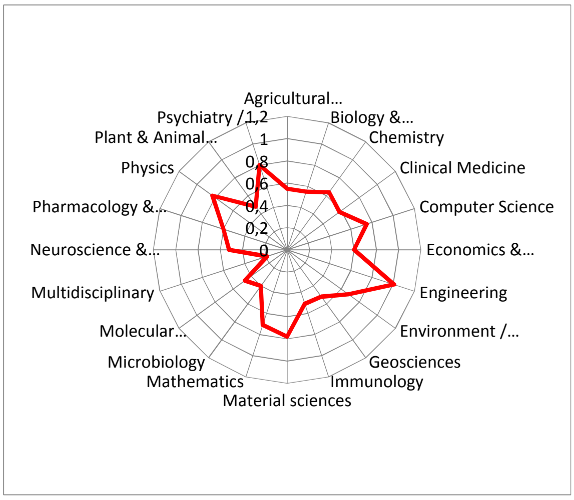
(A) Brazil



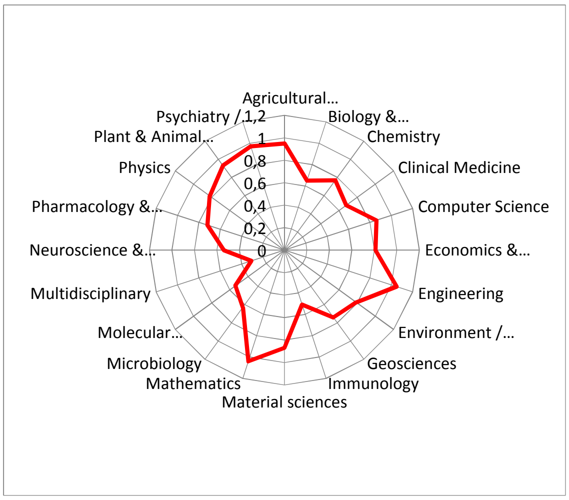
(B) Russia



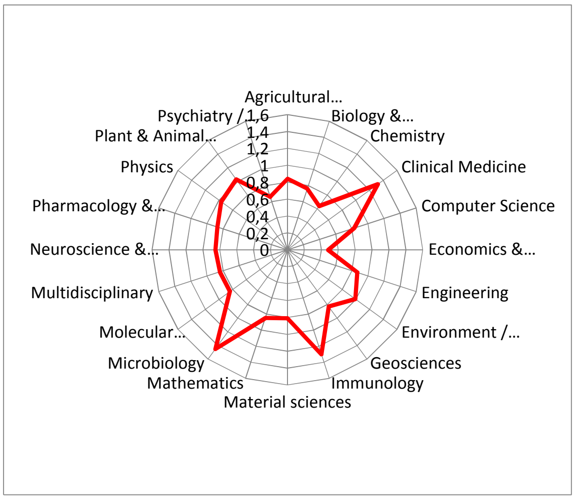
(C) India



(D) China



(E) South Africa



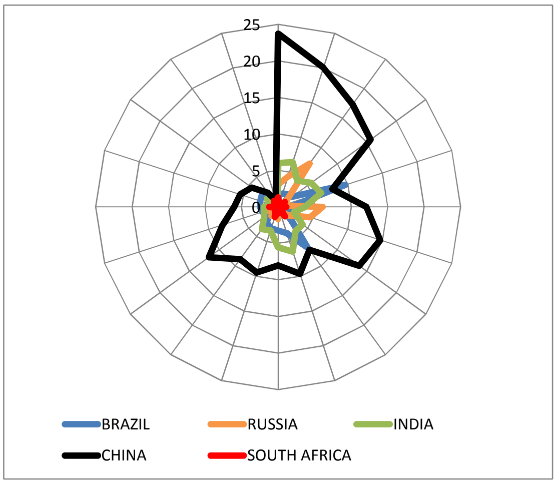
Source: Own calculations using Thomson Reuters data.

As we can see when comparing Figures 8 and 9, trends change dramatically when we look at impact rather than quantity. Brazil is no longer that relevant in Agricultural sciences nor in Plant & Animal sciences. Brazilian scientists are much more influential in Physics, Mathematics and Engineering, although their output is very small in these subjects. Citations to Russian papers are by far concentrated in Multidisciplinary studies, not in Physics nor in Geosciences, the top publishing areas in terms of quantity by scientists based in Russia. India is relatively strong in Engineering, China in Mathematics and Engineering. South African scientists are more cited in Microbiology, Immunology and Clinical Medicine, revealing a relative strength of this country in Health sciences in general.

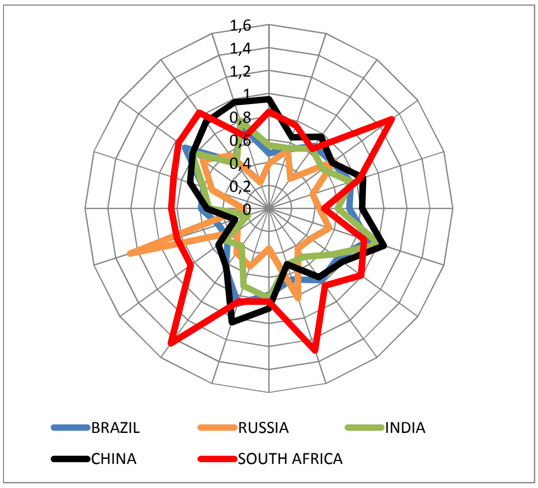
These trends are important indicators to reveal relative strengths of each of the BRICS countries. From these data, the BRICS countries can build effective channels of collaboration in science. Relative strengths of each country can help the others to build capabilities and enhance science activity. And it is interesting to note that the massive expansion of engineering labor showed in the previous sections of this paper are also followed by relatively high impact of the scientific output, especially in China, India and Brazil. Looking at research output without considering its impact is not reasonable. And the scenario can change significantly when we move from quantity to quality, as Figure 10 below illustrates.

Figure 10: Changes in trends when looking at quantity and when looking at quality of research output.

(A) Trends in terms of quantity of papers



(B) Trends in terms of impact of the papers

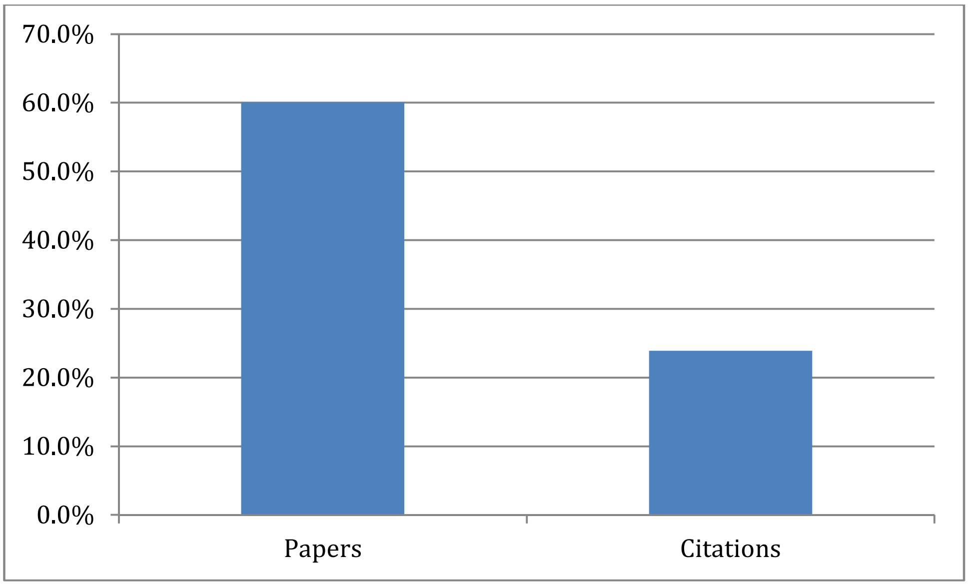


Source: Own calculations using Thomson Reuters data.

As we can see, China is by far leading the BRICS when quantity of published papers is the considered indicator. When we move to quality measures, however, South Africa is more relevant in most of the areas – although China still dominates some areas, regardless the fact that most of the visible international science is produced in English (Archibugi e Coco 2004) and Chinese-based scientists may not be native English speakers.

The BRICS, however, are not relevant global players in terms of impact. Considering all areas together between 2003 and 2012, papers with at least one author from one of the BRICS countries represented 60.1% of the total research output of the US. In terms of total number of citations, however, the ratio was only 23.9% - as shown in Figure 11.

Figure 11: BRICS-US ratios in terms of total number of papers and total number of citations between 2003-2012, in all areas.



Source: Own calculations using Thomson Reuters data.

5. Final remarks

This paper presented some trends in Tertiary (particularly Engineering) education and in research output to highlight: 1) whether higher education systems in these countries are likely to be prepared to produce highly skilled, especially technical, graduates in quantity and quality; 2) what is the relevance and which is the specialization of each of these countries in terms of science production (measured as number of published articles and received citations).

Results suggest that BRICS nations already play an important role in both labor supply and scientific output. However, this rise is mostly numerical and the relevance of BRICS countries is not as clear in terms of quality.

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