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A comparison of performances of Brazilian and Chinese Universities in academic and industrial products using the "U-Multirank"

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ANTONIO PRADO*

Instituto Nacional de Pesquisas Espaciais (INPE), Av. dos Astronautas 1758, São José dos Campos-SP-Brazil

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CONFERENCE PAPER

ABSTRACT

Background and aims: The present work studies the performances of Brazilian and Chinese Universities considering academic and industrial related products. A comparison of the behavior of Universities that belong to these two countries are important, because they have similar characteristics and both of them are considered to be emergent countries, being part of the group known as BRICS. *Methods:* The data is obtained from the "U-Multirank" in the years from 2017 to 2020, which are recent, but not yet affected by the pandemic, since the results for the year 2020 were obtained in 2019. This ranking used 36 Indicators in those years, with some of them related to academic production (number of papers published, citations received by the papers, etc); while some others are related to industrial products (number of patents obtained, citations made in patents, etc). This analysis is made for the average performances of Brazilian, Chinese and all the universities listed in the "U-Multirank" in the years under study. *Results:* The results show the number of institutions listed every year and the average grades of Brazilian and Chinese institutions, as well as the world averages, in all the Indicators studied. *Conclusions:* The results show that Chinese Institutions have a good balance in terms of quantity and quality of academic researches, with both numbers ahead of world averages. Brazil is better in quantity of publications compared to quality, having grades similar to China in number of publications and well above world averages, but the indicators "Citation Rate" and "Top-cited" publications are well below world and Chinese averages.

KEYWORDS

University-Industry relations, evaluation of educational system, academic rankings, multidimensional institutional evaluation

INTRODUCTION

The production of good quality graduates for the society is the primary and most important mission of an Academic Institution. In modern days, some other functions were added, in particular making cutting edge research to increase the knowledge of mankind. This is known as the second mission of the Universities. An important aspect of this research is the development of technology, since this development can prepare high specialized personnel that help to increase the efficiency of the economy by making new discoveries that may become new and/or better products for the society.

Lately, it is defined a third mission for the universities, usually called "extension" (Laredo, 2007). This is the mission more connected with society, because it is directed to actors that are not formally part of the University, like students and professors. There are many activities under this group, in particular the offering of courses, cultural activities, etc, for the external public. An important task directed to the external public are the "University-Industry" links (Clark, 1998), which include formal and informal consulting, joint applied research, etc. These links are considered by many scholars as the most important form of collaboration

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*Corresponding author.
Tel.: +55 12 991760323.
E-mail: antonio.prado@inpe.br

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with society. The main goals are to develop new techniques, high technological products, etc. These developments increase the technical capability for a country to compete in a globalized economy.

There is also a theoretical model defined for this type of collaboration. It is called "Triple Helix" model (Thune, 2010). It defines the rules of collaborations between Academic Institutions, Industry and Government. Under this model, the Academic Institutions act as the "knowledge provider", which main function is to offer knowledge using their laboratories, experts and infra-structure for the research to be performed. The Industry is the "knowledge demander", assuming that it has specific demands to create or develop their products. The third helix is the government, which has the function of organizing those links. This framework is also usually called "Sabato Triangle" (De Campos & Da Costa, 2014; Sabato & Botana, 1969), which is a triangle that has the same players, but located in the three vertex of a triangle. This vision was later expanded by Dagnino (2004), which replaced the triangle by a square, adding a vertex to represent social demands.

Those are very important relations. China is working to make a competitive industry, moving from the mass production of low technological products to a more attractive industry involving the production of high technological products. University-Industry links have a key role in this process. In that sense, a comparison of the behavior of those two countries in that aspect is very important for Brazilian universities, because they may have a good parameter to be used to define their next steps in increasing those relations. A comparison of academic and industrial products, instead of looking only at industry-related products, is important in emerging countries, because their academic systems usually increase fast, so all the numbers have a tendency of fast growing. Therefore, to see if the focus of "industry-related" research is increasing, the relative numbers are very important. It is also interesting to look at those numbers compared to the world average for a better comparison.

There are many solutions for this problem. The present research uses the academic international ranking "U-Multirank" (https://www.umultirank.org/) to make this comparison. It is a recent ranking that started in 2014. Its main characteristic is to be multidimensional and its goal is to show the strengths and weaknesses of each University, not focusing in a classification of universities. This ranking evaluates the academic institutions in five Dimensions, which are composed by several Indicators, with 35 of them used in the period from 2017 to 2020.

As a summary, a comparison will be made of the average grades received by Chinese and Brazilian Universities with the average grades received by all the universities listed in the "U-Multirank" in the years 2017–2020.

"UNIVERSITY-INDUSTRY" LINKS IN BRAZIL

In Brazil, universities were created initially as "Classical Universities", with strong emphasis on teaching and basic research. It followed the American model, where large universities dominated the educational system using this model. Stronger relations University-Industry faces the problem of low demand for "new knowledge" from Industry. Most of the activities developed in Brazil are based in adaptation and quality control of products, which demand small technological steps. Bernasconi (2008) pointed that Latin America needs larger economic growth to increase technological demands from the academic system, so the government needs to stay making most of the financial support to the public universities.

The literature also says that "University-Industry" links occur more often in larger industries, usually international companies that already have a strong culture of using those links in their home countries. It happens because they have more technological capabilities, so they can use better researches made in universities (De Campos, 2010).

Brazil and Latin America in general still have educational activities as the most important "University-Industry" link, but evidences of moves to the "Triple Helix" model exist since the end of the 20th century (Etzkowitz & Brisolla, 1999). An increase in the number of patents made by Brazilian Universities is also reported in the beginning of the 21st century (Etzkowitz, De Melo, & Almeida, 2005). The reduction of governmental expenses with universities is one of the main reasons for those increased "University-Industry"links, but most of the academic personnel see good aspects in this fact, like extra resources and new ideas for research (Dutrenit & Arza, 2010).

There are several examples of successful academic and productive "University-Industry" links in Brazil, like the ones coming from the aerospace sector in São José dos Campos (Cintra, Costa, & De Campos, 2019; Pellegrini, De Campos, De Chagas, & Furtado, 2017). Some others can be found in Campinas (Dagnino & Velho, 1998).

A recent comparison of academic and industry related products of Brazilian and Latin American universities using the "U-Multirank" is available in Prado and De Campos (2022).

"UNIVERSITY-INDUSTRY" LINKS IN CHINA

There are several studies regarding University-Industry links in China. Some of them are described here, as an introduction to this important topic.

Jun and Gui-Sheng (2006) takes a look at the primary context and the main dimensions of the "Triple Helix" model. It also introduces relative domestic research and practices. They mention that the "Triple Helix" model was build having in mind developed and high technological countries, so it should be used carefully when applied in China.

Lu and Etzkowitz (2008) shows the context of innovation in China based in the "Triple Helix" model. The results show that China assumed the role of a major power in the world economy, but they pointed out that there are still several

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challenges facing Chinese firms, academics, government agencies and policy makers.

Zhou (2008) studies the evolution of an entrepreneurial university working under the "Triple Helix" model in China using the Northeastern University (NEU) as an example, because there is a dominant government-pulled "Triple Helix" model there. The results show that to build an entrepreneurial university it is necessary to have actions coming from the government to increase the industry-university collaborations. After that there is a gradual development of those relations, where the companies fund academic research with potential industrial use, which is the starting point of a university-pushed "Triple Helix" model of research.

Liu and Sun (2009) compares the spatial distribution of innovative activities in China and the United States using the number of patents as an indicator. It makes recommendations to China and other developing countries to optimize the spatial distribution of their innovative activities. It shows that the number of patents had a rapid growth and significant fluctuation in the first years of the 21st century in China, while in the United States this number was relatively stable. It is also noted that both countries have a concentration of innovative activities from the inland areas to the coastal regions.

Fan (2014) makes a critical review of the literature about the innovation capabilities of China. It starts by looking at its current status, as measured by human capital, output of academic research and the number of patents, products, and services directly involved in economic growth. A review of the evolution of this system, starting at the economic reforms, including policies, functions of the government and different actors in the system is also made. The case of China is used to study the relationship between innovation capability and economic development, in particular looking at how the uneven spatial distribution of innovation capabilities affects regional economic development.

Balzer and Askonas (2016) compares Chinese and Russian efforts to implement a "Triple Helix" model program in their innovative system. This is done by examining institutional changes, epistemic communities, funding, and the role of the state, using the nanotechnology field as an example. The results showed that both nations have introduced major programs and allocated significant funding to this system. They concluded that China had better results in promoting collaboration among universities, business and government to develop research and innovation activities.

Li, Fei, Jiaxin, and Chunyang (2018) studies the structural evolution of innovation networks of agricultural government-industry-university-research institutes in China, from 1985 to 2014, based on the "Triple Helix" model theory. The results show that the level of the agricultural innovation in China has been substantially increased since 1985, but the cooperation to produce patents is made usually with authors of the same unit. It is also shown that enterprises leads the process and the effects of the government are not clear. In the end, they noticed that the science, education funding and personnel investment from the city are key factors to determine the agricultural cooperative innovation.

Liu and Huang (2018) studies the "Triple Helix" model from a micro-foundational perspective. They suggest that the university capabilities are resource bases, motivation/objectives, resource allocation and coordination mechanisms, and regional outcomes. They used qualitative data from two leading Chinese cities in terms of innovation and regional development to make an empirical study that explains how to deal with university capabilities. The goal was to better understand the functions of the 'university' and its relationship with the other actors under the "Triple Helix" model.

Ye and Wang (2019) makes a study, based on the pattern formation of the reaction of the Belousov-Zhabotinsky, to get an equation to predict the evolution of China by comparing the ideal and the current states in China. The results showed that, if the industrial absorptive capacity and the academic knowledge transfer capability are well balanced, stronger incentive policies are more important than weak policies; the performance of collaborative innovation is not at the best point in China, but the industrial absorptive capacity has exceeded the capability of knowledge transfer in academia, so it is now the main driving force for innovation.

Li, He, and Zhao (2020) studies the influence of the "Triple Helix" model system on regional entrepreneurship in China. They used surveys sent to proprietary of industrial firms, academic institutions, and government agencies in five Chinese regions to make this study. The results showed that the relations between the three actors of the "Triple Helix" model system give positive influences to regional entrepreneurship in China. It also shows that there are significant regional differences in the functioning of the "Triple Helix" model system in China. In particular, trilateral collaboration and network relationship are more visible in developing regions, while complementary synergies are more effective in developed regions.

A very recent and interesting paper is Zhuang, Zhou, and Li (2021). The paper measures innovation efficiency of each regional innovation system in China in the period 2012–2018. The reason to make this study is to identify the effects of the "Triple Helix" model relationship in regional innovation efficiency. The results show that this regional innovation efficiency is increasing slightly every year; but there are obvious regional differences and that the relations among universities, industries, and governments are very important to improve regional innovation comprehensive efficiency and scale efficiency.

ACADEMIC RANKINGS

Just after the turn to the XXI century, several Academic International Rankings were created with the objective of classifying Academic Institutions (Righetti, 2015, 2019). The "Academic Ranking of World Universities" (ARWU) was

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the first international ranking to appear (http://www.shanghairanking.com/ARWU2020.html), also known as "Shanghai Ranking", in 2003. After that we have "The Webometrics Ranking of World Universities" (http://www.webometrics.info/en), which started in 2004, and the "THE-QS" ranking, which was divided in "Times Higher Education World University Rankings" (https://www.timeshighereducation.com/world-university-rankings) and "QS World University Rankings" (https://www.topuniversities.com/university-rankings).

After that, an important new idea appeared in Europe in 2008, leading to the concept of "multidimensional rankings" (van Vught & Ziegele, 2012). Based on that, the "U-Multirank" (https://www.umultirank.org/) was created. It evaluates academic institutions in five Dimensions: (1) Teaching and Learning, (2) Research, (3) Knowledge Transfer, (4) International Orientation and (5) Regional Engagement.

The dimension "Teaching and Learning" deals with aspects related to the number of graduates and if they finish their degrees in the expected time. This dimension is not used in the current research.

The dimension "Research" deals with aspects related to the production and citation of papers. It looks at aspects like number of papers published, number of citations received in those papers, percentage of papers in the top-cited papers in the field, etc. It is a very important dimension for the present research, because it measures quantity and quality of scientific output. Some indicators from this dimension will be used for the comparisons of academic production.

The dimension "Knowledge Transfer" deals with aspects related to the development of products. It looks at aspects like number of patents obtained, joint publications with non-academic authors, publication cited in patents, etc. It is also a very important dimension for the present research, because it measures results obtained from academy-industry links. Activities under the "Triple Helix" model generate good numbers in these indicators. So, some indicators from this dimension will be used for the comparisons of industry related production.

The dimension "International Orientation" deals with aspects related to the level of internationalization. It measures elements like the number of degrees offered in foreign languages, number of international students and professors, number of publication with international authors, etc. This dimension is not used in the current research.

The dimension "Regional Engagement" approaches topics related to the number of graduates working in the region, number of publications having co-authors working in the region, income from regional industries, etc. This dimension is also not used in the current research.

The "U-Multirank" does not aim to prepare a general classification of Educational Institutions. Rankings are made only on each of the specific performance indicators, showing strengths and weaknesses of the Universities in each Indicator. Then, each user can make their own ranking, with the indicators they consider to be the most important ones.

The larger number of indicators of the "U-Multirank" generates some missing data. There are 39.84% missing data in 2020. Despite this fact, the "U-Multirank" gives a more comprehensive view of the Education Institutions, helping students to make their choices for future studies. Some initial studies show that its dimensions and indicators have weak correlation, so they can be considered independent forms of measurement (Prado, 2021c). Several Brazilian (Prado, 2021a) and Chinese institutions are included in this ranking, which makes the present comparison possible. The website of the "U-Multirank" can also make general classifications, if asked (Prado, 2021b, 2021c, 2022).

METHODOLOGY OF THE RESEARCH

The present research looks at the average performances of Chinese and Brazilian Academic Institutions listed in the "U-Multirank", in the years 2017–2020. Thirty-five Indicators were used in this period. From them, four are related to academic production: Citation rate, Research publications (absolute numbers), Research publications (size-normalized) and Top cited publications. Another four Indicators measure "University-Industry" relations: Co-publications with industrial partners, Patents awarded (absolute numbers), Patents awarded (size-normalized), Publications cited in patents. Considering the objectives of the present research, those eight Indicators will be used. Their definitions are taken from https://www.umultirank.org/export/sites/default/press-media/documents/Indicator-Book-2019.pdf.

The Indicator "Citation rate" is "the average number of times the research publications of the university are cited in other research in a period of four years before the evaluation; normalized at the global level to take into account differences in publication years and to allow for differences in citation customs across academic fields."

The Indicator "Research publications (absolute numbers)" is "the number of research publications of the university (indexed in the Web of Science Core Collections database), where at least one author is affiliated to the source University or higher education institution."

The Indicator "Research publications (size-normalized)" is "the number of research publications (indexed in the Web of Science database), where at least one author is affiliated to the university (relative to the number of students)."

The Indicator "Top cited publications" is "the proportion of the research publications of the university that, compared to other publications in the same field and in the same year, belong to the top 10% most frequently cited worldwide."

The Indicator "Co-publications with industrial partners" is "the percentage of the research publications of the university that list an author affiliate with an address referring to a for-profit business enterprises or private sector R&D unit (excludes for-profit hospitals and education organizations)."

The Indicator "Patents awarded (absolute numbers)" is "the number of patents assigned to (inventors working in) the university (over the period 2008–2017)." Those years are valid for the 2020 version of the ranking.

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The Indicator "Patents awarded (size-normalized)" is "the number of patents assigned to (inventors working in) the university over the period 2008–2017 (per 1,000 students)." Those years are valid for the 2020 version of the ranking.

The Indicator "Publications cited in patents" is "the percentage of the research publications of the university that were mentioned in the reference list of at least one international patent (as included in the PATSTAT database).

The Indicators that measure patents are obtained from the "European Patent Office" (https://data.epo.org/access-control/patstatsubscription.jsp), considering only granted patents.

The "U-Multirank" gives letter grades for all the indicators, not numbers. The Institutions are evaluated using public data, like database of publication and patents, as well as questionnaires received from former students and the Institutions. After that they are ranked into five groups (called A to E, with A indicating 'very good' and E 'weak' performance). This is done for all the indicators used.

Since averages of the grades are made in the present research, we transformed letter grades to numerical ones, using the rules: A = 5, B = 4, C = 3, D = 2 and E = 1. In this way it is possible to make tables and figures that show the comparisons made in the present research.

SOCIO-ECONOMIC AND CONTEXTUAL FACTORS

Socio-economic and contextual factors play a significant role in shaping the higher education systems in both Brazil and China. While each country has its unique characteristics, there are some common themes in how these factors impact higher education.

Brazil

Economic Inequality: Brazil faces significant economic inequality, and this inequality extends to access to higher education. While there are public universities that offer free education, many students still struggle to cover living expenses, books, and transportation.

Public vs. Private Universities: Brazil has a mix of public and private universities. Public universities are generally considered to provide better quality education, but they often have limited capacity and are highly competitive.

Affirmative Action: Socio-economic factors intersect with issues of race and ethnicity in Brazil, and affirmative action policies have been introduced to address this. These policies aim to increase access for historically marginalized communities.

International Collaboration: Brazilian higher education institutions have increasingly sought international partnerships and collaborations, aiming to enhance the quality of education and research.

Economic Recession: Economic factors, including recessions, can influence government funding for higher education. Periods of economic downturn can lead to budget cuts and reduced investment in universities.

In this context, it is becoming more usual the interest of academic institutions in making partnerships with industry, to get access to more sources of funding to compensate reductions in governmental financial support. Economic inequality and affirmative actions also require extra funding to support low income students. Those facts increase the search for the relations with private sector and drive more researches for the applied field.

China

Rapid Economic Growth: China's rapid economic growth has allowed it to invest heavily in higher education. It has developed world-class universities, which has attracted international students and faculty.

Urban vs. Rural Divide: Socio-economic factors are evident in the urban-rural divide. Major cities like Beijing and Shanghai have prestigious universities, while rural areas may have limited access to higher education.

Gaokao Exam: China's national college entrance examination, the Gaokao, is highly competitive. Socio-economic status can influence the quality of preparation and access to resources, impacting a student's performance.

Government Control: China's higher education system is tightly controlled by the government, and it often reflects national policies and political priorities.

Internationalization: China's higher education system is increasingly international, attracting students and faculty from around the world. This has economic and cultural implications.

Emerging Middle Class: The emergence of a large and growing middle class has increased demand for higher education and influenced the types of programs and majors offered.

In both Brazil and China, socio-economic and contextual factors influence the accessibility, quality, and structure of higher education. Efforts to address issues related to inequality, access, and the global competitiveness of their higher education systems are ongoing. These factors are important for policymakers, educators, and students to consider as they work to improve higher education opportunities in these countries.

The fast economic growth of China can partially explain the fact that China has better numbers than Brazil in terms of applied research, number of patents and similar activities.

RESULTS

As a first step, it is searched for the number of Brazilian and Chinese institutions listed in this ranking. The results show that all the numbers increase in time, but China has a much larger number of Universities listed in this ranking compared to Brazil (Table 1).

Next, Table 2 shows the performance of the Chinese (CH) and Brazilian (BR) Universities, as well as the world

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Table 1. Number of Academic Institutions from Brazil, China and the world total in the U-Multirank for the period 2017–2020

	2017	2018	2019	2020
Brazil	15	15	17	20
China	93	96	112	117
World Total	1,497	1,613	1,711	1,759

average (WR), in the eight Indicators used for the comparisons. It shows that the average performances of Chinese and Brazilian Universities are not bad in the Indicators used here.

To take a closer look at the Brazilian and Chinese Institutions, we make a summary of the comparisons of their grades with the world averages. It is shown in Tables 3 and 4, which gives their relative grades with respect to the world averages (averages grades of Brazilian and Chinese Universities divided by the world averages) in the four years studied.

A similar detailed comparison of Chinese and Brazilian Universities is also made. It is shown in Table 5 and Fig. 1, which gives the relative grades of Chinese Institutions with respect to the Brazilian grades (grades of China divided by Brazilian grades) in the four years studied. It is noted that Fig. 1 does not show a line for the Indicator "Co-Publications with industrial partners", but just the two points available are plotted in the figure. The reason is the lack of Brazilian data in 2018 and 2020 in this Indicator.

In terms of "Citation rate", China is always slowly improving its results from year to year in the period studied. Both Brazil and the world averages are oscillating without a clear tendency in this same period. China is ahead of Brazil

Table 3. Average of the relative grades of Chinese Institutions in 2017–2020 compared to world averages

Indicator	2017	2018	2019	2020
Citation rate	0.9778	1.0028	1.0510	1.0891
Research publications absolute numbers	1.1877	1.1971	1.2932	1.2695
Research publications size-normalized	1.1330	1.1425	1.1117	1.2550
Top cited publications	0.9806	1.0110	1.0737	1.1278
Co publications with industrial partners	0.8128	0.7793	0.8531	0.7458
Patents awarded absolute numbers	1.0426	1.1181	1.0394	1.1992
Patents awarded size-normalized	0.9846	1.0311	0.9526	1.5289
Publications cited in patents	0.7888	0.8863	0.8879	0.9222

Table 4. Average of the relative grades of Brazilian Institutions in the period 2017–2020 (Prado & De Campos, 2022)

Indicator	2017	2018	2019	2020
Citation rate	0.61	0.63	0.63	0.65
Research publications absolute numbers	1.17	1.14	1.27	1.20
Research publications size-normalized	1.02	1.02	1.15	1.20
Top cited publications	0.55	0.59	0.60	0.57
Co publications with industrial partners	0.70	–	0.58	–
Patents awarded absolute numbers	0.65	0.76	0.73	0.68
Patents awarded size-normalized	0.82	0.83	0.79	1.01
Publications cited in patents	0.64	0.64	0.66	0.63

Table 2. Average performance of China, Brazil and world average in the indicators selected for the comparisons

Indicator	2017	2018	2019	2020
Citation rate	CH 3.52	CH 3.64	CH 3.71	CH 3.79
	BR 2.20	BR 2.27	BR 2.24	BR 2.26
	WR 3.60	WR 3.63	WR 3.53	WR 3.48
Research publications absolute numbers	CH 4.05	CH 4.13	CH 4.19	CH 4.24
	BR 4.00	BR 3.93	BR 4.12	BR 4.00
	WR 3.41	WR 3.45	WR 3.24	WR 3.34
Research publications size-normalized	CH 4.09	CH 4,17	CH 3.88	CH 4.38
	BR 3.67	BR 3.73	BR 4.00	BR 4.20
	WR 3.61	WR 3.65	WR 3.49	WR 3.49
Top cited publications	CH 3.54	CH 3.67	CH 3.79	CH 3.97
	BR 2.00	BR 2.13	BR 2.12	BR 2.00
	WR 3.61	WR 3.63	WR 3.53	WR 3.52
Co-publications with industrial partners	CH 3.04	CH 2.79	CH 3.02	CH 2.64
	BR 2.60	BR –	BR 2.06	BR –
	WR 3.74	WR 3.58	WR 3.54	WR 3.51
Patents awarded absolute numbers	CH 2.69	CH 2.84	CH 2.64	CH 2.89
	BR 1.87	BR 1.93	BR 1.82	BR 1.65
	WR 2.58	WR 2.54	WR 2.51	WR 2.41
Patents awarded size-normalized	CH 2.56	CH 2.65	CH 2.41	CH 3.70
	BR 2.13	BR 2.13	BR 2.00	BR 2.45
	WR 2.60	WR 2.57	WR 2.53	WR 2.42
Publications cited in patents	CH 2.54	CH 3.04	CH 3.09	CH 3.08
	BR 2.07	BR 2.20	BR 2.29	BR 2.11
	WR 3.22	WR 3.43	WR 3.45	WR 3.34

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Table 5. Average of the relative grades of Chinese compared to Brazilian Institutions in the period 2017–2020

Indicator	2017	2018	2019	2020
Citation rate	1.6000	1.6035	1.6563	1.6770
Research publications absolute numbers	1.0125	1.0509	1.0170	1.0600
Research publications size-normalized	1.1144	1.1180	0.9700	1.0429
Top cited publications	1.7700	1.7230	1.7877	1.9850
Co publications with industrial partners	1.1692	–	1.4660	–
Patents awarded absolute numbers	1.4385	1.4715	1.4505	1.7515
Patents awarded size-normalized	1.2019	1.2441	1.2050	1.5102
Publications cited in patents	1.2271	1.3818	1.3493	1.4393

by a large amount, starting with a 60% advantage, which increases every year, reaching near 68% in 2020. Regarding the world average, China was a little behind in 2017 (just 2% below), but is ahead in 2018 and reached an advantage near 9% in 2020. It gives a clear indication that the numbers related to citations are improving in China in the period considered.

In terms of "Research publications (absolute numbers)", China is improving slightly its results in this same period, except by a small decrease in 2020, while Brazil and the world averages are oscillating without a clear tendency. China is ahead of Brazil every year, but by small amounts, ranging from 1 to 6% advantage, without tendency of increasing or decreasing. Regarding the world average, China is always ahead, with advantages ranging from 19 to 30%. There was a slight decrease in this advantage in 2020, but the numbers increased from 2017 to 2019, with emphasis in a jump of 10% from 2018 to 2019.

Similar results are observed in the indicator "Research publications (size-normalized)". Chinese grades are always ahead of world averages, with this advantage ranging from 11% to 26%. The best result was achieved in 2020. Compared to Brazil, China is ahead by margins ranging from 4% to 12%, except for the year 2019, where it is behind by 3%. Therefore, the results of Brazil and China are similar in this indicator. It also confirms the tendency of increasing numbers in Brazil (Cross, Thomson, & Sinclair, 2017).

The Chinese results are very near the world averages in the Indicator "Top-cited publications". Once again, China is improving slightly its results from year to year and Brazil and the world averages are oscillating without a clear tendency. China is behind world averages by just 2% in 2017, but it is 1% ahead in 2018, keeping increasing the advantages, which reaches 13% in 2020. Compared to Brazil, China is far ahead, with advantages in the order of 72%–99%, with the maximum value obtained in 2020, which gives a tendency of growing differences.

Looking now at the indicator "Co-publications with industrial partners", we see that China is below world averages every year. The absolute grades have no clear tendency and they oscillate from year to year. The best result was obtained in 2019, when it reached 85% of the world average, but there is a large drop in 2020, by about 10%, to reach a level of 75% of the world averages. The comparison with Brazil is poor, because Brazil has no data reported in the years 2018 and 2020. In the years with data available, China is ahead of Brazil by 17% in 2017 and this advantage increased to 47% in 2019. This is the worst indicator of Chinese Universities.

Moving now to the production of patents, which is one of the most important topics in the present research, we have the Indicator "Patents awarded (absolute numbers)" and "Patents awarded (size-normalized)". In terms of "Patents awarded (absolute numbers)", China is always ahead of world averages, from 4% to 20% advantage. There is no tendency and these advantages oscillate from year to year, but it is noticed that the maximum advantage was obtained in 2020. Compared to Brazil, China has large advantages, ranging from 44% to 75%. This maximum value was also obtained in 2020, which indicates that China has made large advances in this year.

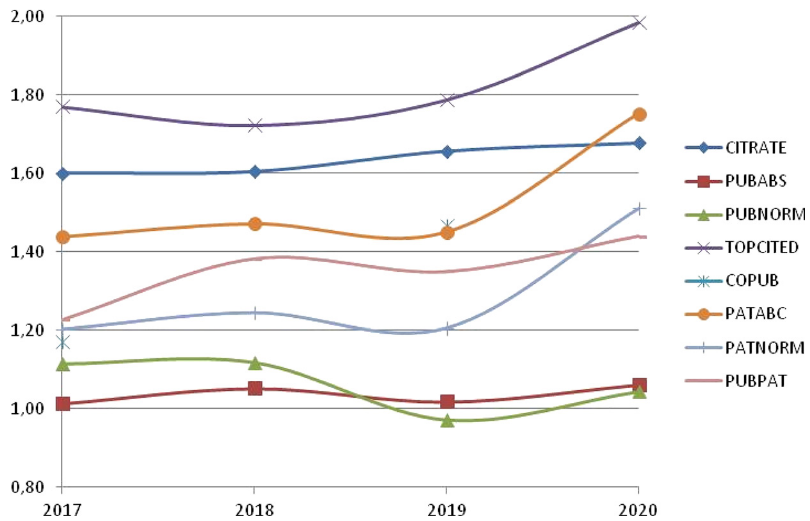

Fig. 1. Relative grades of Chinese compared to Brazilian Institutions in the period 2017–2020

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Looking at the Indicator "Patents awarded (size-normalized)", Chinese numbers oscillated from 2017 to 2019, being behind world average by 2% in 2017 and 5% in 2019, but 3% ahead in 2018. There is a very large jump in 2020, reaching 53% above world average. It is one more sign that China had very important results in this matter in 2020. Comparing to Brazil, we see the same waves, but with China always ahead. These advantages are in the interval from 20% to 24% in the period 2017–2019, with a large jump to 51% in 2020. This is the second worst indicator of Chinese Universities.

For the last indicator studied here, "Publications cited in patents", China is behind world averages every year, with results ranging from 79% to 92% of the world averages. The interesting result is that this number is always increasing from year to year and the value of 92% was obtained in 2020. This same jump appears when comparing those results with Brazilian universities, but this time China is always ahead. The differences are in the interval from 23% to 44%

CONCLUSIONS

A general observation of Table 3 shows that China has slow but steady growing numbers in almost all indicators. This is in agreement with the comments made by Zhuang et al. (2021), which emphasizes the slow but constant improvements of the numbers related to University-Industry production in China. There are only two exceptions to this rule: a large jump in the grade for the number of patents normalized by the number of students of the university in 2020, going from a relative grade of 0.9526 in 2019 to a grade of 1.52989 in 2020; and a decrease in the grades for co-publications with industrial partners, going from 0.8531 in 2019 to 0.7458 in 2020.

Another fact to be observed is that China is ahead of world averages almost every year in the indicators Citation rate, Research publications (absolute numbers), Research publications (size-normalized), Top cited publications, Patents awarded (absolute numbers), Patents awarded (size-normalized). Only the indicators Co-publications with industrial partners and Publications cited in patents are always below world averages.

Those observations may indicate that the production of patents is in good shape in China, but the collaboration between Universities and Industries in this process is below world average. It means that Universities and Industries are producing a good number of patents, but they are working more isolated from each other compared to the rest of the world. This is a point that deserves better studies, because there is room for improving University-Industry relations. It seems to be aligned with the comments made by Li et al. (2018), which pointed that "the cooperations to produce patents are made usually with authors of the same unit". This comment was made for the agricultural sector, but the results showed here indicate that it can be a general problem in China and deserves to be better studied.

Looking at Fig. 1, it is clear that China is ahead of Brazil in all the indicators almost every year, but the larger advantages are in the grades related to citations (Citation rate and Top cited publications). The smaller advantages are in the grades related to the number of publications (Research publications (absolute numbers), Research publications (size-normalized)), where the grades are very similar. The indicators related to "University-Industry" production are in the middle, with the advantage of China in the range 29–50%, except for the normalized number of patents, which reached 75% of advantage in 2020, which is a result of the large jump in numbers related to the production of patents in China in 2020.

A summary of the results presented here shows that, regarding quantity and quality of academic researches, Chinese Institutions have a good balance, with both numbers ahead of world averages by similar values. On the opposite side, Brazil is better in quantity of publications compared to quality, having grades similar to China in number of publications and well above world averages, but not so good in quality, because the results in the indicators "Citation Rate" and "Top-cited" publications are far below world and Chinese averages. The positive point is that Brazilian results are increasing every year, but this is a point to be observed in the future and more attention to quality may be required.

These points need a more detailed study and the present research has the goal of giving a quick first look at this problem. In particular, longer periods of time should be studied, as well as alternative data sources should be considered to compare with the results obtained from the "U-Multirank".

This point, and the fact that there are missing data, in particular in 2020, emphasizes the limitations of the present work. It looks for a short window of time, which does not give a long term evolution of the problem. Besides that, the present study uses a database with numerical grades for the indicators considered and does not look of the reasons why those numbers occur. It gives a external view of the problem, which is useful to detect points to be better studied in the future from an internal view, trying to explain the real reasons of the numbers observed and how to improve the points that are considered important.

A specific point that deserves better attention in future studies is the large jump in the number of patents that China had in 2020. It is important to know if this is a tendency or just a punctual fact. The slow, but consistent tendency of growing numbers in almost all the Indicators studied here also needs to be verified using future data, in particular to measure the effects of the pandemic in the Chinese production of academic and industry related activities.

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