

# The Perspective of Researchers on the Challenges of Research in Brazil\*<sup>1</sup>

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## Abstract

The Brazilian scientific and technological development has presented important advances in the last decades. However, several obstacles still limit the impact of Brazilian research on the international scenario. Thus, the objective of this study is to identify the main challenges of scientific and technological research in Brazil, analyzing latent factors, according to the perception of researchers working in Brazilian public universities. For this purpose, an exploratory-descriptive study was carried out, combining qualitative (content analysis) and quantitative (factor analysis) techniques, employing data collected through 16 interviews and 722 questionnaires filled out by researchers working in postgraduate programs (master's and doctorate) of Brazilian public universities. The results indicated the presence of eleven challenges, which can be grouped into three latent factors: (i) research environment, represented by working conditions regarding access to resources, deficient infrastructure, high bureaucracy and work overload; (ii) research practices, represented by the low interaction of researchers with each other and with the demands of society, low dissemination/appropriation of the knowledge produced and excessive valuation of scientific articles and (iii) training and qualification of human resources, represented by the lack of commitment and qualification of researchers, besides the low relevance of the

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research developed. These results are important for the identification of the main obstacles of research in Brazil, allowing new reflections for the advancement of the National System of Science, Technology and Innovation (SNCTI).

## **Keywords**

Scientific Research – Science, Technology and Innovation (STI) – University – Innovation – Researchers.

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## **Introduction**

What motivates a researcher to get involved in research activities? Surely the motivations can be diverse, such as: (i) personal interests, including the intellectual challenge of research, curiosity and emotion of discovery; (ii) professional interests, including scientific reputation, student education, career development and promotion, as well as financial incentives; finally, (iii) social interests, such as seeking benefits for organizations, communities or society at large (SILVER, 2009).

However, it is not difficult for a Brazilian researcher, with experiences in good universities abroad, to list a series of problems that make research activities in Brazil difficult and discouraging. Challenges related to the scarcity of resources allocated to research; excessive bureaucracy; the lack of a support team for fundraising or project management; overload of researchers working concomitantly with teaching and extension activities; poor infrastructure for research; low interaction of researchers with other institutions for the development of partnerships and the difficulty of meeting the demands of society arise as easily recognized barriers.

Part of this problem is due to the absence of a structured political agenda to encourage research and innovation in Brazil, in addition to a complex structure plastered on the post-graduate and research system implemented in Brazil. Thus, in addition to low investments and recent cuts in research in recent years, there is an excessive appreciation of academic indicators such as the number of publications (SCHWARTZMAN, 2008; ANGELO, 2016; ANDRADE, 2019), stimulating a standard behavior of researchers through routines recognized as efficient and legitimized to ensure access to university performance indicators (BALBACHEVSKY, 2008).

Besides these problems, other challenges are present for the expansion, consolidation and integration of the National System of Science, Technology and Innovation (SNCTI), such as: increase in the impact of research, expansion and modernization of research infrastructure, training and qualification of human resources and stimulation of innovation processes through better articulation of universities with society (MCTI, 2016).

Thus, the objective of this study is to identify the main challenges of scientific and technological research in Brazil, analyzing latent factors according to the perception of researchers working in Brazilian public universities. The study is relevant in pointing out

paths for the advancement of SINCTI, allowing new reflections for the development of more relevant and competitive researches in the international scenario.

## **Challenges of scientific and technological research in Brazil**

Scientific and technological research has been increasingly recognized as an important activity for generating innovation and promoting sustainable economic and social development (EUROPEAN COMMISSION, 2010; BORGES, 2016). In this regard, the context of academic research has been undergoing changes due to the scarcity of resources and the notion that science must assume its share of responsibility in solving society's problems (BALBACHEVSKY, 2008; AURANEN; NIEMINEN, 2010; EUROPEAN COMMISSION, 2010; HICKS, 2012).

Such changes have put pressure on universities and research institutions for more relevant and effective results (BALBACHEVSKY, 2008; AURANEN; NIEMINEN, 2010; EUROPEAN COMMISSION, 2010; HICKS, 2012; MUSCIO; QUAGLIONE; VALLANTI, 2013), and it is possible to identify initiatives for the evaluation of academic research in several countries, such as Germany, Finland, France, Netherlands, Italy, United Kingdom, Australia, among others (AURANEN; NIEMINEN, 2010; EUROPEAN COMMISSION, 2010; HICKS, 2012).

In Brazil, the history of science and, in particular, policies to encourage research are very recent (BORGES, 2016). Until the beginning of the 20th century, Brazilian higher education consisted of professional schools, military academies, among other varied institutions (BARRETO; FILGUEIRAS, 2007). The model that was the basis of current Brazilian universities emerged only in the 1920s, having as its central mission the institutionalization of higher education, until then dispersed and deregulated (GUIMARÃES, 2002).

Until the 1940s, scientific research was concentrated in only a few public centers of applied research, such as in the areas of health, agriculture and industrial technology. Systematic actions to support scientific research occurred only in the post-war period, based on the linear model of North American innovation. In this period, it was believed that the incentive to basic science would automatically lead to the production of technological innovations (GUIMARÃES, 2002; FURTADO, 2005; OTTOBONI, 2011).

Since the creation of the development agencies in the 1950's and the consolidation of the post-graduation policies implemented in the main Brazilian universities in the 1960's, the Brazilian research system has gained strength (UNIVERSITY REFLECTION FORUM, 2002; FURTADO, 2005; OTTOBONI, 2011; BORGES, 2016).

The university reform, which took place in 1968, also contributed to the consolidation of the SINCTI. It modernized and expanded the main universities, instituted the departmental structure and formalized the existence of regular postgraduate courses, at master's and doctorate levels, aligning teaching activities with research activities (SCHWARTZMAN, 2008; MARTINS, 2009).

As a result of the strong political and financial imbalance of the public sector, the SNCTI went through a transition phase between the 1970s and 1980s, which contributed to the weakening of public policies regarding the link between universities and the productive sector (FURTADO, 2005; OTTOBONI, 2011).

The 1990s can be characterized by the attempt to bring academic research closer to the productive sector. Cavalcante (2013) states that during this period the Brazilian government tried to create a not so linear and limited system, which promoted research environments with broader perspectives, reaching the market, society and academia. Despite the little growth, this period strengthened scientific and technological research, strengthening its relationship with the productive sector responsible for innovation.

Since 2000, the SNCTI has gained strength, being marked by the maturity of the system with the increase in the number of researchers, fiscal and budgetary incentives for research, and international recognition (OTTOBONI, 2011; BORGES, 2016). During this period, Science, Technology and Information (STI) policies favored the generation and communication of scientific-technological research, in addition to expanding the formation of human resources in post-graduate programs (SCHWARTZMAN, 2008; MCTI, 2016).

Despite these advances, the University Reflection Forum (2002) warned that the main challenge to be faced in the new century would be to establish a solid research system capable of promoting the development of a science that is not dissociated from major national problems, in addition to a great mobilization of the whole society about the importance of academic research for economic and social development.

In order to list the main challenges for the advancement of SNCTI, the National Strategy of Science, Technology and Innovation (MCTI, 2016) has identified five fundamental pillars: (i) improving the quality of scientific and technological research; (ii) improving research infrastructure; (iii) new ways of promoting and financing research; (iv) qualification of human resources dedicated to research and (v) stimulation of innovation.

The first challenge concerns scientific and technological research, recognized as being the key to overcoming current adversities and positioning Brazil among the most developed countries. This pillar represents “the basis of knowledge generation and theoretical support for the generation of technology and therefore innovation” (MCTI, 2016, p. 74).

While Brazilian scientific production has grown systematically, the production of knowledge for society’s problems is declining, especially regarding the generation of innovations (SCHWARTZMAN, 2008; BORGES, 2016). “This means that the country produces high level research with international quality, but fails to transform the knowledge generated into wealth and development for society” (BORGES, 2016, p. 10).

The research infrastructure provides the necessary support for the development of excellent work. Physical facilities, equipped laboratories and available material resources are fundamental, not only for the development of groundbreaking knowledge, but also for the training of human resources and the development of new processes, products and services (MCTI, 2016).

Negri and Squeff (2016) identified that the research infrastructure in Brazil is relatively new, mostly represented by small laboratories scattered throughout universities.

When compared to other more developed countries, it can be seen that the Brazilian research infrastructure has very few large facilities of shared use, a fact that limits the development of groundbreaking research.

The funding pillar is important because it provides the necessary conditions for the development of quality research (MUSCIO; QUAGLIONE; VALLANTI, 2013; MCTI, 2016), as well as contributing to addressing social challenges through the advancement of scientific and technological knowledge (MCTI, 2016).

Auranen and Nieminen (2010); Muscio; Quaglione and Vallanti (2013) assert that public funding represents the main source of academic research. This scenario of great state dependence creates the need for new fundraising strategies (BORGES, 2016; GONZALEZ-BRAMBILA; JENKINS, LLORET, 2016).

In the Brazilian context this dependence becomes even more evident, since the production of the largest share of research is concentrated in public universities. This shows itself to be a worrying challenge, given the successive cuts in public budgets linked to education, further limiting the conditions necessary for the development of groundbreaking research (GIBNEY, 2015; ANGELO, 2016; ANDRADE, 2019).

However, many countries recognize that just increasing investments in research does not guarantee results in terms of scientific and technological development. The production of knowledge is also dependent on the training of qualified researchers (BRASIL, 2010; BORGES, 2016; MCTI, 2016). Thus, the pillar of training and qualification of human resources is essential for the development of groundbreaking research.

Finally, the innovation pillar comes from idea management processes, project development, dissemination of scientific knowledge and management of various forms of intellectual property (BARANDIKA et al., 2014). The notion of innovation highlights the importance of universities in the production of groundbreaking scientific and technological knowledge, which contributes to socioeconomic development (BORGES, 2016).

Therefore, improvements in scientific and technological research, greater investment in infrastructure, new forms of promotion and financing, training of qualified human resources and innovation-oriented research models are essential strategies (GREEN; AGARWAL; LOGUE, 2015; MCTI, 2016). Only by strengthening these pillars will it be possible to promote the expansion, consolidation and integration of SNCTI to face the challenges evidenced (MCTI, 2016).

## **Research method**

To meet the proposed objective, the study used mixed research methods, combining qualitative and quantitative approaches for a better understanding of the theme (CRESWELL CLARK, 2011). At first, interviews were conducted with researchers from a public university in Minas Gerais. The objective of this stage, predominantly exploratory, was to identify the perception of researchers regarding the challenges faced in research development, considering the Brazilian context.

For the selection of researchers, two main criteria were chosen: (i) research group leadership and (ii) research productivity level. In the absence of productive scholars in

any major area of knowledge, it was considered the number of bibliographic production available in the lattes curriculum of each researcher.

Once the target audience was defined, two researchers from each major area of knowledge were interviewed, totaling 16 interviews. The interviews were recorded and transcribed to facilitate the analysis. The data were treated through the thematic and frequency type content analysis technique, which consists in discovering sense nuclei (categories) in the respondents' speeches (BARDIN, 2016).

Based on the categories emerging from the interviews, a structured questionnaire was developed about the challenges of the research in Brazil. In order to test the scales and verify the possible problems of understanding, duration and wording of the questions, a pre-test of the questionnaire was conducted. In this phase, researchers working in different public universities were asked to describe the limitations of the questionnaire and possible suggestions for improvement, obtaining a return of 120 valid answers.

Once the necessary adjustments were made, the questionnaire was sent to researchers working in postgraduate courses *stricto sensu* (master's and doctorate degrees) in the ten best ranked public universities in Brazil by the Times Higher Education (World University Rankings), considering only the research dimension for the year 2017.

At this stage, predominantly descriptive, it was opted to use the survey technique for a more comprehensive analysis about the results evidenced in the qualitative stage. The SurveyMonkey® platform was used to send surveys to researchers through email addresses available on the universities' websites. The data collection phase took place between February and June of 2017, obtaining a total of 722 valid responses.

The data was collected using scales of the Likert type, assumed as intervals for the proposed statistical calculations. The statistical software SPSS was used for the data analysis. Initially, a descriptive analysis of the data was performed in order to identify the most significant frequency and perceptions of respondents. In a second step, factor analysis was used to group the challenges evidenced in latent factors (FÁVERO et al., 2009; HAIR Jr. et al., 2009).

## **Results and discussion**

After stages of coding, abstraction and categorization of the units of records in each of the sixteen interviews conducted, the content analysis allowed the identification of eleven categories capable of summarizing the perceptions of researchers about the challenges of research in Brazil. The name of the identified categories, their description and the frequency of responses can be observed in Table 1.

**Table 1** – Emerging categories in content analysis

Category name	Description	Respondents	%
Shortage of resources for research	Lack of resources (financial and human) for the development of relevant research.	E1; E2; E3; E4; E5; E6; E7; E8; E9; E10; E11; E13; E14; E15; E16	93,75
Low relevance of conducted researches	Low creativity, impact, originality and critical sense of research. Low level of relevant scientific discoveries and/or generation of innovations.	E3; E4; E5; E6; E7; E8; E9; E10; E11; E12; E14; E15	75,00
Work overload	Lack of time for the researcher to dedicate to research activities due to the accumulation of teaching, research, extension and management functions.	E1; E2; E4; E5; E6; E7; E9; E10; E15; E16	62,50
Low interaction with the productive sector and/or society	Isolation of researchers on the problems of society and distance from academia with the productive sector for the development of partnerships.	E3; E5; E6; E7; E8; E10; E12; E14; E15; E16	62,50
Poor research infrastructure	Lack of laboratories and equipment that allow the development of leading research.	E2; E3; E4; E5; E6; E9; E10; E15; E16	56,25
Low dissemination and appropriation of the generated knowledge	Low dissemination of research results for the legitimization of invested resources and application in social and/or economic problems.	E2; E3; E7; E8; E10; E11; E14	43,75
Low appreciation of other forms of knowledge production	Excessive valuation of scientific articles in detriment to other forms of production of scientific knowledge, capable of generating economic and/or social impacts.	E1; E2; E6; E8; E11; E12; E14	43,75
Low engagement of researchers	Low level of commitment of professors and/or graduate students (master and/or doctorate) involved in research activities.	E5; E7; E8; E11; E12; E14	37,50
High bureaucracy involved in the research stages	Excessive bureaucracy in the stages of planning, execution and evaluation of research, ranging from delays in research schedules to administrative and operational difficulties.	E1; E2; E5; E8; E13	31,25
Lack of a support team for research	Lack of a support team to assist the researcher in administrative, bureaucratic and operational research activities.	E4; E5; E6; E15; E16	31,25
Low interaction between researchers	Low interaction between researchers with different expertise. Lack of partnerships and discussions for the development of multidisciplinary studies.	E4; E8; E10; E15	25,00

Source: Research data.

The scarcity of resources applied in research proved to be the most frequent category in the respondents' discourse, present in 93.75% of the interviews analyzed. As exemplified in a respondent's speech:

The number one problem is financial resources. We do not have enough resources, we always have to work with very scarce resources, either for the execution of the experiments themselves, or for the financing of work force in all spheres. (E4).

This category is justified by the low level of investment in research activities (GIBNEY, 2015; ANGELO, 2016; MCTI, 2016) and the high state dependency on public universities (SCHWARTZMAN, 2008; BORGES, 2016; MCTI, 2016).

Another highlighted challenge refers to the low relevance of research in scientific and/or technological terms, present in the speech of 75% of the interviewees. As mentioned by one of the interviewees:

Science has lost this bias of having a different speed, of having the creativity, the imagination. People are not creating anymore, it's difficult, they repeat things, they keep replicating, replicating [...]. So much is said about innovation, but where is it? (E11).

Despite recent advances in STI policies in the Brazilian context (MCTI, 2016), it is possible to note that there is still a great challenge in making research more relevant, especially in the generation of technologies and innovations (BORGES, 2016).

The function accumulation of researchers (teaching, research, extension, management activities), present in 62.50% of the analyzed interviews, also proved to be a very frequent category. Bianchetti (2012) points out that in the last decades demands have been inserted to which they have transformed the life of the professor and the researcher from "time with time" to "time without time", compromising the development of a qualified work. This notion is aligned to a researcher's speech by saying that:

[...] the teacher is not only a researcher, he is a researcher, he works with extension, he has an administrative function, so there are many matters in which the teacher needs to split up in order to do his research with a little bit of quality. (E2).

Low interaction with the productive sector and/or society was also a frequent category, being mentioned in 62.5% of the interviews. Part of the scientific literature highlights that the legitimacy of scientific research has been undergoing profound changes in recent decades due mainly to the scarcity of public resources and the perception that science must assume its share of responsibility in solving society's problems (BALBACHEVSKY, 2008; AURANENA; NIEMINEN, 2010; EUROPEAN COMMISSION, 2010; HICKS, 2012).

Several scholars recognize that the relationship between science and society transcends the economic dimension as new reflections emerge about the use of knowledge as a phenomenon of social appropriation (THORN; SOO, 2006; LIMA; WOOD Jr., 2014). Thus, issues such as education, security, health, environment, unemployment, social inequality, among other social problems, also depend on scientific knowledge to solve problems, especially in developing countries like Brazil (SCHWARTZMAN, 2008; MCTI, 2016).

Such a perspective can be seen in the speech of one of the researchers interviewed when he states that:

[...] the problem is that the university has become an island, we don't think about society as a whole, we think about the day-to-day life here. And in real life that doesn't work [...]. We are not too concerned about what is happening outside the wall and when we don't have this experience of what is happening outside, what happens is that you do research outside of reality. The university should be well focused on solving regional problems, it should do this job. (E12).

The poor research infrastructure also stood out as an important challenge in the Brazilian context, being identified in 56.25% of responses. As mentioned by one of the interviewees:



[...] The first and great challenge is the structure for research, because we have a very deficient structure for research. That is the big challenge. This lack of structure has become more drastic at this time when things have evolved so much that you are no longer able, for example, to publish in a high-impact magazine. Sometimes you have good ideas, but can you execute them? For example, we need a lot of equipment that we don't have today. (E15).

The researcher's speech is aligned to the study by Negri and Squeff (2016), which identified that the research infrastructure in Brazil is deficient, with few large and shared use facilities, a fact that limits the development of leading research. In this context, MCTI (2016) highlights that the availability of adequate physical facilities, equipped laboratories and material resources are fundamental, not only for the development of leading research, but also for the training of human resources and the development of new processes, products and services.

There is a concern among scientists and political entities for the best way to organize scientific activities so that they are efficient and achieve social results. Therefore, themes, projects, teams and fields of expertise are some options analyzed to collectively structure scientific practices (VINCK, 2010).

Another challenge identified was the low dissemination and ownership of the knowledge produced, present in 43.75% of the interviews analyzed. The dissemination of research is fundamental not only for the epistemological integrity of science, but also to inform society about the value of science and, consequently, public support for the investments made (GREGORY, 2015). These results meet the argument of Douglas (2007), who advocates that science is a social activity that plays an important role in daily life. As one participant says:

I think that there is still a need for greater dissemination of research so that people understand, in fact, what the research is, what it proposes to do and what the applicability of its results is. Research is often restricted [...] in the library and this knowledge does not circulate, and then society does not know why to invest in a country that has so many problems. (E2).

Thus, universities play a social role in disseminating research to the community.

The excessive valuation of articles in detriment to other indicators was pointed out as another obstacle to the dynamism of research activity in the country, present in 43.75% of the analyzed interviews. As presented by a researcher:

[...] we always care about the scientific article, we don't care about other vehicles, and then again, it's our mistake [...] people are not interested in information anymore, they are interested in fattening up the curriculum. I am a little afraid of the direction things have taken in research, due to this trend. (E11).

Another researcher's speech is more emphatic in pointing out that "the researcher also has to worry about generating GDP, not just papers" (E8).

Therefore, it is perceived that science also shapes policy and scientific practice to the extent that governments need evidence to develop public policies and technologies in various areas for society (SISMONDO, 2010).

Schwartzman (2008) asserts that several criticisms can be attributed to the Brazilian research system, especially regarding the excessive valuation of academic indicators to the detriment of the social impact of the investigations carried out. According to Balbachevsky (2008), in most Latin American countries a single discourse tends to validate the excellence of academic research: productivity, measured in terms of publications and citations. The current system encourages a stereotyped behavior of researchers who tend to adhere to routines recognized as efficient and legitimized by institutions or regulatory agencies to ensure access to current performance indicators.

Hence, it is observed that scientific practice is not restricted to the establishment of norms between a community of researchers and the organization of science activities. This practice is inserted in a socio-political context. Thus, the speed of social dynamics, as well as decisions and regulations about the scientific policies and practices of a society tend to be faster than the formation of a broad consensus in scientific knowledge (COLLINS; EVANS, 2002; 2009).

Part of this problem is due to the low commitment and level of training of researchers, present in 37.5% of the interviews, as presented in the following excerpt:

[...] I particularly had the opportunity to work on projects in France, the dynamics of work is totally different from our life as a professor at university (Brazilian), the demand is totally different. The meetings are less frequent, you have to be accountable at every moment because you have an investment. So, I mean, you go through a consciousness, you go through a process of adaptation and then you come back to the individual, in the sense that: does he really have that interest? (E5).

Comparing different contexts from the results presented, it can be seen that from an European perspective, Audretsch; Lehmann and Paleari, (2015) state that higher education is currently directed towards the search for qualified, globalized and technology-oriented human capital in various areas of human knowledge, for example: the natural sciences, engineering and business administration.

In this context, the training of researchers committed to the advancement of scientific and technological knowledge is essential for the development of pioneering research, capable of generating innovative processes and products. In addition to intellectual competence, the training of researchers with an innovative profile, capable of contributing to the economic and social development of the country, is expected (BORGES, 2016; MCTI, 2016).

The bureaucracy in the planning, execution and evaluation processes, present in 31.25% of the interviews, also represents a challenge to be overcome, as presented in the following excerpt:

[...] you become a guy who fills out forms, gives reasons to use this or that and you don't have time to do research. So one of the first problems in doing research in Brazil is the immense bureaucratization. (E1).

Guimarães et al. (2012) emphasize that the high bureaucracy present in the SNTI compromises the efficiency of research, appearing the need for improvements in the bureaucratic mechanisms of promotion/funding, greater agility in the stages of ethical appreciation, besides the need to decentralize and make more flexible the stages of execution and evaluation of investigations.

In a classical text, Merton (1979) established conceptual bases about the discussion of scientific activity as a collective space. In summary, this author proposes that the practice of science is the result of a set of socially accepted rules that demand the use of logical criteria, validation among peers in the scientific community, the objectivity of scientific knowledge, and that scientific discoveries are a collective property and aim at social advancement. This is essentially a normative approach to scientific practice. In the cases under analysis, the predominance of normative aspects of scientific practice in evidence in Brazilian science is perceived, but the bureaucratic issue is observed as a significant obstacle.

Finally, the lack of a support team to assist the researcher (present in 31.25% of the interviews) and the low interaction among researchers (present in 25% of the interviews) are also important challenges in the Brazilian context. As presented in the following sections:

[...] support staff, we hardly have any. So this one I would also say is a major bottleneck, because there is no support staff. Inside the university, the support staff is the students. (E16).

A job that someone else could do to take the load off the teacher who has to do everything [...] so it's a different structure that allows you to put in more time, if you have more time, you'll have time to discuss better and create new ideas. (E15).

Regarding the low interaction between researchers, one of the participants made the following comment:

I think we have some interaction problems between professionals with different backgrounds. I did, for example, my doctorate abroad, there we had work teams with different backgrounds and I think this optimizes the research, because if I have a person from the laboratory area, associated with someone from the scientific writing area, associated with someone from the statistics area, associated with someone from the planning area or someone to do the reports, to ask for the resources, all this would be fundamental to optimize and allocate each professional in the tasks they best perform. (E4).

The excerpt highlights the need for interaction between researchers, especially those from different areas, for the development of multidisciplinary studies through theoretical and methodological perspectives, in addition to the dynamic interaction between different actors, resulting in heterogeneous research practices (HESSELS; LENTE, 2008).

## Identification of the challenges of scientific research through latent factors

In order to broaden the researchers' perception and minimize biases derived from the context in which the qualitative step was performed, the results were summarized in a structured questionnaire, and then applied to researchers from the ten best ranked public universities in the research category by the Times High Education.

In relation to the profile of the sample researched, an expressive participation of researchers active in all major areas of knowledge can be observed. The researchers working in the large area of Exact and Earth Sciences represent the group with the highest percentage of responses, with 16.1% of the total. They are followed by researchers in Health Sciences (15.1%); Biological Sciences (13.6%); Engineering (12.5%); Human Sciences (11.9%); Agricultural Sciences and Applied Social Sciences (11.5% each); Linguistics, Literature and Arts (7.2%) and other areas (0.6%).

The representativeness of participating researchers can be assessed by the high number of respondents (49.4% of the total) who claimed to have or have already had some type of productivity scholarship in research, this being an important metric of evaluation about the quality and reputation of researchers.

Another important characteristic of the respondents refers to their international experience with research activities. Of the 722 respondents, 78.5% said they had research experience in other countries and/or with foreign researchers. These results contribute to the experience of other practices, cultures, and to the researcher's own training (MCTI, 2016), allowing new perceptions about the challenges of the research in the Brazilian context.

Regarding the main challenges that emerged from the content analysis, the scarcity of resources; the bureaucracy in the processes of planning, executing and evaluating surveys and the lack of a support team were the variables with the highest averages attributed by respondents, as presented in Table 2.

**Table 2** – Average scores about the perception of research challenges in Brazil

Main challenges analyzed	Average	Standard Deviation
1. Lack of resources for research	4.32	0.96
2. Bureaucracy in planning, execution and evaluation processes	4.27	0.98
3. Lack of a support team to assist the researcher	4.17	1.06
4. Accumulation of functions of the researcher (teaching, research, extension etc.)	4.07	1.14
5. Poor research infrastructure	3.89	1.12
6. Excessive valuation of articles in detriment to other indicators	3.78	1.27
7. Low interaction between researchers from different areas	3.46	1.13
8. Low interaction with companies and/or social demands	3.45	1.18
9. Low dissemination and appropriation of the produced knowledge	3.44	1.13
10. Low scientific and/or technological relevance of research	3.11	1.25
11. Low commitment of researchers and/or graduate students	2.79	1.24
<b>Overall Average</b>		<b>3.70</b>

Source: Research data.

On the other hand, the low commitment of researchers and/or graduate students, the low relevance of research in scientific and/or technological terms and the low dissemination and appropriation of the knowledge produced were the variables with the lowest averages attributed by respondents.

Among the major areas of knowledge, the scarcity of resources proved to be a more evident challenge among researchers working in the Health Sciences (4.63); Linguistics, Literature and Arts (4.42) and the Human Sciences (4.41). On the other hand, it presented the lowest average scores among researchers working in the Exact and Earth Sciences (4.13) and Engineering (4.15).

Excessive bureaucracy also proved to be a category with a high degree of agreement among participants, with an average score of 4.27. Among the large areas of knowledge, it can be seen that the excessive bureaucracy presented the highest average scores among researchers in the large areas of Biological Sciences (4.40) and Health Sciences (4.31) and the lowest average scores among researchers in the large areas of Agricultural Sciences (4.12) and Applied Social Sciences (4.19), as shown in Table 3.

**Table 3** – Average scores about the perception of research challenges (by major area of knowledge)

Challenges	Exact	Biological	Engineering	Health	Agrarian	Applied Social	Human	Linguistics
1	4.13	4.30	4.15	4.63	4.22	4.25	4.41	4.42
2	4.28	4.40	4.25	4.31	4.12	4.19	4.26	4.26
3	4.08	4.31	4.03	4.50	3.93	4.24	4.22	4.10
4	3.89	4.17	3.86	4.08	3.87	3.89	4.22	4.10
5	3.77	3.89	3.57	4.19	3.75	4.03	4.09	3.83
6	3.52	3.42	3.93	3.94	3.86	3.77	3.99	4.26
7	3.23	3.31	3.45	3.74	3.52	3.40	3.46	3.35
8	3.33	3.32	3.84	3.63	3.53	3.45	2.96	2.91
9	3.22	3.24	3.23	3.64	2.97	3.40	3.57	3.55
10	3.25	2.78	3.16	3.23	3.36	3.14	2.82	2.83
11	2.98	2.82	2.87	2.67	2.92	2.86	2.44	2.35

Source: Research data.

It is interesting to note that, regardless of the major areas of knowledge, the scarcity of resources and excessive bureaucracy proved to be the categories with the highest levels of agreement among the participants, with average scores above 4.00. These categories also presented the lowest values of standard deviations, indicating lower levels of dispersion of responses among respondents. These results indicate that scarcity of resources and excessive bureaucracy represent the main challenges of academic research in the perception of participants.

Faced with this scenario, the need arises to expand existing public investments and encourage the development of partnerships with the productive sector (BORGES, 2012; GIBNEY, 2015; ANGELO, 2016; MCTI, 2016), expand and modernize available facilities, stimulating their sharing (MCTI, 2016; NEGRI; SQUEFF, 2016), to reduce bureaucratic

obstacles (THORN; SOO, 2006; SCHWARTZMAN, 2008; GONZALEZ-BRAMBILA; JENKINS, LLORET, 2016) and to allocate resources for hiring new researchers through the university expansion promoted in the country (MCTI, 2016).

In order to group the variables (challenges) into latent factors, which are not possible to be observed directly, factor analysis was performed (FÁVERO et al., 2009; HAIR Jr. et al., 2009). As proposed by Hair Jr. et al. (2009), an exploratory analysis of the data was initially performed to identify missing data and outliers outside the standard range of [-3,50 to 3,50], being identified and eliminated 11 cases. Performed the exploratory analysis, the final sample resulted in a total of 711 observations.

For the extraction of the factors, it was opted to use the main components method, besides considering factors with own values higher than 1. To facilitate the data grouping it was used the Varimax rotation method, which aims to increase the discrimination between the factors, so that each variable is more influenced by a given factor and less influenced by another (FÁVERO et al., 2009; HAIR Jr. et al., 2009). In addition, the suppression of factor load below 0.30 was chosen, considering only the most relevant ones.

The sample suitability tests showed a Kaiser-Meier-Olkin (KMO) coefficient of 0.71, considered a satisfactory value for the use of factor analysis (HAIR Jr. et al., 2009). Bartlett's sphericity test identified the existence of correlations between the variables, being significant at 1%, indicating that the data set is adequate for the use of factor analysis (HAIR Jr. et al., 2009).

As for the levels of communality (degree to which the data are associated with the linear combination of the extracted factors), it is noticed the existence of values higher than 0.5 for most of the analyzed questions. Except for three variables: (i) accumulation of functions of the researcher; (ii) bureaucracy in the processes of planning, execution and evaluation of research and (iii) excessive valuation of articles in detriment to other indicators. According to Hair Jr. et al. (2009), levels of communality below 0.5 run the risk of not presenting sufficient explanation in data variability. However, it was decided to keep the variables in the analysis, even if such decision implies a limitation of the study.

The rotated matrix grouped the variables in three main components, which, accumulated, explain 51.64% of the total variance. In addition, tests of the internal consistencies of all factors showed Cronbach Alpha coefficients higher than 0.60, the minimum value recommended by Hair Jr. et al. (2009) for exploratory research.

The first grouping (factor 1) corresponds to the challenges related to research environments (working conditions) in Brazil. Challenges related to the scarcity of resources applied in R&D activities, low investment in research infrastructure with advanced technical capabilities, lengthy and inflexible bureaucratic processes and overload of teaching activity may figure as common characteristics.

Kannebley Jr.; Borges (2016) state that the availability of resources, laboratories and working conditions contribute to the advancement of scientific knowledge. Environments with good material and intellectual infrastructure provide numerous internal and external opportunities for collaboration, for the acquisition of new knowledge/technics, for specialization in activities capable of increasing production efficiency and for dealing with complex problems (KANNEBLEY Jr.; BORGES, 2016).

In the Brazilian context, low public investment in research activities when compared to other more advanced countries (MCTI, 2016), along with the heavy bureaucracy (GUIMARÃES, 2012) and working conditions of the researcher (BIANCHETTI, 2012) compromise the efficiency of research. Perhaps this explains the participants' high concern regarding the challenges related to working conditions for research development in Brazil, since the average attributed to this latent factor was high (4.14).

In this scenario, there is a need to increase investment in existing public funding and promotion instruments, reduce bureaucratic obstacles faced in research activities and allocate resources for hiring new researchers through the university expansion promoted in the country.

The second grouping (factor 2) corresponds to the challenges related to research practices of researchers in Brazil and represents a latent factor with intermediate mean values (3.53). This factor includes the challenges related to greater interaction between researchers from different areas, to bringing academia closer to the demands of society and the productive sector, and to improvements in the processes of dissemination and appropriation of the knowledge produced, mainly in the valuation of other academic indicators.

As proposed by MCTI (2016), the improvement of research goes through the change of practices institutionalized by SNETI, such as the low interaction among researchers for the development of multidisciplinary and strategic studies, low dissemination and appropriation of the produced knowledge and the low interaction of academia with market and society demands. In addition, there is an excessive valuation of scientific articles in detriment to other indicators, which contributes to a stereotyped behavior of researchers on routines legitimized as necessary to access the "valuable" performance indicators (BALBACHEVSKY, 2008; SCHWARTZMAN, 2008).

Finally, the third grouping (factor 3) corresponds to training and qualification of human resources and represents the latent factor with the lowest average (2.95) among those analyzed. This factor corresponds to the challenges related to training and commitment of the actors involved in research activities, in addition to highlighting the low relevance of research in scientific and technological terms, when compared to other more developed countries.

Several authors highlight that the training of researchers committed to the advancement of knowledge is essential for the development of more relevant research in scientific and technological terms (BORGES, 2016; KANNEBLEY Jr; BORGES, 2016; MCTI, 2016). The National Postgraduate Plan (2011-2020) asserts that the research developed in Brazilian postgraduate programs should be evaluated for its scientific and technological quality. To do so, it would be necessary to reflect on the "relevance of new knowledge, its importance in the social context and the impact of innovation in the globalized and competitive world" (BRASIL, 2010, p. 36).

In summary, the challenges of research in the Brazilian context can be characterized, as a matter of priority, as related to research environments (scarcity of resources; poor research infrastructure; lack of a support team; high bureaucracy; accumulation of functions of the researcher). The challenges related to research practices are less acute (low interaction between researchers and between academia and society; low dissemination

and appropriation of knowledge; and excessive valuation of scientific articles). Finally, the challenges related to the training and qualification of human resources are highlighted (low commitment of researchers and low relevance of research).

## Final considerations

This study contributed to the understanding of the challenges of scientific and technological research by revealing that the working environment (working conditions) represents the main obstacle in the Brazilian context, emphasizing the need to expand existing public investments; to encourage the development of partnerships; to expand, modernize and stimulate the sharing of available facilities and reduce bureaucratic obstacles.

The study also revealed that current research practices also represent challenges to be overcome, regarding the need to value other forms of knowledge production besides scientific articles, to improve communication and dissemination of research results and to increase the interaction of academia with society demands and among researchers for more effective results.

Given the successive cuts in public research funding in Brazil and the worsening of the challenges highlighted (GIBNEY, 2015; ANGELO, 2016; ANDRADE, 2019) such contributions may foster new discussions on academic research planning, pointing the way to the development of more relevant and competitive research on the international scene.

Despite the relevance of the study and the rigor used, the results should be cautiously analyzed, since they may present limitations in the qualitative stage, given that the researchers are from a single university, and statistical limitations, by presenting low levels of communalities in some analysis variables.

In addition, the results instigate new agenda for future studies, such as the investigation of the obstacles faced by researchers in specific perspectives of relationship with companies, governments and/or civil society, which could reveal new challenges and contribute to an increasingly systemic view of scientific and technological research in Brazil.

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