Androcentrism in the Scientific Field: Brazilian Systems of Graduate Studies, Science and Technology as a case study

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Roberta Arêas^{1,4,a}, Alice Abreu^{2,b}, Carlos Nobre^{3,c}, Marcia C. Barbosa^{1,d} and Ademir E. Santana^{5,e}

¹Instituto de Física, Universidade Federal do Rio Grande do Sul, 91501-970, Porto Alegre, RS, Brazil.

²Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil.

³Institute for Advanced Studies, Universidade de São Paulo, São Paulo, SP, Brazil.

⁴CAPES, Ministério da Educação, 70040-020, Brasília, DF, Brazil.

⁵International Center of Physics, Universidade de Brasília, 70910-900, Brasília, DF, Brazil.

^aroberta.silva@capes.gov.br, ^balicepabreu@gmail.com, ^ccnobre.res@gmail.com,
^dmarcia.barbosa@ufrgs.br, ^easantana@unb.br

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Acknowledgments: We acknowledge the support of the Brazilian grant agencies Capes and CNPq

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Roberta Arêas^{1,4,a}, Alice Abreu^{2,b}, Carlos Nobre^{3,c}, Ademir E. Santana^{5,e} Marcia C. Barbosa^{1,d}

¹Instituto de Física, Universidade Federal do Rio Grande do Sul, 91501-970, Porto Alegre, RS, Brazil.

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^aroberta.silva@capes.gov.br, ^balicepabreu@gmail.com, ^ccnobre.res@gmail.com,
^dmarcia.barbosa@ufrgs.br, ^easantana@unb.br

Abstract. This article will carry out an analysis of female participation in science, considering the Brazilian system of graduate studies and scientific research as a case study. **Goals.** Considering that science is a central supporting structure for modern societies, a detailed analysis of the scientific power structure behind academic policy creation can reveal aspects of androcentrism in scientific activity. The main goal of this work is to identify the process of misogyny in science through the description of its reproductive pattern. **Theoretical and methodological procedures.** The concept of a scientific field developed by Bourdieu is used to analyze the data identifying the dynamic structure of misogyny in science. Initially, a historical and present-day outline is constructed in such a manner. This panoramic description is analyzed, taking into consideration the essential elements for knowledge production in Brazil, including women participation in the initial levels of scientific research as undergraduate and graduate students, in the organization of research groups, and in their participation at senior management positions in science. **Results.** A significant increase in female percentage in scientific activities is observed at the initial and intermediary levels, except for the most prestigious areas as hard science. However, a scissor effect is identified between the initial level and the more prominent positions. At the top of the scientific career, the presence of women is extremely low. This unbalanced participation reveals that female occupations in science are basically as labor force since in this career, women are quite far from the social circles of decisions.

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ACKNOWLEDGMENTS. We acknowledge the support of the Brazilian grant agencies Capes and CNPq.

1. INTRODUCTION

Symbolic violence in the scientific field is a remarkable social phenomenon that is studied from different points of view. Nonetheless, from a gender point of view this violence often falls upon women¹ in the form of ubiquitous moral and cultural coercion

1 In this article the terms sex and gender are used according to the accepted academic distinctions, sex referring to biological characteristics and gender referring to cultural attitudes and behaviors. As well

through a process of naturalization of social patterns. Unfortunately, these aspects have not been fully explored and determined (Santana, 2014).

Symbolic oppression is characterized by the principle of denial of differences (Young, 1990). This principle is the describing factor of the naturalization process dynamics resulting in moral violence. Under this situation, there is an unbalanced accumulation of symbolic capital supporting social structures of production based on a praxis of cultural and economic imperialism (Heinich, 1997). This is present in the perspective of disputes in different realms, as much in inter-classes as in intra-classes, but also in geopolitical contexts (Elias, 1990; Bourdieu, 2012).

According to Bourdieu, discrimination is a phenomenon that takes place in the dispute process for capital appropriation in the social realm. This leads to the naturalization of a group's dominating actions on another. In other words, naturalization is a procedure developed in order to assure the dominant *status quo*. It leads to the symbolic violence pervasive in scientific communities, particularly in the context of gender issues, with a direct impact on the *intelligentsia* of contemporary societies (Bourdieu, 2003).

For the occupation of socio-spatial positions, the accumulation and importance of symbolic-cultural capital by scholars (university professors, researchers, doctoral students, among others) is only equivalent, in terms of social power, to the economic capital of businesspeople, industry CEOs and some liberal positions. In the case of academic culture such positions are intimately linked to political-state capital, which is, in turn, the ruler and guide for economic activities, developments in knowledge and innovation, as well as cultural activities that include education and arts (Jourdain & Naulim, 2017). Regarding these aspects, modern universities, and research centers play

described by Tannenbaum et al. (2019) “[...]Sex refers to the biological attributes that distinguish organisms as male, female, intersex (ranging from 1:100 to 1:4,500 in humans, depending on the criteria used) and hermaphrodite (over 30% of noninsect nonhuman animals). (...) Gender refers to psychological, social and cultural factors that shape attitudes, behaviours, stereotypes, technologies and knowledge. Gender includes three related dimensions. Gender norms refer to spoken and unspoken rules in the family, workplace, institution or global culture that influence individuals. Gender identity refers to how individuals and groups perceive and present themselves within specific cultures. Gender relations refer to power relations between individuals with different gender roles and identities. [...]”. Another careful description of the distinction can be found at <http://genderedinnovations.stanford.edu/terms.html>. In this text, the dynamic structure of misogyny in science is analyzed from a gender perspective while the statistics used to create indicators are disaggregated by sex.

an important role as a construct supporting and guaranteeing the perpetuation of hegemonic industrial and post-industrial societies.

The scientific field, with its disputes and mediations, has been analyzed under different aspects due to its importance, including the issue of gender. Nevertheless, the symbolic violence and elements of an intra-field of androcentric discrimination in social *intelligentsia* formation are phenomena demanding further investigations.

Considering the *intelligentsia* organization in contemporary industrial or post-industrial societies, dominant groups express their specific discrimination regarding the former through a false naturalization of scientific achievements discourse. The notion of “scientific competence” in scientific research, for example, is naturalized in a way to favor androcentric points of view (Bourdieu 2003). Even today, one can easily observe that men are a majority in higher levels of research and academic institutions in all scientific areas (Abreu et al., 2016; GenderInSite, 2018). Bourdieu associates this context with the notion of “*racism² of the intelligentsia*” that, in the case of gender, is forged initially at home and school. Indeed, “(The) *School classification is a euphemized social classification, therefore, naturalized, absolutized, a social classification that has already been censored, thus, an alchemy, a transmutation tending to transform class differences into the differences of “intelligence”, “gift”, that is to say, differences in nature*” (Bourdieu, 2003).

The discrimination arising from school rank-classification is quite often sanctioned by science itself. However, “intellectual capacity” and “gifts” are developed by an accumulation process of cultural capital worked out since childhood. In this scenario, the aforementioned “racism of the *intelligentsia*” takes place not only in the context of inter-social class disputes as the concept was originally introduced, but also intra-class, within social groups. One instance is the family, a social superstructure that starts to impose a process of segregation regarding particular preferences such as colors, clothes, body postures, toys, and dreams of professional activities upon young girls. Those girls that proceed in the opposite direction during their lives will inevitably face

2 It is essential to highlight that the term racism is extensive and, in some interpretations, may be related to the skin color of individuals. Bourdieu argues in his original article “racism of intelligentsia” (2003) that there are various types of racism and that this term can be applied whenever there is a discriminatory process, regardless of its nature. In the present paper, the term racism is inseparable from the term intelligentsia – as the matter of fact, the proposal is even more specific: to use the term Discrimination of Intelligentsia to designate the marginalization process that women suffer in the scientific field.

hindrances construed by naturalized discrimination. This process, with all types of implicit symbolic violence, is not exotic to intellectual-academic institutions.

Though many aspects of the explicit (physical) violence against women have been explored and discussed under different perspectives (Heinich, 1997; Brasil, 2004; Fontenele-Mourão, 2006), those of implicit nature, marked by symbolic violence (Swim et al., 2010; Swain, 2017; Hooks, 2019), gained much less attention; certainly due to this issue's intrinsic difficulties. Indeed, from a theoretical point of view, much more research is required in order to develop an acceptable narrative about androcentrism's naturalization and perpetuation mechanism in areas such as science (Santana, 2014). Gender symbolic violence can be seen in science in a still preliminary approach by looking at the participation of women in a typical male area such as physics. The percentage of Ph.D. women in physics in some geopolitical regions are: 10 % in North America; 12 % in Latin America; 7 % in Anglo-Saxon Europe; and 22 % in Latin Europe and East Europe (Saitovitch, et al. 2015).

These data compared with the aforementioned graduate students' ones seems somewhat contradictory. The undergraduate level is the first step in science but is primarily dedicated to providing people to participate in the productive network system. In some cases, female participation diminishes drastically proceeding to further levels in science training as the doctoral or postdoctoral levels. The usual explanation for this is a highly naturalized argument: "a lack of genuine interest for science in women!" From this disguised narrative, which is but a naturalistic fallacy, the racism of *intelligentsia* emerges, and as such it demands a careful investigation. Considering science, it is acceptable and convenient to denominate such a type of racism as *discrimination of intelligentsia* in order to emphasize that it takes place not only in inter-social class contexts but also an intra-social class atmosphere¹.

Given that science is a supporting construct for modern societies (Jourdain & Naulin, 2017), a detailed analysis of its power structure, in which academic policies are defined, can reveal aspects of androcentrism in scientific activity. Indeed, focusing on the *discrimination of intelligentsia*'s reproductive pattern, the process of misogyny becomes evident. This analysis is the present work's main objective, i.e. to consider academic androcentrism as a case study through the available data from two central research funding agencies of the Brazilian federal government.

The analysis will use theoretical elements of Bourdieu and Thompson hermeneutics (Thompson, 1981; Demo, 2001; Thompson, 2011). The initial hypothesis

is the understanding that, although female participation has been increasing in different areas – including technical activities associated to science –, androcentrism is hegemonic in the higher spheres of power and at the scientific field's decision-making level.

The presentation is organized in the following manner. In Section 2, a general view about women participation in the workforce is introduced, bringing data regarding the roles of women in academic and research areas. In Section 3, the methodology is presented. In Section 4, an exposition regarding women participation in higher education and science is carried out with data from CNPq and CAPES, two Brazilian federal government agencies. In Section 5, female roles as professionals in higher education and science is analyzed. In Section 6, data considering the senior management of Brazilian science and technology is presented. In Section 7, considering the theoretical and methodological background provided, the data presented in Sections 4, 5, and 6 are analyzed and contrasted with the current debate as presented in Section 2. Final concluding remarks are presented in Section 8.

2. A PANORAMIC VIEW ON WORK AND GENDER

2.1 Women and Work: Tendencies in Modern Societies

The role played by women in modern societies has been systematically analyzed in several studies with a diversity of perspectives. From an economic point of view, for example, the World Bank has identified female empowering as a key element for poverty reduction (Malhorta et al., 2002). The role of women as providers has also been looked at. In monoparental families, where women are responsible for the family budget, the family group seems to be in a better situation when compared with those in which the economic family head is a male (Duflo, 2012). In political activities, female presence is inversely proportional to corruption levels, i.e., a greater presence of women in parliament reduces the level of corruption (Dollar et al., 2001; Swamy et al., 2001). Women researchers introduce more novelty in science than men researchers (Hofstra et al., 2020)

There is a significant number of research and evidence demonstrating that female presence in professional activities induces greater efficiency, social egalitarianism, and a sustainable environment (United Nations Women [UN Women],

2015). The United Nations has been an important advocate of gender equity since the Millennium Development Goals, agreed in 2000, where one of the 8 goals were to “promote gender equality and empower women.” More recently, with the Sustainable Development Goals, this position was strengthened, since one of the 17 new goals for the 2030 agenda is still “gender equity”, but where gender is clearly mentioned in the targets of the other 16 goals.

In Brazil, in the last decades, it is possible to find many initiatives to increase gender equity: the creation of the National Council for Woman Rights (1980) and the creation of specialized police stations to handle women's rights (1985). Nevertheless, these actions are very far from being enough, since, regarding gender, Brazil is at the 92nd position in the rank of 159 countries analyzed in 2015 by the UN. Some weak indicators explain Brazil's place in this list: high levels of teenage pregnancy; a strong gap in women's wages compared with men's in the same type of activity; and a very low representation in government. This last issue, in the Brazilian Congress, can be measured by a comparison with other countries that have a lower HDI (Human Development Index). The Central Africa Republic, for instance, the country with the lowest HDI in the world, has 12,5 % of women in parliament, while in Brazil this index is 10,8 % (United Nations Development Programme [UNDP], 2015; Cancian, 2017).

2.2. The Academic Scene in Science: “A Boys’ Club”

The gender problem in science, in spite of recent advances, remains very unbalanced in favor of men. At the undergraduate level, the first step in a scientific career, female participation increased along the 20th century. In the higher levels of scientific careers, however, there is a strong prevalence of male positions, a result of historically naturalized preconceived ideas about women (Abreu et al., 2016). Many stereotypes are prevalent for many years, such as the one which posits that the “weaker sex” does not have the necessary characteristics of high intelligence and brightness, considered as two necessary conditions for doing competent and competitive science. These concepts give rise to an invisible barrier, sometimes called the glass ceiling, preventing women from reaching the higher levels of a scientific career (Leslie et al., 2015; Bian et al., 2017). These barriers are the result of discrimination of *intelligentsia* that aims to keep the direction and control of science as an “old boys’ club” with its

praxis. Some recent studies analyzing those stereotypes against women deserve to be mentioned here.

Studying the concept of what is considered “a brilliant person,” Bian et al. (2017) have demonstrated that boys and girls up to 5-year old, when asked to choose an intelligent person, tend to select persons of the same gender. A turning point nonetheless takes place at the age of 6 to 7 years old, when there is a tendency to select predominantly male figures. In short, Bian and his co-authors demonstrate that the stereotyped idea that males are “more intelligent or capable, or better” starts at home in an earlier age, engendering since then the discrimination of the *intelligentsia* in a soft and invisible process.

Although rooted in historical prejudices, the iconic picture of a scientist as a bald male with eyeglasses has been systematically deconstructed in recent research. For instance, Leslie et al. (2015) investigated the existence of an innate talent to become a brilliant person. The research measured attributes for extended and exhausting working time, and systematic thoughts and empathic behavior capability – ubiquitous characteristics in main arguments used in social stereotypes formation. Analyzing 1820 students in 30 courses of American universities, males and females were evaluated according to hours of study, grades in standardized tests, and interviews regarding behavior patterns. The results showed no significant difference to support the naturalized (common sense) argument that males have a natural tendency to be more brilliant, or capable, than females in those academic activities.

These types of studies provide a compelling understanding that gender inequity in science is the result not of a biological or innate capacity, but a biased social construction. This process is marked by naturalistic fallacies, leading to “glass ceilings”, i.e., difficulties forbidding equalitarian access of women to all strata of scientific activity.

Lerback & Hanson (2017) concluded that the difficulties for women to attain higher ranks in scientific careers are related to the fact that women do not participate as equal partners in fundamental activities of science production as, for instance, in refereeing committees for academic journals. The study analyzed publications between 2012 and 2015 in 20 journals of the American Geophysical Union (AGU). The result was that only 20 % of referees were women. This amount is much less than expected, since, for instance, 28 % of AGU affiliations are women; 23 % of the articles were

written by women; and considering the first author in an article, this number reaches 27 % (Lerback & Hanson, 2017).

Regarding the matter of funding research projects, it is interesting to mention the work by Lee & Ellemers (2015). Their study shows financial support in favor of male scientists, in general, by investigating its unbalanced distributions in different areas. Some contradictions are observed in projects analysis, reinforcing an action based on discrimination of *intelligentsia*. For instance, women are ranked on a lesser degree considering the quality of the researcher. However, there is no difference in rank degree for research quality and scientific background skill (Lee & Ellemers, 2015).

Similar results were found by Wessel (2016), analyzing data from Wisconsin University from 2010 to 2014. The initial distribution of financial support for research projects had been equal between men and women. Nevertheless, projects headed by men were renewed in larger numbers, even though projects headed by women had been assigned a better rank. For Wessel, the androcentric paradigm is the key to understand this paradox, since men occupy 80 % of high-level positions in this career.

Bailey (2016) obtained results in the same direction by looking at the numbers of female and male Professors in the Medical Faculty of Harvard University since 1980. Although since 2016, there are more women than men at the career's initial stages, women represent only 17 % of the Full Professor level. Bailey (2016) also shows that female participation in high-level management committees and as deans is about 16 % in the USA.

Considering similar studies that confirm explicit and implicit bias, Moss-Racusin et al. (2014) had proposed a framework of strategies to implement a group of interventions at research universities to bring diversity. The authors stated that the fair treatment of other scientists is an essential aspect of scientific quality and progress.

2.3. Brazilian Women in Science

In Brazil, following a world trend, the participation of women in science has been growing over the decades. In the webpage of CNPq (the Brazilian National Research Council, a federal Government agency) a brief history of pioneer Brazilian women in science can be found. Berta Lutz is mentioned as a typical example of women working in Brazilian science at the beginning of the XX Century. Bertha Lutz, daughter of the scientist Adolfo Lutz, graduated in sciences in Sorbonne, France. Coming back to

Brazil at 24 years old, she started working as a biologist at the National Museum of Rio de Janeiro. Bertha has been reputed as one of the first woman scientists in Brazil and the first woman working as a civil servant. An activist for women's rights, she started a parallel career as a politician, being elected for the federal parliament as deputy. In this capacity, she represented the country in many international meetings as in the UN. She also had an important scientific contribution, discovered new species, organized her father's first herbaria, and published many scientific articles that gave her a high international reputation in zoology. Her remarkable political and scientific careers paved a road for many others (Melo & Rodrigues, 2018).

Since the 1960s, with the increase of female education, the number of women in science working in diverse areas raised significantly over the decades. Several indicators show the advances in this field. Primary education is almost universal: 90 % of female and male children receive primary education. In 2008, 55 % of undergraduate students in Brazilian universities were women and 60 % of those completing the course were women. However, when analyzing the percentage of working men and women four years later, in 2012, 89 % of men were doing so and only 80 % of women. This distortion is larger when you look at global numbers: 72,6 % of men in working age are working, while only 50,1 % of women do so. The most dramatic situation is concerning wages. Even if Brazilian women have, in average, more years of education than men, men still receive 28,9 % higher wages (Abreu et al., 2016).

Women represent about 50 % of lecturers and researchers in public universities in Brazil. Nevertheless, this percentage changes according to the scientific area considered (Areas et al., 2019). Following a trend found in other countries, women are present in greater numbers in humanities, biology, and health sciences. This changes for the so-called hard sciences physics, mathematics, and computing. (Abreu et al., 2016). In physics, for example, according to Barbosa and Lima (2013), one of the causes for this low representation is that women entered undergraduate studies in physics much later than men.

A new report by the Elsevier Foundation in 2017 brought some interesting data. Using a new methodology allowing to distinguish author gender in a large database of peer-reviewed articles from 12 countries for the last 20 years, the report looked at important indicators, such publication number, citations, mobility and co-authorship as a collaboration index. The results are very favorable to Brazil, since Brazilian women scientists publish as much as men (total number of papers for the period divided by the

total number of researchers for the period) by five-year period (Elsevier, 2017). Nonetheless, other databases demonstrate, as will be analyzed in the following session, that Brazilian women scientists still face many challenges.

3. METHODOLOGY

As a starting point we investigated two databases which are essential for the research: the first one from CAPES, Coordination for the Improvement of Higher Education Personnel, linked to the Ministry of Education and with the mission of training the teaching staff of public universities, and the second from CNPq, the Brazilian National Research Council, linked to the Ministry of Science and Technology and funding research. We also acquired data from the Brazilian Academy of Sciences, the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística [IBGE] in Portuguese), World Bank, and the Anísio Teixeira National Institute for Education Research (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira [INEP] in Portuguese). The data from CAPES were accessed directly from the agency, while the other databases were collected from their webpages or were requested through the Electronic System of Information to the Citizen (e-SIC, in Portuguese) accordingly to the Law for Access to Information.

CAPES is responsible for the evaluation of all graduate programs in Brazil. As such, up to 2012, CAPES used a database called Coleta, which collected data sent to CAPES by all Graduate Programs coordinators around the country every three years. From 2013 up to now, the database was significantly modified and improved, receiving the name Plataforma Sucupira. The new platform collected data annually. To merge information from both databases is complex and many indicators had to be recalculated.

The other database, CNPq, was consulted in two different ways. On the one hand, we used data from the Agency's electronic (public) website. In the case of data from the Advisory Committees, on the other hand, they were collected through an official request using the e-SIC system under the protocol numbers 01390000915201798 and 01390001071201701. It is important to emphasize that the level of data disaggregation available from CNPq is different from data available from CAPES. The classification of scientific areas is also slightly different in the two agencies. It was not always possible, therefore, to aggregate data from both agencies.

Other socio-demographics and general data were gathered in other webpages of relevant organizations. This was the case for the Anísio Teixeira National Institute for Educational Research (INEP in Portuguese), the Brazilian Institute of Geography and Statistics (IBGE in Portuguese), the World Bank, and the Brazilian Academy of Sciences data. Information about the number of ministers and presidents of CAPES and CNPq were collected in the related webpages or in the Official Union Daily-Press (DOU in Portuguese), an official daily publication of the Brazilian Federal Government that publishes all governmental acts. Using this methodology, we use statistics that refer to more than 5 million observations.

4. BRAZILIAN HIGHER EDUCATION AND SEX

This section presents a profile of Brazilian institutions associated with science and higher education, disaggregated by sex the data reflect the unbalanced participation of women in those activities.

4.1 Brazilian Population Disaggregated by Sex

Today, the Brazilian population has a majority of women. In 2010, the demographic census of the Brazilian Institute of Geography and Statistics (IBGE in Portuguese) detected that the Brazilian population is composed of 93.406.990 men and 97.358.809 women; this is equivalent to 49 % of males and 51 % of females (IBGE, 2010). This proportion is similar to the results in the Brazilian National Household Sample Survey (PNAD in Portuguese) that demonstrate that women were 51,3 % in 2005; 51 % in 2010; and 51,6 % in 2015 (IBGE, 2015).

The Brazilian system of science and technology is organized by the two agencies already mentioned: CAPES, Coordination for the Improvement of Higher Education Personnel, associated to the Ministry of Education, and CNPq, the Brazilian National Research Council, associated to the Ministry of Science and Technology. Therefore, the data below refers to CAPES and CNPq.

4.2 Students in Brazilian Universities

In Brazil, the percentage of men and women in different levels of education is very different according to grade, and in the case of higher education, the area of knowledge. At the elementary school level, the percentage is almost the same for males and females. From high school to universities the percentage of women is higher. In 2010, considering young people from 18 to 24 years old, 15.1 % of women were enrolled at the undergraduate level, while for men this number was 11.3 %. (IBGE, 2010). The proportion of women students enrolled in undergraduate university courses is 57 %, corresponding to 4.588.668 students, while men represent 43 %, i.e. 3.438.629 students (INEP, 2015).

At the graduate level, this pattern is similar. Looking at a historical series, it is possible to observe that this is the result of changes carried out over the last two decades. According to Figure 1, in 2018, 54 % (210.163) of graduate students (Master and PhD) were women, while men represented 46 % (180.258).

Figure1. Distribution of graduate students by sex. Total (sum of all years) $n=3.934.442$. Note that the y-axis scale has been modified for better data visualization. Source: CAPES. From 2004 to 2016, available at <https://dadosabertos.capes.gov.br/dataset?groups=avaliacao-da-pos-graduacao>, accessed on 08/01/2019. From 2017 to 2018, only internal use.

Considering only the Master's degree, in Figure 2, the number of women finishing a Master's program is larger than men since 1998. Similar numbers can be found for women finishing a Ph.D. program in 2004, according to Figure 3. Some of these results were known until 2009 (Centro de Gestão e Estudos Estratégicos [CGEE], 2010). After our updating, going over 10 more years, the results show a strong trend for maintaining the majority of women, both in MSc. and Ph.D. However, these results are not reflected at the professional level when men and women enter a scientific career, especially if we look at the different disciplinary areas.

Figure2. percentage of Master's degrees by sex. Total (sum of all years) $n=646.692$. Note that the y-axis scale has been modified for better data visualization. Source: CAPES. From 2004 to 2016, available at <https://dadosabertos.capes.gov.br/dataset?groups=avaliacao-da-pos-graduacao>, accessed on 08/01/2019. From 2017 to 2018, only internal use.

Figure3. percentage of Ph.D. degrees by sex. Total (sum of all years) $n=213.059$. Note that the y-axis scale has been modified for better data visualization. Source: CAPES. From 2004 to 2016, available at <https://dadosabertos.capes.gov.br/dataset?groups=avaliacao-da-pos-graduacao>, accessed on 08/01/2019. From 2017 to 2018, only internal use.

groups=avaliacao-da-pos-graduacao, accessed on 08/01/2019. From 2017 to 2018, only internal use.

Regarding the influence of areas of knowledge, there is no general pattern in the temporal series. In some areas you may find an increase in the number of women, but this is not the case with areas associated with new technologies production. For instance, in Figure 4, for exact and earth science areas (which include physics, chemistry, geophysics, geology and mathematics), in 2005, women were 35 % of the total of students at the undergraduate level; while in 2018 this number decreased to 32 % (a difference of 3 % is equivalent to 1.122 female students).

Figure 4. percentage of female graduate students by area of knowledge. Total graduate students (male and female) in 2005 n=166.325, in 2010 n=226.264, in 2015 n=335.855 and in 2018 n=390.421. Note that the y-axis scale has been modified for better data visualization. Source: CAPES. Data from 2005, 2010, and 2015 available at <https://dadosabertos.capes.gov.br/dataset?groups=avaliacao-da-pos-graduacao>, accessed on 01/08/2019. From 2018 only internal use.

4.3 Scholarships in Brazil

Considering the total amount of scholarships awarded by CAPES and CNPq, it is clear from Figure 5 that the percentage of women is larger than men, though at CNPq the difference is smaller than at CAPES.

Figure 5. percentage of national scholarships for females. Total CAPES national fellowships (male and female) in 2005 $n=36.333$, in 2010 $n=63.212$ and in 2015 $n=122.590$. Total CNPq national fellowships (male and female) in 2005 $n=14.103$, in 2010 $n=19.203$ and in 2015 $n=17.323$. Source: CAPES and CNPq. CNPq data available at <http://www.cnpq.br/series-historicas> accessed on 21/02/2019.

CAPES organizes the greater areas of knowledge as: (1) Exact and Earth Sciences (chemistry, computational science, geology, mathematics, statistics, physics), (2) Engineering, (3) Applied Social Sciences (administration, architecture, communication, economy, law, social sciences, urban development, (3) Agriculture Sciences (agronomy, fishery resources, food science, veterinary, zootechnics), (4) Multidisciplinary (biotechnology, environmental sciences, teaching, material), (5) Humanities (anthropology, political sciences, international relations, education, geography, history, philosophy, psychology, sociology, theology), (6) Biological Sciences (biological

sciences, biodiversity), and Health Sciences (collective health, medicine, nursing, nutrition, odontology, pharmacy, physical education.) Looking at the stratification by areas of knowledge we observe, according to Figures 6 and 7, that in hard sciences women are always a minority. For the Exact and Earth Sciences area, women correspond to 37 % of the CAPES scholarships, while in CNPq they reach only 34 %. It is worth noting that in Figure 4 the undergraduate scholarships were considered, and because of that the total percentage is different from Figure 5. Besides, women in “hard sciences” areas at the undergraduate level correspond to 32 %.

Figure 6. percentage of Master’s and Ph.D. CAPES national scholarships for females by area of knowledge. Total CAPES national fellowships (male and female) in 2005 n=36.406, in 2010 n=63.901 and in 2015 n=121.601. Note that the y-axis scale has been modified for better data visualization. Source: CAPES.

Figure 7. percentage of Master's and Ph.D. CNPq national scholarships for females by area of knowledge. Total CNPq national fellowships (for males and females) in 2005 $n=49.464$, in 2010 $n=75.782$ and in 2015 $n=90.689$. Note that the y-axis scale has been modified for better data visualization. Source: CNPq. Available at <http://www.cnpq.br/series-historicas> accessed on 02/21/2019.

4.4 Scholarships Abroad

CAPES provides scholarships for students to study abroad through its International Relations Directory. In an overview of Figure 8 an unbalanced distribution in favor of male students can be observed, which is disproportionate to the majority of female students. The main distortion is with undergraduate scholarships. In this modality of scholarships for female students corresponded to 40 % in 2015, although they were 57 % of the undergraduate students in Brazil. A similar distortion occurred in the same year at the Ph.D. level: while female students were 54 % of graduating Ph.D. candidates, the Full Ph.D. fellowship rate was only 47 % for women.

Figure 8. percentage of CAPES scholarships abroad for females Total CAPES scholarships abroad (for males and females) in 2005 n=3.442, in 2010 n=4.850 and in 2015 n=39.332. Note that the y-axis scale has been modified for better data visualization. Source: CAPES.

The distribution of scholarships abroad by CNPq is still more inconsistent regarding the total amount of female students and all the different scholarship modalities according to Figure 9. In all modalities, this percentage is less than or equal to 48 %.

Figure 9. percentage of CNPq scholarships abroad for females. Total CNPq scholarships abroad (for males and females) in 2005 $n=396$, in 2010 $n=433$ and in 2015 $n=9.404$. Until 2012, CNPq did not offer fellowships to undergraduate internships. Note that the y-axis scale has been modified for better data visualization. Source: CNPq. Available in <http://www.cnpq.br/series-historicas> accessed on 02/21/2019.

In Figure 10, a large heterogeneity by sex is shown by analyzing scholarships for studies abroad by different knowledge areas in CAPES. The percentage of women receiving scholarships to study abroad is inversely related with the growing percentage of female students inside the country. In 2005, the percentage for this kind of scholarships for females was 45 %. In 2015, this number decreased to 43 %. A different phenomenon can be observed by looking at the data from CNPq in Figure 11, where there was an average 7 % increase in abroad scholarships for females. It is important to notice, though, that in some areas a decrease was observed, as in Exact and Earth Sciences, where the percentage was 33 % in 2005 and in the last period it was 28 %. In both agencies there was a noticeable increase in the percentage of scholarships for females in areas as Applied Social Science, Agriculture Science and Health Science. In

the case of CNPq, looking at all abroad study scholarships from 2005 to 2015, we see a 300 % increase in that number. This is the result of the creation of the Science Without Borders program in 2011, as the results of a Brazilian Federal Government policy for the internationalization of science. This program supported researchers, as well as undergraduate and graduate students, with scholarships by CAPES and CNPq. This program only lasted until 2017.

Figure 10. percentage of CAPES scholarships abroad for females by area of knowledge. Total CAPES scholarships abroad (for males and females) in 2005 n=3.496, in 2010 n=4.979 and in 2015 n=40.093. *the total percentage in 2005 and 2010 was the same. Note that the y-axis scale has been modified for better data visualization. Source: CAPES.

Figure 11. percentage of CNPq scholarships abroad for females by area of knowledge. Total CNPq scholarships abroad (for males and females) in 2005 $n=396$, in 2010 $n=433$ and in 2015 $n=9.404$. Note that the y-axis scale has been modified for better data visualization. *the total percentage in 2005 and 2010 was the same. Source: CNPq. Available in <http://www.cnpq.br/series-historicas> accessed on 12/22/2019.

5. PROFESSIONALS IN HIGHER EDUCATION AND RESEARCH

In this section, a gender profile of professionals acting in science and higher education Brazilian institutions is presented. Most of this group is living the "rush hour" the stage of life, in which career and domestic demands are high to a point they compete. It imposes crossroads particularly on women, who have to constantly make choices related to having children, for example, or to develop their career (European Science Foundation [ESF], 2009). The data reflect the unbalanced participation of women in scientific activity and, to some extent, provide a measure of *discrimination of intelligentsia* in Brazilian scientific institutions. In the professional level, the policies for higher education and research started to be defined. These results provide essential

elements for the identification of the androcentric dynamics observed in the scientific areas of the *intelligentsia*, addressed in the following section.

5.1 Lecturers and Researchers in Higher Education

In the domain of the teaching staff working in Brazilian Universities, the National Higher Education Census identified a total of 388.004 professionals in 2015, from which 211.889 (55 %) were men and 176.115 (45 %) women (INEP, 2015). Specifically working in graduate programs, we have 43 % of women and 57 % of men. Analyzing these numbers over the last decade, from 2005 to 2018, we can see an increase in the percentage of women working in these activities. Looking at the numbers by areas of knowledge, according to Figure 12, only in the area of Language, Literature, and Arts the average percentage of women in the four periods is bigger than 50 %. The worst case is in Hard Sciences (Exact and Earth Sciences and Engineering). In this case, the average percentage of women in the four periods is less than 25 %.

Figure 12. percentage of female teaching staff in graduate programs by area of knowledge. Total number of teaching staff (males and females) in 2005 n=24.171, in 2010 n=34.058 and in 2015 n=68.390 and in 2018 n=103.439. Note that the y-axis scale has been modified for better data visualization. Source: CAPES.

Another critical aspect being analyzed is the amount of female Graduate Programs Coordinators. The numbers are presented in Figure 13, considering the distribution by areas of knowledge. In total, only 41 % are female coordinators; in Exact and Earth Science, this number is about 20 % over one decade. This number is greater than 50 % in two areas: Language, Literature, Arts and Health Science. It is important to note that there was no change in the total percentage over the analyzed series.

Figure 13. Distribution of female Graduate Courses Coordinators by sex and area of knowledge. Total Graduate Courses Coordinators (males and females) designated until 2009 n=2.110, until 2014 n=3.554, until 01/2019 n= 5.434, after 02/2019 n= 5.374. *the total percentage in 2005, 2010 and 2015 was the same. Note that the y-axis scale has been modified for better data visualization. Source: CAPES.

5.2 Research Group Leadership and Grants

In Brazil, the graduate system and scientific research are intimately connected since it is at the universities where the main parts of applied and theoretical scientific knowledge are developed. Therefore, if you want to have a clear picture of science production in Brazil, an analysis of the national system of graduate programs has to be carried out in parallel to the national system of science, technology, and innovation. The country's main research groups are registered and organized by CNPq, which maintains an updated platform for such a purpose. CNPq is also the main institution in Brazil providing grants for researchers. Through CNPq data we can analyze two aspects regarding sex: the leadership of research groups and distribution of scientific grants.

Every research group in Brazil can register at CNPq's Census of Research Groups data platform. Although voluntary, the historical series gathered since 1995 can provide us a fair picture of research groups in Brazil, usually working at Public Universities, at State or Federal levels, and in a few established research centers. We have raised data from 1995 to 2016 for all the research areas, considering the research group's leader and non-leader members' sex. In 1995, female leaders were 34 % of the total, while in 2016 this number jumped to 47 %. In non-leader female group members, the percentage was 41 % in 1995 and increased to 51 % in 2016. We can see, therefore, an advance in women participation in research (Figure 14). This data is sometimes questioned, however, due to the voluntary nature of the registration and the lack of information monitoring, in contrast with the official data collected by CAPES.

The numbers related to CNPq's very competitive Productivity in Research Fellowship are a much more prestigious indicator that gathers major scientific leaderships in Brazil. This CNPq grant is divided in five levels according to ranks: 1A, 1B, 1C, 1D, and 2. The most prestigious is the 1A category; researchers who also influence national policies for science and technology. The fellowship selection process is well organized: first, a public edict is released establishing rules and inviting qualified researchers to present research projects; then, the proposals are evaluated by Committees distributed in the different areas of knowledge that use peer-review through CNPq's usual referee system .

Figure 14. Research group leaders by sex. Note that the y-axis scale has been modified for better data visualization. Total research (males and females) in 2005 n=26.766 and in 2016 n=199.528. Source: CNPq. Available at <http://lattes.cnpq.br/web/dgp/por-lideranca-e-sexo> accessed on 01/21/2019.

Figure 15. percentage of female CNPq Researcher Fellowship Recipients by category. Total CNPq Research Fellowships (males and females) in 2005 n= 8.815, in 2010 n=12.621 and in 2015 n=13.993. *the total percentage in 2005, 2010, and 2015, was the same. Note that the y-axis scale has been modified for better data visualization. Source: CNPq. Available at <http://www.cnpq.br/series-historicas> accessed on 01/21/2019.

6. SCIENCE AND TECHNOLOGY SENIOR MANAGEMENT IN BRAZIL

In this section we present data from science and technology top management in Brazil. This section is particularly important since it is in this top management level that policies for education, science, and technology are defined. This information is the core for understanding the dynamics of discrepancies between sexes that were observed in previous sections. The starting point is CAPES and CNPq, but we consider many other institutions in the national sphere as the Ministries and the Brazilian Academy of Sciences.

6.1 The Area of Knowledge Coordinator at CAPES

The Area of Knowledge Coordinator is a very a prestigious position in the National Graduate System monitored by CAPES. This distinct group is formed by lecturers, mainly from public universities, working as scientific advisors for CAPES. Such Coordinators are responsible for the evaluation of graduate programs in different areas of knowledge. The academic community votes in three names, usually very active researchers, and the Superior Council of CAPES elects one name for a mandate of three years. During this period, the Coordinator participates in CAPES high-level commissions and workgroups in order to define financial resources allocation, rules and norms for graduate programs, among other activities.

Taking into consideration this position's importance, we have analyzed this group' composition by sex in the periods of 2011-2014, 2014-2017, and 2018-2022. Figure 16 shows a strong oscillation regarding this group's sex composition and a discrepancy among areas. One very clear evidence is that the percentage of female coordinators in hard science areas is less than 25 % in the average period. This quite unbalanced participation of women science disciplinary areas is consistent with other results discussed above. Another important observation is that the global female percentage among area coordinators had a reduction from 40 % in the period of 2011-2014 to 35 % in the period of 2018-2012.

Figure 16. Distribution of female coordinators by Area of Knowledge at CAPES. Total coordinators (males and females) 2011-2014 n=144, 2014-2017 n=144 and 2018-2022 n=147. Note that the y-axis scale has been modified for better data visualization. Source: CAPES.

In CNPq there are equivalent positions in terms of duties and responsibilities: the member of Advisory Committees of the different disciplinary areas. There are about 300 members in total in these Advisory Committees, in all disciplinary areas. The CNPq Deliberative Council, the agency's highest council, selects each member after receiving the names voted by the academic community. Figure 17 shows that the percentage of female advisors was 26,4 % in 2005 and increased to 36 % in 2019. It is hard to discern a trend with the available data, although a strongly unbalanced distribution of positions in this likewise important group can be confirmed.

Figure 17. Distribution of CNPq Advisory Committee Members by sex. Total advisors (males and females) in 2005 n=295, in 2010 n=338, in 2015 n=338 and in 2019 n=358. Source: CNPq.

6.2 Brazilian Academy of Sciences' Selection Committee

The Brazilian Academy of Sciences (ABC, in Portuguese), founded in 1916, operates as an honorific scientific society and as a consultant for the government when requested to do so, to perform technical studies and research on scientific policies. Its focus is scientific development in Brazil, interaction among Brazilian scientists, and their interaction with researchers of other nations. One of the most prestigious committees is the Selection Committee, composed of the Academy President and other 12 members. The election of new members is organized by the ABC Selection Committee, composed of 13 members, that agree on the candidates that will run. Such a Committee's composition is closely related to the androcentric nature of the ABC. Under this perspective, we have analyzed Committee formation in terms of sex from 2005 to 2018.

According to Figure 18, in the years 2005, 2006, 2013, and 2014 the Committee was composed only of men. From 2015 to 2018 there was only one woman; in 2018 there

were three women, corresponding to 23 % of females in the Committee composition. Though the temporal series is of 13 years, it is hard to define a precise trend due to the small Committee components number. We also looked at the sex composition of the administrative structure of the Academy, which included the Board and different councilors, a total of 46 people of which 24 % were women.

Figure 18. Brazilian Academy of Sciences' Selection Committee representatives by sex. Source: ABC.

6.3 Higher leadership in Brazilian institutions of Graduate and Science and Technology Systems

In this section, data describing the percentage of women in the highest positions of institutions associated with the Graduate and Science and Technology Systems are presented. These positions include the Minister of Education, Minister of Science, Technology, and Innovation, and presidents of the federal agencies CAPES and CNPq. These leading positions are, in ultimate analysis, the source of institutional policies. The data are presented in Table 1. From 2005 to 2015, all analyzed institutions had only men in the highest leadership positions³.

³ Before the analyzed period, the Ministry of Education and CAPES had women in charge.

Institution	2005	2010	2015
Ministry of Education	Tarso Genro Fernando Haddad	Fernando Haddad	Cid Gomes Renato Janine Ribeiro Aloizio Mercadante
CAPES	Jorge Almeida Guimarães	Jorge Almeida Guimarães	Jorge Almeida Guimarães Carlos Nobre
Ministry of Science, Technology, and Innovation	Eduardo Campos Sérgio Machado Rezende	Sérgio Machado Rezende	Clélio Campolina Diniz Aldo Rebelo
CNPq	Erney Felício P. Camargo	Marco Antônio Zago Carlos Alberto A. C. Filho	Glaucius Oliva Hernan Hernan Chaimovich

Table 1. Leaders of main institutions of Graduate and Science and Technology Systems by sex.

7. DISCUSSION

In this section, we present an analysis of the set of information collected in previous sections. Even though some preliminary evaluation has been presented, at this moment we will consider how different sections interrelate.

An overview of women participation in science was presented in Section 2 focusing on studies regarding Brazilian and other regions situation, pointing to a historical and present-day perspective. From this, two primary results are inferred, which permeate a diversity of social circles. The first result comes from, for instance, the work by Leslie et al. (2015). Their study clearly shows that sex discrimination in science cannot be supported by a naturalistic fallacy for such a discrepancy is a social construction. This type of work gives rise to a shift from an androcentric naturalism to *discrimination of intelligentsia* in the analysis as a social phenomenon in the scientific field. A second result, from Section 2, is the effective increase in female participation in many areas of human activities, including science.

Following the methodological guide considered in this study (Thomson, 1981; Demo, 2004; Thomson, 2011), some interpretative results from Section 2 are now revisited, considering the data presented in Sections 4, 5, and 6.

The display of data in previous sections reveals a hierarchical chain regarding the production of scientific knowledge. It starts in undergraduate and graduate courses.

In 2005, the percentage of women in all graduate courses was 51 %. In 2018, this proportion rose to 54 %. Similar results are observed for students finishing Master's and Ph.D. courses according to Figures 2 and 3.

A general increase in scholarship number is observable for women. In the period from 2005 to 2015, the average increase was 3,5 % for CAPES scholarships at all levels, in the country and abroad. Nevertheless, heterogeneity has to be considered in this evolution. Indeed, in all raised data there are differences associated with the Agency, the modality, and the areas of knowledge. For instance, female percentage is more significant than its male counterpart in CAPES for scholarships inside Brazil and in areas of humanities and arts. On the other hand, male percentage is higher than female percentage for CNPq scholarships abroad or in hard sciences.

Considering the number of researchers and teaching staff, an improvement in the total number of female positions was observed for ten years. In 2005, such positions were 39 %; while in 2015 this number was 46 %. Data from CNPq research leaders reflect this fact. In 1995, women in research leadership positions were 35 %; a number that jumped to 46 % in 2016.

Such asymmetry regarding the overall growing female percentage reaches the high hierarchy circles in science, including researchers with prestigious grants by CNPq and in science senior management. From total research grants in 2015, 35 % were for women. However, this percentage falls to 25 % for the 1A level, the most prestigious grant.

In Figure 18, detailed data about the Selection Committee for the Brazilian Academy of Sciences' 13-member compositions regarding sex is presented. Considering then a period of 14 years from 2005 to 2018, the strong minority of women participation is observed: in 9 out of 14 years, only one woman occupied a position in this committee, while in the other four years the Selection Committee was entirely composed by men.

Top management positions in graduate and science and technology institutions have also been studied. These positions include the presidency of CAPES and CNPq, the Minister of Education, and Minister of Science and Technology. The collected data reveals that the highest positions in these institutions were occupied by only men in the studied period.

In short, Figure 19 provides a global view of these data gathered in previous sections. They were arranged in such a way to reveal position occupation dynamics in

the Graduate Studies and Science and Technology Systems. It is clear that women have been entering the system in significant numbers, and have a higher percentage than men in the initial stages. However, the percentage of women historically diminishes as higher positions are taken into consideration. The arrangement presented in Figure 19 demonstrates this situation. One consequence of this view is that androcentrism biases different institutions' policies. These kinds of policies permeate the entire structure, from the entrance in undergraduate levels to the graduate positions. Albeit that the percentage of women is higher than men throughout all of these levels, women are being used as labor force in the process of knowledge production. This conclusion comes from the fact that women are definitely very far from the level of political decisions, as it is shown in Figure 19.

Figure 19. Positions occupation by sex. * data from 2015. ** data since the institution's inauguration until 2019. Source: CAPES, CNPq, MEC, MCTIC and ABC.

Questions raised in the Introduction regarding *intelligentsia* discrimination, can now be investigated in detail. Although some works point to a vertical exclusion of women, as in the study by Lerback & Hanson (2017), the analysis has also been carried out taking into consideration other assumptions. For instance, Lerback & Hanson emphasize the low participation of women in activities considered fundamental for reaching equity in science. These activities include, for instance, taking place in the process of refereeing in scientific journals. However, what is primary is to take place in the highest circles of decisions where policies are designed. Notwithstanding, in this case, global female percentage is only 2 %. Therefore, an androcentric bias is pervasive throughout the whole system.

Actions with the mark of androcentric policies come from higher hierarchical positions toward lower levels. This leads to the *intelligentsia* discrimination, already observed in lower levels of education and science as undergraduate and graduate courses in the most prestigious areas in terms of power, as those in hard science. These areas are intrinsically connected with knowledge production for new technologies, and as such, are associated with modern society's central political power, granting the governments capability to interfere in local or even global geopolitics. The androcentric mark is present in these areas, and gender inequality is thus significant. Under this view, the increasing number of women in science becomes labor force in scientific work. The analysis from secondary assumptions as in the work by Lerback & Hanson (2017) leads to either a false trend or false possibility of equity.

The large-scale employment in science since the beginning of the 20th Century, a movement defined by geopolitical issues, generated a vertiginous increase of women in knowledge production. This is not a properly new observation; however, this increase does not reach the same percentage in the higher circles of decision. As observed in previous sections, the social topologies of political decisions such as in banks, parliaments, departments, and governments, are systematically androcentric. This is reflected in the spheres of scientific knowledge production.

Women have been engaged in work and social production of goods and knowledge since immemorial time. In productive sectors of organized and democratic modern societies in the 21st Century, female participation percentage reaches, in some areas, the 92,3 % mark (Abreu et al., 2016). In a cartography of careers (Jourdain &

Naulin, 2017) there are typically long-term male spots that, depending on social conditions of productions, can be changed in order to employ female labor force. Nevertheless, some other spots resist changing their androcentric characteristics, even when the scales of times in the order of centuries are considered. These irretrievable bunkers are closely connected to central structures of power which include government circles, parliaments, senior management positions, and, as it has been observed in this work, inner scientific circles.

We have proceeded with a theoretical and methodological analysis of female participation in science considering as a case study the Brazilian Graduate and Science Systems and the notions of scientific field and racism of *intelligentsia* as defined by Bourdieu (2003). Initially, an overall perspective is drawn considering data that points toward a movement in the direction of gender equity in science. This panoramic description was analyzed in contrast with the most critical elements in the knowledge production network in Brazil, including female participation in initial levels of scientific research as undergraduate and graduate courses, positions in research groups organization, and participation in the senior management positions in science. All of these include more than 5 million data entries.

In the initial levels, a significant increase in female percentage in scientific activities occurs except in the most prestigious areas. This increase is not followed by significant participation of women in inner scientific circles of political decisions. An astonishing scissor effect is observed between initial level positions and prominent positions at the top of the scientific career. This is explicitly pictured in Figure 19, from which we observe that in the high-level positions the presence of women is extremely low or even zero when these highest management posts are observed. Some consequences are in order to be inferred here from these results.

A first note is that androcentrism is strongly fixed as a pervasive mark in scientific activity. In other words, due to the observed scissor effect, the accentuated presence of women in initial and intermediary levels of scientific activity demonstrates that female occupations are mostly as labor force, since in this career women are quite far from the social circles of political decisions.

A second observation is that *intelligentsia* gender discrimination is systemic in the academic arenas. Therefore, looking for gender equity in science demands a structural modification in the present-day division of scientific labor. These

modifications have to be consistent with an equitable division of power in all the scientific centers of decision. Otherwise, the situation presents a perpetuation trend.

8. CONCLUSIONS AND RECOMMENDATIONS

In order for Brazilian science to be more productive and qualified, it is urgently necessary to implement supporting policies for women scientists in all areas of knowledge, especially those linked to the hard sciences, such as the promotion and encouragement of female leadership in order to disseminate alternative examples of success and stimulate new discourses regarding scientific careers. Future research that discusses the processes of ascending to the highest levels of the scientific career may also create new subsidies toward gender-balanced policies development.

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