Motherhood and ex-ante evaluation: Special criteria for female researchers in public funding in Brazil

Ana Maria Carneiro[*], Luiza Maria Capanema Bezerra[**], Adriana Bin[***], Larissa Aparecida Prevato Lopes[****], João Gabriel Pedreira de Moura Gomes[****], Luciane Graziele Pereira Ferrero[***]

[*] anamacs@unicamp.br
0000-0001-6688-1881
Center for Public Policy Studies, State University of Campinas, Brazil

[**] luiza.bezerra@sp.gov.br
0000-0002-5906-4645
Center for Analysis and Technological Research of Grain and Fiber Agribusiness, Agronomic Institute, Brazil

[***] adribin@unicamp.br; lucianee@unicamp.br
0000-0001-9774-2753; 0000-0001-7892-4113
School of Applied Sciences, State University of Campinas, Brazil

[****] larissaplopes05@gmail.com; j241749@dac.unicamp.br
0000-0002-5586-5189; 0009-0005-1887-9281
Institute of Geosciences, State University of Campinas, Brazil

Abstract
Funding agencies worldwide have been establishing institutional policies to address gender inequalities stemming from women's performance biases and family obligations, which affect the allocation of grants and the career progression of female researchers. At the Brazilian National Council for Scientific and Technological Development, some advisory committees have established 'special criteria' to evaluate the curricula of female researchers since 2019 regarding the Research Productivity Grant. Of the 48 committees in this period, 16 implemented specific criteria, covering a broad spectrum of knowledge areas. The criteria extend the evaluation period for childbirth or adoption to compensate for motherhood's impact on scientific productivity. Most committees embraced these criteria to promote gender equity in science and technology. Additionally, we investigated the results of implementing these criteria based on identified microdata related to grant applications and approvals.

1. Introduction
Gender studies widely discuss the lack of gender diversity in academia. Research consistently shows that female researchers tend to be less productive than their male counterparts, which contributes to the overall underrepresentation of women in academia. While this disparity is acknowledged across different fields and countries, the extent of the difference can vary (Aksnes et al., 2019).

In addition to productivity, studies on gender inequality in academia also seek to understand qualitatively and quantitatively the gender gap in issues such as mobility, cooperation, and career progression. Such research highlights barriers for women, who often face additional obstacles than men in advancing their careers. In this sense, despite advances in the representation and participation of women in higher education, there are still "glass fences"

separating them from the academic elite, which continues to be dominated by men (Uhly et al., 2017; Arêas et al., 2020).

Uhly et al.'s (2017) investigation into gender patterns in international collaborations revealed that men with academic partners and no children are more likely to participate in research collaborations, suggesting that they benefit from their gender, spousal support and the absence of parental responsibilities. The results observed by Cunha and Dantas (2021) corroborate these findings, indicating that women are more numerous in the early stages of their careers and under-represented in deliberative positions in scientific and technological policies. This pattern of inequality is a recurring finding in various contexts and countries (Carpes et al., 2022; Machado et al., 2019; Arêas et al., 2020).

Exploring a more focused perspective in the literature on gender and science, we observe some gender studies that investigate the effect of parenthood on scientific productivity and seek to identify the differences in results between women and men. Understanding this effect considers the type of partnership, which may or may not be equal in parental responsibilities (Vohlídalová, 2017). In a study on the effect of partnerships on academic mobility, Ackers (2004) pointed out that the type of partnership affects women's academic careers, influencing progression time and even career abandonment. These results highlight the importance of understanding the challenges women academics face, especially those related to motherhood, and their impact on their careers.

Jenkins (2020) highlights the existence of "intangible costs" or "emotional labor" associated with family commitments, usually related to motherhood, which overburden women academics and should be considered as important as financial and logistical issues when it comes to mobility. This emotional labor can affect productivity, mobility or immobility, and cooperation, among other aspects.

In a research about Brazilian researchers, Machado et al. (2019) found that children's birth immediately reduced women's scientific output, persisting for around four years after the event. The authors point out that balancing personal and professional life is more difficult for women, and motherhood becomes a more important variable in this context. In addition, the survey revealed that 81% of the women interviewed in Brazil declared that motherhood had had a negative effect on their careers.

Arêas et al. (2020), in a study on the gender gap in the Brazilian S&T system between 2015 and 2019, observed the "scissors effect". The discrepancy between the number of women and men continues to increase when looking at positions and functions that require a combination of technical skills and political leadership, which vary from coordinating undergraduate programs to the position of Minister of Science and Technology. In addition, the authors highlighted the importance of the Research Productivity Grant (PQ in the acronym in Portuguese) from the National Council for Scientific and Technological Development (CNPq) as an indicator of leadership recognition in the S&T system. However, they also observed that the proportion of women who receive this grant is lower than those who occupy teaching and advisory positions at undergraduate and postgraduate levels, corroborating the existence of the "scissors effect."

Research carried out by Cunha and Dantas (2021) and Oliveira et al. (2021) on the award of PQ grants offered by CNPq in 2019 highlighted that women accounted for approximately one-third of the grants awarded and that men and women are concentrated in different

disciplines of knowledge. In addition, they pointed out that women face difficulties both in accessing PQ grants in various areas of knowledge and in reaching senior grant levels.

The study by Cunha and Dantas (2021) highlights that, historically, the CNPq has favored investment in the PQ program in the areas of Life Sciences and Engineering, Exact and Earth Sciences, to the detriment of the Humanities and Applied Social Sciences. The latter area is closer to gender equity, according to the research results. Corroborating the findings of Cunha and Dantas (2021), Oliveira et al. (2021) confirm that the under-representation of women in areas that receive more grants reinforces the role that the PQ program has played in establishing hierarchies in the academic field and in reproducing gender inequalities in Brazilian science.

We analyze the effects of changing ex-ante evaluation criteria regarding motherhood as a novel balancing factor for assessing the quality of female researchers' trajectories in the Research Productivity Grant from the Brazilian National Council for Scientific and Technological Development (CNPq). This grant, awarded to distinguished researchers in their fields, provides salary supplementation and funding for research projects. This grant is also recognized as a merit indicator and represents a competitive advantage for getting additional funding.

At CNPq, some advisory committees have established 'special criteria' to evaluate the curricula of female researchers since 2019. However, the evaluation process of the 2023 call caused controversy because one of the evaluators expressed that the candidate's pregnancies hindered her performance. We analyzed the calls from 2019 to 2023. Of the 48 committees in this period, 16 implemented special criteria covering a broad spectrum of knowledge areas. The criteria extend the evaluation period for childbirth or adoption to compensate for motherhood's impact on scientific productivity. Most committees embraced these criteria to promote gender equity in science and technology. Additionally, we investigated the results of implementing these criteria based on identified microdata related to grant applications and approvals.

2. Materials and methods

This study adopted a qualitative and quantitative approach to analyze two data sets. The first was made up of the CNPq Research Productivity calls, covering the period from 2019 to 2023, available on the agency's website. The analysis focused on the criteria specifically related to the expansion of analysis time due to pregnancy and adoption. In these calls for proposals, the analysis criteria are established by Advisory Committees made up of researchers from different areas for a period of generally three years. In this way, the criteria for analyzing projects and CVs are part of the annexes to the Call for Proposals and are defined separately by each Committee. As a result, the criteria are quite different and adhere to the dynamics of the areas of knowledge. During the period analyzed, most of the 48 committees established two sets of criteria: for the 2018 and 2020 periods and the 2021 and 2023 periods.

The second set of information analyzed refers to the CNPq panel with microdata of grant applications and approvals[1]. The panel contains all submission proposals from 2013 to 2023, including the beneficiary's name, gender, race/color, project title, Advisory Committee,

[1] Avaliable at: https://www.gov.br/cnpq/pt-br/acesso-a-informacao/dados-abertos/paineis-de-dados/painel-de-chamadas-de-bolsas-de-produtividade-pq

Knowledge Area, the start and end date of the process, the Call, the institution of affiliation, region and city of the institution, and the result of the selection process, among others.

We conducted descriptive statistical analyses in this exploratory study to summarize the data. To assess the significance of differences between groups, we employed the Chi-Square test and Fisher's exact test.

3. Results and discussion

The first result of the CNPq Area Committees' analysis criteria for the PQ grant is that they are very recent in most areas. Only the Electrical and Biomedical Engineering Committee included this special condition to promote gender equity in science and technology in 2019. The proposal extends the evaluation window by 2 years for each pregnancy or adoption, with additional intellectual productions considered. The issue was raised cautiously in the Committees' selection criteria until 2020.

An important change was seen in the subsequent period, between 2021 and 2023. During this period, 16 committees (out of 48) established criteria of this nature. In this context, the adoption of the special criterion was observed in Committees linked to the three major areas of knowledge: Life Sciences (6% of these committees), Applied Human and Social Sciences (70%) and Exact and Earth Sciences and Engineering (50%) (Box 1). In this second period, the inclusion of the criteria follows the pattern inaugurated by the area of Electrical and Biomedical Engineering, that is, the extension of the evaluation window by 2 years for each pregnancy or adoption in the period, considering publications, orientations and other items of intellectual production.

Of the 16 Committees, 9 consider the evaluation period to be 10 years and propose extending the evaluation window by 2 years for each pregnancy or adoption during the period to compensate for the impact of maternity on the scientific productivity of female researchers and, in 4 of the 9 cases, also promoting equity between men and women in science and technology. Of these 9 cases, eight refer exclusively to the female gender through the term "female researchers"; only one case (Agronomy Committee) mentions both genders in the text.

For four Committees, the time window used for evaluation varies between 5 and 10 years, depending on the grant level. In these cases, the female gender is exclusively referenced. However, the length of the analysis period varies: Three committees follow the previous pattern, with two additional years for each pregnancy or adoption, while one of them (Scientific Dissemination) proposes one additional year. The need to compensate for maternity's impact on female researchers' scientific productivity is explained in 2 cases.

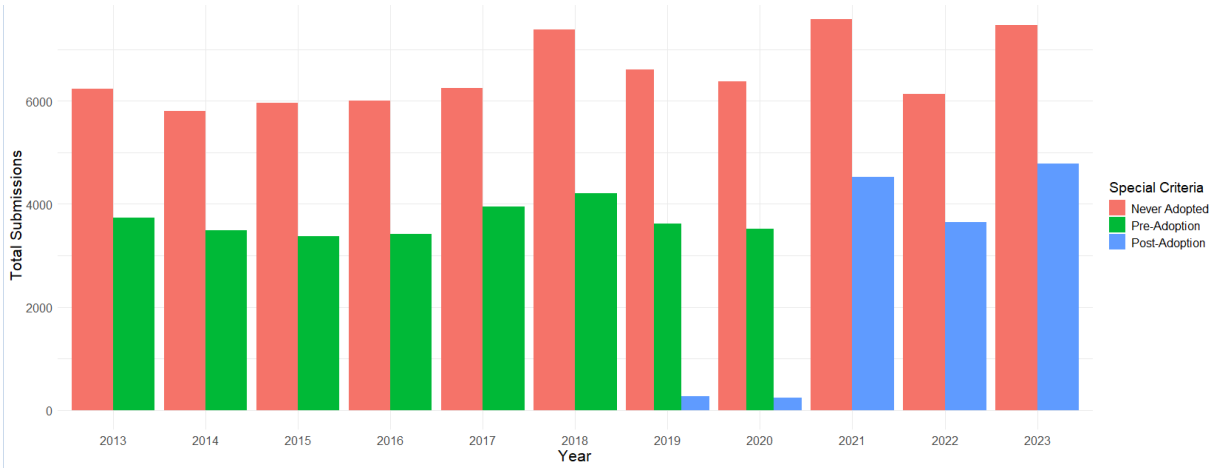
The last 3 cases refer to Committees establishing 5 years of analysis or making this period explicit in their criteria. Once again, there is an exclusive reference to the female gender, and the extension period for the analysis is 2 years, with one exception, which proposes 2 years for one birth or adoption and 3 years for two or more births or adoptions (Mathematics, Probability and Statistics). There is also an explicit restriction in one of the Committees, which grants the benefit if the birth or adoption does not occur in the last year of the evaluation period (Mechanical, Naval and Oceanic Engineering and Aerospace).

Box 1 - Adoption of special criteria for female researchers by Area Committee according to Areas of Knowledge, criteria in force between 2019 and 2023 for Pq Scholarships, CNPq

Humanities and Applied Social Sciences (70%) 1. Anthropology, Archaeology, Political Science, Law, International Relations and Sociology 2. Philosophy and Theology 3. History 4. Psychology and Social Service 5. Architecture and Urbanism, Demography, Physical Geography, Human and Regional Geography, Urban and Regional Planning, Tourism 6. Scientific Divulgation 7. Languages and Linguistics	**Exact, Earth Sciences and Engineering (50%)** 1. Electrical and Biomedical Engineering 2. Design 3. Mechanical, Naval Oceanic and Aerospace Engineering 4. Mathematics, Probability and Statistics 5. Civil Engineering 6. Physics and Astronomy 7. Geosciences 8. Microelectronics
Life Sciences (4%) 1. Agronomy	

Concerning the second analysis, based on application data, we sought to analyze the effect of implementing the special criteria on 16 committees. Figure 1 presents the data on proposal submissions by committee, organized between committees that have never adopted and those that have adopted (before and after adoption). The Electrical and Biomedical Engineering Committee adopted maternity-related criteria for the first time in 2019. In 2021, when most committees adopted the special criteria, all applications increased compared to the two previous years. The 32 committees that never adopted the criteria received around 60% of the total submissions from 2013 to 2023.

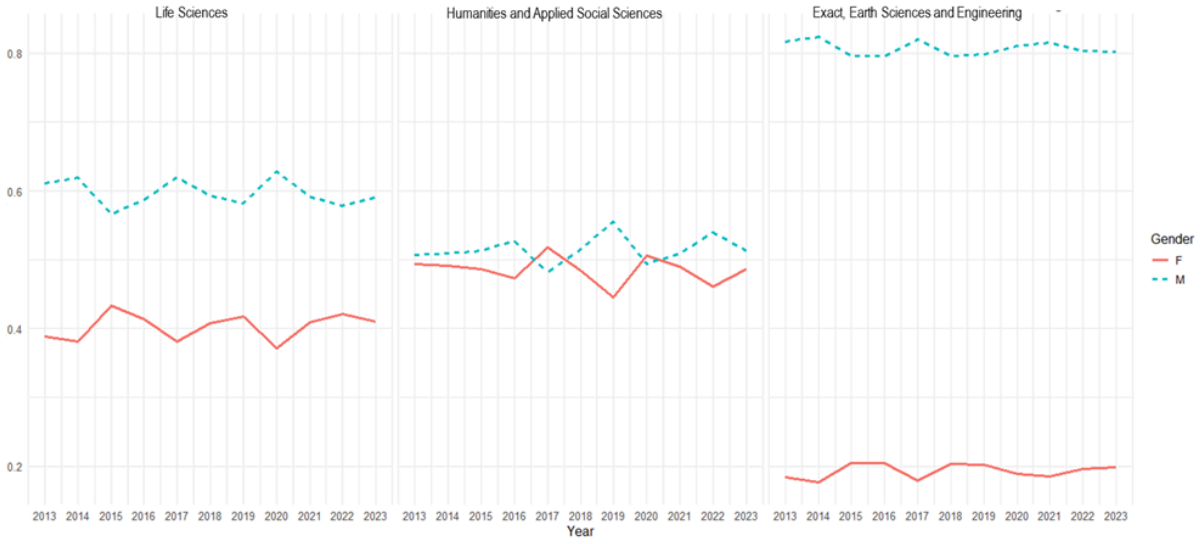
Figure 1 - Distribution of submissions according to the adoption of special criteria between 2013 and 2023



There is a difference in approval rate among men (44.9%) and women (39.3%), and this difference is statistically significant (X squared = 347.59 df = 1 p-value < 2.2e 16). This difference occurs in all races/ethnicities and knowledge areas (Figure 2). The most significant

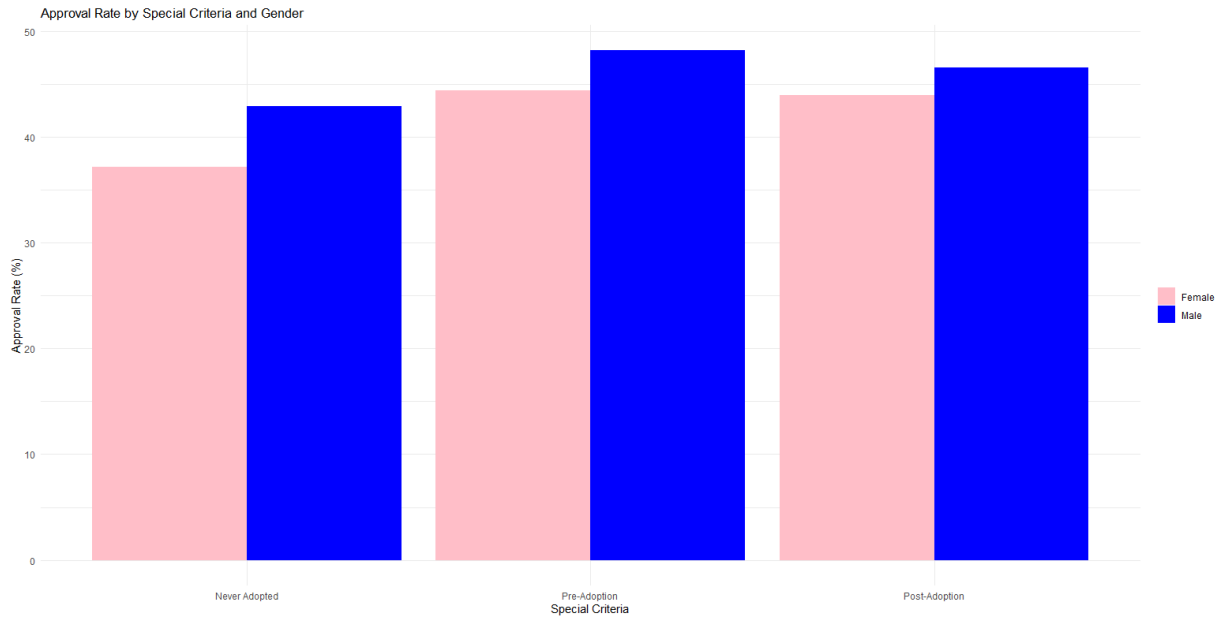
disparities in approval rates are observed in Exact, Earth Sciences, and Engineering. At the same time, a near-equitable distribution is evident in Humanities and Applied Social Sciences.

Figure 2 – Proportion of approvals by gender according to Area



The approval rate for men is higher in committees that never adopted the special criteria and those that did, although the gender gap is smaller in the latter (Figure 3).

Figure 3 – Approval rate by special criteria adoption and gender



We aimed to test whether the approval rate for women changed after the special criteria were adopted. First, we compared the approval rate among the committees that adopted them. Comparing all committees that adopted before and after, there was no statistically significant difference (Pearson's Chi-squared test with Yates ' continuity correction X squared = 0.16927

df = 1 p-value = 0.6808). The approval rate of women decreased in 11 out of the 16 committees, with 2 of these showing statistically significant decreases.

The difference is not statistically significant at the 0.05 level in the four committees that increased the approval rate. The change in the proportion of women approved may be due to random variation.

However, there was a statistically significant effect in the Electrical and Biomedical Engineering Committee, part of the STEM field, which was the first to adopt (Table 1). The approval rate for men after adopting the special criteria is still higher than that of women, although the difference is smaller than before 2019.

Table 1 – Two-sample test for equality of proportions with continuity correction

Measure	**Before 2019**	**After 2019**
X-squared	32.993	43.816
p-value	9.25e-09	0.03633
Confidence Interval (95% CI)	[0.1736995, 0.3232396]	[0.01035065, 0.18216272]
Approval rate of men	46.7%	39.8%
Approval rate of women	21.9%	30.1%

When the committees that adopted the criteria were compared with those that did not, there was a significant positive difference in the approval rate for women (X squared = 70.813 df = 1 p-value < 2.2e -16).

4. Final Considerations

The data analysis leads to two main conclusions: the first refers to the timid incorporation of specific criteria for women researchers as a result of pregnancy and childbirth, with an expansion of the analysis period. As can be seen, by 2019, only one of the 48 Advisory Committees included criteria of this nature. In the following period, between 2021 and 2023, 16 committees out of the 48 were included, i.e., a third of the total.
The study focused on a valuable time window: In 2024, the CNPq made adopting special criteria mandatory across all 48 Committees.

A significant effect was observed when comparing the committees that adopted the special criteria with those that did not. However, no noticeable differences in women's approval rates have been observed in the committees that adopted the special criteria, except for the EE Committee, which pioneered the adoption of these criteria in 2019. We can list at least three possible explanations for these results. Firstly, the approval rate for women before adoption in the committees that adopted the criteria was already higher than in the committees that never adopted the criteria. Secondly, a more favorable outcome may emerge over a longer time horizon, as we see in the Electrical and Biomedical Engineering Committee case. Finally, the current extension period might not be sufficient. As shown by Machado et al. (2019), children's birth led to an immediate decline in women’s scientific productivity, which persisted for around four years after the event.

It is important to discuss the limitations of this study. The most significant limitation is the lack of detailed information on the use of special criteria. Ideally, comparisons should be made between those who benefited from the extension of the analysis period due to maternity and those who did not. More comprehensive data on gender, maternity leave, and caregiving responsibilities for elderly or dependent family members is necessary for a more thorough analysis of relevant indicators (Reichert et al., 2022).

With such information, it would be possible to determine whether the two-year extension of the period for pregnancy or adoption has effectively reduced inequalities in the PQ grant, thereby informing discussions on the potential need for additional measures to address gender disparities in CNPq funding.

Analyzing these factors in an integrated manner would support the development of policies and affirmative actions aimed at advancing women's careers, promoting their inclusion in highly competitive environments, and ensuring the benefits of diversity in science (Naideka et al., 2020).

The proposed research agenda involves systematically monitoring trends in the coming years to evaluate if and how implementing special criteria, initially limited to a select number of Committees and expanding universally from 2025 onwards, alters the pattern of awards.

Open science practices

The content analyzed is available online in the link indicated above.

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Author contributions

Ana Maria Carneiro conceptualized and designed the methodology, supervised the research process, and contributed to the original draft and subsequent review and editing phases.

Luiza Maria Capanema Bezerra worked on conceptualizing and selecting appropriate literature and contributed to the subsequent revisions.

Adriana Bin was responsible for formal analysis and contributing to the original draft and subsequent review.

Larissa Aparecida Prevato Lopes was responsible for data collection and curation, was responsible for formal analysis and contributed to the subsequent review.

João Gabriel Pedreira de Moura Gomes was responsible for data collection, contributing to the subsequent review.

Luciane Graziele Pereira Ferreiro was responsible for formal analysis and contributing to the subsequent review.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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