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ABSTRACT

This study examines women's participation in the executive boards of the Brazilian Physical Society (SBF) and the Brazilian Association of Medical Physics (ABFM) up to 2025, based on publicly available data and social network analysis techniques. Considering scientific societies as key governance structures within the scientific field, the study investigates how leadership positions relate to the distribution of political capital and the reproduction of inequalities. The results reveal persistent underrepresentation of women and consistent patterns of vertical segregation, with women concentrated in administrative roles. Network analysis highlights structural cores of power and stable circuits of co-participation. Although women occupy structurally relevant positions, this does not translate into equivalent representation in high-level decision-making roles. The findings indicate that gender inequalities contribute to the concentration of power in the Brazilian scientific field, with territorial implications for regional scientific development.

Keywords: Gender. Scientific governance. Social networks. Inequality. Regional scientific development.

RESUMO

O presente artigo analisa as restrições à consolidação da bioeconomia inclusiva na Amazônia, com foco na cadeia Este estudo analisa a participação feminina nas diretorias da Sociedade Brasileira de Física (SBF) e da Associação Brasileira de Física Médica (ABFM) ao longo de sua trajetória até 2025, com base em dados públicos e técnicas de análise de redes sociais. Partindo da compreensão das sociedades científicas como instâncias de governança do campo científico, investiga-se como a distribuição de posições de liderança se articula com a concentração de capital político e suas implicações para a reprodução de desigualdades. Os resultados revelam sub-representação feminina persistente e padrões consistentes de segregação vertical, com maior concentração de mulheres em funções administrativas. A análise de redes evidencia a existência de núcleos estruturais de poder e circuitos relativamente estáveis de coparticipação. Embora mulheres estejam presentes em posições estruturalmente relevantes, essa inserção não se traduz de forma equivalente na ocupação de cargos de maior poder decisório. Conclui-se que tais padrões, além de expressarem desigualdades de gênero, contribuem para a manutenção de dinâmicas concentradas de poder no campo científico brasileiro, com implicações territoriais para o desenvolvimento científico regional.

Palavras-chave: Gênero. Governança científica. Redes sociais. Desigualdades. Desenvolvimento científico regional.

INTRODUCTION – "PEOPLE ARE MEANT TO SHINE"[1]

The organization of science is not limited to the production of knowledge but involves institutional structures that set agendas, distribute symbolic resources, and guide research priorities. In this sense, scientific societies play a central role in the governance of the scientific field, acting as bodies for legitimization, coordination, and political representation of academic communities (Balbachevsky, 2017; Bueno, 2022). In Brazil, organizations such as the Sociedade Brasileira de Física (Brazilian Physical Society - SBF) and the Associação Brasileira de Física Médica (Brazilian Association of Medical Physics - ABFM) not only organize events and promote scientific exchange but also influence, directly or indirectly, the distribution of opportunities, visibility, and recognition among groups and regions (Roitman, 2018).

This institutional dimension of science has significant territorial implications. The literature on regional development and the geography of science has highlighted that scientific and technological output is unevenly concentrated across Brazil, with a strong predominance of institutions located in the Southeast region, especially in the states of São Paulo and Rio de Janeiro (Diniz; Gonçalves, 2005). This concentration is not limited to infrastructure or funding but is also evident in collaborative

1 VELOSO, Caetano. Gente. Performed by: CAETANO VELOSO. In: Bicho. Rio de Janeiro: Philips, 1977. 1 audio disc (3 min 30 s), stereo.

networks, prestige circuits, and decision-making forums (Diniz; Gonçalves, 2005; Suzigan; Albuquerque, 2011). Thus, understanding who holds leadership positions in scientific societies also involves investigating how the power flows that influence regional scientific development are structured.

Within these structures, gender inequalities constitute an additional dimension of asymmetry. Physics and medical physics are fields historically marked by male predominance, both in education and in the occupation of institutional leadership positions (Mendes; Renha; Sá, 2016). Although female participation has grown in recent decades, evidence points to the persistence of barriers to advancement to positions of greater prestige and decision-making power a phenomenon often described as vertical segregation (Hirata; Kergoat, 2007). This pattern not only limits representation but also affects the diversity of perspectives in setting scientific agendas, with potential impacts on research priorities and institutional policies.

Feminist literature on science has demonstrated that the underrepresentation of women in leadership positions does not stem from isolated individual choices, but from institutional, cultural, and epistemological structures that historically define who can produce legitimate knowledge and occupy positions of authority in the scientific field (Harding, 1991; Schiebinger, 2001). In this context, gender inequality is not limited to the quantitative dimension of participation but involves processes of symbolic exclusion, unequal distribution of recognition, and barriers to advancement in scientific careers, especially in traditionally male-dominated fields such as physics. These dynamics have implications that extend beyond academic communities, insofar as they influence the setting of scientific agendas and, consequently, science's ability to respond to broader social demands.

From Pierre Bourdieu's perspective, these dynamics can be understood as part of the unequal distribution of capital within the scientific field. Holding leadership positions in academic professional associations constitutes a form of accumulation of political and symbolic capital, which can be converted into influence over institutional decisions, access to prestigious networks, and the ability to set agendas (Bourdieu, 1983; Ocasio; Pozner; Milner, 2020). In this sense, an analysis of the executive boards of these associations allows us to observe not only the representation of social groups but also the power structure that underpins scientific governance.

This study analyzes the historical composition of the boards of directors of the Sociedade Brasileira de Física (Brazilian Physical Society - SBF) and the Associação Brasileira de Física Médica (Brazilian Association of Medical Physics - ABFM) , focusing on women's participation and the structure of co-participation networks among leaders. By integrating gender analysis, social networks, and scientific governance, this study seeks to understand how the distribution of leadership positions relates to the concentration of political capital in the Brazilian scientific field and what its implications are for the reproduction of inequalities, both gender-based and, potentially, territorial.

This study seeks to answer the following questions: (1) how has women's participation on executive boards evolved over time; (2) is there evidence of vertical segregation in the distribution of positions by gender; and (3) do co-participation networks indicate patterns of power concentration and differences in integration between men and women.

METHODOLOGY – "ONE MUST WEAVE, WEAVE, AND WEAVE, WEAVE ALL THE TIME"[2]

Data were collected directly from the official websites of the SBF and the ABFM, based on publicly available information regarding the composition of their boards of directors during different periods. Subsequently, the information was organized into spreadsheets, containing the following variables for each administrative term: period (start and end years), position held, name of the executive, and gender identified based on publicly available information (names, institutional profiles, and biographies). In ambiguous cases, verification was conducted using secondary sources. We acknowledge that this procedure employs a binary classification (M/F) and does not account for trans and non-binary identities, which constitutes a limitation of the study. This standardization enabled the cleaning and harmonization of the records, ensuring consistency and comparability between the two organizations analyzed.

In the analytical phase, statistical and social network analysis methods were applied. First, logistic regression was used to assess the probability of having at least one woman on each board over time, and Poisson regression was used to estimate the average number of women per term, with both models using the board's start year as the independent variable. In addition, co-membership

2 NASCIMENTO, Milton; BORGES, Márcio. "Tecer." Performed by MILTON NASCIMENTO. From: *Tambores de Minas*. Rio de Janeiro: BMG, 1997. 1 audio disc (4 min 02 s), stereo.

graphs were constructed, in which each node represents an individual and each edge indicates joint membership on the same board, with a weight proportional to the number of terms served together. This structure made it possible to visualize and quantify the connections among individuals who held leadership positions. The metrics used included: degree, which measures the number of direct connections for each person; *betweenness*, which indicates the extent to which an individual acts as a bridge between different groups; and *closeness*, which expresses how close a node is to all others in the network. A combined centrality was also calculated—the normalized average of degree and *betweenness*—to simultaneously capture local influence and structural intermediation. Communities were identified using the modularity (Q) maximization algorithm, whose value ranging from 0 to 1 reflects the degree of network segmentation values close to 1 indicate well-defined clusters and little overlap between groups. This approach made it possible to identify central actors, recurring patterns of collaboration, and levels of cohesion and fragmentation within the boards over time. This framework facilitates the identification of recurring trajectories, although it introduces a temporal bias associated with the longer tenure of certain individuals an aspect considered relevant for the analysis of political capital accumulation.

The choice of logistic regression to model the presence of at least one woman and Poisson regression for the number of women per administration is based on the nature of the variables analyzed. Given the limited number of observations, the results are interpreted with an emphasis on the magnitude of the effects and confidence intervals, rather than solely on statistical significance. Possible limitations include overdispersion in the Poisson model and temporal dependence between terms.

It should be noted that the territorial dimension was not directly operationalized in the empirical analysis, since data on the institutional location of the actors were not incorporated at this stage. Nevertheless, the interpretation of the results considers that co-participation networks reflect, to some extent, the spatial organization of the Brazilian scientific system, constituting an analytical hypothesis consistent with the literature on the geography of science and regional development, which indicates that collaboration networks and scientific governance structures are intrinsically associated with the spatial organization of knowledge production (Diniz; Gonçalves, 2005; Suzigan; Albuquerque, 2011), an aspect to be explored in greater depth in future research.

ASSOCIAÇÃO BRASILEIRA DE FÍSICA MÉDICA (BRAZILIAN ASSOCIATION OF MEDICAL PHYSICS - ABFM) – "AS LONG AS THERE IS SPACE, BODY, TIME, AND SOME WAY TO SAY NO, I SING"[3]

Over the years analyzed, 77 different individuals served on the boards of the Associação Brasileira de Física Médica (Brazilian Association of Medical Physics - ABFM) , holding a total of 115 positions. Of this group, 68.7% of the positions were held by men and 31.3% by women, highlighting a historical male predominance in the composition of the boards.

In the early years (from 1969 to 1981), all positions were held exclusively by men. Women began to appear tentatively in the following decades, gradually increasing their presence starting in the 1990s and gaining greater representation on more recent boards, when women came to hold between 30% and 40% of the positions in some administrations.

Regarding the distribution by role, it is observed that the positions of President and Vice President remained predominantly male throughout most of the historical series, while women had a greater presence in administrative and secretarial roles. To quantify this pattern, the gender dissimilarity index[4] among executive positions was calculated. The value obtained (D = 0.40) indicates a moderate to high level of segregation in the distribution of men and women across roles. In interpretive terms, this result suggests that approximately 40% of the positions would need to be redistributed to achieve an equitable distribution between the genders. This finding reinforces that, although women are present on the boards of directors, their participation is concentrated in administrative roles, while positions with greater decision-making power remain predominantly held by men. This trend suggests a pattern of vertical segregation in the occupation of leadership positions within the ABFM, although there are slight indications of greater gender diversity in more recent administrations.

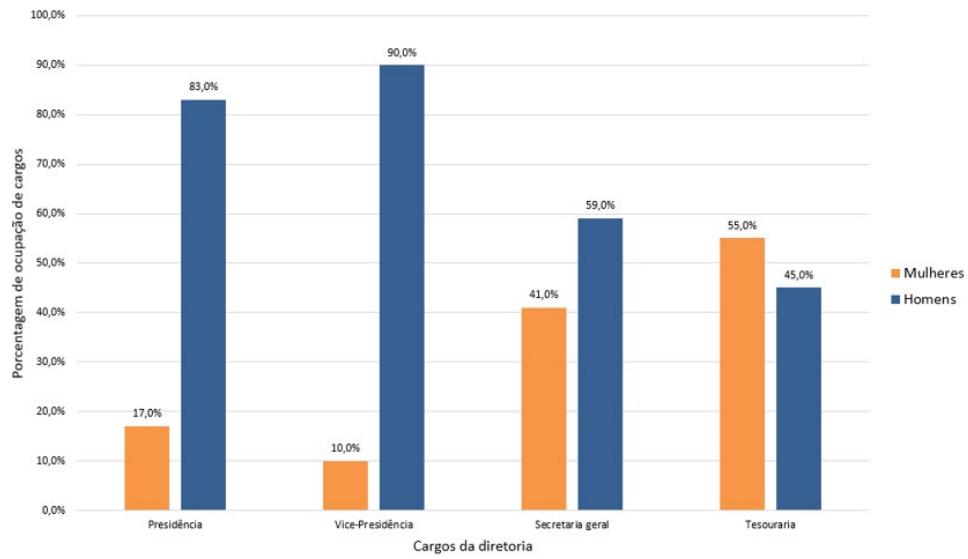
3 DUNCAN, Zélia. Alma. Performed by: ZÉLIA DUNCAN. In: Zélia Duncan. Rio de Janeiro: Warner Music Brasil, 1994. 1 audio disc (4 min 53 s), stereo.

4 The dissimilarity index (D) is a widely used measure to assess unequal distribution among groups across different categories. In the present study, it was applied to measure gender segregation among executive positions and was calculated as , where wiand micorrespond to the number of women and men in position i, and W and M represent the total numbers of women and men, respectively. The index ranges from 0 (perfectly balanced distribution) to 1 (total segregation) and can be interpreted as the proportion of individuals that would need to be redistributed among the categories to achieve balance between the groups.

According to the 2015 ABFM Census (Brazilian Association of Medical Physics, 2014) , among the 427 respondents, 65% were men and 35% were women. Meanwhile, the Professional Survey of Medical Physics in Brazil (ABFM Census 2023) (Brazilian Association of Medical Physics, 2023) , conducted between June and August 2023 with 380 valid responses, shows a distribution of 62.9% men and 36.1% women among active professionals. The analysis demonstrates that, despite gradual progress at the base of the profession, female representation in leadership positions remains below the category average, suggesting the persistence of structural barriers to women's advancement into institutional decision-making roles.

Comparing these results with data from past ABFM executive boards, it is observed that female representation on the boards (31.3%) remains slightly lower than the overall proportion of women in the professional category (35% in 2015 and 36.1% in 2023), as can be seen in Figure 1. A comparison between the proportions of women in the association's membership (34.9%) and on the boards of directors (31.3%) did not reveal a statistically significant difference (proportion test, p = 0.47). However, this parity does not hold when considering positions with greater decision-making power, such as the presidency and vice presidency, where female representation remains low. This suggests the existence of specific barriers to advancement to the highest levels of leadership, characterizing vertical segregation.

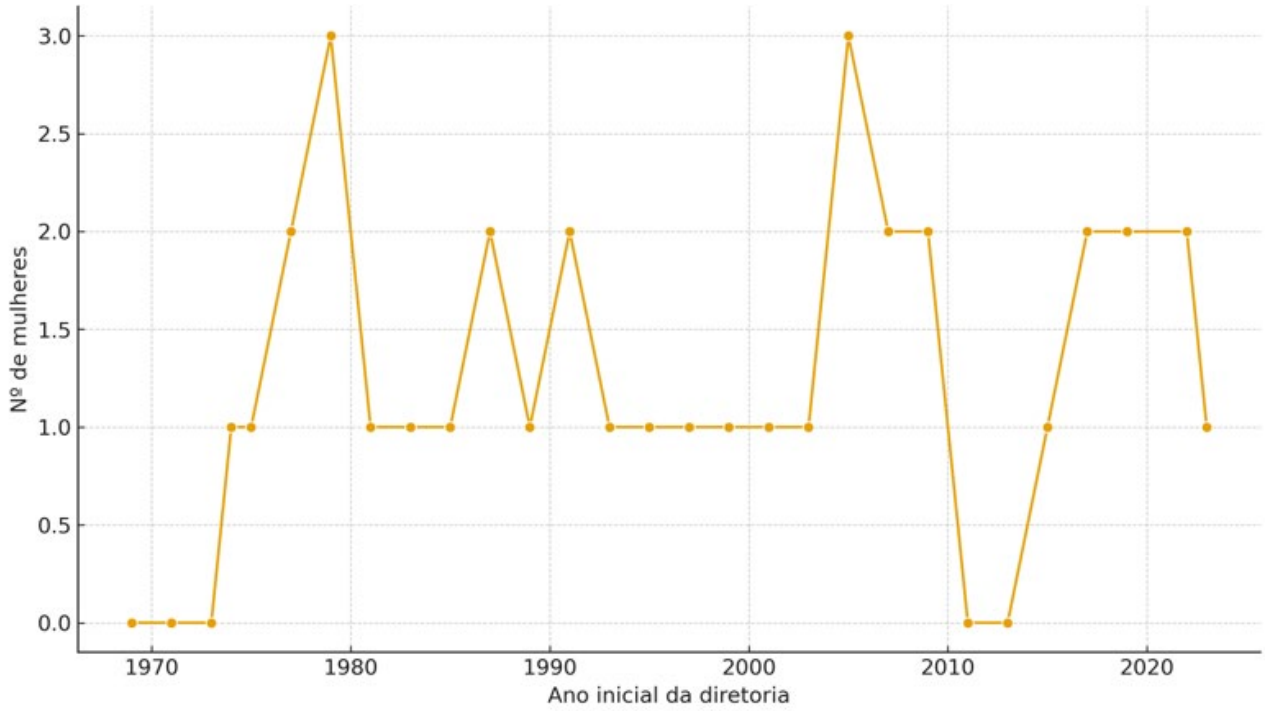
Figure1 | Graph showing the distribution of positions on the ABFM boards by gender (1969–2025).



Source: Author's own analysis.

A temporal analysis of the boards of directors of the Associação Brasileira de Física Médica (Brazilian Association of Medical Physics - ABFM) revealed a modest increase in female representation over the decades. The data regarding the ABFM, showing its evolution over time, can be seen in Figure 2. Logistic regression indicated that the odds of having at least one woman on each board increased by approximately 46% per decade (OR = 1.46; 95% CI: 0.76–2.81; p = 0.254), although this was not statistically significant. Similarly, the Poisson model showed that the average number of women increased by approximately 10% per decade (IRR = 1.10; 95% CI: 0.90–1.34; p = 0.346).

Figure2 | Timeline of the number of women per ABFM board over time.



Source: author's own work.

These results suggest a positive trend, but one that is still insufficient to confirm consistent progress.

SOCIEDADE BRASILEIRA DE FÍSICA (BRAZILIAN PHYSICAL SOCIETY - SBF) – "THE NEW IS ALWAYS COMING"[5]

Over the years analyzed, 134 different individuals served on the SBF's boards, holding a total of 189 positions. Of this total, 82% of the positions were held by men and 18% by women, which highlights a broad male predominance in the society's historical leadership.

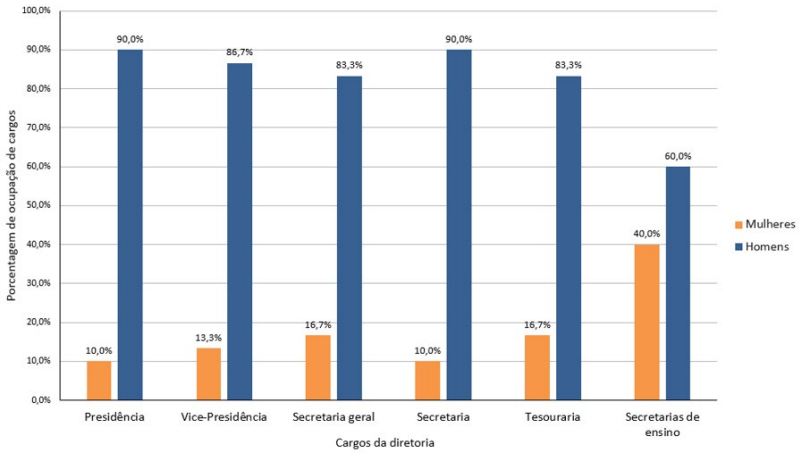
In the early periods (from 1966 through the late 1980s), all positions were held exclusively by men. Women began to appear sporadically in the 1990s and 2000s, with their representation increasing modestly in more recent administrations, though gender parity has yet to be achieved. Even in the most recent boards, the number of women rarely exceeds 25% of the positions, and the SBF presidency has remained predominantly male throughout the entire historical series. Over this period, only three presidencies were held by women, corresponding to approximately 10% of the total.

The distribution of positions indicates that women have been more frequently found in roles such as Secretary, Treasurer, and specific coordinating positions, while the positions of President, Vice President, and Council members remain concentrated among men—revealing a persistent pattern of vertical segregation in the society's leadership. The dissimilarity index calculated for the SBF (D = 0.25) indicates a moderate level of segregation in the distribution of positions by gender. In interpretive terms, approximately 25% of the positions would need to be redistributed among the roles to achieve balance. This result reveals that, although gender inequality persists, the distribution of women across different roles is less concentrated than in the ABFM, suggesting a relatively more widespread presence in leadership structures.

Comparing these results with the SBF's general membership data, as reported in the "Physics Statistics in Brazil – 2020" report (Schulz, 2021) , it is observed that women represent approximately 25% to 30% of the physics community (3). Thus, female representation on the boards of directors (18%) is well below the overall proportion of women affiliated with the society, which reinforces the fact that, although the base of female members has grown in recent decades, the transition to institutional leadership positions remains slow and uneven.

5 BELCHIOR. "Velha roupa colorida." Performed by ELIS REGINA. In: Elis. Rio de Janeiro: Philips, 1977. 1 record (4 min 45 s), stereo.

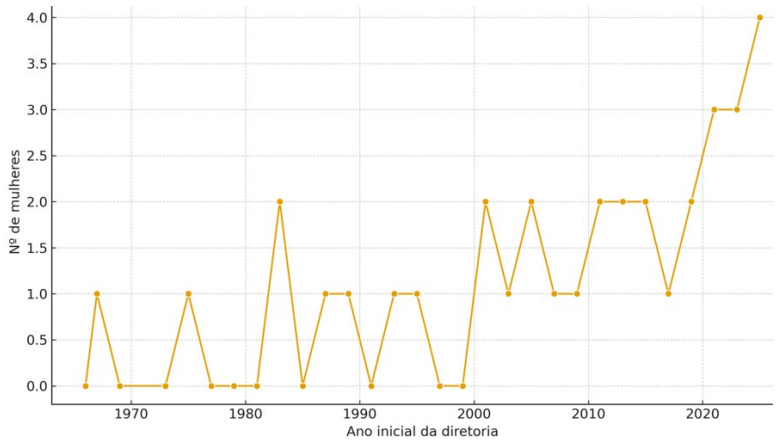
Figure 3 | Chart showing the distribution of positions on the SBF's executive boards by gender (1966–2025).



Source: author's own analysis.

At the SBF, a similar trend of increasing female representation was observed, although it was also not statistically significant. Logistic regression indicated a 27% increase in the odds of having at least one woman on each board per decade (OR = 1.27; 95% CI: 0.83–1.94; p = 0.340), while the Poisson model indicated a 12% increase in the average number of women (IRR = 1.12; 95% CI: 0.93–1.36; p = 0.280).

Figure 4 | Timeline of the number of women on the SBF board over time.



Source: author's own work.

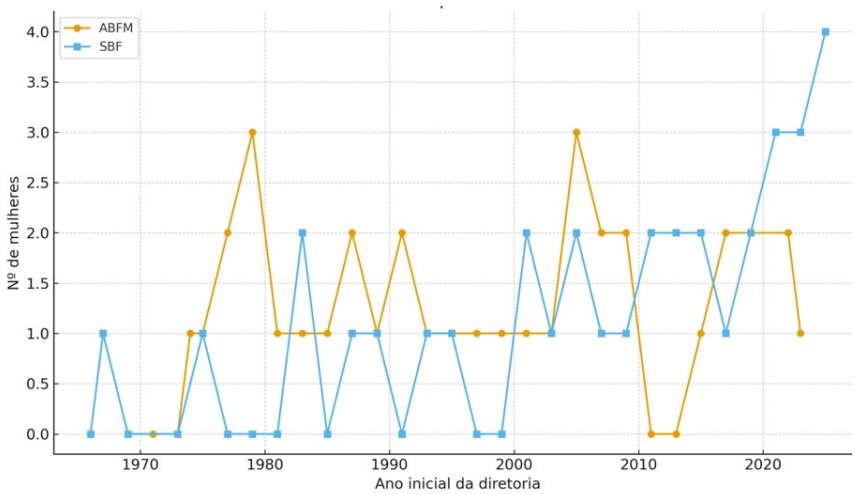
Although the effects are modest, they indicate gradual progress in the inclusion of women over time, as shown in Figure4 .

COMPARISON BETWEEN ABFM AND SBF – "DESPITE YOU, TOMORROW WILL BE ANOTHER DAY"[6]

An analysis of these results allows for a deeper understanding of the relationship between scientific governance and regional development. The literature has highlighted that scientific and technological output is not distributed evenly across the country, but is heavily concentrated in certain institutional hubs and regions, particularly in the Brazilian Southeast (Diniz; Gonçalves, 2005; Suzigan; Albuquerque, 2011). In this context, scientific societies—by organizing collaborative networks, setting priorities, and structuring decision-making spaces—act as institutions that not only reflect but also contribute to the reproduction of these inequalities. The presence of structural centers of power and the recurring presence of certain actors on governing boards indicate that scientific governance operates through relatively stable networks, which tend to concentrate political and symbolic capital in already established actors and institutions.

A comparison between the two societies reveals similarities and some relevant differences. In both, the general trend was toward an increase in female participation over t , though not statistically significant. At ABFM, the effect was stronger in terms of the probability of a minimum number of women on each board, while at SBF the increase was more consistent in the average number of women per term.

Figure 5 | Trends in the number of women on each board: ABFM vs. SBF.



Source: Author's own analysis.

6 BUARQUE, Chico. "Apesar de você." Performed by CHICO BUARQUE. In: Chico Buarque de Hollanda, Volume 4. Rio de Janeiro: Philips, 1970. 1 record (4 min 15 s), stereo.

Despite these differences in magnitude, the results confirm that, in absolute terms, men continued to hold the majority of board positions in both associations. This comparison is summarized in Figure 5, which shows the trend in the number of women on each board.

COMMUNITY REPORT - "AND WHAT REMAINED OF THE SKY STAYED TO LIGHT OUR WAY"[7] BRAZILIAN ASSOCIATION OF MEDICAL PHYSICS

The network analysis of the ABFM boards was conducted by constructing a co-participation graph, in which nodes represent individuals and edges indicate joint service during the same term, weighted by the frequency of these interactions throughout the terms. The resulting network comprises 72 nodes and 157 edges, organized into four connected components, and seven communities identified by a modularity detection algorithm. The obtained modularity value (Q = 0.694) indicates a highly segmented structure, with a strong presence of internally cohesive subgroups that are relatively unconnected to one another. This pattern suggests that the composition of the boards of directors is not random or homogeneous, but rather structured into relatively stable relational blocks, possibly associated with historical periods, institutional affinities, or dynamics of continuity within management groups.

With regard to centrality metrics, significant differences are observed in the structural position of the actors. Betweenness centrality highlights the existence of individuals playing a strategic role in the network's articulation, notably Homero Lavieri Martins (0.2369), Marília Teixeira da Cruz (0.1781), Renato Di Prinzio (0.0935), and Adelino José Pereira (0.0903). These actors occupy key positions in mediating between communities, functioning as bridges that enable the network's overall connectivity. This configuration indicates that structural cohesion depends on a small number of agents, which may imply greater vulnerability to disruptions should these actors cease to occupy connecting positions. Additionally, the weighted degree and proximity centrality metrics reinforce the centrality of Homero Lavieri Martins and Marília Teixeira da Cruz, suggesting not only broad connectivity but also a privileged position in central regions of the network.

7 O RAPPA. "O que sobrou do céu." Performed by: O RAPPA. From: Lado B Lado A. Rio de Janeiro: Warner Music, 1999. 1 audio disc (4 min 29 s), stereo.

Finally, *eigenvector centrality* points to the relational relevance of the actors based on the importance of their connections, particularly highlighting Marília Teixeira da Cruz as a node embedded in a highly influential core. Taken together, the results indicate an organizational structure characterized by dense clusters of interaction and a significant reliance on intermediary actors for integration among communities. This configuration suggests that the dynamics of ABFM board membership are associated with patterns of relational reproduction and concentration of social capital, in which certain individuals play recurring roles in maintaining institutional cohesion over time.

BRAZILIAN SOCIETY OF PHYSICS

The co-participation network within the SBF's executive boards, comprising 129 nodes and 463 edges, exhibited low density (0.056) and high modularity (Q = 0.716), indicating a highly segmented structure composed of cohesive communities. The identification of eight communities revealed groupings that are not random but strongly associated with the temporal continuity of leadership terms. Relatively stable historical blocks can be observed, in which individuals tend to recirculate in similar compositions over time, suggesting the existence of structured dynamics of recruitment and retention on the boards of directors. The fragmentation of the network into three connected components reinforces the idea of partial discontinuity between more distant cycles.

Centrality measures highlight a significant structural concentration among certain actors. The highest values of *betweenness centrality* were observed for Gil C. Marques (0.307) and Adalberto Fazzio (0.306), followed by F. Cesar Sá Barreto (0.134), indicating that these individuals play a critical role as bridges between different communities. This structural position suggests an enhanced capacity for mediation between distinct historical blocs, which is potentially more significant than mere high local connectivity. The weighted strength analysis corroborates this pattern, with the same individuals ranking among the most central, pointing to trajectories marked both by recurrence in leadership roles and by cross-cutting integration into the network.

The gender distribution across communities reveals a recent shift in the composition of leadership bodies. While communities associated with earlier periods show low female participation (for example, 7.7% and 11.1%), more recent communities exhibit greater balance, reaching 57.1%

in one of the most recent groups. However, the higher female presence in recent communities does not, in and of itself, imply an equivalent redistribution of structural positions of power, since the nodes with the highest centrality remain predominantly associated with trajectories consolidated over time. These results suggest that changes in composition may be occurring more rapidly than changes in the structure of centrality and mediation within the network.

When compared to the ABFM, the SBF network exhibits greater community diversity and higher modularity, indicating a broader scope of activity and less hierarchical concentration. Nevertheless, both share the trait of female underrepresentation in positions of influence, although there is a trend toward increased connectivity among women in more recent administrations.

COMPARISON BETWEEN ABFM AND SBF

Co-participation analyses reveal that both ABFM and SBF exhibit dense networks of internal connections among individuals who held leadership positions across different administrations. The **ABFM** network comprises **7 communities** and has a modularity value of **Q = 0.694**, indicating **well-defined clusters but with interconnections between blocks**. The **SBF**, on the other hand, exhibited **8 communities** and a modularity **of Q = 0.716**, reflecting **greater structural diversity and more pronounced segmentation** among groups. These differences suggest that the SBF, being a larger society with a broader thematic scope, houses **more autonomous specialized groups**, while the ABFM, with a more technical scope, exhibits **greater overlap in leadership** across administrations.

The cross-analysis of formal position (position held) and structural position within the network (node centrality) reveals distinct patterns between the two societies. In the ABFM, women are found among the nodes with the highest connectivity, indicating significant integration into the network's relational structure. However, this presence does not translate equivalently into the holding of positions with greater decision-making power, highlighting a disconnect between structural centrality and formal leadership position.

At SBF, on the other hand, the network exhibits greater structural concentration among a few individuals, with less dispersion of centrality. In this context, the presence of women among the most central nodes is more limited, suggesting that gender inequality manifests itself both in the

positions held and in the network structure itself.

Taken together, these results indicate that the distribution of power within associations is determined not only by the holding of formal positions but also by individuals' relational standing, revealing complementary dimensions of gender inequality.

In this context, gender inequalities cannot be understood merely as an internal dimension of scientific communities, but as part of the dynamics that structure the very realm of science itself. As Kabeer (1999) argues, access to resources, agency, and recognition constitutes a central dimension of development processes and is directly affected by structural power relations, such as those based on gender. The underrepresentation of women in leadership positions implies not only less diversity in profiles but also a limitation of perspectives in defining institutional agendas, priorities, and strategies. Given that such decisions influence the distribution of resources, opportunities, and visibility across regions and institutions, gender inequality contributes to the perpetuation of concentrated patterns of scientific development.

The gender distribution reveals **similar patterns of female underrepresentation**, albeit with varying degrees of balance. At **ABFM,** women accounted for **29.6%** of all members of the historical executive boards. At **SBF**, the proportion was slightly lower, **at 27.9%,** though with **greater dispersion across communities** and a female presence in all identified clusters.

Despite the lower absolute proportion, the SBF demonstrates **greater inclusion of women in positions of structural influence**, with figures such as **Adriana Calvo, Angela Villela,** and **Heloisa R. M. Goulart** among the most central nodes, while at the ABFM, **Marília Teixeira da Cruz, Vilma Ferrari,** and **Márcia de Carvalho Silva** play similar roles.

In both associations, women tend to occupy **intermediate nodes and serve as liaisons** between communities, which highlights **their political capital and capacity for mediation**, even in contexts of numerical underrepresentation.

In both networks, recurring names are observed across administrative terms, indicating **an accumulation of symbolic and political capital** within the associations. The ABFM shows **a greater concentration of centrality among a few actors**, with strong continuity of leadership across successive terms. The SBF, on the other hand, exhibits **a more homogeneous distribution of centralities**,

suggesting **periodic renewal and greater turnover** of participants in leadership positions.

These results point to **differences in governance structures**: the ABFM tends to operate under a logic of **technical continuity**, while the SBF is organized in a **more pluralistic and federative** manner, integrating research groups and diverse regions of the country.

In both networks, the identified communities combine **institutional and geographic patterns**, groups linked to universities, research institutes, or thematic areas (such as medical physics, education, or theoretical physics). In **the ABFM**, women have **a strong presence in mixed communities**, connecting technical subgroups; and in **the SBF**, there is **greater internal diversity**, with women active on various fronts: administrative, academic, and scientific outreach.

The analysis reveals that the **interconnectedness of women across communities** is a key factor in fostering cohesion and the circulation of ideas, reinforcing women's role as **organizational bridges** within both societies. In Latin American contexts, marked by historical inequalities in the distribution of resources and opportunities, the interplay between gender, knowledge, and territory takes on even greater significance. As Walsh (2009) points out, the power relations that underlie knowledge production are deeply intertwined with historical processes of exclusion and social hierarchization. In this sense, the low representation of women in scientific governance spaces not only reproduces inequalities within the field but also limits the plurality of perspectives in the development of scientific agendas capable of responding to the demands of different territories, especially those that have historically been marginalized.

These findings reinforce the idea that scientific governance is not merely an internal mechanism for organizing the field, but an active factor in the production of regional inequalities, insofar as it structures the distribution of resources, opportunities, and recognition among regions.

WHAT ABOUT THE FUTURE? - "AND WHAT WILL BE REVEALED TO THE PEOPLE AT THAT MOMENT / WILL SURPRISE EVERYONE NOT BECAUSE IT IS EXOTIC, BUT BECAUSE IT MAY BE SIMPLE."[8]

The results of this study suggest that the underrepresentation of women in positions of greater institutional prestige stems not only from numerical presence but also from structural patterns in the distribution of opportunities and recognition. However, identifying the mechanisms that produce these patterns requires further research.

It is important to remember that leadership positions in these associations are **elected, not appointed**, which means that increasing women's representation also depends on women's willingness to **run** for **and compete** for these positions. This aspect is not overlooked in this study: there is a component of individual agency that must be recognized, even though it is conditioned by historical structures of inequality and the prevailing institutional culture in these spaces.

In this context, the debate presented in **Beyond the Pipeline** (Leonard, 2025) helps us understand the movements that can transform women's participation in *STEM* fields (an acronym for *Science, Technology, Engineering, and Mathematics*) and, by extension, in scientific societies. In this discussion, two main vectors stand out: "*Push*" and "*Pull*."

"*Pulling*" involves creating **safe, attractive, productive, and accessible educational and work environments**. It means building equitable systems that accelerate progress and shape institutional cultures in which the presence of women is not the exception, but the norm. It is about recognizing that women are naturally drawn to workplaces that reflect their values, potential, and expectations: environments that offer **financial stability, purpose, intellectual challenges, and social impact**. Thus, rather than merely inviting women to participate, it is necessary to structure organizational spaces that foster their full and sustained participation.

"*Pushing*," on the other hand, refers to policies and actions that, although well-intentioned, end up being **forced or careless**, reducing women to statistics or quotas. The drive to meet metrics can lead to placing women in environments that remain ill-suited, hostile, or unequal, perpetuating the cycle of disengagement and demotivation. This "pushing" also manifests itself in subtle ways

8 VELOSO, Caetano. "Um índio." Performed by CAETANO VELOSO. From: *Bicho*. Rio de Janeiro: Philips, 1977. 1 record (3 min 55 s), stereo.

- in praise conditional on conformity to narrow ideals, in incentives that ignore individual choices, and in veiled pressure not to "waste potential."

When there is no suitable environment for women's growth, leadership, and recognition, there is no point in pushing them into these spaces. They are unlikely to be interested in filling these roles if it means becoming empty symbols of representation - what is known as tokenism. Without structural changes, holding a leadership position may cease to be an achievement and become just another symbolic burden imposed by a system that refuses to change.

Therefore, when scientific institutions and professional associations fail to evolve in their structure and culture, simply **increasing the number of women is not enough to set things right**. Action must be taken to reform the **system that shapes the conditions for** these professionals **to remain in their roles, gain recognition, and advance**.

In medical physics, this challenge is even more evident. Although 36% of professionals are women, they hold only 31% of leadership positions at the ABFM, with a strong concentration in administrative roles - **primarily in treasury and secretarial functions**. These positions, historically associated with support, care, and organizational tasks, **reproduce gender roles deeply entrenched in society**, where women are expected to perform functions of **assistance, coordination, and domestic or emotional management**, rather than positions of decision-making and power (Hirata; Kergoat, 2007). This pattern highlights **vertical segregation**, in which women enter in support roles rather than in positions of highest authority, such as the presidency and vice presidency.

In physics, the situation is even more restrictive: only 18% of positions on the SBF's executive boards have been held by women throughout its history, a percentage lower than the proportion of female members. Although there have been isolated instances of progress, women's advancement to the most prestigious positions remains limited by symbolic and institutional barriers.

Given this, building the future requires **structural changes** - not merely encouraging women to run for office, but **transforming the conditions that make women's leadership possible and sustainable**. Furthermore, institutional policies that recognize and value **care work**, the **diversity of career paths**, and the **versatility of women who move between science, education, and health** are crucial for breaking the pattern of "masculinization" of scientific prestige. Promoting equity

depends on institutional transformations that expand the actual conditions for participation and recognition.

Based on these elements, it is argued that analyzing women's participation on the boards of scientific societies allows us not only to understand gender inequalities but also to shed light on broader mechanisms governing the organization of the Brazilian scientific system. In a country marked by strong regional disparities, the concentration of political capital in specific networks tends to reinforce existing inequalities, limiting the flow of resources, opportunities, and scientific agendas across regions. In this sense, promoting greater diversity in scientific governance structures - including expanding women's participation - can contribute to the development of a more pluralistic, less concentrated scientific system that is more responsive to regional needs.

In summary, the future of Brazilian physics and medical physics will depend less on "pushing" women to the top and more on **reforming the steps** that support the path. Progress will depend on the ability of scientific societies to **improve their governance structures and practices** in order to ensure **transparency, equity, and diverse participation** in their decision-making processes.

Thus, gender equity in science should not be understood merely as an issue of inclusion, but as a strategic condition for strengthening regional development. By expanding diversity in decision-making spaces, we create the possibility of building scientific agendas that are more inclusive, territorially grounded, and socially committed, in line with Sustainable Development Goal 5 (gender equality). Such movement can contribute to the consolidation of a more democratic scientific system, capable of responding more equitably to contemporary challenges.

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