

## The Retention Of Researchers In Brazilian Regions

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### **Abstract:**

**Background:** Regional development policies in Brazil date back to the 1950s, particularly after World War II, and encompass scientific and technological issues. Institutions like CNPq and CAPES were established to promote science and technology. Despite these efforts, the effectiveness of these policies in retaining highly qualified researchers in underdeveloped regions remains uncertain, necessitating further evaluation.

**Hypotheses and Methods:** This study investigates whether postdoctoral fellowships provided by CNPq contribute to the retention of doctoral researchers in Brazil, with a specific focus on the North, Northeast, and Midwest regions. Four hypotheses were formulated: the existence of researcher mobility, the prevalence of researcher retention in regions of national interest, the impact of government incentives on retention, and the overall contribution of CNPq fellowships to national retention. Data from the Lattes and Fomento Panels were analyzed, utilizing multiple regression and logistic regression methods to assess relationships between researcher retention, location, and fellowship status.

**Results:** The findings indicate significant mobility among researchers, with negative mobility noted in the South and Southeast and positive mobility in the North and Midwest. While postdoctoral fellowships positively influence retention in regions of interest, non-fellow researchers show even higher retention rates. Additionally, receiving a CNPq fellowship is associated with a lower likelihood of researchers staying in Brazil, suggesting that other factors beyond government incentives may play a more decisive role in researcher retention.

**Conclusion:** CNPq postdoctoral fellowships do not consistently or significantly contribute to the retention of researchers in Brazil.

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### **I. Introduction**

In general, public policies should consider spatial interactions and human capital to promote growth, noting that economic growth in micro-regions is influenced by factors such as per capita GDP and local characteristics (Cravo; Becker; Gourlay, 2015). Additionally, the combination of social, industrial, regional, and science and technology policies aims to reduce inequalities and promote regional development[1].

According to Caldas and De Moraes (2021)[2], public policies to promote innovation and technology are essential for fostering social and economic development, coordinating state and private resources to achieve relevant objectives. Furthermore, the implementation of these policies contributes to increased employment, income, and sustainable development, demonstrating the importance of investment in this sector for local and national progress [2].

The policies of scientific and technological development in Brazil date back to the 1950s, particularly in the post-World War II period, marked by the establishment of the National Council for Scientific and Technological Development (CNPq)[3] and the Coordination for the Improvement of Higher Education Personnel (CAPES)[4] in 1951. Subsequently, recognizing the need for resources to financially support priority scientific and technological programs and projects, the National Fund for Scientific and Technological Development (FNDCT)[5] was instituted in 1969, operated by the Financing Agency for Studies and Projects (FINEP)[6].

Ferreira and Araújo (2019)[7] discuss the role of funding agencies in postgraduate studies by encouraging the training of researchers, improving and consolidating programs, and funding research, coordinating projects, promoting innovation, and supporting editorial activities, as well as scientific and technological management.

Collaboration in emerging industries is often mediated by students and company employees, as highlighted by Schaeffer, Fischer, and Queiroz (2018)[8], underscoring the importance of retaining trained researchers. Although still insufficient to meet the real needs for scientific development, governmental investments in Science, Technology, and Innovation have significantly contributed to the increase in the number of masters and doctoral graduates, the growth in the publication of internationally circulated scientific articles, and the increase in the number of patents, as observed by Lazzareschi (2015)[9].

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According to Benedicto et al. (2018)[10], human capital and talents are considered intangible assets that generate a competitive advantage for organizations. Talent retention allows companies to maintain and develop their internal capabilities, which are essential for standing out in the market.

Based on the need to retain these talents, CNPq has recently been working with FAPs to attract and retain PhDs in the country, as evidenced by the launch of the Support Program for the Placement of Young Doctors in the Country[11][12], and the Knowledge Brazil Program - Attraction and Retention of Talents[13].

Thus, the aim is to understand the dynamics of the formation of doctoral researchers in various regions of the country and whether their professional activities remain in the same region or if there has been migration, as well as to verify if there is any interference in this situation when granting postdoctoral fellowships to researchers.

## II. Hypotheses And Methods

### Hypotheses

The CNPq Lattes Panel[14] shows that between 2019 and 2023, 112,562 researchers obtained a doctoral degree. However, 43,320 of these researchers, or 38%, did not report their sector of activity, suggesting a possible lack of allocation. It is not possible to ascertain whether the others are in stable or precarious positions, as the "fellowship holder" status may not be as consistent as expected.

Through the Science, Technology, and Innovation Funding Panel[15], CNPq disclosed an investment of R\$ 374,879,659.00 (three hundred seventy-four million, eight hundred seventy-nine thousand, six hundred fifty-nine reais) over the five years studied, specifically in scholarships for doctoral researchers, benefiting an average of 10,844 researchers per year.

In this context, although there is a tacit understanding of the need for researchers in the country, studies focused on the retention of researchers in Brazil are scarce, in contrast to the extensive literature on talent retention in companies. One of the available studies is "A Spatiotemporal Analysis of Brazilian Science from the Perspective of Researchers' Career Trajectories" by Furtado et al. (2015)[16], which states that there is a strong retention of researchers in Brazil. Most researchers undergo all stages of their education in the same region, and less than 20% work more than 500 km away from their initial institution[16]. Additionally, the demand for doctorates abroad is low, with institutions in São Paulo being the focus of interest[16].

Thus, the aim of this study is to verify whether postdoctoral scholarships, specifically those granted by CNPq, contribute to the retention of doctoral researchers in Brazil. Specifically, it seeks to determine if this premise is valid for the national interest regions, which include the North, Northeast, and Midwest regions. Furthermore, the study attempts to understand if there is mobility among titled researchers and the regions where they are working.

To address the proposed objective, four research hypotheses were formulated:

- First Question:** Is there mobility among titled researchers and the region where they are working?
- o **H0:** There is no significant mobility among titled researchers and the region where they are working.
- o **H1:** There is significant mobility among titled researchers and the region where they are working.

This question is essential for determining whether researchers remain in the regions where they were trained or if there is a pattern of movement to other regions, which can influence regional development policies and the distribution of resources for science and technology.

- Second Question:** Is the retention of doctoral researchers more prevalent in the regions of national interest (North, Northeast, and Midwest)?
- o **H0:** There is no significant difference in the retention of researchers in the regions of national interest compared to other regions.
- o **H1:** There is a significant difference in the retention of researchers in the regions of national interest compared to other regions.

Assessing the retention of researchers in these regions allows for checking whether postdoctoral scholarships are fulfilling one of their explicit objectives, which is to strengthen scientific and technological capacity in less developed areas of the country.

- Third Question:** Does government incentive, in this case, the scholarships, influence the retention of researchers in regions of national interest?
- o **H0:** Government incentive is not effective in retaining researchers in less developed regions.
- o **H1:** Government incentive is effective in retaining researchers in less developed regions.

This question aims to evaluate the effectiveness of public policies in science, technology, and innovation, particularly in relation to their role in encouraging the permanence of qualified researchers in regions that can significantly benefit from their expertise.

- Fourth Question:** Do CNPq postdoctoral scholarships contribute to the retention of doctoral researchers in Brazil?

- o **H0:** CNPq postdoctoral scholarships do not have a significant effect on the retention of researchers in Brazil.
- o **H1:** CNPq postdoctoral scholarships have a significant effect on the retention of researchers in Brazil.

This is the central question that seeks to directly assess the impact of postdoctoral scholarships on retaining talent within the Brazilian scientific system. The answer to this question can provide critical insights into the effectiveness of these scholarships in keeping researchers within the Brazilian scientific community, contributing to the sustainable and autonomous development of national science.

## Methods

The data used in this work were obtained from the Lattes Panel[14], accessible on the CNPq portal. The Lattes Panel[14] gathers information extracted from the curricula of master's and doctoral graduates who have updated their records in the last five years. It is important to note that, as stated on the portal, the data filled out in the Lattes Curriculum[17] are self-declared, provided directly by the researchers when updating their curricula.

The data extraction was carried out using the option provided by the panel itself, filtering for researchers who declared themselves as having a doctorate. After extraction, the remaining information was manually removed to perform the necessary cross-referencing on-site, that is, without using the filters provided by the Panel.

Data related to gender, race/color, educational institutions, main field of knowledge, and area of knowledge, as well as formation scholarships such as Scientific Initiation, Sandwich Undergraduate, Master's, and Doctorate, were excluded from this research. The exclusion of these data does not reflect their irrelevance to issues of mobility and retention, but rather because they do not align with the specific focus of this work, which is not aimed at understanding whether the scholarships facilitated the formation of researchers. Productivity scholarships and technological development scholarships, in any modality, were also removed, considering that these presume an already established career, unlike postdoctoral scholarships, which are generally granted to researchers with more precarious institutional ties. Moreover, information about the place of education or work that was declared as "not informed" was excluded from the analysis, as it would be impossible to establish any correlation with these data.

To provide a more accurate assessment of the distribution of researchers across regions, it was necessary to normalize the data concerning researchers relative to the local population sizes[18] [19]. The specific formula used for normalization is as follows:

$$\text{Normalized Researcher Density} = \left( \frac{\text{number of Researchers}}{\text{Population of the Region}} \right) \times 100,000$$

This approach, similar to that used by Ramírez Varela, A. et al. (2021) [20], ensures fair comparisons across regions by mitigating the impact of population size on our analysis. Population data were sourced from the Brazilian Institute of Geography and Statistics (IBGE)[20] to maintain accuracy and relevance.

This step is crucial to prevent policy distortions—misinterpretations that can arise when raw data does not account for population variations among regions. Without this normalization, data might misleadingly suggest that regions such as the South and Southeast, which show the highest numbers of programs and active researchers, are disproportionately well-resourced. This could lead to skewed policy decisions, as noted by Ferreira et al. (2019)[7], who pointed out the potential for misinterpreting the concentration of resources based on non-normalized data. In contrast, our normalized figures reveal that while the South and Southeast regions represent 88% of the total current scholarships, the Midwest and Northeast account for 10%, and the North only 2%. By adjusting these figures for population size, we can more accurately discuss investment trends and ensure that policy decisions are based on proportional representation rather than absolute numbers, thereby promoting a more equitable allocation of resources across all regions.

The methodology specifically addresses mobility by analyzing geographical shifts from where researchers obtained their doctoral degrees to their current professional locations. This domestic focus reflects unique career paths within Brazil, adapted from broader international mobility definitions found in studies like those within the European Union [21], [22] and the OECD's Frascati Manual [23]

By employing these adapted definitions, the study aims to fill gaps in our understanding of domestic researcher mobility and retention, providing insights that are crucial for policy-making in science and technology.

For the first question, which addresses the existence of mobility between titled researchers and the state where they are working, the original spreadsheet was prepared to verify the average difference between 2018 and 2023 of researchers educated and researchers working by state (UF), normalized by 100,000 inhabitants. Additionally, the data were divided between fellowship holders and non-fellowship holders. See Table no 1 and Figures no 1 and 2.

The second question, which investigates the retention of doctoral researchers in the regions of national interest (North, Northeast, and Midwest), followed a similar procedure. The original spreadsheet was prepared to verify the average difference between 2018 and 2023 of researchers educated and researchers working by state (UF), normalized by 100,000 inhabitants, with data divided between fellowship holders and non-fellowship holders. See Table no 2 and Figures no 3 and 4.

For the third question, it is important to emphasize that the postdoctoral fellowship provided by CNPq is not a specific public policy for the retention of researchers in the region where they were educated. In this sense, the aim was to understand whether these fellowships somehow influence researchers to remain in their states of education. To do so, using the data presented in the previous questions, the regression technique was applied, according to Fávero (2017), to assess whether there is a significant relationship between researcher retention (dependent variable) and factors such as location in a region of interest and the presence of fellowships (independent variables).

Regarding the fourth question, which deals with the contribution of CNPq postdoctoral fellowships to the retention of doctoral researchers in Brazil, Table 3 summarizes the data obtained. The variable "Number of Researchers" reflects the number of doctoral researchers in each group. The data structure included the following combinations: researchers who were not educated in Brazil, do not work in Brazil, and are not fellowship holders (1,927 people); those who were not educated in Brazil, do not work in Brazil, but are fellowship holders (39 people); among other combinations, up to those who were educated in Brazil, work in Brazil, and are fellowship holders (3,342 people).

For each research question, specific data sets were prepared:

- For mobility, we compared the state of education and current work location of researchers, normalized per 100,000 inhabitants, distinguishing between fellowship holders and non-holders.
- For retention, similar data sets were prepared focusing on the regions of national interest (North, Northeast, and Midwest).
- To determine the influence of CNPq fellowships, regression analyses were employed to identify significant factors affecting researcher retention, utilizing STATA version 16.0 for all statistical computations.

This methodological framework ensures that the study not only identifies patterns of researcher mobility and retention but also provides insights into the effectiveness of specific fellowship programs in influencing these patterns.

### **III. Result**

The analysis of researcher mobility in Brazil reveals significant geographic movement among doctoral researchers. Approximately 34.07% of the 109,305 researchers analyzed have moved to a different state for professional opportunities. States like Rio Grande do Sul, São Paulo, and Rio de Janeiro exhibit a net outflow of researchers, suggesting that although these regions are educational hubs, they do not retain a large proportion of the talent they educate. Conversely, states such as Roraima, Amapá, Rondônia, and Tocantins are notable for their net inflow, attracting researchers from other regions.

The differences in mobility patterns suggest varying regional capabilities in retaining and attracting talent, influenced by factors such as available job opportunities, research infrastructure, and quality of life. Annualized data from 2018 to 2023 further illustrate the dynamic nature of these patterns, with each state displaying unique trajectories of researcher density per 100,000 inhabitants. These insights are crucial for policymakers aiming to enhance scientific development and regional equity in research capabilities.

These insights are crucial for policymakers aiming to enhance scientific development and regional equity in research capabilities. The states of Rio Grande do Sul, São Paulo, and Rio de Janeiro stand out for their negative mobility, where the difference indicates that many researchers titled do not remain in the state. That is, although they are educated in these states, they end up moving to other states or countries. This situation may be due to students who came from other places and, after graduating, returned to their place of origin, since these states have a higher number of postgraduate programs, more options in fields of knowledge, and possibly greater tradition or quality than in their place of origin.

On the other hand, positive mobility, when the number of researchers working is greater than the number of researchers educated, indicates that the state is attracting researchers from other regions. The highlights for positive mobility were Roraima, Amapá, Rondônia, and Tocantins.

These variations suggest that some states are more effective at retaining or attracting researchers than others. Mobility may be influenced by various factors, such as job opportunities, research infrastructure, quality of life, and regional incentives. Similarly, data on fellowship holders and non-fellowship holders were used to assess the influence of fellowships on the retention and mobility of researchers, as shown in Figure 1.

Given the availability of annualized data and with the aim of evaluating the significance of researcher mobility over the years in each state, the annual averages of the normalized difference between educated and

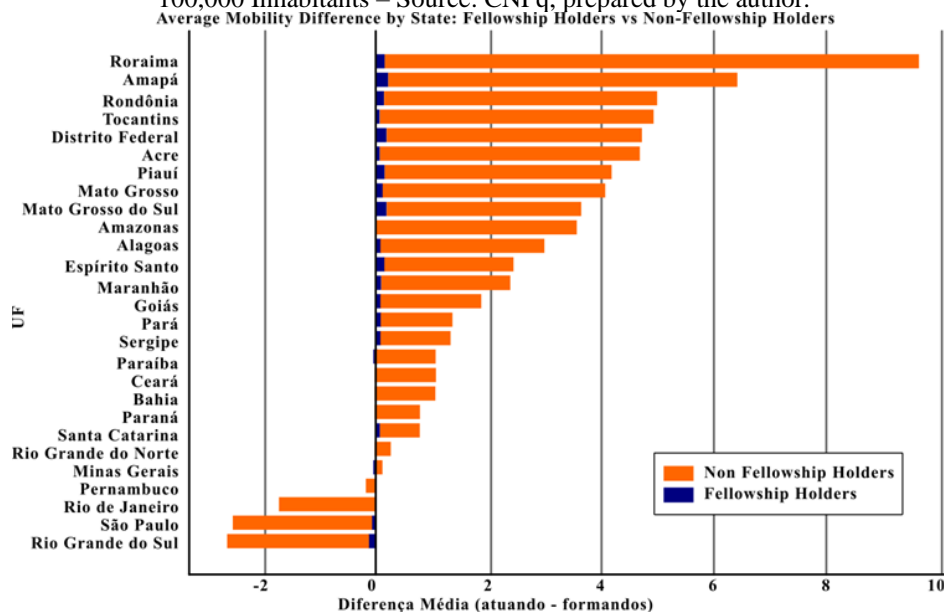
working researchers by state were calculated. The visualization in Figure 2 shows the trajectories of the average mobility of researchers by state from 2018 to 2023. Each line represents a state and how the difference between educated and working researchers per 100,000 inhabitants varied over time.

**Table no 1 and Figures no 1 and 2 Overview:** The provided graphs and table illustrate the mobility of researchers between fellowship holders and non-fellowship holders across different states in Brazil, from 2018 to 2023, per 100,000 inhabitants. The table shows annual variations in mobility between these two groups, highlighting significant differences, such as the high mobility rate in Roraima for non-fellowship holders. The first bar graph represents these average mobility differences by state, with Roraima showing a notable disparity between fellowship holders and non-fellowship holders. The second line graph details the annual mobility of researchers by state, highlighting trends and variations over the years, with visible fluctuations that may indicate specific patterns or events affecting the mobility of these groups. Together, these data help to understand how fellowships may influence the mobility of researchers within the national territory.

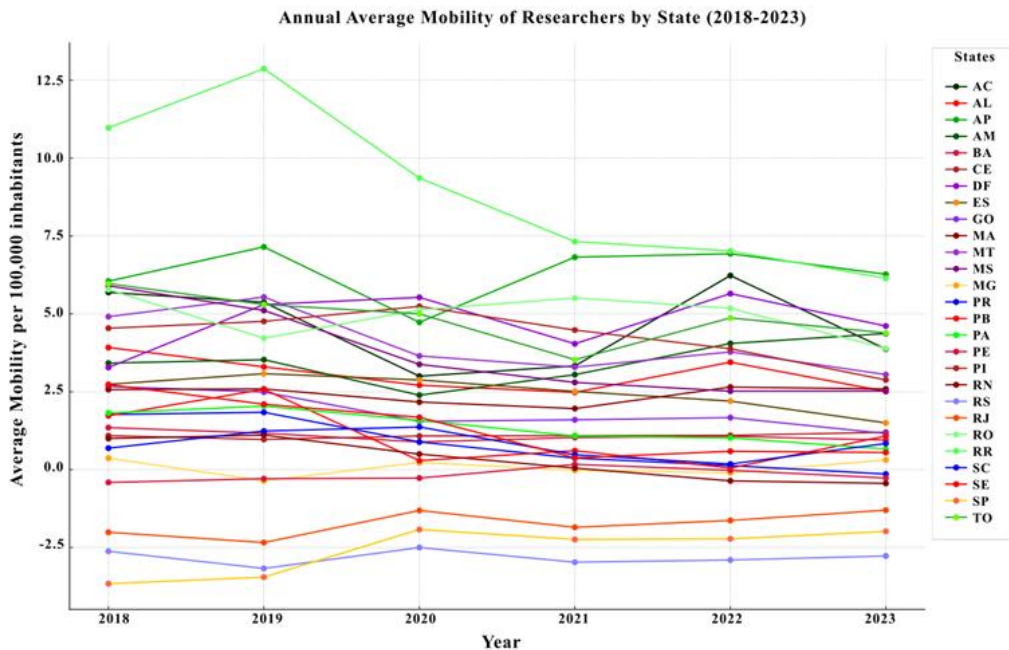
**Table no 1:** Average Mobility Difference by State: Fellowship Holders vs Non-Fellowship Holders (2018 - 2023), per 100,000 Inhabitants

Year	2018		2019		2020		2021		2022		2023	
	Non	Fellowship	Non	Fellowship	Non	Fellowship	Non	Fellowship	Non	Fellowship	Non	Fellowship
Acre	5,98	0,12	5,36	0,11	3,02	0,11	3,42	0	6,31	0	3,87	0
Alagoas	3,91	0,09	3,27	0,09	2,48	0,27	2,5	0	3,49	-0,03	2,51	0
Amapá	6,39	0,24	7,21	0,47	4,76	0,23	7,06	0	6,83	0,22	6,27	0
Amazonas	3,6	0,07	3,79	-0,05	2,5	0	2,97	0,16	4,2	-0,09	4,39	-0,02
Bahia	1,36	0,01	1,14	0,05	0,94	-0,03	0,99	0,05	1,04	0,03	0,9	0,04
Ceará	1,11	0,01	1,04	-0,04	1,14	-0,04	1,08	0,02	1,08	0,03	1,22	-0,02
Distrito Federal	3,23	0,27	5,31	0,27	5,7	0,03	3,98	0,16	5,53	0,19	4,55	0,06
Espírito Santo	2,79	0,1	3,06	0,15	2,83	0,15	2,46	0,1	2,1	0,12	1,45	0,05
Goiás	2,73	0,12	2,56	0,06	1,52	0,1	1,62	0,01	1,62	0,07	1,18	-0,01
Maranhão	2,52	0,13	2,56	0,08	2,15	0,06	1,92	0,06	2,59	0,08	2,59	0
Mato Grosso	5,06	0,15	5,68	0,11	3,66	0,11	3,28	0,08	3,71	0,11	2,99	0,05
Mato Grosso do Sul	5,68	0,55	5,11	0,22	3,38	0,11	2,78	0,07	2,44	0,1	2,52	0
Minas Gerais	0,42	-0,05	-0,28	-0,09	0,25	-0,03	0,04	-0,06	-0,02	-0,08	0,33	-0,02
Pará	1,77	0,13	2,1	0,02	1,59	0,05	1,08	0,01	1,02	0,01	0,64	0,02
Paraíba	1,85	-0,08	2,61	0,02	0,37	-0,07	0,74	-0,12	0,17	-0,12	1,02	0,05
Paraná	1,74	0,1	1,94	-0,05	0,99	-0,09	0,33	0,04	0,11	0,02	-0,11	-0,03
Pernambuco	-0,43	0,01	-0,39	0,09	-0,28	0	0,17	0	-0,05	0,03	-0,27	0
Piauí	4,47	0,12	4,64	0,15	5,03	0,24	4,38	0,12	3,85	0,03	2,85	0,03
Rio de Janeiro	-2,03	-0,03	-2,37	-0,02	-1,36	0,03	-1,9	0,03	-1,58	-0,06	-1,29	-0,02
Rio Grande do Norte	0,95	0,09	1	0,14	0,42	0,08	0,06	0	-0,28	-0,08	-0,3	-0,14
Rio Grande do Sul	-2,52	-0,15	-3,07	-0,15	-2,37	-0,16	-2,87	-0,12	-2,75	-0,17	-2,7	-0,07
Roraima	13,01	0	14,03	0,5	9,98	0,16	7,66	0	7,16	0	6,14	0
Santa Catarina	0,76	-0,03	1,12	0,18	1,31	0,11	0,57	-0,08	0,13	0,05	0,83	0,01
São Paulo	-3,67	-0,13	-3,49	-0,07	-1,96	0	-2,21	-0,07	-2,22	-0,02	-1,97	0
Sergipe	2,46	0,4	2,09	0,09	1,85	-0,13	0,47	-0,09	0,51	0,08	0,55	0
Tocantins	6,24	0,06	5,53	0	5,03	0,13	3,61	0	4,86	0,06	4,27	0,12

**Figure no 1:** Average Mobility Difference by State: Fellowship Holders vs Non-Fellowship Holders, per 100,000 Inhabitants – Source: CNPq, prepared by the author.



**Figure 2:** Annual Average Mobility of Researchers by State (2018-2023), per 100,000 Inhabitants - Source: CNPq, prepared by the author



The results for the second question reveal significant retention of doctoral researchers in the North, Northeast, and Midwest regions, with notable differences in mobility patterns. The South and Southeast exhibited a net outflow of researchers, suggesting these regions, despite their educational capacities, do not retain as many researchers as they educate. In contrast, the North and Midwest demonstrated a net inflow, indicating their effectiveness in attracting researchers.

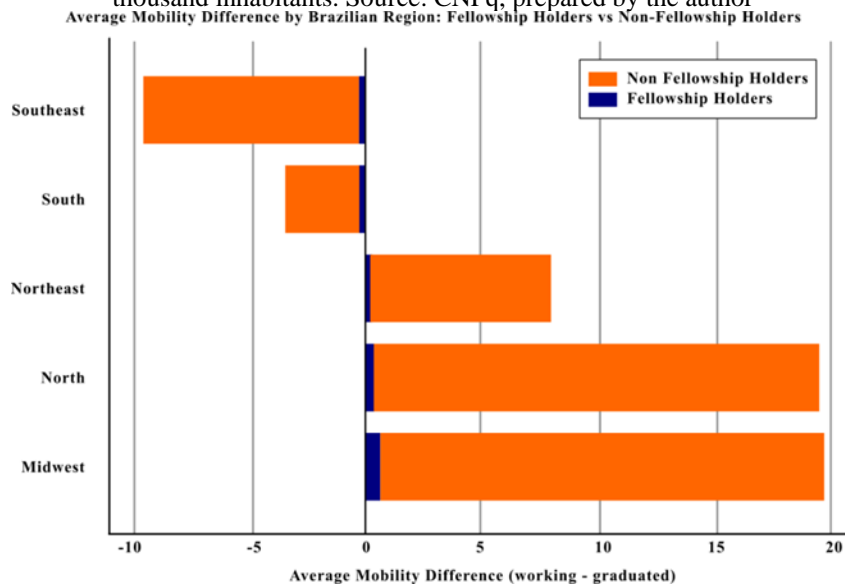
Detailed regression analyses further substantiate these patterns, showing a statistically significant higher retention in the regions of national interest for both fellowship and non-fellowship holders. Specifically, fellowship holders in these regions had a positive retention coefficient (0.1015) with a significant p-value ( $p < 0.001$ ), while non-fellowship holders exhibited even greater retention, indicated by a coefficient of 3.5784 with a p-value ( $p < 0.001$ ). The absence of heteroscedasticity ( $p = 0.1560$ ) in these models confirms the reliability of the regression results, supporting the robustness of the findings.

Consequently, the null hypothesis is rejected, affirming that regions of national interest—North, Northeast, and Midwest—demonstrate a higher capacity to retain doctoral researchers compared to other regions. This conclusion underscores the need for targeted policy interventions to enhance researcher retention in these strategic areas, potentially influencing future educational and research development policies.

The longitudinal analysis of researcher retention across Brazilian regions highlights significant regional disparities. The Midwest, Northeast, and North consistently demonstrate positive retention rates from 2018 to 2023, suggesting these areas not only retain their locally educated researchers but also attract those from other regions. This trend may be attributed to effective local policies, emerging research opportunities, or more supportive academic environments that resonate with the needs and interests of doctoral graduates. In contrast, the Southeast shows a persistent negative retention rate, indicating a continuous loss of talent to other regions or countries. This could reflect factors such as saturation in job markets, higher living costs, or perhaps less competitive research incentives compared to other regions. The South shows relatively stable but low mobility, indicating neither significant loss nor gain of researchers, which might suggest a balanced but static academic environment. These patterns underline the importance of tailored regional strategies to enhance not only the retention but also the attractiveness of regions as hubs for academic and research excellence.

**Table no 2 and Figures no 3 and 4 Overview:** The line graph and table summarize the annual average mobility of researchers in five Brazilian regions from 2018 to 2023. The Midwest region exhibited the highest mobility, peaking in 2020 before a slight decline, while the Northeast maintained consistent mobility levels around 1.5 minutes. The North region showed a notable decline from near Midwest levels to much lower by 2023. In contrast, the Southeast consistently reported negative mobility, suggesting a net outflow of researchers or decreased internal movement. Meanwhile, the South region displayed a gradual increase, although it remained the lowest among the regions. This data highlights significant regional disparities in researcher mobility, offering valuable insights for policy and academic considerations.

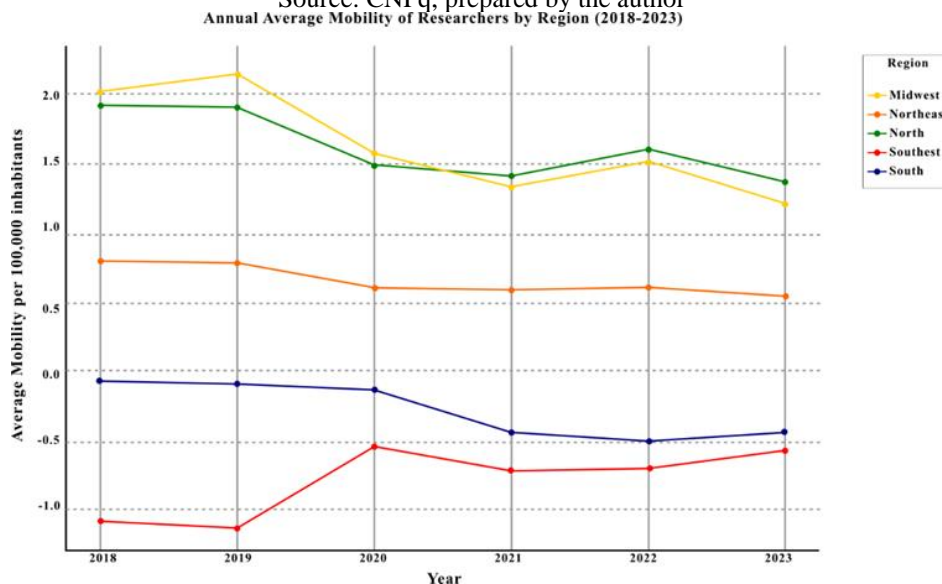
**Figure no 3:** Total difference in Mobility by Region: Scholarship holders vs Non-scholarship holders, per 100 thousand inhabitants. Source: CNPq, prepared by the author



**Table no 2:** Average Annual Mobility of Researchers by Region (2018 – 2023), per 100.000 inhabitants

Year	Midwest	Northeast	North	Southeast	South
2018	1.6	1.5	1.4	-0.5	0.0
2019	1.8	1.5	1.3	-0.75	0.1
2020	2.0	1.5	1.2	-0.75	0.15
2021	1.9	1.5	1.1	-0.75	0.2
2022	1.8	1.5	0.8	-0.75	0.2
2023	1.8	1.5	0.5	-0.75	0.25

**Figure no 4:** Average Annual Mobility of Researchers by Region (2018-2023), per 100,000 inhabitants - Source: CNPq, prepared by the author



In Brazil, the mobility and retention of researchers exhibit pronounced intraregional variations, reflecting a complex tapestry of factors that influence academic and professional movements within the same region. For instance, while some states in the Northern region like Roraima experience high rates of researcher influx, others may not see the same level of attraction. This indicates that even within a single geographical and administrative boundary, there are significant differences in how states manage to retain and attract talent. Such intraregional dynamics suggest that local policies, academic opportunities, and research facilities vary widely, impacting the distribution and retention of researchers. These variations are crucial for understanding the mobility patterns that can lead to more targeted and effective regional development strategies.



The presence of intraregional variability in researcher mobility and retention necessitates a nuanced approach to policy-making. It challenges regional authorities to consider not just broad regional strategies but also localized interventions that address specific state-level needs and opportunities. By acknowledging the distinct characteristics of each state, policymakers can craft more precise and effective measures that cater to the unique contexts of researcher mobility. This approach ensures that strategies are not only tailored to the broad needs of a region but are also adaptable to the specific conditions of each state within that region, potentially leading to a more balanced and equitable development across the entire area.

**Table no 3:** Number of doctoral researchers trained from 2018 to 2023 and their characteristics of education, practice, and scholarship. Source: CNPq, prepared by the author.

Educated In Brazil?	Works In Brazil?	Post-Doctoral Fellowship?	Number Of Researchers
0	0	0	1927
0	0	1	39
0	1	0	5054
0	1	1	151
1	0	0	2556
1	0	1	151
1	1	0	96085
1	1	1	3342

For the third question, the utilization of multiple regression analysis to explore the impact of government incentives on researcher retention has yielded significant insights. The positive and significant influence of CNPq postdoctoral fellowships on retaining researchers in the North, Northeast, and Midwest is evidenced by a coefficient of 0.1015 with a p-value of 0.000. This statistical result underscores the effectiveness of fellowships in enhancing researcher retention in these key regions, affirming the role of governmental support in nurturing scientific and academic growth.

Interestingly, the retention of non-fellowship holders, indicated by a much higher coefficient of 3.5784, suggests that other factors may be at play in enhancing retention more robustly among researchers without fellowships. This finding prompts a deeper examination of the regional attributes or other support mechanisms that might be contributing to this enhanced retention. It indicates that while fellowships do have a positive impact, the stronger retention of non-fellowship holders could be influenced by aspects such as local economic conditions, institutional support, or community engagement, which warrant further investigation.

The data presented in Table no 3 from CNPq offers a detailed view of the distribution of researchers according to their educational and professional status, as well as their fellowship reception. With entries ranging from researchers educated and working in Brazil, with or without fellowships, to those neither educated nor working in Brazil, the table provides a comprehensive snapshot of the academic and professional landscape for researchers. This detailed dataset is crucial for understanding not only mobility but also the broader impacts of scholarship programs and other incentives on the academic and professional trajectories of doctoral graduates in Brazil.

Regarding the fourth question, whether CNPq postdoctoral fellowships contribute to the retention of doctoral researchers in Brazil, the positive coefficient of 2.634 for researchers educated in Brazil highlights a strong correlation between local education and retention within the country. This suggests that those who are educated in Brazil are significantly more likely to continue working there, implying a robust local academic environment or stronger professional ties that encourage retention.

Conversely, the negative coefficient of -0.324 for postdoctoral fellowship holders indicates that receiving a fellowship is associated with a lower probability of these researchers working in Brazil long-term. This unexpected result suggests that fellowships, while beneficial in many respects, might encourage or require periods of research abroad or could be structured in ways that do not support long-term career development within the country.

The high significance of these coefficients (p-values below 0.001) underscores the reliability of these findings, ruling out random variations as the cause. Although the Pseudo R<sup>2</sup> value of 0.1347 indicates that the model explains about 13.47% of the variance, this still offers valuable insights into the factors influencing researcher retention.

These results challenge the assumption that fellowships unilaterally improve researcher retention within Brazil and suggest a need for policy adjustments. The negative impact of fellowships on long-term retention may call for a reevaluation of the conditions associated with these grants. It is crucial for policy makers to consider modifications that could make fellowships more conducive to sustaining the domestic scientific workforce.

The findings point to the necessity of revisiting the structure and expectations of CNPq postdoctoral fellowships to better align them with the goals of national talent retention and development. Enhancing support



structures and considering the long-term career paths of fellowship recipients might improve the effectiveness of these programs in retaining top-tier scientific talent within Brazil.

#### **IV. Discussion**

##### **University-Industry Collaboration and Intra-regional Mobility**

University-industry collaboration has been identified as a crucial driver of innovation, especially in emerging industries [21], [22]. Freitas et al. (2013)[23] highlight that in Brazil, students and company employees play mediating roles between public research organizations and the private sector, facilitating knowledge transfer. However, the impacts of this collaboration are often localized, with Schaeffer et al. (2018)[24] arguing that universities significantly contribute to innovation in local ecosystems, but with effects primarily limited to city levels.

The results of the present study indicate that states such as Roraima and Tocantins exhibit significant influxes of researchers, while other states in the same region do not share this pattern. This intra-regional variability, as noted by Fischer et al. (2020)[8], may be related to the ability of local universities to effectively integrate into innovation ecosystems and connect their outputs to the market. Such differences reinforce the need for policies that address state-specific characteristics, recognizing local disparities as opportunities for targeted interventions.

##### **The Role of Human Capital and the Impact of Fellowships**

The development and retention of human capital are central to scientific and technological advancement[25], [26]. The study revealed that CNPq postdoctoral fellowships positively impact researcher retention, especially in the regions of national interest. Garcia et al. (2012)[27] point out that investing in people and promoting international mobility has been an effective strategy in Latin America to enhance scientific qualifications. However, the negative coefficient for fellowship holders regarding long-term retention suggests a gap in the fellowship structure, potentially linked to associated conditions, such as incentives for international research.

Furtado et al. (2015)[16] emphasize that while most Brazilian PhDs graduate from national institutions, many seek postdoctoral opportunities abroad, highlighting a pursuit of international cooperation. International collaboration, as suggested by McManus et al. (2020)[28], increases the impact of Brazilian research but may weaken researchers' connection to the country.

##### **International Mobility and Scientific Cooperation**

International researcher mobility is often associated with advancements in productivity and academic impact. Petersen (2018)[29] observes that mobile researchers tend to publish more and achieve higher citation rates. Furthermore, mobility facilitates the exchange of tacit and codified knowledge, fostering cosmopolitan identities and diversified scientific practices [30].

Conversely, Bouwel et al. (2014)[31] argue that international mobility does not necessarily guarantee benefits for the countries of origin, especially in the absence of policies to repatriate talent. Garcia et al. (2012)[27] cite Argentina's strategy of recruiting researchers working abroad, contrasting with Brazil's approach, where talent retention seems to rely more on institutional factors and local incentives.

##### **Regional Disparities and Retention Policies**

The results highlighted significant disparities in retention between regions. While the Southeast and South face challenges in retaining talent, the North, Northeast, and Midwest demonstrate higher retention rates, aligning with the objectives of incentive policies. Fischer et al. (2020)[8] emphasize that retention capacity is linked to local infrastructure and institutional support.

The retention capacity is linked to local infrastructure, institutional support, economic opportunities, and community support, playing critical roles[7], [31], [32]. It emphasizes that continuous training and education can enhance innovative capacity, a point that can be explored to further strengthen regional retention.

##### **The Challenge of National Mobility**

Furtado et al. (2015)[16] suggest that Brazilian researchers tend to seek employment near the institutions where they earned their degrees, indicating low internal mobility. However, the findings of this study demonstrate that states with higher attraction rates, such as those in the North, show evidence of positive mobility. This reflects the impact of local policies and regional incentives that create attractive conditions for researchers.

Conversely, limited mobility in states like São Paulo and Rio de Janeiro may be attributed to saturated job markets and high living costs[16], [29], [31]. These conditions necessitate a review of strategies to promote balanced retention and mobility.

## V. Conclusion

The results of this study suggest that, despite investments in postdoctoral fellowships by CNPq, the impact of such scholarships on the retention of researchers in Brazil may not be as consistent as anticipated. It is possible that researchers awarded CNPq scholarships possess skills, expertise, or qualities that make them particularly attractive to prestigious organizations both in Brazil and abroad. This could potentially benefit the researchers' personal careers while inadvertently contributing to their mobility.

The recognition of their qualifications through a CNPq fellowship might enhance their visibility and desirability to international research institutions, universities, and private enterprises. These entities could offer more competitive conditions, such as higher salaries, advanced research facilities, or broader professional growth opportunities, which might encourage these researchers to pursue careers outside their home country or within elite institutions domestically.

While there appears to be some contribution to the retention of researchers in certain Brazilian regions, particularly in the North, Northeast, and Central-West, these findings may indicate that current public policies and the resources allocated are not entirely sufficient or effectively aligned to achieve the goal of retaining researchers in areas of national interest.

Moreover, this study does not explore in detail other factors that could influence the analysis, such as the non-completion or incorrect updating of the Lattes Curriculum[17], which might affect the accuracy of these observations. Additionally, some researchers may remain in Brazil but engage in paid activities that do not necessitate updating the Lattes Curriculum[17], potentially limiting the reliability of the conclusions drawn here.

In this context, it could be worth considering whether CNPq policies should allow or even encourage scholarship holders to undertake internships or concurrent employment during the scholarship period. Such measures might help strengthen the acquisition of more permanent ties in Brazil, ensuring that researchers maintain strong connections to the domestic academic and professional landscape while they are still in the country.

## References

- [1] A. Abdal, "Trajetórias Regionais De Desenvolvimento No Brasil Contemporâneo: Uma Agenda De Pesquisa", Rbeur, Fev. 2020, Doi: 10.22296/2317-1529.Rbeur.202005.
- [2] R. C. D. S. G. Caldas E K. C. De Moraes, "Políticas Públicas Municipais De Fomento Ao Setor De Inovação E Tecnologia De São Bernardo Do Campo - Sp", Rjdsj, Vol. 8, Nº 11, Set. 2021, Doi: 10.61389/Rjdsj.V8i11.2928.
- [3] C. C. Brasil, Lei Nº 1.310, De 15 De Janeiro De 1951. 1951. Acesso Em: 21 De Novembro De 2024. [Online]. Disponível Em: [Http://Www.Planalto.Gov.Br/Ccivil\\_03/Leis/1950-1969/L1310.Htm](http://www.planalto.gov.br/ccivil_03/Leis/1950-1969/L1310.htm)
- [4] C. C. Brasil, Decreto Nº 29.741, De 11 De Julho De 1951. 1951. Acesso Em: 21 De Novembro De 2024. [Online]. Disponível Em: [Https://Www2.Camara.Leg.Br/Legin/Fed/Decret/1950-1959/Decreto-29741-11-Julho-1951-336144-Publicacaooriginal-1-Pe.Html](https://www2.camara.leg.br/legin/fed/decret/1950-1959/decreto-29741-11-julho-1951-336144-publicacaooriginal-1-pe.html)
- [5] C. C. Brasil, Decreto-Lei Nº 719, De 31 De Julho De 1969. 1969. Acesso Em: 21 De Novembro De 2024. [Online]. Disponível Em: [Https://Www.Planalto.Gov.Br/Ccivil\\_03/Decreto-Lei/Del0719.Htm](https://www.planalto.gov.br/ccivil_03/Decreto-Lei/Del0719.htm)
- [6] C. C. Brasil, Decreto Nº 61.056, De 24 De Julho De 1967. 1967. Acesso Em: 24 De Novembro De 2024. [Online]. Disponível Em: [Https://Www.Planalto.Gov.Br/Ccivil\\_03/Decreto/1950-1969/D61056.Htm](https://www.planalto.gov.br/ccivil_03/Decreto/1950-1969/D61056.htm)
- [7] L. R. Ferreira E J. G. De Araújo, "Papel Do Cnpq No Fomento À Pesquisa Em Educação: Análise Sobre O Perfil Do Bolsista Produtividade Em Pesquisa (Role Of The Cnpq In The Promotion Of Research In Education: Analysis Of The Profile Of The Bulletin Productivity In Research)", Revista Eletrônica De Educação, Vol. 13, Nº 3, Art. Nº 3, Set. 2019, Doi: 10.14244/198271993553.
- [8] B. B. Fischer, P. R. Schaeffer, N. S. Vonortas, E. S. Queiroz, "Quality Comes First: University-Industry Collaboration As A Source Of Academic Entrepreneurship In A Developing Country", J Technol Transf, Vol. 43, Nº 2, P. 263–284, Abr. 2018, Doi: 10.1007/S10961-017-9568-X.
- [9] N. Lazzareschi, "Conhecimento, Informação E Inovação: Condições Para A Promoção Do Desenvolvimento Nacional", Impulso, Vol. 25, P. 7–17, Ago. 2015, Doi: 10.15600/2236-9767/Impulso.V25n63p7-17.
- [10] S. C. D. Benedicto, C. R. Sugahara, E. R. De Lames, E C. F. S. Filho, "Challenges And Strategies In Large Companies To Attract And Return Human Capital", Nº 4, 2018.
- [11] Cnp. Brasil, "Lançado Chamamento Para Programa De Apoio À Fixação De Jovens Doutores No Brasil", Conselho Nacional De Desenvolvimento Científico E Tecnológico. Acesso Em: 22 De Novembro De 2024. [Online]. Disponível Em: [Https://Www.Gov.Br/Cnpq/Pt-Br/Assuntos/Noticias/Cnpq-Em-Acao/Lançado-Chamamento-Para-Programa-De-Apoio-A-Fixacao-De-Jovens-Doutores-No-Brasil](https://www.gov.br/cnpq/pt-br/assuntos/noticias/cnpq-em-acao/lançado-chamamento-para-programa-de-apoio-a-fixação-de-jovens-doutores-no-brasil)
- [12] F. Brasil, "Fapesp E Cnpq Lançam Nova Chamada Para Fixação De Jovens Doutores", Agência Fapesp. Acesso Em: 22 De Novembro De 2024. [Online]. Disponível Em: [Https://Agencia.Fapesp.Br/Fapesp-E-Cnpq-Lancam-Nova-Chamada-Para-Fixacao-De-Jovens-Doutores/50506](https://agencia.fapesp.br/fapesp-e-cnpq-lancam-nova-chamada-para-fixacao-de-jovens-doutores/50506)
- [13] Cnp. Brasil, Portaria Cnpq Nº 1.708, De 9 De Abril De 2024. 2024. Acesso Em: 22 De Novembro De 2024. [Online]. Disponível Em: [Http://Memoria2.Cnpq.Br/Web/Guest/View-/Journal\\_Content/56\\_Instance\\_0oed/10157/21594631](http://memoria2.cnpq.br/Web/Guest/View-/Journal_Content/56_Instance_0oed/10157/21594631)
- [14] Cnp. Brasil, "Painel Lattes", Conselho Nacional De Desenvolvimento Científico E Tecnológico. Acesso Em: 24 De Novembro De 2024. [Online]. Disponível Em: [Https://Www.Gov.Br/Cnpq/Pt-Br/Acesso-A-Informacao/Dados-Abertos/Paineis-De-Dados/Painel-Lattes](https://www.gov.br/cnpq/pt-br/acesso-a-informacao/dados-abertos/paineis-de-dados/painel-lattes)
- [15] Cnp. Brasil, "Painel De Fomento Em Ciência, Tecnologia E Inovação", Conselho Nacional De Desenvolvimento Científico E Tecnológico. Acesso Em: 24 De Novembro De 2024. [Online]. Disponível Em: [Https://Www.Gov.Br/Cnpq/Pt-Br/Acesso-A-Informacao/Dados-Abertos/Paineis-De-Dados/Painel-De-Fomento-Em-Ciencia-Tecnologia-E-Inovacao](https://www.gov.br/cnpq/pt-br/acesso-a-informacao/dados-abertos/paineis-de-dados/painel-de-fomento-em-ciencia-tecnologia-e-inovacao)
- [16] C. A. Furtado, C. A. Davis, M. A. Gonçalves, E J. M. De Almeida, "A Spatiotemporal Analysis Of Brazilian Science From The Perspective Of Researchers' Career Trajectories", Plos One, Vol. 10, Nº 10, P. E0141528, Out. 2015, Doi: 10.1371/Journal.Pone.0141528.
- [17] Cnp. Brasil, "Plataforma Lattes". Acesso Em: 24 De Novembro De 2024. [Online]. Disponível Em: [Https://Www.Lattes.Cnpq.Br/](https://www.lattes.cnpq.br/)

- [18] A. Rodríguez-Navarro E R. Brito, “Research Assessment Based On The Number Of Top Researchers”, *J Scientometric Res.*, Vol. 11, N° 3, P. 286–294, Jan. 2023, Doi: 10.5530/Jscires.11.3.32.
- [19] L. L. Moreira, M. M. De Brito, E M. Kobiyama, “Effects Of Different Normalization, Aggregation, And Classification Methods On The Construction Of Flood Vulnerability Indexes”, *Water*, Vol. 13, N° 1, P. 98, Jan. 2021, Doi: 10.3390/W13010098.
- [20] I. Brasil, “Cidades@ | Brasil | Panorama”. Acesso Em: 25 De Novembro De 2024. [Online]. Disponível Em: <https://Cidades.Ibge.Gov.Br/Brasil/Panorama>
- [21] S. Ankrah E O. Al-Tabbaa, “Universities–Industry Collaboration: A Systematic Review”, *Scandinavian Journal Of Management*, Vol. 31, N° 3, P. 387–408, Set. 2015, Doi: 10.1016/J.Scaman.2015.02.003.
- [22] T. Schofield, “Critical Success Factors For Knowledge Transfer Collaborations Between University And Industry”, *Journal Of Research Administration*, Vol. 44, N° 2, P. 38–56, 2013.
- [23] I. M. Bodas Freitas, R. A. Marques, E E. M. D. P. E. Silva, “University–Industry Collaboration And Innovation In Emergent And Mature Industries In New Industrialized Countries”, *Research Policy*, Vol. 42, N° 2, P. 443–453, Mar. 2013, Doi: 10.1016/J.Respol.2012.06.006.
- [24] P. Schaeffer, B. Fischer, E S. Queiroz, “Beyond Education: The Role Of Research Universities In Innovation Ecosystems”, *Foresight And Sti Governance*, Vol. 12, N° 2, Art. N° 2, Mar. 2018, Doi: 10.17323/2500-2597.2018.2.50.61.
- [25] V. G. R. Chandran, C. S. Hayter, E D. R. Strong, “Personal Strategic Alliances: Enhancing The Scientific And Technological Contributions Of University Faculty In Malaysia”, *Economics Of Innovation And New Technology*, Vol. 24, N° 5, P. 421–435, Jul. 2015, Doi: 10.1080/10438599.2014.988501.
- [26] S. A. Azizan, “Strengthening Malaysia’s Scientific And Technological Development Through Human Capital Development”, *Procedia - Social And Behavioral Sciences*, Vol. 91, P. 648–653, Out. 2013, Doi: 10.1016/J.Sbspro.2013.08.465.
- [27] C. R. S. Garcia, A. J. Parodi, E G. Oliva, “Growing Latin American Science”, *Science*, Vol. 338, N° 6111, P. 1127–1127, Nov. 2012, Doi: 10.1126/Science.1232223.
- [28] C. Mcmanus, A. A. Baeta Neves, A. Q. Maranhão, A. G. Souza Filho, E J. M. Santana, “International Collaboration In Brazilian Science: Financing And Impact”, *Scientometrics*, Vol. 125, N° 3, P. 2745–2772, Dez. 2020, Doi: 10.1007/S11192-020-03728-7.
- [29] A. M. Petersen, “Multiscale Impact Of Researcher Mobility”, *Journal Of The Royal Society Interface*, Vol. 15, N° 146, P. 20180580, Set. 2018, Doi: 10.1098/Rsif.2018.0580.
- [30] C. Coey, “International Researcher Mobility And Knowledge Transfer In The Social Sciences And Humanities”, *Globalisation, Societies And Education*, Vol. 16, N° 2, P. 208–223, Mar. 2018, Doi: 10.1080/14767724.2017.1401918.
- [31] L. V. Bouwel, K. Leuven, R. Veugelers, E K. Leuven, “The Effects Of International Mobility On European Researchers: Comparing Intra-Eu And U.S. Mobility”.
- [32] S. F. Way, A. C. Morgan, D. B. Larremore, E A. Clauset, “Productivity, Prominence, And The Effects Of Academic Environment”, *Proc. Natl. Acad. Sci. U.S.A.*, Vol. 116, N° 22, P. 10729–10733, Maio 2019, Doi: 10.1073/Pnas.1817431116.