Funding of basic science in Mexico: the role of gender and research experience on success

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ABSTRACT

Whether women researchers find themselves at a disadvantage in comparison to men researchers in obtaining research funding, is a contentious matter. The Mexican National Council of Science and Technology supports basic science research projects. Mexico has a National System of Researchers (SNI), which, by peer review, assigns researchers to four different categories according to their productivity. In this study, data from 16,308 basic science research proposals submitted between 2009 and 2015 were analyzed looking for possible gender bias. The results showed that success rates were strongly associated to the applicant’s SNI level. A logistic regression analysis indicated that the odds ratio for SNI level was 1.91, while neither gender nor scientific discipline had an influence on the odds for success. The results show that for basic science grants in Mexico, gender does not play a role in the assignment of funds. However, it was also found that women applicants are underrepresented at the highest levels of the SNI, which had the highest odds of success, constituting a possible indirect gender bias in the funding of basic science in Mexico.

KEYWORDS

Research funding; Mexico; basic science; gender; research evaluation

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significativa. Concluímos que, para outorgar apoios para ciência básica no México não existe preconceito por gênero. Entretanto, também se encontrou que as pesquisadoras solicitantes estão pouco representadas nos níveis mais alto do SNI, que são os que têm maiores possibilidades de êxito, já que isto poderia se considerar um preconceito indireto por gênero no México para a obtenção de recursos para a pesquisa básica.

**Financiamiento de Ciencia Báscica en México. El papel del género y de la experiencia en la obtención de éxito**

**RESUMEN**

Si las investigadoras están en desventaja en relación a los investigadores para obtener fondos para investigación es un asunto bajo discusión. El CONACYT de México apoya proyectos de investigación científica básica. México tiene un Sistema Nacional de Investigadores (SNI) el cual, mediante evaluación por pares y de acuerdo a su productividad, asigna a los investigadores a cuatro diferentes categorías. En este estudio se analizaron 16,308 propuestas de investigación científica básica enviadas entre 2009 y 2015 buscando posibles evidencias de discriminación por género. Los resultados muestran que la frecuencia de éxito está fuertemente asociada al nivel del SNI del proponente. Un análisis de regresión logística indicó que la proporción de posibilidades de éxito ("odds ratio") por nivel del SNI fue de 1.91, mientras que ni el género ni la disciplina científica tuvieron influencia significativa. Concluímos que, para el otorgamiento de apoios para ciencia básica en México no hay discriminación por género. Sin embargo, también se encontró que las investigadoras solicitantes están poco representadas en los niveles más altos del SNI, que son los que tienen mayores posibilidades de éxito, esto podría considerarse una discriminación indirecta por género en México para la obtención de recursos para investigación básica.

1. **Introduction**

Currently, there is interest in determining whether gender is a factor that influences decisions that affect the development of a woman’s scientific career. Several studies have been published suggesting that this seems to be the case. Women reach fewer academic leadership positions than men and are paid lower salaries (Niemier and González 2004; Valian 2004; Ley and Hamilton 2008). They are invited less frequently as speakers at important meetings related to their research (Klein et al. 2017) and junior faculty women receive less start-up support from their institutions than junior faculty men (Sege, Nykiel-Bub, and Selk 2015). In Latin America, as in the whole world, in most of the countries the proportion of women scientists is significantly lower than the proportion of men scientists (UNESCO 2018). The situation of women scientists in Mexico has been the subject of several studies. In general, they are underrepresented in the scientific system. Thirty-six percent of researchers in the Mexican public research centers system and only 23% of members of the Mexican Academy of Sciences are women (Evangelista García, Tinoco Ojanguren, and Tuñón Pablos 2012; Mendieta-Ramírez 2015). Mexico has a
National System of Researchers (SNI, for the initials in Spanish) and in this system, again, only around 32% of members are women (Didou and Etienne 2009; Evangelista García, Tinoco Ojanguren, and Tuñón Pablos 2012; Pérez Armendáriz and Ruíz Azuara 2012; Cárdenas Tapia 2015). In Mexico, women scientists also face an inequity situation in promotion. In the public research centers system, women are overrepresented in the lower research category (83%) while they are only 37% in the top research category (Evangelista García, Tinoco Ojanguren, and Tuñón Pablos 2012). In the Universidad Nacional Autónoma de México (UNAM), 43% of the academics are women but in the top researcher category they only represent 27% (Bustos Romero 2012). The Mexican SNI has different category levels and only around 20% of the top level category (SNI level 3), are women (Didou and Etienne 2009; Bustos Romero 2012; Evangelista García, Tinoco Ojanguren, and Tuñón Pablos 2012; Pérez Armendáriz and Ruíz Azuara 2012; Cárdenas Tapia 2015).

Obtaining research grants is of particular importance for the development of a successful scientific career. Research grants are mostly assigned after a peer review process, which is considered essential to select the best proposals. Nevertheless, human judgement is susceptible to bias (Thorngate, Dawes, and Foddy 2009) and bias by race, age, social class, or gender could be present in the peer review process. Gender bias is one of the most contentious and has been the subject of numerous studies (e.g. Bornmann, Mutz, and Daniel 2007 or Marsh et al. 2009). Some studies have shown that women are at disadvantage in review processes for performance, promotion or reception of awards, as reviewers tend to set higher competence standards for women than for men with similar levels of performance or professional development (Foschi 1996; Biernat and Kobrynowics 1997; Heilman and Haynes 2005). A conscious or unconscious bias could be caused by cultural stereotypes that assume that women are less competent than men in the field of science (Wenneras and Wold 1997; Kaatz, Gutierrez, and Carnes 2014). These situations could cause women to be less likely than men to obtain research grants, in which case they will be at disadvantage to increase their scientific and academic productivity and so, to be promoted. Some studies have shown that, in fact, women scientists are discriminated in some way and are less successful in obtaining research and other types of grants (Bornmann, Mutz, and Daniel 2007; Bedi, Van Dam, and Munafò 2012; Moss-Racusin et al. 2012; Head et al. 2013; Shen 2013; Van der Lee and Ellemers 2015; Tamblyn et al. 2016). In other studies, though, no bias against women has been detected (Waisbren et al. 2008; Marsh et al. 2009; Pohlhaus et al. 2011; Mutz, Bornmann, and Daniel 2012; Volker and Steenbeek 2015; Beck and Halloin 2017). There are no studies that try to explain this lack of agreement. One possibility is that more experienced and productive researchers may be more successful in obtaining a research grant than less experienced and less productive ones. In several of the studies on gender bias this point is not addressed, as all applicants for grants are considered in the same way (Mutz, Bornmann, and Daniel 2012; Head et al. 2013; Beck and Halloin 2017). If this assumption is true and the proportion of women is lower within the more experienced and productive researchers, this could result in an overall lower success rate not due to the evaluation process, but to an indirect gender bias caused by inequities in the opportunities for career development. In fact, several studies have indicated that women have less opportunities for career development when compared to men (Seachrist 1994; Moss-Racusin et al. 2012; Shen 2013; Sege, Nykiel-Bub, and Selk 2015).

In some studies, the level of research experience is considered in different ways. Tamblyn et al. (2016) considered young researchers as those below 45 years of age and
analyzed them separately from researchers that are 45 years old and older; Svider et al. (2014) considered publication experience and h-index of the proponents and Waisbren et al. (2008) used academic rank (assistant, associated, or full professor). Although these considerations might help take into account the variables of research experience or stage of career development, there is no clear information on their effectiveness.

The already mentioned Mexican SNI system was created in 1984 by the government and is managed by the National Council of Science and Technology (CONACYT). Researchers voluntarily apply to the SNI and their scientific productivity, impact and national and international recognition are evaluated by one of seven different panels which are made up of researchers of the SNI of the highest ranking. Upon being accepted, the applicant is assigned a category: those researchers that are starting their careers are appointed as candidates (which will be referred to as SNI-C candidate level) and researchers that are considered as established are appointed as national researchers with three levels (1, 2, and 3), three being the top category (referred to as SNI level 1, SNI level 2, and SNI level 3).

The reviewing panels are composed of SNI level 3 researchers and are grouped according to expertise in one of the following panels: (1) physics, mathematics and earth sciences, (2) biology and chemistry, (3) medicine and health sciences, (4) humanities and behavioral sciences, (5) social sciences, (6) biotechnology, agricultural and livestock sciences, and (7) engineering. Each panel establishes the specific requirements of scientific productivity, impact and recognition for each SNI level. They consider the number of scientific papers and books published as well as their impact, the importance of the journals or editorials where they are published and the times they have been cited. The number of Master’s and PhD theses that have been supervised and the recognition and leadership of the candidate in their field is taken into account, which is judged by their participation in editorial boards of prestigious journals or editorials, invitations to give plenary lectures in international meetings and the establishment or development of new research groups in the country.

The SNI appointment is usually for three, four, or five years, after which the researcher must apply for renewal. The result of the renewal application can be another appointment in the same SNI level or promotion to a higher level. If the productivity falls below the standards for the SNI level of the applicant, he/she can be either appointed to a lower level (for SNI level 2 or 3) or can lose his/her appointment as an SNI member.

One of the primary objectives in establishing the SNI was to stop, reduce or prevent the scientific brain drain from the country, as the appointment comes with a monthly stipend in addition to whatever salary is received from the researcher’s institution. After more than three decades of operation, it has also become a way to assess, by peer review, the scientific and career development of scientists working in Mexico. Due to the impact that the SNI has had in the development of science in Mexico, it has been taken as a model to create similar systems in other Latin American countries. That is the case for Colombia, Uruguay, Paraguay and Venezuela (Didou and Etienne 2009; Contreras Gómez et al. 2015).

CONACYT funds basic research projects, currently through a trust fund that was established by law in 2002 with the Ministry of Education. Each year research proposals are received by CONACYT’s Director of Basic Research who is responsible for receiving the proposals, for their organization, supervision, evaluation, and follow-up.

The allocation of funds for projects is made on the basis of competition and peer review. The trust fund has a governing body who, based on the score and ranking given by the panels (see materials and methods) and the available budget, select the
proposals to be funded. The fund has had an annual budget of between $50 and $70M USD and receives proposals from public and private universities and research centers. Each year between 1500 and 3000 proposals, grouped in 10 scientific disciplines, are received and processed. There are no set priorities for scientific fields or disciplines. The budget is proportionally distributed among all scientific disciplines based on the demands of each discipline, which leads to similar success rates among them.

The fund has had an important impact on the development of basic science in Mexico (Fabila-Castillo 2014) and is very competitive, with a global success rate of 25% for the 2009–2015 period. Although no formal studies have been carried out, it is reasonable to assume that the scientists that are supported by the fund boost their scientific career.

The possibility of gender bias in this fund has not been studied. The peer review classification of the researchers working in Mexico in the four SNI levels made on the basis of scientific productivity, experience and recognition, in principle, offers an unusual opportunity to study the possibility of gender bias in the allocation of basic science grants, reducing one possible confounding variable, the stage of career development. On the other hand, and due to the conflicting reports on the presence or absence of gender bias for the allocation of research funds, it is important to study the situation of the Mexican fund regarding basic science research in order to be able to recommend public policy action to avoid discrimination against women scientists, which might result in an increase in the participation of women in science.

In this study, the 2009–2015 period of basic science research grant proposals made to CONACYT were analyzed regarding SNI level, gender, and success rate. It was found that applicants with higher SNI levels have higher odds of receiving a grant, but there were no significant differences in the success rates of men or women applicants of the same SNI levels. However, the proportion of women applicants decreased significantly in the higher SNI levels, which might imply an indirect gender bias in the process.

2. Materials and methods

2.1. Data collection

The author was the Director of Basic Science in CONACYT from 2010 to 2016 and, with the agreement of CONACYT’s directives at the time, was allowed to use the files of all 16,308 proposals that were received in the annual basic science calls for projects from 2009 to 2015. All data were reviewed for completeness and absence of duplicates. Since gender is not part of the information required for a proposal, gender was assigned manually based on the given name of the principal investigator (PI). In the case of applicants whose given names were difficult to assign to a gender, such as foreign names, a Google search was carried out until the gender was unequivocally found, as was the case for 152 of the applicants (0.9% of the total); therefore, gender was established for all proposals examined.

2.2. Characteristics of the proposals

The proposals are received in 10 scientific disciplines: biology, biotechnology, chemistry, earth sciences, engineering, humanities, medicine, physics, and mathematics (as one discipline), social sciences, and multidiscipline. The multidiscipline category includes
proposals involving two or more scientific disciplines. The call for proposals specifies three different categories: young researcher (for researchers that are in the first five years of their scientific career), researcher (for established researchers with more than five years of experience), and research groups (two or more groups of researchers from the same or different institutions). The maximum budgets for category are around $100,000 USD for young researcher; $150,000 USD for researcher, and $250,000 USD for research groups.

The applicants for the basic science research funding are mostly members of the SNI, although non-SNI members are allowed to apply. In the period analyzed, 15.4% of the applicants were non-SNI members.

2.3. Evaluation of proposals

The proposals are evaluated by a panel of researchers of each of the 10 scientific disciplines. The number of panelists depends on the number of proposals received for each discipline and are usually between 5 and 25. The evaluation process is carried out in two steps. In the first step, the panelists send each proposal to several external reviewers, in order to obtain three to five opinions. The external reviewers judge originality, generation of relevant new knowledge, soundness, trajectory of the PI and the expected academic products, by assigning one of a four letter score (from excellent to bad) to six questions that explore these aspects. All scores must be substantiated. In the second step, all panelists of each scientific discipline have a face-to-face meeting to analyze the external reviewers’ opinions for each proposal. Based on the scores and arguments of the external reviewers, the panel decides if the proposal is recommended for funding or not. If a proposal is recommended, it is given a score between 8 and 10 (with two decimal places). Proposals are ranked according to their score. In case of a tie, the panel must again review the proposals more carefully, and examine the external reviewers’ scores and arguments more thoroughly to rank them. Both the external reviewers and panelists have access to the SNI level of the applicant and although this is not scored in itself directly, it is used to judge the trajectory of the applicant. Panel members are not obliged to abide by the external reviewers’ scores or arguments and can even disregard one of the reviewers if the panel agrees that the scores or arguments are inconsistent or seem to be biased. Considering all the calls, 694 panelists participated, 66% were men and 34% women.

2.4. Funding of the proposals

The trust’s governing body selects the proposals with the highest scores and rankings for funding, working down the list until the available budget is fully allocated. The budget is distributed proportionally across all the scientific disciplines based on the amount of recommended proposals per discipline, so their success rates are similar.

2.5. Statistical analyses

All data are presented as means ± SDs. Statistically significant differences were considered when \( p \leq .01 \). Two-way ANOVA and Tukey’s test was used to compare the mean success rates by SNI level of the applicant and by the different categories of the proposals. A
logistic regression analysis was performed using funding success as the outcome and as variables for prediction of success: SNI level of the applicant, category of the proposal, gender of the applicant and the scientific discipline of the proposal. The independence of success and gender was also analyzed in contingency tables by Pearson’s $\chi^2$ test. Logistic regression and all tests were carried out using R (R Development Core Team (2017), http://www.R-project.org).

3. Results

The success rate for each category of proposals (young researcher, researcher, and research groups) was calculated for each year’s call (2009–2015) and for each SNI level of the applicant. As the SNI level of the applicant may vary from time to time, the SNI level considered for each applicant was the one he/she had at the moment of the application. Results are shown in Figure 1. As the young researcher category is for researchers in their first five years of a scientific career, in this category most of the applicants were SNI level 1 and below. For this category, 23% of the proponents were non-SNI members, 40% were SNI candidate level, 36% were SNI level 1, and only 0.8% were SNI level 2 (specific numbers are given in the Figure 1 footnote). For the researcher category, most of the applicants were SNI level 1 and above. For this category 10% of the applicants were non-SNI members, 4% were SNI-C candidate level, 49% were SNI level 1, 24% were SNI level 2, and 11% were SNI level 3. For the research group category, most of the proponents were SNI level 1 and above. Some applicants were non-SNI members or SNI-C candidate level, but they had a low success rate (Figure 1). For the research group category, 12% of

Figure 1. Success rate by category of the proposals (young researcher: Young Res.; researcher: Res., and research groups: Res. Groups) and by SNI level of the proponent (non-SNI member: NSNI; SNI candidate level: SNI-C; SNI level 1: SNI-1; SNI level 2: SNI-2, and SNI level 3: SNI-3). Data are presented as mean ± SDs, averaged over years. For young researcher the total number of proposals was 5352 (1263 from NSNI; 2121 from SNI-C; 1924 from SNI-1 and 44 from SNI-2). For researcher the total number of proposals was 9397 (1060 from NSNI; 410 from SNI-C; 4614 from SNI-1; 2278 from SNI-2, and 1035 from SNI-3). For research groups the total number of proposals was 1559 (193 from NSNI; 47 from SNI-C; 602 from SNI-1, 463 from SNI-2, and 254 from SNI-3).
the applicants were non-SNI members, 3% were SNI candidate level, 39% were SNI level 1, 30% were SNI level 2, and 16% were SNI level 3. The results presented in Figure 1 suggest that for all proposal categories, the higher the SNI level, the higher the success rate and that there were differences in the degree of success among the categories, that were also dependent on the SNI level.

A two-way ANOVA was performed to analyze the various combinations. A significant difference was found regarding SNI level \((F(4, 83) = 42.0, p < .0001)\) and category of proposals \((F(2, 83) = 23.0, p < .0001)\). No correlation was found between SNI level and category of proposal \((F(7, 83) = 0.99, p = .439)\).

A Tukey’s post hoc test for the data from Figure 1 was carried out. Table 1 shows the results of comparing the mean success rate for each SNI level against the other SNI levels. In all cases that an SNI level mean success rate is compared to the one of a higher SNI level, the difference was negative and in all the cases that an SNI level mean success rate is compared to one of a lower SNI level, the difference was positive. This is found for all SNI level comparisons, which indicates that the higher the SNI level, the higher the success rate. Since the main conclusion that can be drawn from this analysis is that the SNI level of the applicant is related to success rate, it was decided to analyze the results by SNI level for the rest of the study.

In relation to the category of the proposals, the Tukey’s post hoc test indicated that the young researcher category had a significantly higher mean success rate when compared both to the researcher category (mean difference = 13.9, \(p < .0001\)) and to the research group category (mean difference = 20.5, \(p < .0001\)), while the difference between researcher and research group categories was not significant (mean difference = 6.5, \(p = .069\)). Although the difference between research and research group categories did

| SNI level (I) | SNI level (J) | Difference in means (I–J) | Lower confidence interval | Upper confidence interval | Adjusted p-value |
|---------------|---------------|---------------------------|--------------------------|--------------------------|-----------------|
| NSNI          | SNI-C         | −3.1                      | −13.6                    | 7.4                      | 0.924           |
|               | SNI-1         | −12.9                     | −23.5                    | −2.3                     | 0.008           |
|               | SNI-2         | −33.9                     | −44.6                    | −23.2                    | 0.000           |
|               | SNI-3         | −42.6                     | −54.5                    | −30.8                    | 0.000           |
| SNI-C         | NSNI          | 3.1                       | −7.4                     | 13.6                     | 0.924           |
|               | SNI-1         | −9.8                      | −20.3                    | 0.7                      | 0.080           |
|               | SNI-2         | −30.8                     | −41.5                    | −20.1                    | 0.000           |
|               | SNI-3         | −39.5                     | −51.3                    | −27.7                    | 0.000           |
| SNI-1         | NSNI          | 12.9                      | 2.3                      | 23.5                     | 0.008           |
|               | SNI-C         | 9.8                       | −0.7                     | 20.3                     | 0.080           |
|               | SNI-2         | −20.9                     | −31.6                    | −10.2                    | 0.000           |
|               | SNI-3         | −29.7                     | −41.5                    | −17.9                    | 0.000           |
| SNI-2         | NSNI          | 33.9                      | 23.2                     | 44.6                     | 0.000           |
|               | SNI-C         | 30.8                      | 20.1                     | 41.5                     | 0.000           |
|               | SNI-1         | 20.9                      | 10.2                     | 31.6                     | 0.000           |
|               | SNI-3         | −8.7                      | −20.6                    | 3.1                      | 0.254           |
| SNI-3         | NSNI          | 42.6                      | 30.8                     | 54.5                     | 0.000           |
|               | SNI-C         | 39.5                      | 27.7                     | 51.3                     | 0.000           |
|               | SNI-1         | 29.7                      | 17.9                     | 41.5                     | 0.000           |
|               | SNI-2         | 8.7                       | 3.1                      | 20.6                     | 0.254           |

Notes: Data are the same as in Figure 1. The mean success rate for each SNI level (I) was compared to the mean success rates of all the other SNI levels (J) and the value of the difference is indicated (I–J). Lower and upper 95% confidence interval and the adjusted p-value are indicated (Tukey’s post hoc test). The statistical significance of the mean success differences \((p \leq .01)\) are highlighted in bold, a p-value of .000 indicates that the value is below .0001.
not vary statistically, the three different categories were analyzed separately to avoid any possible underlying difference.

The young researcher category comprises the lower SNI levels, so it was surprising to find that it had a significantly higher mean success rate than the researcher and research group categories. To examine this finding in more detail, the success rates of NSNI, SNI-C and SNI-1 proponents in the young researcher and in the researcher categories were compared. Table 2 shows that, although in both categories, the higher the SNI level, the higher the success rate, for each SNI level the success rate is significantly higher in the young researcher category when compared to the researcher category.

A logistic regression analysis (logit) was then performed considering the success rate as the dependent variable. The independent variables “SNI level” + “category” (of the proposal) + “gender” + “scientific discipline” were used to determine which variable had an influence on success; results are shown in Table 3. SNI level and category were the only variables that were statistically significant. There was no suggestion of an association between gender and success as this variable was not statistically significant. In this analysis, none of the scientific disciplines showed any significant effect on success. The odds ratio for SNI level was calculated and found to be 1.91, this means that the odds of success almost double when the proponent’s SNI is increased by one level. This finding indicates the strong effect of the SNI level of the applicant on the likelihood of success and hence, the importance of analyzing the results of this study by SNI level. The odds ratio for category was 0.57 and, as described above, the young researcher category (coded as 1) had a significantly higher mean success than the researcher and the research group categories and this might explain why the odds ratio are below 1.0. The odds ratios for all scientific disciplines were very close to 1.0 as expected from the non-significant p-values. Likewise, an interaction analysis was performed for all the variables against gender (gender:SNI level, gender:category, and gender:scientific disciplines) and no statistically significant correlation was found (Table 3).

The fact that gender was not a statistically significant variable in the logit analysis is not necessarily an indicator that the probability of success is independent of the gender of the applicant. Therefore, Pearson’s χ² tests of independence of gender and success rate were performed for each of the categories of the proposals by SNI level.

Table 4 shows that for all the categories and all SNI levels, there were no significant differences between the success rates of men and women applicants. Interestingly, when the χ² test was performed without separating the proponents by SNI level, the mean success rate of women was significantly lower than for men, both for the research

| Table 2. Success rates of applicants of the same SNI level in two different proposal categories. |
|----------------------------------|-----------------|-----------------|-----------------|-----------------|
| SNI level | Young researcher | n | Success rate (%) | Researcher | n | Success rate (%) | χ² | p |
|-----------|----------------|----|-----------------|------------|----|-----------------|----|----|
| NSNI      |                | 1263 | 22.8            |            | 1060 | 9.4            | 47.5 | .000 |
| SNI-C     |                | 2121 | 26.5            |            | 410  | 12.9           | 19.2 | .000 |
| SNI-1     |                | 1924 | 47.6            |            | 4614 | 24.7           | 115.8 | .000 |

Notes: Success rates for each of the indicated SNI level (NSNI: non-SNI members; SNI-C: SNI candidate level; SNI-1: SNI level 1) in the young researcher and the researcher category are shown. The total number of applicants (n) for each proposal category and each SNI level is indicated. Success rates for young research and research category were analyzed for the same SNI level by Pearson’s χ² to determine if they are statistically different. Significant p-values (p ≤ .01) are highlighted in bold. A p-value of .000 indicates that the value is below .0001.
The different proportion of men and women in each SNI level could explain why there was a significant difference when not considering the SNI level. As shown in Table 4, for the three categories, the proportion of women drops as the SNI level rises, particularly for SNI-2 and SNI-3 levels. Since higher success rates are observed among applicants with higher SNI levels, the lower proportion of women

Table 3. Results from the logistic regression analysis (logit model) performed on the 16,308 proposals and modeling the probability of success or unsuccess depending on the variables “SNI,” “category,” “gender,” and “scientific discipline” (Sci Disc) taken independently.

| Variables considered independently: “SNI,” “category,” “gender” and “scientific discipline” | Coefficients | Estimate | Standard error | z-Value | Pr (>|z|) | Odds ratio |
|---|---|---|---|---|---|---|
| SNI | 0.649 | 0.021 | 30.213 | **0.000** | 1.91 |
| Category | −0.557 | 0.037 | 14.827 | **0.000** | 0.57 |
| Gender: men | −0.001 | 0.040 | -0.018 | 0.986 | 1.00 |
| Sci Disc: “Biology” | −0.008 | 0.086 | -0.101 | 0.920 | 0.99 |
| Sci Disc: “Biotechnology” | −0.010 | 0.089 | -0.118 | 0.906 | 0.99 |
| Sci Disc: “Chemistry” | 0.008 | 0.086 | 0.101 | 0.919 | 1.00 |
| Sci Disc: “Earth science” | 0.113 | 0.117 | 0.970 | 0.332 | 1.12 |
| Sci Disc: “Engineering” | −0.004 | 0.086 | -0.049 | 0.961 | 1.00 |
| Sci Disc: “Humanities” | 0.009 | 0.111 | 0.081 | 0.935 | 1.01 |
| Sci Disc: “Medicine” | −0.134 | 0.089 | -1.503 | 0.133 | 0.97 |
| Sci Disc: “Multidisciplinary” | 0.104 | 0.131 | 0.795 | 0.426 | 1.11 |
| Sci Disc: “Physics and Mathematics” | −0.079 | 0.090 | -0.880 | 0.379 | 0.92 |
| Sci Disc: “Social Sciences” | −0.050 | 0.106 | -0.478 | 0.633 | 0.95 |

Notes: Statistically significant Pr values (Pr ≤ 0.01) are highlighted in bold, a Pr value of 0.000 indicates that the value is below 0.0001. No significant interactions were found between gender: SNI, gender: category or gender: any of the scientific disciplines.

and for the research group categories. The different proportion of men and women in each SNI level could explain why there was a significant difference when not considering the SNI level. As shown in Table 4, for the three categories, the proportion of women drops as the SNI level rises, particularly for SNI-2 and SNI-3 levels. Since higher success rates are observed among applicants with higher SNI levels, the lower proportion of women

Table 4. Comparisons of success rates of men and women by category of the proposals and by SNI level (NSNI: non-SNI members; SNI-C: SNI candidate level; SNI-1: SNI level 1; SNI-2: SNI level 2; SNI-3: SNI level 3; ALL: all proponents together).

| Category/SNI level | (n) Men | (n) Women | % Women | % Men's success rate | % Women's success rate | χ² | p |
|---|---|---|---|---|---|---|---|
| Young researcher: NSNI | 809 | 150 | 36.0 | 18.5 | 18.7 | 1.5 e^{-5} | 0.999 |
| NSNI-C | 1340 | 781 | 36.8 | 21.0 | 20.8 | 0.001 | 0.968 |
| NSNI-1 | 1252 | 672 | 35.0 | 33.0 | 30.8 | 0.924 | 0.336 |
| NSNI-2 | 36 | 8 | 18.2 | 55.5 | 62.5 | 8.9 e^{-31} | 1.000 |
| All | 3437 | 1915 | 35.8 | 25.2 | 24.0 | 0.849 | 0.356 |
| Researcher: NSNI | 652 | 408 | 38.5 | 8.7 | 8.3 | 0.014 | 0.905 |
| NSNI-C | 262 | 148 | 36.1 | 8.4 | 16.9 | 5.913 | 0.015 |
| NSNI-1 | 2772 | 1842 | 40.0 | 19.7 | 20.1 | 0.082 | 0.773 |
| NSNI-2 | 1675 | 603 | 26.5 | 35.0 | 37.0 | 0.643 | 0.422 |
| NSNI-3 | 818 | 217 | 21.0 | 54.9 | 60.8 | 2.221 | 0.136 |
| All | 6179 | 489 | 34.3 | 26.8 | 24.3 | 6.841 | **0.008** |
| Research groups: NSNI | 118 | 75 | 38.9 | 3.4 | 2.7 | 3.9 e^{-32} | 1.000 |
| NSNI-C | 35 | 12 | 25.5 | 8.6 | 0.0 | 0.132 | 0.715 |
| NSNI-1 | 378 | 224 | 37.2 | 15.1 | 14.3 | 0.021 | 0.883 |
| NSNI-2 | 332 | 131 | 28.3 | 30.4 | 30.5 | 1.2 e^{-30} | 1.000 |
| NSNI-3 | 207 | 47 | 18.5 | 50.2 | 36.1 | 2.502 | 0.113 |
| All | 1070 | 489 | 31.4 | 25.1 | 18.6 | 7.696 | **0.005** |

Notes: The number (n) of men and women proponents is indicated as well as the percentage of women. Success rates of men and women were analyzed by Pearson’s χ² to determine if the success rates of men and women were statistically different. Significant p-values (p ≤ .01) are highlighted in bold.
in the two highest SNI levels groups could lead to a lower global observed success rate for women if the analysis does not take SNI level into account. For the young researcher category, the majority of the applicants are in the lower SNI levels so no significant differences were found when the SNI level was not considered.

Pearson’s $\chi^2$ tests of independence of gender and success rate were performed for each of the scientific disciplines in all the three categories of proposals and by SNI level in order to examine the situation for each scientific discipline more closely. It was found that for none of the categories, scientific discipline or SNI level, there was a significant difference between the success rates of men and women applicants. That is, no evidence of bias against women was found in any of the three categories of proposals in any of the scientific disciplines. To illustrate this finding and due to the fact that the proportion of women applicants varied greatly among scientific disciplines, Table 5 shows the result of the analysis for the research category and for the two scientific disciplines that had the lowest composition of women applicants (physics and mathematics and engineering) and the two disciplines with the highest composition of women applicants (medicine and humanities). As shown in Table 5, the proportion of women applicants did not affect women’s success rate. It can also be observed that the proportion of women by SNI level drops as the SNI level increases rate, particularly for SNI-3 level. This was notable for all the scientific disciplines (data not shown), with the exception of humanities, where the composition of women in all the levels is around 40%.

Table 5. Comparisons of success rates of men and women for the scientific disciplines of physics and mathematics, engineering, medicine, and humanities by SNI level (NSNI: non-SNI members; SNI-C: SNI candidate level; SNI-1: SNI level 1; SNI-2: SNI level 2; SNI-3: SNI level 3).

| Sci disc/ SNI level | (n) Men | (n) Women | % Women | % Men's success | % Women's success | $\chi^2$ | $p$ |
|---------------------|---------|-----------|---------|----------------|------------------|---------|-----|
| Physics and mathematics$^a$ | | | | | | | |
| NSNI | 110 | 21 | 16.0 | 18.2 | 28.6 | 0.632 | 0.426 |
| SNI-C | 143 | 38 | 21.0 | 17.5 | 23.7 | 0.404 | 0.524 |
| SNI-1 | 605 | 145 | 19.3 | 25.3 | 24.8 | 7.2e−05 | 0.993 |
| SNI-2 | 460 | 73 | 13.7 | 30.7 | 26.0 | 0.440 | 0.507 |
| SNI-3 | 311 | 35 | 10.1 | 50.8 | 57.1 | 0.284 | 0.594 |
| Engineering$^a$ | | | | | | | |
| NSNI | 135 | 36 | 21.1 | 5.9 | 5.6 | 3.8e−31 | 1.000 |
| SNI-C | 63 | 11 | 14.9 | 4.8 | 18.2 | 0.970 | 0.324 |
| SNI-1 | 597 | 186 | 23.8 | 19.4 | 24.2 | 1.688 | 0.193 |
| SNI-2 | 322 | 59 | 15.5 | 39.1 | 33.9 | 0.377 | 0.539 |
| SNI-3 | 66 | 7 | 9.6 | 63.6 | 85.7 | 0.564 | 0.452 |
| Medicine$^b$ | | | | | | | |
| NSNI | 169 | 175 | 50.9 | 12.4 | 10.3 | 0.207 | 0.648 |
| SNI-C | 148 | 180 | 54.9 | 18.9 | 16.1 | 0.271 | 0.602 |
| SNI-1 | 492 | 637 | 56.4 | 22.4 | 22.1 | 0.000 | 0.986 |
| SNI-2 | 186 | 134 | 41.9 | 33.9 | 39.6 | 0.855 | 0.354 |
| SNI-3 | 127 | 46 | 26.6 | 45.7 | 50.0 | 0.110 | 0.740 |
| Humanities$^b$ | | | | | | | |
| NSNI | 73 | 71 | 49.3 | 42.3 | 12.7 | 0.000 | 1.000 |
| SNI-C | 60 | 48 | 44.7 | 11.7 | 18.8 | 0.573 | 0.449 |
| SNI-1 | 214 | 192 | 47.3 | 22.9 | 20.8 | 0.145 | 0.702 |
| SNI-2 | 87 | 61 | 41.2 | 34.5 | 39.3 | 0.186 | 0.666 |
| SNI-3 | 27 | 21 | 43.8 | 48.1 | 61.9 | 0.431 | 0.511 |

Notes: The number (n) of men and women proponents is indicated as well as the percentage of women. Success rates of men and women were analyzed by Pearson’s $\chi^2$ to determine if the success rates of men and women were statistically different. Significant $p$-values ($p \leq 0.01$) are highlighted in bold. Data are for the research category of proposals.

$^a$These scientific disciplines had the lowest proportions of women applicants.

$^b$These scientific disciplines had the highest proportions of women applicants.
4. Discussion

The low proportion of women in the scientific community worldwide is a matter of concern for many national and international organizations and institutions, such as UNESCO. There are many social and cultural situations that limit the inclusion of women in the scientific system and there is a vast international literature on this topic. For example, Blickenstaff (2005) reviewed the explanations published within the 30 years before 2005, of the low proportion of women in science, technology, engineering, and mathematics (STEM). He considered that some explanations are without merit and others play a role in a complex interaction of factors. Studies to identify the relevant factors in a particular context of a community or country are then clearly needed.

Women that are already part of the scientific community face discrimination, lower salaries, and funding disparities when compared to men (Shen 2013). As stated in the introduction, access to research funding has been the subject of several studies with conflicting results. The classification of researchers in Mexico by the SNI into four levels allowed, in the present study, to explore the effect of their experience and productivity on the degree of success in obtaining grants for basic research, a factor not always considered in this kind of studies. It was also possible to analyze whether gender played a role in this process.

This study shows that the SNI level of the proponent had a significant effect on the success rate and that the higher the SNI level, the higher the success rate. This fact could be considered as evidence that the evaluation system of the SNI is correctly classifying the experience and productivity of the researchers. The results of the logit analysis confirmed that the SNI level was a statistically significant variable that influences success, while neither gender nor scientific discipline influenced success. The analysis of independence of gender and success by Pearson’s $\chi^2$ test confirmed that gender is not a factor associated to success rate when the test is performed by SNI level, but an interesting finding is that, when the test was performed without separating the applicants by SNI level, women were less successful than men in the researcher and research group categories. This illustrates the confounding effect that could be introduced when experience and productivity of applicants are not considered. In various reports where gender bias is found the applicants were not classified or separated by degree of scientific experience and/or productivity (Head et al. 2013; Van der Lee and Ellemers 2015), or the way they are classified is by proxy, such as by the age of the applicant (Tamblyn et al. 2016).

There are attempts to consider the productivity or experience of the applicants by other means. Waisbren et al. (2008) studied the allocation of research grants by researchers in Harvard-Medical School-affiliated institutions and found a significant difference in success rates between men and women but, when academic rank is taken into consideration, the success rates between men and women were no longer significantly different. Svider et al. (2014) studied the awarded grants in ophthalmology by the NIH and classified the applicants according to academic rank by level of professorship (assistant, associated, or full professor) or as having non-faculty positions (postdoctoral fellows, research fellows, and research associates). They find that if they analyze all the awards without taking into account academic rank or years of experience, men had higher awards than women. When academic rank was considered, only awards at the level of assistant professor were significantly higher for men than for women. So, in these two cases and similar to the results reported here, when experience is taken into account in some way, differences...
between men and women success are reduced or disappear. An important contribution of this work is that we provide evidence that it is possible that reported findings of gender bias could really be an effect of comparing populations (men vs. women) with different experiences in research and in productivity. This is illustrated by the finding in this study that no gender bias was found when the applicant’s SNI level was considered. Therefore, according to the results presented here, it is reasonable to recommend that experience and productivity of the applicant should be considered a variable in future gender studies of this kind.

The results of the logit analysis showed that the category of proposal was also a statistically significant variable that influenced success. A closer look at the results showed that with the same SNI level a proponent had significantly higher success rate when applying in the young researcher category than when applying in the research category. This is a collateral and interesting finding, as the calls do not indicate that young researchers’ proposals should be treated differently from those of researchers or research groups. The fact that young researcher applicants are more successful in obtaining research grants might be explained by an inclination on the part of the evaluation panels and the governing body of the fund, toward considering that these applicants are in their early stages of a scientific career and lean towards a more favorable evaluation over that of the established researchers with whom they might be more demanding. This is important for two reasons: if young researchers have a higher degree of success than established researchers, the result will be the fostering of young researchers to become consolidated or established researchers themselves, in turn, and since according to the results of this study this greater success holds for both men and women, the development of women scientists in the country is also encouraged. According to this finding, a recommendation resulting from this study is to maintain the young research category in future calls.

It is important to remark that the distribution of men and women applicants varied notoriously between the different scientific disciplines and, within disciplines, between the different SNI levels. Nevertheless, the logit analysis showed that scientific discipline was not a variable that influenced success and a detailed analysis also showed that neither gender was associated with success in any of the scientific disciplines.

Based on the results reported in the study presented here, it can be concluded that for the period studied and with the methodology used, no evidence of gender bias was found in the process of peer evaluation of the proposals of basic science.

The results also show that the proportion of women applicants for SNI levels 2 and 3 is noticeably lower than for the other levels in most of the scientific disciplines. As the odds of success are strongly associated to the SNI level of the proponent it might be considered that due to this fact, there is an indirect gender bias in the funding of basic science in Mexico. The lower proportion of women applicants for basic research grants in the higher SNI levels is simply a reflection of the low proportion of women in the higher SNI levels. This situation has been extensively pointed out by different authors (Didou and Etienne 2009; Bustos Romero 2012; Evangelista García, Tinoco Ojanguren, and Tuñón Pablos 2012; Cárdenas Tapia 2015). Blázquez Graf and Fernández Rius 2017 have reviewed the situation of women in the Mexican science system and the policies that the government has put forward to increase their participation. They mention that women have much higher participation than men in domestic activities which limits the time that scientific women can dedicate to activities that are important for their
scientific development, including their inclusion and promotion in the SNI. Cárdenas Tapia (2015) reaches a similar conclusion. Some scientific women decide to postpone or even turn away their plans to have children or engage in a PhD program (the SNI requires applicants to hold a PhD). In fact, Didou and Etienne (2009) pointed out that the youngest man with SNI level 3 was 38 years old while the youngest woman with SNI level 3 was 44. When the SNI was created in 1984 the proportion of women with SNI level 3 was only 10% and the rules were the same for men and women. In the nineties, as a government policy to increase the proportion of women in all SNI levels, a rule was introduced that allowed women scientists to get an extension of one year in their SNI appointment when they have a child, with the intention to compensate for the possible decrease in their scientific productivity due to pregnancy and child care (Didou and Etienne 2009; Blázquez Graf and Fernández Rius 2017). There are no formal studies on the effect of this rule in the composition of women in the higher SNI levels and although the proportion of women with SNI level 3 has gone from around 10% in 1984 to just under 20% in 2016, the slope of the growth curve of women SNI level 3 has not changed noticeably after the introduction of the pregnancy consideration (Rodriguez 2016). Therefore, it is possible to assume that the addition of an extra year in the SNI appointment for women scientists seems to have little or no contribution to their growth in the system, particularly in level 3. As discussed by Didou and Etienne (2009), some scientists have argued that the low proportion of women in the SNI is only a reflection of their participation in the Mexican scientific system. Nevertheless, the figures for 2016 show there were 43% of women with a SNI candidate level and 37% of women with SNI level 1, while there were 30% of women with SNI level 2 and only 19% of women with SNI level 1 (Rodriguez 2016), which illustrates that there is a women gap between the lower and highest SNI levels, so there are limitations of some kind for women to ascend to the higher SNI levels.

The results presented in this study indicate that gender does not play a significant role in obtaining grants for basic research in Mexico. In relation to this, Mendieta-Ramírez (2015) has listed some factors that women scientists in Mexico feel are limiting their growth as scientists which include in general, discrimination, lack of institutional, social or government policies to support them, etc. But they do not mention gender discrimination in obtaining grants.

The main conclusions of this study are that experience and productivity, as determined by the SNI level, but not gender, are the main factors that influence the obtaining of basic science research grants in Mexico, and that women are underrepresented in the higher SNI levels, becoming indirectly discriminated in accessing research funding by this fact. Research is needed to identify the main factors that are limiting the access of women to the higher SNI levels, to propose evidence based policies to address this problem.

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Disclosure statement

No potential conflict of interest was reported by the author.

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