GENDER AND UNDERREPRESENTED MINORITY DIFFERENCES
IN RESEARCH FUNDING

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ABSTRACT

This chapter reviews the data and literature on gender, race and ethnicity differences in research funding in the United States and Europe. The gender gap in research funding has closed at the National Science Foundation and National Institutes of Health in the United States and substantially narrowed in Europe. Underrepresented minorities are less likely to receive research funding that whites in the United States. We found that much of the literature was a series of informative independent studies where many of the potential explanations depended upon the context. Our examination of peer review also found contradictory evidence of its efficacy. The variety of countries, funders, and approaches to peer review make it difficult to make definitive conclusions in the face of contradictory evidence on the gender funding gap. We conclude that access to high-quality administrative data would allow for improved methodological approaches to understanding these differences in research funding.

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Gender and Underrepresented minority differences in research funding[1]

Introduction

This review is about the relationship between research funding allocation, gender and underrepresented minorities (URM). Research on gender and URM disparities in research funding is relevant as it speaks directly to the unexplained gaps in career advancement by illuminating potential effects of gender, race and ethnicity characteristics on productivity, reputation and compensation, offering potential explanations for the distribution of other types of organizational resources and career opportunities.

The allocation of research funding is generally performed by the funding bodies, and it has been traditionally expected to operate under some values and principles shared by the science community such as merit-based allocations and equity and not be based on any ascriptive feature of the individuals, like gender, race or ethnicity. Additionally, social and policy pressures for the adoption of other social values exist, such as gender and race equality, or more generally, the observation of non-discriminatory practices. Despite the abundant literature on gender inequality in academia (see Ceci et al 2014 for a review) and much less regarding URM (NSF Women, Minorities 2021, Bernard & Cooperdock 2018), research remains largely inconclusive as to whether disparities are mainly the result of structural differences, self-selection, or the effect of different types or discrimination or bias during the review and allocation processes. We will argue that there are analytical gaps as well as methodological challenges that should be addressed in order to increase the robustness of research on this topic.

The scope of this review refers to the recent situation of research funding in various countries and agencies with a focus on gender and URM disparities. It also tries to assess the changing trends. We consider research funding allocation is a process and at each phase there are factors that lead to disparities in funding outcomes across groups. Adopting this type of dynamic perspective means that cumulative effects play a relevant role. We focus on grant funding and not on baseline funding allocated through, for instance, hiring. We do not cover issues related to how research funding supports careers since this is addressed in Melkers, Wolley & Kreth (chapter 20 in this *Handbook*). Furthermore, given the complexity and specificity of research funding allocation practices across agencies and countries, their variations and their context dependent effects, we do not discuss funding agency policies designed to provide a more equitable allocation of funding.

Gender and Race Differences in Funding

The allocation of research funding is a multistep and multi-actor process involving application, evaluation, allocation and funding outcomes. This chapter is organized to examine gender and URM differences at each stage of the funding process:

> 1. Do women or URM have a lower probability of applying for research grants from a competitive funding source? If so:

> 2. What are the factors that could account for a lower involvement in applications for funding?

3. Do women or URM have a lower probability of receiving a grant (or receiving less funding) from competitive funding sources? If so:

4. Are differences in outcomes mainly explained by merit or past performance differences between groups? or could be they (partially) the effect of some implicit or explicit bias? If the latter is the case:

5. Does the peer review process account for the observed differences in outcomes?

Some research has shown that women and URM receive fewer research grants and less funding (see Bloch, Kladakis & Sørensen, chapter 11 in this *Handbook* for an analysis of the equality implications of increased funding sizes), in comparison with the other groups, in individual funding agencies in specific fields and under different evaluation criteria (Sato et al 2021 list a few for gender, Ginther et al 2011, Hoppe et al 2019; Erosheva et al 2020). These disparities, if unrelated with past performance, may suggest the existence of bias.

Figure 1 uses data on research success rates by gender and country in Europe and the United States in 2017. In only eight of the 26 comparisons do women have equal or higher success rates than men. Notably at the National Institutes of Health (NIH) in the US, women have success rates that are equal to men's and at the US National Science Foundation, women's success rates are higher. Women's success rates are also notably higher in smaller countries such as Bulgaria and Iceland. We cannot do this same kind of analysis by race because in many countries that data is not collected.

(Figure 1 about here)

The main problem for the analysis of disparities is the identification of the causal mechanisms involved (Reskin 2003). Establishing that funding disparities are related to or are the result of previous differences, self-selection, segregated structures, discrimination practices or biased evaluations requires addressing the underlying mechanisms and moving into the sphere of available theories.

On the methodological side, most of the evidence in this domain is observational, and very few experimental or controlled field studies have been conducted. As we review the literature, we discuss the wide variety of methodologies used to analyse and explain gender, race, and ethnicity differences in research funding. Additionally, the majority of studies have important limitations regarding representativeness, generalizability or external validity as they generally analyse funding processes in a specific context or academic field. Since the funding contexts are very diverse, variation is inevitable but the lack of systematic reporting of the context makes the evidence partial and inconclusive even across studies addressing similar research questions.

In sum, most of the existing literature could be regarded as a series of informative independent studies where many of the potential explanations are related with the specific context of the observations.

The effects of previous differences in the structure of opportunities for research funding

One implication of studying processes is that achievements such as research funding are not independent from other science outputs such as publications and work cumulatively. Merton

acknowledged the Matthew Effect (Merton 1968) where resources are more likely to flow to established scientists. Cumulative advantage (DiPrete and Eirich 2006) will also play a role in research funding.

Previously existing differences create different opportunity structures for various groups that affect the probabilities of grant application or success. The literature, especially regarding female underrepresentation in STEM careers is abundant. In the study of gender and URM inequalities, the list of potential previous factors, structures and events that influence disparities in application and funding is long. Previous reviews have summarized some of the facts and theories regarding gender (e.g. Ceci & Williams 2011; Ceci et al 2014; Williams et al. 2015; Kahn & Ginther 2018; Cruz-Castro & Sanz-Menéndez 2020).

Any serious analysis of funding disparities among social groups needs to take account of previous differences in merit or past performance including publications, citations and Journal Impact Factors (JIFs). The traditional empirical claim has been that men on average publish more papers and receive more citations than female scientists (Cole & Zuckerman, 1984; Xie & Shauman 1998; van den Besselaar & Sandström 2016 among others). A trend towards closing the gap in citation and JIF of publications has also been reported in the literature by Xie and Shauman (1998), Bello and Galindo-Rueda (2020) as well as the finding that productivity of both men and women increases with scientific rank. Ginther et al (2018) found that Black investigators who applied for funding from the National Institutes of Health (NIH) published fewer papers in lower-impact journals than white investigators. Additional research finds that men typically get more credit for co-authored papers in tenure decisions (Sarsons 2017; Sarsons et al 2021) and that women are required to higher standards when trying to publish in top journals (Hengel and Moon 2020; Card et al 2020). Research also reports that in highly selective research institutions the relationship between gender and publications is relatively small for PhD students compared to faculty supervisors (Pezzoni et al. 2016).

Additionally, the gender gap in citations remains important, as well as the gaps at the elite ranges of performance (Aguinis, Ji, and Joo 2018). Recent research confirms that women authors have been persistently underrepresented in high-profile journals (Shen et al. 2018). According to Larivière and Sugimoto (2017) using Elsevier data, the average impact factor of journals for men and women are much closer to parity than citations and the gap in citations is much greater than the gap in impact factors that always favours men. Nevertheless, the Ceci et al (2014) review of the research shows that women's average citations per publication are no different than men's.

The issue is then how much of the funding gap is explained by the publication and citation gaps. Some studies have shown that Black researchers publish less than whites, and this explains about half of the Black/white funding gap (Ginther et al. 2018).

Several explanations of the gender productivity gap have been proposed: cumulative disadvantage (Zuckerman 2001) career attrition (Huang et al.2020) family formation (Long 1992; Symonds et al. 2006; Hunter & Leahey 2010), life choices and social pressures (Ceci & Williams 2011), lower specialization (Leahey 2006; Conti et al. 2014) access to resources (Xie & Shauman 1998) weaker collaboration and co-authoring networks (McDowell, Singell & Stater 2006; Lee & Bozeman 2005; Ductor 2015; Elsevier 2018; Ginther et al 2018).

We also need to pay attention to differences by URM and gender in factors that may represent more reputation than merit but that are used in practice in the funding evaluation: earlier grants, quality of networks, PhD granting institution, postdoctoral training, current academic status and employing institution. At the same time, many funding instruments have formal eligibility criteria or evaluation practices that have associations with academic status, because they are designed and targeted at researchers at specific career stages (Melkers, Wolley & Kreth, chapter 20 in this *Handbook* review this type of career-oriented grants).

The distribution of groups across academic organizations by research intensity, reputation and resources is segregated. Women tend to work at universities with lower reputation, have more part-time jobs and focus more on teaching (Elsevier 2017, Gibney 2016) and service (Guarino & Borden, 2017; Babcock et al 2017). The US National Science Foundation (NSF) reports that as of 2017, 37.8% of the academic doctoral workforce were female and 8.9% were URM. The share of tenured faculty at four-year universities is lower with 31.2% of tenured faculty being female and only 4% of tenured faculty being URM (NSF 2019).

Although the literature is dominated by case studies of the US, there is some research in European universities with results along the same lines. For instance, Conti and Visentin (2015) found that female PhDs are less likely than men to be employed in highly ranked universities in Science and Engineering in Sweden and Switzerland even after controlling for their research output. According to European Commission data, on average, only 7.4% of female academics in Europe hold the highest research position, compared to 16.7% for men (European Commission 2019). However, most of the measurements concerning the scarcity of women at the top of the academic and scientific hierarchy are cross-sectional and not longitudinal.

These systemic or structural differences accumulate and may result in lower productivity and impact and lower access to institutional resources (Holliday et al 2015). The much-cited work of Xie and Shauman (1998) already highlighted that the primary factor affecting women scientists' research productivity was their overall structural position, such as institutional affiliation and rank; when type of institution, teaching load, funding level and research assistance were controlled for, the productivity gender gap disappeared. More recent evidence (Rørstad & Aksnes 2015) also stresses the importance of the academic position and availability of research funds. An important methodological consideration is that interaction effects with gender and URM are worth further examination. In the United States, intersectionality is the interaction of racial and gender disadvantage, often referred to as the "double-bind." Ginther and Kahn (2013) found that women of colour do obtain tenure-track jobs, but they are more likely to be employed at minority-serving institutions.

Application behaviour: Do women and underrepresented minorities apply less for funding? If so, why?

Application behaviour is difficult to study[2]. Unfortunately, research funding agencies do not typically grant researchers access to individual-level application data. In the US, funding agencies provide aggregate data on applications in the form of "success rates" for women (e.g. the probability of receiving an award conditional on making an application). The National Institutes of Health (NIH) does not yet publish data on success rate by race/ethnicity.[3]

Any measure of the decision to apply depends on the number of women or URM researchers in a scientific field, whether the work requires funding, and the unobserved incentives (or lack thereof) to submit applications. A simple count of the number of women and URM employed in academia would over-estimate the applicant pool, making it difficult to evaluate whether there are gender and race/ethnicity differences in the propensity to apply.

Differences—at least the gender ones—are becoming smaller over time, but they are persistent (Ceci et al 2014; Ceci & Williams 2011; Kahn & Ginther 2018). Regarding the causes, as noted by Stephan and El Ganainy (2007), there are structural factors that may result in women or URM being employed in non-research institutions (demand factors), as well as unobserved factors affecting supply (including attitudes towards competition, preferences about work-life balance, family variables).[4]

While many factors affect both men and women, some disproportionately stop women from making applications, especially if they are formalized in the eligibility criteria of the calls for proposals. For instance, rank or employment criteria established by research funders to define who can apply for research funding can produce a gender and URM disadvantage at the application stage because more women and URM are employed on fixed-term contracts, part-time posts and at lower academic ranks. British higher education survey data (Blake & La Valle 2000) showed that women were less likely than men to be eligible for the grants due to their type of employment. They also found that men were more likely to apply as PI than women, a result that could be explained by differences in seniority. Interestingly, women were more likely than men to have applied for their salary to be paid by the grant, which suggests a higher representation of women in non-permanent posts. In sum, many of the gender differences in application behaviour identified in the survey were rooted in higher education institutions' employment practices. Another example is the geographic mobility requirement of some European early and mid-career grants which may disadvantage women given their lower propensity to international mobility (Guthrie et al. 2017, Shauman & Xie 1996).

Unobserved self-selection also plays a role. Self-selection means that not everyone in the population of researchers who is eligible to apply for funding does so. In the case of women, mechanisms identified in the literature include: "shying away from competition" (Niederle & Vesterlund 2007), being more responsive to negative feedback (Kugler et al. 2017), being more shaped by "previous rejection experiences" (Brands & Fernandez-Mateo 2017; Ginther, Kahn & Schaffer 2016), and being more affected by "unprofessional reviews" (Silbiger, and Stubler, 2019 also for URM). However, Ley and Hamilton (2008) data suggest that a large fraction of female biomedical scientists choose to leave US NIH-funded career pipeline at the transition to independence from late postdoctoral to faculty position or early faculty years. Since men and women have near-equal NIH funding success at all stages of their careers, it very unlikely that female attrition was due to negative selection from NIH grant-funding decisions. Hosek et al. (2005) and Pohlhaus et al. (2011) also found a gender gap in subsequent application rates, especially for NIH Type 2 awards.

We must acknowledge that the literature reports contradictory findings and is rather inconclusive about the causes of differences in application. One reason for this lack of robustness is that studies seldom take feedback dynamics into account. An exception is the study of Bol et al. (2018) in which they analyse recent PhD grant proposal submission and find

that early funding introduces a growing funding gap in favour of winners over the following eight years. They conclude that the emergent funding gap is partly created by applicants, who after failing to get one grant, apply for another less often. Application behaviour could also be conditional on the information about the level of competition in previous rounds, and the pressures that researchers face in their own institutions to get funding.

Funding disparities: diverse approaches, divergent findings.

The empirical literature addressing funding disparities is mostly focused on research funding of individual grants; this is partly explained because it is easier in econometric models to test the explanatory power of individual variables such as race, gender, and age to determine whether these factors "explain" the funding outcome. Team science (instrumented by other type of grants) makes the study of inequality much more complex.

Data on the Distribution of Federal Research Funding in the US and EU

Existing research could be organized according to the methodology used. First, there is some descriptive evidence of the differences by gender and race in funding outcomes and more recently success rates (see for example, NIH Reporter). This approach has been used by the funding agencies but also in some academic literature. This type of study does not generally account for differences in individual productivity, institutional affiliation, or previous funding.

We add to this literature in two ways. First, we use data from the European Research Council (ERC), the National Science Foundation (NSF) and the National Institutes of Health (NIH) to show applications and awards by gender and broad field including life (biomedical) science, physical sciences and engineering, and social, behavioural and economic sciences and humanities. Figure 2 shows trends in the number of applications and awards to the ERC from 2014-2019 by broad field. In both life science and social science and humanities the share of female applicants increased each year. In contrast, applications from women in physical sciences and engineering were flat in the past few years, but the share of awards for female applicants were higher especially by 2019. The share of awards was lower in the life sciences than the share of applications, but higher for the years of 2017 and 2018 in social sciences and humanities.

(Figure 2 about here)

We performed the same analysis using data from the US NIH and NSF. Life sciences are proxied by NIH funding to biomedical researchers. Our measure of physical sciences and engineering in the US is the sum of total applications and awards (and those by gender) across the NSF's Computer and Information Sciences and Engineering, Engineering, Geoscience, and Mathematics and Physical Science Directorates. The measure of social sciences comes from the Social, Behavioural and Economic Sciences Directorate at NSF. Figure 3 shows trends in applications and awards in the US. These data show relative parity or a female advantage in research funding at the NIH and NSF. Women make up larger shares of applicants and awards at NIH, and as of 2019 receive the same share of awards as applications (34%). Applications by females in physical science and engineering at the NSF have been flat at between 18-19%; however the share of females receiving awards has exceeded the share of applicants for every year. Females as a share of applicants in social and behavioural science at NSF have trended

downward from a peak of 35% in 2016. However, the share of female grantees exceeded the share of applicants for every year except one.

(Figure 3 about here)

Finally, Figure 4 compares funding rates by gender and race/ethnicity. It shows that women are 3 percentage points more likely to receive NSF funding than men. Whites and Hispanics have higher funding rates (31% and 29% respectively) than Blacks (26%) and Asians (23%).

(Figure 4 about here)

Why do the numbers from the ERC, NIH and NSF differ so much from the data by country that we showed in Figure 1? First, it could be that the various funding mechanisms within each country differ significantly, thus creating disadvantages for women. For example, the success rates vary dramatically across countries with places like Austria, Iceland and Switzerland funding over 40% of proposals. The correlation between the average success rate in the country and the difference in the female-male success rate is .29, indicating that as success rates increase the female-male gap falls. Second, the ERC, NIH and NSF are highly competitive research funders. As a result, the women who apply to these funders may be positively selected, especially in fields where women are relatively underrepresented such as physical sciences and engineering. Third, the trends at ERC, NIH and NSF suggest that women's funding success has improved over time. Thus, data from 2017 across these countries may not reflect the progress that women have continued to make.

From Data to Explanation Gender

There is a second type of observational evidence that includes some correlational and causality approaches. This is the type of evidence that is dominant in the academic literature. Most empirical studies of this type include some characteristics of the applicants that in the best cases also incorporate some indicators of merit or performance; however, this research is rather fragmented and with findings in opposite directions. Some studies have reported lower evaluation scores for female applicants even when accounting for relevant factors related to productivity, seniority, or discipline. The seminal paper of Wenneras and Wold (1997), Tamblyn et al. (2018), and Bornmann et al. (2007) can be cited. On the contrary, other research has argued for the absence of a gender effect in the review (Warner et al. 2016), Marsh et al. (2009), Ginther, Kahn & Schaffer 2016). Replicating the Wenneras and Wold study a decade later, Sandstrom and Hallsten (2008) found nepotism but not gender bias.

In a meta-analysis of 21 studies of funding success rates, Bornmann et al. (2007) found that although the estimates of the gender effect varied substantially from study to study, among grant applicants, men had statistically significant greater odds of receiving grants than women by about 7%. Van der Lee and Ellemers (2015a,b) found that gender disparities were most prevalent in scientific disciplines with the highest number of applications and with equal gender distribution among the applicants (i.e., life sciences and social sciences), but when this was controlled for, the data no longer supported the gender gap (Volker & Steenbeek, 2015). Methodologically, this is an example of how disregarding an exogenous variable can produce a statistical artifact. Stratifying datasets according to key variables like application rate, academic rank, or scientific field (Sato et al. 2021) may yield more robust results.

In the US, Hosek et al. (2005) using data from three federal agencies (NSF, NIH and USDA) found no gender differences in federal grant funding outcomes when they adjusted for other characteristics of applicants, including the researcher's discipline, institution, experience, and past research output. They found, however, a gender gap in the average amount of funding that females received relative to their male counterparts; they also reported a gender gap in subsequent application rates. The most recent evidence of the NIH shows that gender differences in the size of grants awarded to comparable first-time female and male PIs exist, also if one looks at top research institutions only. In most grant types, men get more than women, but for R01 grants (the most frequent award) women receive larger grants (Oliveira et al. 2019). Other research showed that success chances were not significantly different after controlling for productivity (Boyle et at (2015)). Part of the inconclusiveness of the literature relates to how applicants' productivity is measured in empirical research, the variety of bibliometric measures used, and how to account for differences in application behaviour.

From Data to Explanation URM

There is limited but growing research on race/ethnicity differences in research funding. The paucity of this research can be linked to lack of access to administrative data on grant applications that identify the race/ethnicity of applicants. Race and ethnicity is not measured as part of the application process outside of the US. As a result, all of this research has been conducted in collaboration with staff at the NIH. Ginther et al (2011) found that Black researchers were one-third as likely to receive NIH funding as white applicants after controlling for employer characteristics, previous research funding, and publications. Ginther et al (2012) found that Black MDs at medical schools were not disadvantaged in NIH funding after controlling for whether the applications included human subjects. There is only one paper on potential intersectional disadvantages in research funding. Ginther, Kahn and Schaffer (2015) found that women of colour did not experience a double-bind, and that white women were somewhat more likely to receive NIH funding that white men. Ginther et al (2018) used improved measures of publications and bibliometrics to show that half of the Black-white NIH funding gap could be explained by lower publication rates by Black researchers. This work was revisited using a new sample of NIH data. Hoppe et al. (2019) found that topic choice alone accounted for over 20% of the funding gap between African American /Black (AA/B) scientists relative to white scientists in NIH R01 after controlling for multiple variables, including the applicant's prior achievements. However, after controlling for funding rates at NIH Institutes or Centres (ICs), topic choice no longer explains the funding gap between AA/B scientists (Lauer et al 2021).

Finally, there is a third type of evidence emerging from experimental, quasi-experimental, field or controlled experiments usually linked to test causality approaches in evaluation contexts. However, most of this literature is not about research funding, but about hiring or more generally research evaluation. An exception is the recent study of Forscher et al. (2019) where the applicant's gender and race was manipulated in a simulation of an actual grant evaluation process and found no effect of gender or race in the review.

The role of the evaluation processes

In an interesting review, Heilman (2001) identified a number of organizational conditions that may contribute to the undervaluation of women and URM performance. First, ambiguity in

evaluation criteria may introduce bias to fit preconceived ideas about capacity and performance; second, the lack of structure in evaluation and decision-making processes; third, ambiguity about the source of successful performance. For example, when science is produced by teams it may distort the contributions of individual scientists (de Fontenay et al 2018); fourth, ambiguity about the reasons for past success where diversity programs may have unintended consequences in terms of perception of preferential treatment along the career.

Peer review as a context-specific process

In addition to the methodological differences in previous research, there are "contextual" factors that should be reported to have a better assessment of findings and claims of research about the uses of peer review for funding allocation; in exploring causality, similar factors, in different contexts, could produce diverse outcomes.

Peer review in funding agencies is not homogenous and it does not have standardized criteria and processes all over the world (Langfeldt et al 2020), despite the existence of "manuals" or handbooks (Moghissi et al 2013). Therefore, most analyses could be treated as case studies that provide some evidence but may not have external validity.

At the same time, reviewers report different preferences about the merit criteria in evaluations (Cruz-Castro & Sanz-Menéndez 2021), they may have different or inconsistent views regarding what constitutes individual "merit" or "research quality" (Pier et al 2018), or how to address the matching between the definition of "worth" of the specific calls of the funding agencies and their own criteria. Moreover, funding agencies sometimes include policy goals that may interfere with the objective of funding solely on the basis of merit and scientific quality potentially introducing biases in the review process (Costello, 2010).

The amount of time for decision making and the available information are relevant contextual factors. It is known that reviewers, who operate under time limitations, use cognitive shortcuts (Bibliometrics, "reputation" signals like the PhD-granting or employing university, quality of networks, and previous grants, for example).

The evaluation design (individual reviews, panels, commissions) may involve problems of aggregation. If the review is made in based on single evaluators, and there is only a pair who deal independently with each proposal, there is more room for potential bias in the outcome, resulting from a kind of series of measurement errors. The role of peer review and administrative discretion in the funding agencies (Ginther & Heggeness 2020, Goldstein and Kernay 2016) and whether different phases of the evaluation involve different or the same reviewers are also relevant.

In sum, each peer review occurs somehow on a case-by-case basis where each aspect will produce various degrees of influence within every funding context. When addressing the possible factors involved in evaluation bias, the literature has addressed various relevant factors: some are related to panel composition (social dynamics); others to evaluation tools, procedures, and criteria (evaluation methods); and a third type of factors refers to cognitive mechanisms, mainly stereotypes.

The effects of panel composition: who evaluates and who decides

Most empirical evidence about the impact of reviewers' gender on differential evaluation by gender has found no significant effect (Bornmann et al. 2007, Marsh et al. 2009, Marsh et al. 2011). For instance, Mutz et al. (2012) evaluated the grant peer review process at the Austrian Science Fund with respect to gender over 10 years (8,496 research proposals across all disciplines, rated by more than 18,000 reviewers in almost 24,000 reviews) and found no effect of the gender of applicants and reviewers.

Likewise, based on 10,023 reviews by 6,233 external assessors of 2,331 proposals from social science, humanities, and science disciplines, Marsh, Jayasinghe, and Bond (2011) found, moreover, that these non-effects of gender generalized over reviewer's gender (contrary to a matching hypothesis), discipline, reviewers chosen by the researchers themselves compared to those chosen by the funding agency, and country of the reviewers. From the side of the funding agencies, statistics collected by the ERC found no correlation between the percentage of women on its evaluation panels and female success rates (Vernos 2013).

Years ago, based on reviews of around 15,000 grant proposals to the economics program of the National Science Foundation, Broder (1993) presented evidence of significant differences in the reviewing of female and male authors by male and female referees but in the opposite direction. Even when author quality was controlled for by comparing ratings on the same proposal, female reviewers rated female-authored proposals lower than did their male colleagues while no gender differences in the review of male proposals was observed.

Social connections have also been shown to play a role. A study recently reported in *Nature* news (Singh Chawla 2019) examined more than 38,000 reviews from nearly 13,000 Swiss National Science Foundation proposals by about 27,000 peer reviewers from all disciplines between 2006 and 2016. The findings were that reviewers nominated by applicants were more likely to give these applicants higher evaluation scores than referees chosen by the SNSF (Severin et al. 2020). However, not all agencies allow for suggestion or vetoing application reviewers.

Peer review evaluation methods

In peer review panels, bibliometrics and impact factors are often used as a proxy for excellence, quality, and ability. For some, these metrics are gender-blind but some case studies have argued that the use of this type of indicators widen the gender gap in research performance (Nielsen (2017, 2018). Furthermore, Eyre-Walker and Stoletzki (2013) consider the IF a poor measure of merit.

The degree to which the evaluation focuses on candidates or proposals (or both) and in what order has additional explanatory power. A experiment-based paper found that gender gaps in grant funding were attributable to less favourable assessments of women as principal investigators, not of the quality of their proposed research (Witteman et al. 2019 in their study of the Canadian Institutes of Health Research). Van der Lee and Ellemers (2015a) found similar results in their study of research funding in the Netherlands. However, an analysis of the peer review reports of the ERC Starting grants showed that when both the CV and the proposal are assessed without blinding, a high level of correlation between both marks was found (Van den Besselaar & Moom 2020).

The literature also shows that the transparency, clarity and wording of the reviews may have a negative impact on gender differences in the award rates (Magua et al. 2017, Kaatz et al. 2015). Even the type of scales can produce a gendered impact as some numbers may convey symbolic value, with females getting lower scores in 10 point scales than in 6 point scales (Rivera & Tilcsik 2019).

The evidence has found little evidence of the impact of blinded peer review on grant application funding (Tricco et al. 2017). However, Kolev, Fuentes-Medel, and Murray (2019) found that women were disadvantaged in anonymized reviews. In response to the race/ethnicity differences in NIH funding, the Centre for Scientific Review (CSR) conducted an anonymization study. Nakamura et al (2021) found that anonymization did not affect scores received by Black applicants but slightly worsened the scores for white applicants. Furthermore, anonymization did not prevent reviewers from identifying 20% of the investigators.

The amount of information available to the panels, the formalization of evaluation criteria and timeframe in funding organizations, may leave more (or less) room for the activation preconceived stereotypes about differences in performance and quality.

Cognitive factors and stereotyping

One of the sources of bias in judgments is stereotyping. Stereotyping is a cognitive shortcut. When processing information, individuals tend to consider observations that match their stereotypical expectations as more reliable and informative than counter-stereotypical observations (Ellemers 2018).

Most of the evidence on the topic of stereotyping is experimental and although we have not found much specific research related to funding evaluations, findings in related areas provide some useful insights. Heilman (2012) acknowledges that in the vast majority of studies on gender stereotypes no differences have been found in the reactions between female and male respondents; a possible explanation is that stereotypes are widespread in society and affect both men and women alike.

Using an experimental design, Carli et al (2016) found that the higher the proportion of women in a scientific field, the more similar the stereotypes in that field were to stereotypes about women. Their results were congruent with theories that report incompatibility of female gender stereotypes with stereotypes about high status occupational roles, since women were perceived to lack the qualities needed to be successful scientists. These qualities include a number of agentic traits related to assertiveness, independence, competency, and leadership. Organizational interventions to prevent gender and URM bias arising from stereotypes are mostly centred on raising awareness, and also on the provision of information to forestall the use of expectations to "fill in the blanks," but generally no impact analyses are conducted or published.

Conclusion

Our analysis of recent data from the United States and Europe shows a different picture than the one painted by the literature. Women have made progress in terms of applications and awards on both sides of the Atlantic, especially at the most competitive funding agencies: the ERC, NIH and NSF. Women have greater funding success at the US National Science Foundation

than men using the most-recent year of data available. Our data also show that there is a race/ethnicity gap in research funding. Even an impressionistic comparison of the amount of literature that claims that gender bias exists and persists with the literature that claims that it is diminishing or disappearing makes clear the division. However, it is important is to pay attention to rival explanations of gender gaps and be careful with inferring processes from outcomes. Ceci, Ginther, Kahn and Williams (2014) published an overview of the empirical evidence up to then about gender bias in science. In their view the unequal position of women in science would be based on quality differences which are partly the product of own career choices and partly the product of discriminatory arrangements not in science but in society at large. The data we have presented in this chapter support that view.

Although the argument that gender gaps in career advancement are mainly explained by differential performance and previous career choices may be analytically appealing, there is also evidence that the higher we go in the academic hierarchy, the more difficult is to disentangle performance and career differences from other factors that impede women's entry into the most elite ranks. In an recent paper, Treviño et al. (2018) analyse differential appointments by gender to the rank of named professorships in a sample of over 500 management professors at tier 1 American research universities, and found adverse gender effects after controlling for performance.

The literature has yielded heterogeneous results and whereas some show clear effects of the various potential sources of bias, other find only moderate or weak effects. The lack of common definitions, samples, and methods is the most likely explanation of such heterogeneity. In order to test causality of gender or institutional bias, the literature has increasingly introduced measures of performance into the analyses, and it is slowly adopting experimental approaches based on randomized control trials. In terms of methodology, we have identified a need for more conceptual precision, introduction of funding agency contextual factors, stratification of samples, common measures of individual productivity, longitudinal analysis and feedback dynamics.

Underscoring all of this contradictory evidence is a lack of clear data on the potential applicant pool, applications and awards by gender and race/ethnicity. Science funding agencies allocate public money to create the public good of scientific discovery. In this era of heightened awareness of gender and race/ethnicity disparities in socioeconomic outcomes, reporting research funding allocations by demographic characteristics is essential.

Research universities collect data on research funding at the individual level; making this data available for research purposes would be an important advance in data availability. The Institute for Research on Innovation & Science (IRIS) at the University of Michigan curates the UMETRICS data. IRIS is a consortium of over 30 research universities in the United States that share administrative data on research awards and expenditures. The UMETRICS data has been used to track the impact of expenditures on research, publications, patents, and careers. However, it is missing information on the application process. The ERC does not allow access to its administrative funding data, and there are higher barriers to accessing personal data across the European Union. In the United State, the NIH has allowed selective access to its administrative data for research purposes (e.g. Ginther et al. 2011). In contrast, the NSF has not made its

administrative data available to researchers. Placing NIH and NSF data in the Federal Research Data Center network would jump-start fundamental research on gender, race, and ethnicity differences in research funding. Access to high-quality administrative data would allow for improved methodological approaches to understanding these differences in research funding.

There is an ongoing debate in science policy about inequality in the distribution of resources that links with a broader discussion on the relationship between excellence, merit, equity and equality (Hicks and Katz, 2011). Equality is a public value, that is far from being a universally consensual one (see Bozeman chapter 2 in this *Handbook* for an analysis of the relationship between public funding and public values). Equality is not a predominant norm in the distribution of rewards within the science system. The political and policy systems often introduce the equity dimension in the distribution of resources.

Different RFOs may have different values, depending on their mission, and national research councils, private foundations or state agencies may have their own policy objectives which may be more or less aligned with the scientific communities' norms and practices. Funders have latitude in how they allocate resources. A main policy implication is that a variety of funding agencies may be better equipped to address some of the pending challenges highlighted in the chapters of this volume dealing with the individual level. When resources are concentrated in a single source, that funder may have less flexibility in allocating resources more broadly.

We began this review by noting that much of the literature was a series of informative independent studies where many of the potential explanations depend upon the context. Future research should attempt to move beyond description towards explanation. Doing so will require access to information on grant applications as well as awards. Furthermore, researchers are only scratching the surface about the role of peer review in research funding allocations. To the extent that we continue to observe gender and race/ethnicity differences in research funding, a deeper understanding of peer review is warranted.

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Figure 1: Success Rates by Gender in Europe and the United States, 2017.

Success Rates by Gender in Europe and United States, 2017
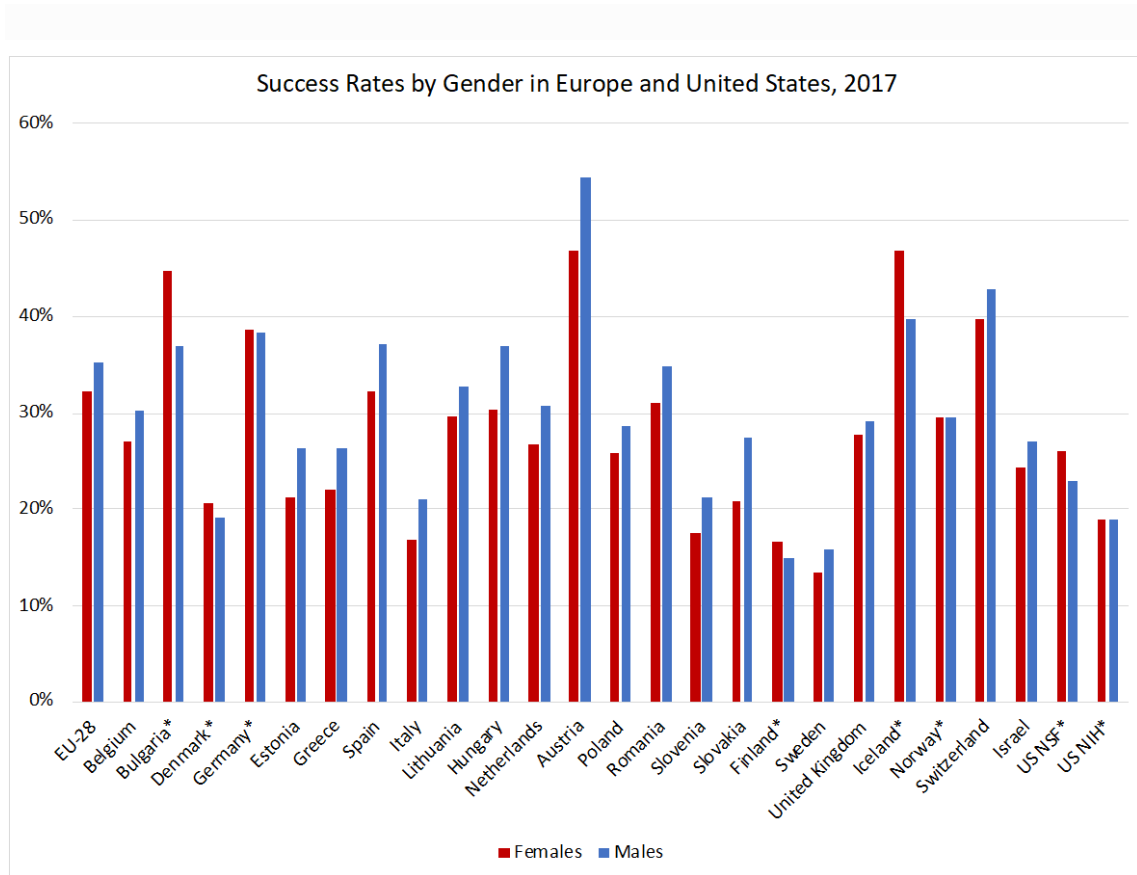
Sources: For European countries: European Commission (2019), for US NSF and NIH Reports

Figure 2: Share of Applicants and Grantees who are Female by Broad Field, European Research Council, 2014-2019.
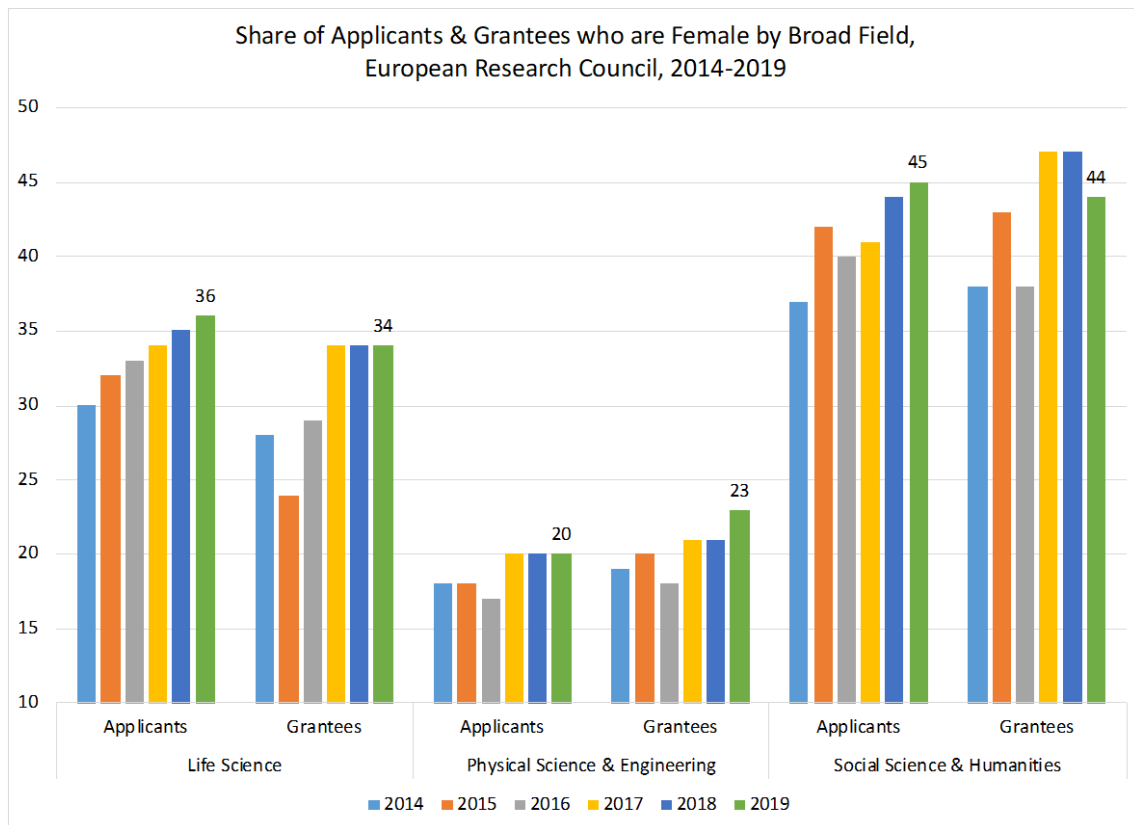
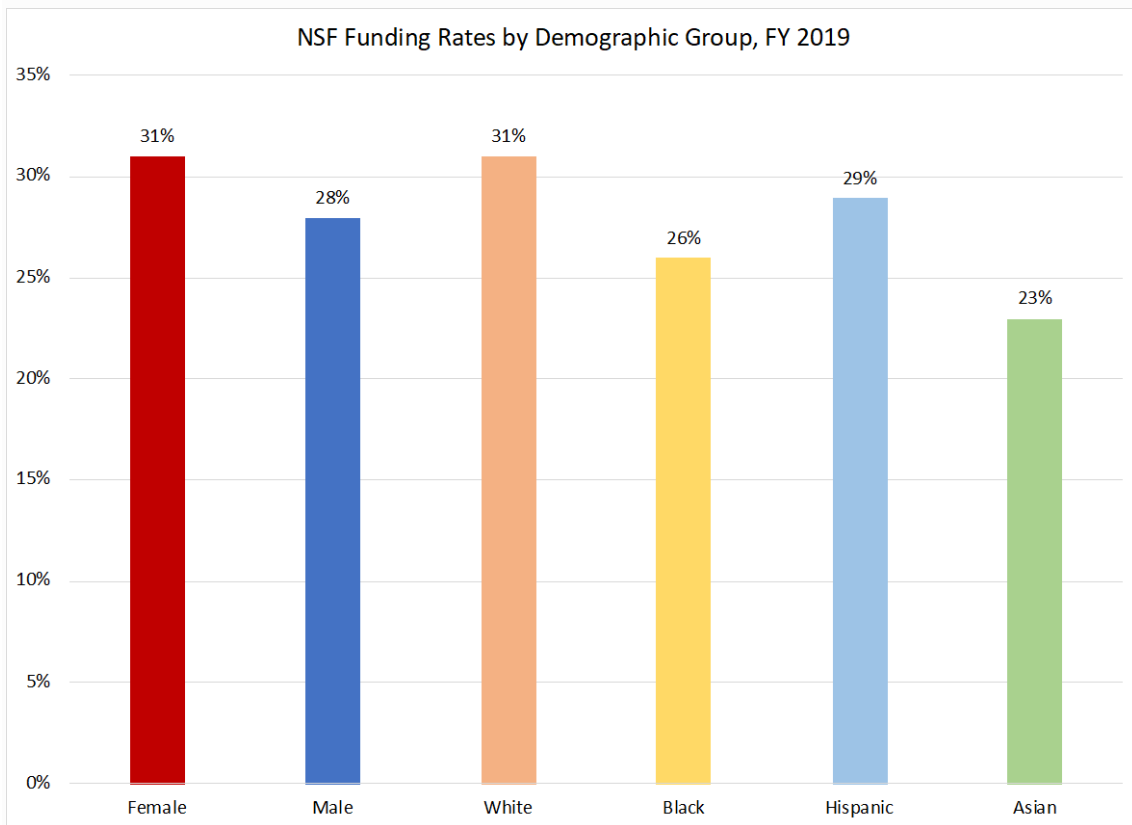Source: European Research Council (ERC).
https://erc.europa.eu/sites/default/files/document/file/ERC_gender_actions_and_data.pdf

Figure 3: Share of Applicants and Grantees who are Female by Broad Field, National Institutes of Health and National Science Foundation, 2014-2019.
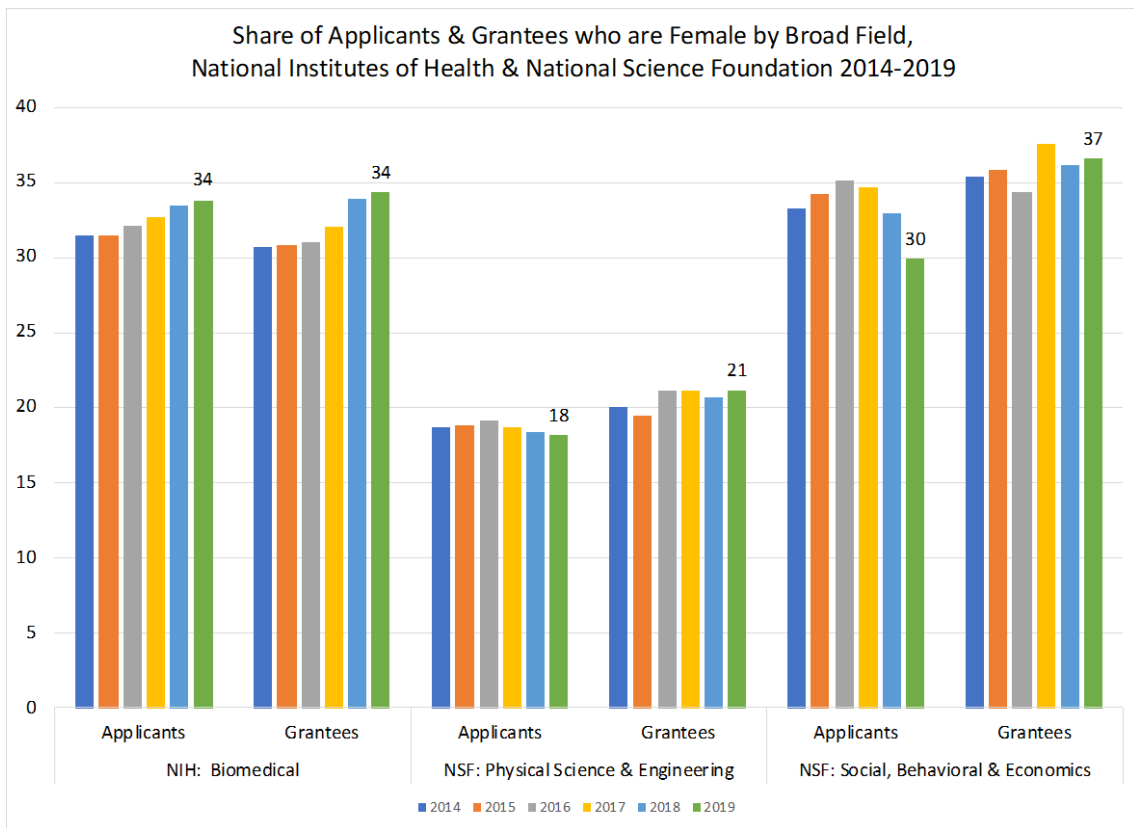
Sources: NIH and NSF

Figure 4: Gender and Race/Ethnicity Differences in Research Funding Rates at the National Science Foundation FY 2019.

NSF Funding Rates by Demographic Group, FY 2019

Demographic Group	Funding Rate
Female	31%
Male	28%
White	31%
Black	26%
Hispanic	29%
Asian	23%

Source: US NSF, National Science Board.

[2] Laudel chapter 18 in this *Handbook* contributes with an analytical exercise to the classification of the researchers' strategies to acquire research funding resources.

[3] The NIH Advisory Committee to the Director Working Group on Diversity in 2021 recommended that the NIH report NIH funding success rates by race/ethnicity. https://acd.od.nih.gov/documents/presentations/02262021Diversity.pdf The National Science Foundation is required by law to report on women, minorities, and persons with disabilities in science https://ncses.nsf.gov/pubs/nsf21321/.

[4] In 2010, the European Research Council (ERC) increased the window of grant eligibility for applicants with children; the number of female applicants increased, as did the number of male applicants so the gap did not narrow, a finding which suggests that gender-neutral policies may have unintended effects.