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Gender, Family and Caregiving Leave, and Advancement in Academic Science: Effects across the Life Course

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Abstract: Family and caregiving leave are increasingly important dimensions for careers in academic science, and for vital, sustainable institutional structures. These forms of leave are intended to support equity, and particularly gender equity. A key question is how the actual use of leave affects critical milestones of advancement for women—compared to men—in (1) time to tenure and (2) the odds of promotion to full professor. We address this question with descriptive statistics and event history analyses, based on responses to a survey of 3688 US faculty members in 4 scientific fields within a range of Carnegie institutional types. We find that leave that stops the tenure clock extends time to tenure for both men and women—the effect is gender neutral. Promotion to full professor is another matter. Being a woman has a strong negative effect on the likelihood of promotion to full professor, and women are especially disadvantaged in promotion when they used tenure leave years earlier. These findings have implications for a life-course perspective on gender and advancement in academic science, the roles of caretaking and leave, and the intended and unintended consequences of leave policies for equitable and sustainable university systems.

Keywords: gender; science; academia; family leave; tenure; promotion; policy

Citation: Fox, M.F.; Gaughan, M. Gender, Family and Caregiving Leave, and Advancement in Academic Science: Effects across the Life Course. *Sustainability* **2021**, *13*, 6820. https://doi.org/10.3390/su13126820

Academic Editor: Ramon Flecha

Received: 18 April 2021
Accepted: 8 June 2021
Published: 16 June 2021

1. Introduction

Tenure and academic rank are milestones of advancement for women and men in academic science. In efforts to improve gender-equitable advancement, initiatives for institutional change and transformation frequently focus on family and caregiving leave [1–5]. This form of leave encompasses leave for birth or adoption of children and for the care of children and elders. Such leave is increasingly common in academia, although it varies in length of time, terms of eligibility, negotiations involved, and levels of pay received (none, partial, or full) [6–8].

Family and caregiving leave is intended to support equity, and particularly gender equity [9–11]. However, a persistent concern is how the actual use of this leave affects the advancement of women compared to men faculty [6,12]. Findings on use are notable for economics faculty. A study of faculty in 50 leading economics departments indicated that "stop the tenure clock" leave for caregiving benefited men more than women [13]. Following the adoption of these leave policies, men published more in top economics journals, and women did not. The leave increased a gender gap in productivity and in advancement; and the implication is that women used the leave more for caregiving, and men more for research.

The use of leave prompts our key questions for academic science more broadly:

1. Does a gender gap exist in time to tenure and in the odds of promotion to full professor?
2. Does taking leave slow down the timing of tenure and, later, promotion to full professor?
3. Do the effects of leave-taking vary by gender?

We address these questions with data from the survey responses of 3088 women and men faculty members in a range of scientific fields (biology, biochemistry, mathematics, and civil engineering) and a span of Carnegie institutional types (research, master's, comprehensive, selective liberal arts colleges, and historically Black- and Hispanic-serving institutions). We specify these in the Methods section.

The status of women faculty is an issue in most developed science systems. However, the policy conditions vary by context. Two major differences exist between the United States and other developed countries. First, academic careers in the United States are structured in a system of tenure, while some other nations incorporate similar features [14]. In the United States—with its longstanding tradition of public and private (both for-profit and not-for-profit) higher education institutions—tenure is conferred by individual universities that agree to conform to the American Association of University Professors' guidelines of permanent tenured positions [15]. This means that tenure is governed by consent in a voluntary association of higher education institutions. No national law regulates tenure for faculty members in the United States, and states are free to institute (or not) their own tenure policies for public (but not private) academic employees. Consequently, employment policies for faculty in the United States result from thousands of independent institutions converging on policies without particular guidance from, or accountability to, any higher, centralized governmental body. Furthermore, even within universities, substantial variation may exist in promotion and tenure policies and practices, leading to uneven conditions, especially with respect to new policies, such as those of family leave. Second, the United States remains one of the few developed countries with no national policy for paid family leave. Rather, "social" benefits flow through employment, with some employers offering generous benefits, and others offering few [16]. Therefore, just as with specific tenure policies, family-related policies can operate based on the specific university in question.

Initial concern about the status of women scientists emerged in the 1970s, in what became a series of national-level policy documents that brought theoretical and empirical attention to the vast under-representation of women at all levels of the science system [17]. Despite this, the capacity to move forward on family-related issues was limited by the generally weak or absent approaches to family issues, conceptualized in the United States as private matters, and without centralized policy guidance in higher education. Nevertheless, during the decade of the 2000s, the situation in US universities began to change rapidly in response to converging dynamics: the increase in the number of women in senior academic positions and the high level of public attention to the MIT Report on the Status of Women [18]; the development and implementation of the National Science Foundation ADVANCE Institutional Transformation program in 2001 [2]; and competition from industry and government, whose employment policies were perceived as more flexible than those in academia [19]. In concert with these, the American Association for University Professors recommended universal adoption of time off the tenure clock in its 2001 guidelines. Thus, in the period covered by our data, the majority of universities adopted policies such as stopping the tenure clock to support caregiving faculty members [6].

The under-representation of women in science has been documented in developed science systems that have more generous national social policies regarding family support [20]. In these systems, when gender disparities in science came to attention, national social welfare traditions were in place, and national and supranational initiatives adopted integrated strategies toward gender equity. These include the Athena SWAN Charter in the United Kingdom [21], and gender mainstreaming in the European Union [22].

Our study is limited to the United States of America, which is nevertheless an important case and a major destination for scientists from around the world. The focal policy we examine in this study—taking time off the tenure clock—may seem small relative to programs in more generous social welfare states. However, in the United States it is a major policy change (one university at a time) that became institutionalized over the course of our observation.

In this study of gender, leave, and advancement in the US, a key distinction is that between advancement to tenure and advancement to full professor. Tenure entails attainment of a permanent faculty position, while the rank of full professor entails fuller status, prestige, and influence in academia. The advancement to full rank, in particular, is a challenge for women faculty [23–25]. Compared to men, women are lower and slower in promotion to full rank [10,26]. This is the case even after considering what is called "demographic inertia." The inertia refers to the representation of women at given ranks, as subject to existing age and gender distributions that affect the proportional representation of newer doctorate holders, including women [27,28]. A range of factors contribute to women's stalled advancement to full professor. These include ambiguous standards for evaluation [24,29], perceptions and experiences of limited social integration into departments [30,31], collaborative arrangements [32,33], and the absence of a timetable for promotion [34]. Leave-taking is a potential aspect of the timetable for the attainment of full rank, and is a focal issue here.

Gender is not the only status that constrains academic advancement. Race and ethnicity operate together with gender to structure academic careers [35,36]. Furthermore, conceptions of family vary by race, ethnicity, and socioeconomic class [37,38]. While quantitative intersectional approaches imply fully interactive models of gender, race, and ethnicity [39], we consider the direct and interactive effects of race and ethnicity to the extent possible with these data.

Overall, academic science is a strategic research site in this study, and a prototype of work–family conflict, for the following reasons. Scientific work largely takes place "on site" in laboratories (or in field settings), with costly equipment and teams of undergraduate, graduate, and postdoctoral students, supported by external funding provided by faculty members [40]. Work expectations are high and demanding [18], and they involve interdependency between people, projects, and human and material resources [2]. Related to this, scientific work roles strongly shape identities. Studies show that scientists (including engineers) are especially responsive to the demands of work, because the success and rewards of their work are central to how they define themselves [41]. Scientific work qualifies as "work devotion" [42,43], which claims time, attention, and dedication.

This long-standing model of scientific "vocation" and "calling" that Weber [44] characterized a century ago still exists. However, social forces and trends also foster initiatives of work–life balance and family leave. In the US (and elsewhere) women's employment is the norm. In 2018, nearly 60% (57.0%) of US women aged 16 and over worked outside the home [45]. The proportion of US faculty in science and engineering who are women reached 35% in 2017, with varying proportions by field, rank, and type of institution [46]. Academic workplaces are now composed of diverse personnel, including women, men, and single parents [47]. This has implications for our conception of gender, leave-taking, and advancement.

Related research points to relationships between gender, family, and performance in academic science. To summarize this, in a survey of academic scientists in nine research universities, both women and men reported that work interferes with family more than family interferes with work, and women reported higher conflict in both directions [48]. The greater interference in family life by work reflects a range of factors. These include broad social and economic pressures emphasizing work over other interests [49–51]; work roles tied to positions in organizations and, in turn, societal status [52]; and negative sanctions that discourage employees from allowing family to interfere with work [53].

Furthermore, widely reported are the effects of marriage and children on publication productivity, which, in turn, relate to advancement in academic science. The findings are non-uniform, and not necessarily intuitive. Studies point to both the neutral and positive effects of marriage on the publication productivity of women in science, and to positive and negative effects of the presence of children [54]. More nuanced and time-sensitive analyses include the age of children, the span of scientists' careers, and the timing of parenthood [55,56]. Extensive literature addresses publication productivity as it determines

advancement [57–59], and this encompasses the relationship between family characteristics and publication productivity, as addressed above. For our purposes, we include publication productivity as an important marker of merit, but it is not the focus of this research.

Guidelines from the American Association for University Professors [15] influence university policies for academic advancement. However, the actual decisions for tenure and advancement to full rank occur after extensive consultation with disciplinary peers (in similar or related fields to those of the candidates). Fields vary in their practices [60], and are relevant controls in the analysis of the timing of advancement. Postdoctoral fellowships are increasingly important in the life course of scientists and engineers [61,62]. In its ideal form, this position promotes independent scholarship and productivity in the tenure track [63]. Scientists who have completed postdoctoral fellowships prior to beginning a tenure track position have potential advantages in moving toward tenure in their early careers. With this background and these controls for career variables (further specified in the Methods section), the focus here is on whether an independent effect of gender on advancement occurs with leave-taking, including that for family and caretaking leave.

In the study of gender and advancement, our perspective emphasizes the hierarchies of gender and of academic science, and the ways in which these hierarchies connect and reinforce one another. First, and fundamentally, gender relations are systems of stratification built around women's and men's unequal status in society, broadly [42,64,65]. Second, the academic sciences are strongly hierarchical, with vast disparities in levels of research funding, equipment, and materials available, as well as rewards received [40]. Third, scientific fields are powerful influences that have shaped graduate education, patterns of external funding, and research autonomy [66]. Fourth, in academic sciences, the hierarchies of women and men appear in their disparate ranks, networks, and collaborative ties, recognition, and rewards, along with other areas [25,67–69]. Fifth, academic institutions themselves are hierarchical organizations that reflect gender relations [70] in ways that shape evaluation, advancement, and the organizational contexts and climates in which these occur. Taken together, our argument is that scientific fields exemplify and reinforce hierarchies of gender [71], making these fields a strategic site for our study.

Within this framework, we consider the extent to which family and caregiving leave supports or reverses gender hierarchies in academic science, and the ways in which leave can foster and sustain equity. Issues of sustainability are important here. Just as scientific fields exemplify hierarchies of gender, so too can they be critical sites for countering gender disparities and sustaining equity. The academic sciences, and the universities in which they are located, are sites for sustainable development because they employ key personnel, produce knowledge, train students, and are agents for change. They also intersect with government and public funding, and thus, social institutions more widely [66]. These features make them focal locations for interventions to support and sustain gender equity.

In the Conclusions section, we consider how patterns of leave and advancement relate to gender equity and inequity in academic science. We address ways in which leave policies and practices can be shaped to eliminate gender disparities and promote the sustainability of an increasingly diverse and globalized workforce in academic science.

2. Methods

2.1. Data

We use survey data from Netwise II (Julia Melkers, PI), collected in a 2012 national study and funded by the National Science Foundation. Scientists working in 2012 were asked retrospective questions that allowed us to construct their academic life course, including educational, occupational, and family timing. These life courses developed during a theoretically relevant period of time, with sustained policy attention to issues of gender differences in scientific careers. Other national datasets do not include the relevant information allowing for the reconstruction of such career timing.

Respondents included 3688 faculty members in biology, biochemistry, mathematics, and civil engineering. These particular fields represent those with high, medium, and low participation of women in academic positions [72]. In the life sciences, women are 44.8% of junior faculty and 28.8% of senior faculty. In mathematics, women are 32.1% of junior faculty and 11.8% of senior faculty. In engineering, women are 17.9% of junior faculty and 6.4% of senior faculty [72].

The sampling plan also included a range of Carnegie institutional types: research, master's, comprehensive, selective liberal arts colleges, historically Black colleges and universities, and Hispanic-serving institutions. We identify research, comprehensive, and master's universities with the Carnegie Classification of Institutions of Higher Education [73]. We identify additional categories: (1) selective liberal arts colleges [74]; (2) historically Black colleges and universities (HBCU) [75]; (3) Hispanic-serving institutions [76]; and (4) women's colleges [77].

To enable intersectional analyses, the survey oversampled women and members of domestic minority groups. The goal was to sample 200 individuals from each of 112 unique cells, defined by field, institutional type, gender, and a binary definition of race/ethnicity. However, the following cells comprised less than 200 individuals in the entire nation: All women of color and all men of color, with the exception of civil engineers and mathematicians in research-extensive universities. The oversampling of members of underrepresented minority groups allows for direct testing of such effects, and the examination of racial and ethnic effects while controlling for gender. Non-minority women were better represented than members of domestic minority groups. For example, in the research-extensive universities, sampling proportions for women ranged from 38% for mathematics to 77% for civil engineers. Given the complex sampling design, all analyses were weighted to reflect the differential probabilities of selection, which ranged from 5.3% representation of White male mathematicians in research-extensive universities to certainty for most faculty of color and many categories of female faculty. The weighted means and standard deviations of the characteristics of the sample appear in the subsection on descriptive statistics in the Findings section.

2.2. Variables

2.2.1. Dependent Variables

The principal dependent variables are respondents' reports of: (1) the year in which tenure occurred, and (2) the year of promotion to full rank. These are highly salient career events. Thus, respondents' reports of them are likely to be valid, and unlikely to be subject to reporting bias. For the tenure timing models, the beginning of observation is the starting year of the tenure track position, and the ending year is when tenured (or censored in 2012). For the full professor timing models, the beginning of the observation is the year tenured, and the ending year is when promoted or censored.

2.2.2. Independent Variables

The independent variables encompass family status, caregiving, and use of policies; background characteristics of gender and race and ethnicity; and career characteristics of field, performance in publication productivity, and completion of a postdoctoral fellowship prior to accepting a tenured or tenure track position.

The focal independent variables are measures of caregiving, derived from responses to the question: "Since you have been a faculty member at your institution, have you: (1) extended or reset your tenure clock; (2) cared for dependent children; or (3) provided care for an aging parent or relative?" The first of the responses reflects use of an institutional leave policy, and relates to the tenure clock and use of policy in the pre-tenure period. The second and third responses reflect caregiving that may or may not involve institutional leave policy, and could have occurred at any time during the respondent's employment at the sampled university.

Family status variables are marital status and the presence and timing of dependent children relative to the academic life course. The survey questionnaire asked "Are you currently . . . ?" and then provided six options of marital status, coded as currently married and all other statuses. The survey also asked the ages of up to five dependent children. We used these ages to determine whether any of the children were born prior to attaining tenure.

The demographic characteristics were self-reported responses to the survey. The categories for gender were woman (1) or man (0), with 54 missing responses imputed from publicly available web sources. These binary gender categories, collected in 2012, do not reflect the transgender identities that have become increasingly important norms for gender. Human subjects' guidance restricted asking about sexual identity, as it was considered to be outside the scope of the research questions. Consistent with US Census Bureau practice, the original survey questions first asked about Hispanic ethnicity. The survey offered the following racial categories: White, African American, American Indian/Alaskan Native, Asian/Pacific Islander, and Other. Respondents could choose as many options as preferred. For the purposes of this study, we created single racial/ethnic groups with the following classifications: Black, Hispanic, Asian, and non-Hispanic White. The study does not include faculty identifying as Asian Pacific Islanders or Alaskan Natives. We use non-Hispanic White as the reference category for most analytic models.

The fields of respondents were biology, biochemistry, mathematics, and civil engineering. These fields were identified from publicly available departmental websites during the development of the sampling frame. Respondents self-reported whether or not they completed a postdoctoral fellowship prior to appointment as faculty members in tenure-track jobs. The time spent in the postdoctoral fellowship was not included in calculations of the time to tenure and promotion.

We measure publication productivity by responses to the question: "During the past two academic years, how many of the following have you produced?" Four different publication types appeared in the survey, but only peer-reviewed journal articles were included in the creation of this variable. One might argue that faculty members have an interest in over-reporting peer-reviewed article productivity in a survey. However, data indicate that self-reported counts correlate highly with those listed in independent sources [78]. A two-year window does not reflect the entire period of an academic career, and for some faculty (those who had already earned tenure at the time of the study), that window is problematic. These limitations notwithstanding, the significant positive effect of publication productivity is dwarfed by the larger social dynamics revealed in the analyses to follow. While complete bibliometric data histories may meet the gold standard for examining productivity, we do not believe such measurement would result in any change in the pattern, significance, or magnitude of the effects we document here.

2.3. Means of Analysis

Descriptive analyses include the means and standard deviations of dependent and independent variables for the sample, and we provide two-tailed *t*-tests of differences between women and men. For the event history analyses, we employ the Cox proportional hazards model [79], which is robust to violations of distributional assumptions. This enables estimation of unbiased effects on the likelihood of the event(s). The multivariate analyses address complex issues of years to tenure and years to promotion to full professor. These are complex because the number of years reflects the average for those who have experienced the event. The number of years is biased to the extent that it excludes those who have not yet accrued tenure or promotion to full professor. These are exactly the issues that the event history analysis is designed to address. The resulting models handle observations for those who have not yet experienced a focal event in any period, and generate estimates of time to event.

We use event history analysis to estimate: (1) the risk/hazard of gaining tenure, and (2) the risk/hazard of gaining promotion to full professor in any given year of the academic career. Our analytic tables present log odds coefficients, interpreted in this way:

positive coefficients increase the likelihood an event, and negative coefficients decrease the likelihood of experiencing an event in any year. For the purposes of prose, we use the intuitive odds ratios, obtained by exponentiating the log odds coefficients. The odds ratios express the effects of significant variables on the percentage increase or decrease in the likelihood of the event.

In the analysis of tenure, the log odds coefficients appear in a series of nested models, with controls for demographic and career characteristics. In these, the first model for tenure is a baseline against which we evaluate changes in the explanatory power and the fit of subsequent models. Models 2–4 include marriage and child rearing, as they affect the timing of tenure. Models 5–8 introduce the focal independent variables—caregiving and leave-taking—as they affect the timing of tenure. We assess the fit of the model using the Chi-squared test of difference in the −2 log-likelihood results. We follow the same approach of nested models in the analysis of promotion to full professor. These models for tenure and promotion to full professor test the direct effects of our focal interests: gender and caregiving responsibilities.

In order to examine whether women are especially disadvantaged by taking time off the tenure clock, we model interactions in these ways. We present a hazard model of time to tenure with log odds of the best fit model for caregiving. This shows the interaction between being a woman and taking time off the tenure clock; and also allows examination of how the overall model works for men and women, respectively, and by race and ethnicity. A separate, analogous presentation shows the interactive effects of gender and taking time off the tenure clock on earning promotion to full rank.

3. Findings

3.1. Descriptive Characteristics: Samples by Gender and by Leave-Taking

The characteristics of the sample appear in Table 1. Given the complex sampling design described in the Methods section, weightings apply to ensure that statistics represent the population means. The overall weighted means and standard deviations for the sample of 3688 respondents appear in the first columns of the table. The majority of the sample (80%) was tenured, and the average time to tenure was 5.8 years. Half of the faculty in the sample had attained the rank of full professor, and the average time to full professor was 5.5 years.

For the independent variables, less than one-third of the faculty were women, and more than three-quarters were non-Hispanic White, with Black and Hispanic faculty constituting 7%. About half of the faculty were in civil engineering and mathematics, and the other half were in biology and biochemistry (reflecting the sampling design). The average professional age of respondents (from time they earned their PhDs) was 22 years. Two-thirds of respondents completed postdoctoral fellowships prior to beginning their tenure track appointments, and the average publication productivity was slightly more than 2.5 peer-reviewed publications per year. In family characteristics, over four-fifths of respondents were married, 70% had children, and over half had children before attaining tenure. Caregiving was extensive. Over half of respondents reported child care, one-fifth reported elder care, and nearly 10% took time off the tenure clock prior to earning tenure.

Characteristics, by gender, appear in the second and third columns (Table 1). No gender differences occurred for racial or ethnic identities. Women were less likely to be tenured and less likely to be at full professor rank. However, women and men were similar in terms of years to tenure, and women who had attained full rank did so one year sooner than men. For almost every other indicator, we observed significant gender differences. Women were over-represented among life scientists, and under-represented among mathematicians and engineers. Women were six years younger than men (in professional age), were more likely to have completed a postdoctoral position, and had lower publication productivity. In family characteristics, women were less likely to be married, less likely to have children, and less likely to have had children before tenure. By contrast, they were more likely to care for children, and three times more likely to have taken time off the tenure clock prior to tenure.

Table 1. Weighted univariate and bivariate analyses of the sample.

Variables	All	Women	Men	Time off	No Time off
N	3688	1599	2089	345	2895
Career Trajectory					
Tenured	0.80	0.71	0.83 ***	0.63	0.81 ***
	(0.62)	(0.69)	(0.82)	(0.70)	(0.61)
Years to Tenure	5.81	5.87	5.80	6.68	5.78 ***
	(4.39)	(3.18)	(5.00)	(3.70)	(4.48)
Promoted to Full Professor	0.49	0.32	0.55 ***	0.20	0.50 ***
	(0.78)	(0.58)	(0.87)	(0.57)	(0.78)
Years to Full Professor	5.52	4.69	5.96 ***	5.47	5.74
	(9.39)	(6.46)	(10.93)	(10.87)	(9.38)
Demographic Characteristics					
Woman	0.28			0.56	0.25 ***
	(0.70)			(0.71)	(0.68)
Black	0.03	0.04	0.03	0.06	0.03 *
	(0.28)	(0.25)	(0.31)	(0.35)	(0.27)
Hispanic	0.04	0.04	0.03	0.07	0.04 *
	(0.30)	(0.26)	(0.33)	(0.36)	(0.30)
White	0.77	0.77	0.77	0.73	0.78 *
	(0.65)	(0.52)	(0.73)	(0.64)	0.64)
Asian	0.14	0.13	0.14	0.14	0.13
	(0.53)	(0.42)	(0.60)	(0.50)	(0.53)
Family Characteristics					
Married	0.83	0.73	0.87 ***	0.81	0.83
	(0.58)	(0.55)	(0.59)	(0.56)	(0.59)
Any Children	0.70	0.64	0.72 ***	0.75	0.69 *
	(0.71)	(0.60)	(0.78)	(0.62)	(0.72)
Children before Tenure	0.56	0.53	0.57 *	0.67	0.55 ***
	(0.77)	(0.62)	(0.87)	(0.67)	(0.78)
Leave Type					
Care for Children	0.53	0.58	0.52 ***	0.66	0.52 ***
	(0.77)	(0.62)	(0.88)	(0.68)	(0.78)
Care for Elders	0.21	0.22	0.21	0.26	0.21 *
	(0.64)	(0.51)	(0.72)	(0.64)	(0.64)
Time off Clock	0.09	0.18	0.06 ***		
	(0.45)	(0.48)	(0.40)		
Care Volume	0.84	0.98	0.79 ***	1.92	0.73 ***
	(1.17)	(0.99)	(1.28)	(0.98)	(1.05)
Career Controls					
Year of PhD	1990.2	1994.6	1988.5 ***	1993.9	1989.9 ***
	(17.91)	(12.00)	(20.59)	(13.45)	(18.40)
Postdoctoral	0.64	0.67	0.63 **	0.67	0.64
	(0.75)	(0.59)	(0.85)	(0.68)	(0.75)
Publications	5.14	4.08	5.55 ***	3.64	5.30 ***
	(12.46)	(8.27)	(14.84)	(11.11)	(12.65)
Field Controls					
Engineering/Math	0.49	0.39	0.53 ***	0.35	0.49 ***
	(0.78)	(0.61)	(0.87)	(0.69)	(0.78)
Biology/Biochemistry	0.51	0.61	0.47 ***	0.65	0.51 ***
	(0.78)	(0.61)	(0.87)	(0.69)	(0.78)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The last two columns examine differences between people who had taken time off the tenure clock (n = 345) and those who had not (n = 2895). Fifty-six percent of faculty members taking time off the tenure clock were women, and 44% were men. Among those who did not take time off the tenure clock, one-quarter were women and three-quarters were men. Those taking time off were less likely to be tenured or promoted to full professor, and they took a year longer to earn tenure than those who had not taken time off the tenure clock. Among those who were promoted to full professor, the number of years it took did not vary relative to time taken off the tenure clock; however, those faculty who took time off the tenure clock were significantly less likely to be promoted to full professor. Faculty taking time off the tenure clock were more likely to be Black or Hispanic, and less likely to be White. Unsurprisingly, people with children, and especially those who had children before tenure, were more likely to have taken time off the clock.

3.2. Event History Findings

3.2.1. Does a Gender Gap Exist in Time to Tenure?

We begin with findings from event history analysis that appear in the baseline model for tenure. The baseline model shows that women are 13% less likely than men to earn tenure. Black faculty are also 13% less likely, and Hispanic faculty 18% less likely, to earn tenure than non-Hispanic Whites. Considering career characteristics, more recent PhDs are less likely to earn tenure, and those who have completed a postdoctoral fellowship are 17% more likely to earn tenure. The risk period does not include the postdoctoral period; it begins with entry into the assistant professor rank. Each peer-reviewed article increases the odds of earning tenure by 1%, and faculty in engineering and mathematics are 18% more likely to earn tenure than those in biology and biochemistry.

3.2.2. Does Taking Leave during the Tenure Track Extend Time to Tenure?

The results of the baseline model (Model 1) are consistent with prior research on determinants of tenure. In Models 2 through 4, we add marital status, the presence of children, and a measure of whether the children were born or adopted prior to tenure. Each model results in a significant improvement in model fit. It is noteworthy that controlling for family-related variables eliminates the negative effect of being Black on earning tenure, but the direct negative effect of being Hispanic persists.

Here, we interpret Model 4, which has the best fit for the family characteristics model. Marriage is advantageous, increasing the likelihood of earning tenure by 17%. Ever having had children is also advantageous, improving tenure odds by 71%. Importantly, having children before earning tenure reduces the odds of earning tenure by over 37%. Caring for children (Model 5) and caring for elders (Model 6) reduce the likelihood of earning tenure by about 8%. Model 7 estimates the effect of formally taking time off the tenure clock, with important results. First, using this formal policy reduces the likelihood of earning tenure by nearly half. This makes sense: stopping the clock by definition extends the time to promotion. In the Conclusions section, we address this as evidence of a strong policy effect in the manner intended by the policy. Furthermore, and even more importantly, women's disadvantage in earning tenure is eliminated when accounting for stopping the tenure clock.

3.2.3. Does the Effect of Taking Time off the Tenure Clock on Tenure Vary by Gender?

In addition, findings on interactive effects address the question: Are women who take time off the tenure clock especially disadvantaged relative to their male colleagues who also take time off the tenure clock? The findings that address this question appear in Table 2. Here, Model 1 replicates Model 7 of Table 3, and constitutes our new baseline. In Model 2, we include an interaction term to assess whether women are especially disadvantaged in taking time off the clock prior to tenure. The results indicate that they are not. Men and women are equally disadvantaged when taking time off the tenure clock, and we note no significant improvement in overall model fit. The non-effect of being Black and the negative effect of being Hispanic on tenure timing persist, and the negative effect of being Hispanic is experienced only by men.

Table 2 also estimates Model 1 separately by gender in order to see whether differences exist for women and men in the pattern of effects. Two notable differences appear: (1) being Hispanic is a disadvantage for men, but not for women; and (2) the engineering/mathematics advantage exists only for men.

3.3. Event History Findings: Promotion to Full Professor

3.3.1. Does a Gender Gap Exist in Time to Promotion to Full Professor Rank?

The findings on promotion to the rank of full professor appear in Table 4, using the same analytic and model-based testing approaches as for the tenure decision. The models for promotion (Table 4) exclude faculty who have not been awarded tenure in the institution, and show the following. First, the baseline model (Model 1) reveals a strong negative effect of being a woman in earning promotion to full professor. Women are 25% less likely than men to earn full rank in any given year. Second, the negative effect of being Black is pronounced in every model—the opposite of what was observed in the time-to-tenure models. Black faculty are half as likely to earn full rank in any given year. The negative effects of being a woman and being Black persist no matter how we specify the model. Furthermore, the negative effect we observed of being Hispanic on earning tenure does not persist into the decision for promotion to full professor. Third, the career characteristics operate as they did in the tenure model. Specifically, more recent doctorates are less likely to be promoted to full professor; those in engineering and mathematics are more likely to be promoted than those in life sciences; the advantage of having completed a postdoctoral position persists; and peer-reviewed publications predict promotion to full rank.

3.3.2. Does Taking Leave during the Tenure Track Extend Time to Promotion to Full Professor Rank?

In promotion to full professor, family characteristics play less of a role than in the tenure decision. Marriage confers neither advantage nor disadvantage. Having any children predicts promotion, but the effect is weaker than in the tenure decision. Caring for children (Model 5) or elders (Model 6) does not have the negative effect on promotion to full professor that it did for the tenure decision. We focus, therefore, on the effect of having children before tenure (Models 4–8), and the effect of taking time off the tenure clock (Models 7 and 8). Recall from the Methods section that we are considering the likelihood of promotion to full professor rank in any year, starting in the year that tenure begins. Faculty who had children prior to earning tenure continue to be disadvantaged in attaining the rank of full professor; however, this penalty operates more weakly than for the tenure decision. The strongest disadvantage comes from having taken time off the tenure clock as a pre-tenure faculty member. Faculty who did this are nearly half as likely to have earned full rank. Unlike patterns for the tenure decision, taking time off the tenure clock does not fully mediate the negative effect of being a woman. Rather, women are 16% less likely to attain full rank (Model 7), and they experience a penalty for time taken off the tenure clock.

3.3.3. Does the Effect of Taking Leave during the Tenure Track on Time to Promotion to Full Professor Rank Vary by Gender?

Recall that the negative effect of taking time off the tenure clock was gender neutral for the tenure decision. Both men and women took longer to earn tenure when they used one of these policies, and being a woman was only partially mediated by including the time taken off the clock. For promotion to full professor, we examine this effect in more detail in Table 5. The first model in Table 5 replicates Model 7 of Table 3. The second column shows the interaction term of gender with time taken off the tenure clock. We find that the direct negative effect of being a woman persists, reducing the odds of earning promotion to full rank by 14%. The direct negative effect of taking time off the tenure clock is mediated substantially by the interaction term. The interaction term reveals a moderating effect, whereby women who take time off the clock are particularly disadvantaged in earning promotion to full professor; the interaction reduces their odds by 40%.

Table 2. Cox proportional hazards model of time to tenure: log odds coefficients of best model, by gender.

Variables	Time off Clock	Interaction	Women	Men
Demographic Characteristics				
Woman	−0.02	−0.01		
	(0.03)	(0.03)		
Black (a)	−0.12	−0.13	−0.20	−0.11
	(0.07)	(0.07)	(0.13)	(0.09)
Hispanic	−0.19 **	−0.19 **	0.12	−0.28 ***
	(0.07)	(0.07)	(0.13)	(0.08)
Family Characteristics				
Married	0.16 ***	0.16 ***	0.23 ***	0.15 **
	(0.04)	(0.04)	(0.07)	(0.05)
Any Children	0.51 ***	0.51 ***	0.50 ***	0.51 ***
	(0.04)	(0.04)	(0.09)	(0.05)
Children before Tenure	−0.43 ***	−0.43 ***	−0.56 ***	−0.39 ***
	(0.04)	(0.04)	(0.08)	(0.04)
Leave Type				
Time off Clock	−0.58 ***	−0.52 ***	−0.67 ***	−0.51 **
	(0.05)	(0.08)	(0.07)	(0.08)
Women*Time off Clock		−0.11		
		(0.11)		
Career Controls				
Year of PhD	−0.01 ***	−0.01 ***	−0.01 ***	−0.01 ***
	(0.001)	(0.001)	(0.003)	(0.002)
Postdoctoral	0.17 ***	0.17 ***	0.17 ***	0.16 ***
	(0.03)	(0.03)	(0.07)	(0.04)
Publications	0.01 ***	0.01 ***	0.01 ***	0.003 *
	(0.001)	(0.001)	(0.003)	(0.002)
Field Controls				
Engineering/Math (b)	0.10 ***	0.10 **	−0.005	0.12 ***
	(0.03)	(0.03)	(0.07)	(0.03)
Measure of Fit				
Likelihood Ratio	529	530	226	292
Degrees of Freedom	11	12	10	10

(a) Reference group for race and ethnicity is White and Asian faculty; (b) reference group is biology; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 3. Cox proportional hazards model of time to tenure: log odds of nested models.

	1	2	3	4	5	6	7	8
Variables	**Baseline**	**Married**	**Children**	**Before Tenure**	**Child Care**	**Elder Care**	**Time off Clock**	**Total Care**
Demographic Characteristics								
Woman	−0.14 ***	−0.10 **	−0.11 ***	−0.11 ***	−0.10 **	−0.10 **	−0.02	−0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Black (a)	−0.14 *	−0.10	−0.11	−0.12	−0.12	−0.11	−0.12	−0.10
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Hispanic	−0.20 **	−0.20 **	−0.24 ***	−0.19 **	−0.19 **	−0.20 **	−0.19 **	−0.20 **
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Family Characteristics								
Married		0.24 ***	0.17 ***	0.16 ***	0.16 ***	0.15 ***	0.16 ***	0.15 ***
		(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Any Children			0.17 ***	0.54 ***	0.60 ***	0.54 ***	0.51 ***	0.66 ***
			(0.03)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)
Children before Tenure				−0.46 ***	−0.47 ***	−0.46 ***	−0.43 ***	−0.47 ***
				(0.04)	(0.04)	(0.04)	(0.04)	(0.04)

Table 3. *Cont.*

	1	2	3	4	5	6	7	8
Variables	**Baseline**	**Married**	**Children**	**Before Tenure**	**Child Care**	**Elder Care**	**Time off Clock**	**Total Care**
Leave Type								
Care for children					−0.08 *			
					(0.04)			
Care for elders						−0.08 **		
						(0.03)		
Time off Clock							−0.58 ***	
							(0.05)	
Care Volume								−0.16 ***
								(0.02)
Career Controls								
Year of PhD	−0.01 ***	−0.01 ***	−0.01 ***	−0.01 ***	−0.01 ***	−0.01 ***	−0.01 ***	−0.01 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Postdoctoral	0.16 ***	0.16 ***	0.14 ***	0.16 ***	0.16 ***	0.16 ***	0.17 ***	0.16 ***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Publications	0.01 ***	0.01 ***	0.01 ***	0.01 ***	0.01 ***	0.01 ***	0.01 ***	0.004 **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Field Controls								
Engineering/Math (b)	0.17 ***	0.15 ***	0.14 ***	0.11 ***	0.11 ***	0.10 ***	0.10 ***	0.08 *
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Measure of Fit								
Likelihood Ratio	190	214	261	390	395	396	529	453
Degrees of Freedom	7	8	9	10	11	11	11	11

(a) Reference group for race and ethnicity is White and Asian faculty; (b) reference group is biology; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 4. Cox proportional hazards model of time to full professor: log odds of nested models.

	1	2	3	4	5	6	7	8
Variables	**Baseline**	**Married**	**Children**	**Before Tenure**	**Child Care**	**Elder Care**	**Time off Clock**	**Total Care**
Demographic Characteristics								
Woman	−0.28 ***	−0.26 ***	−0.26 ***	−0.25 ***	−0.26 ***	−0.25 ***	−0.18 ***	−0.23 ***
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Black (a)	−0.68 ***	−0.68 ***	−0.75 ***	−0.75 ***	−0.76 ***	−0.72 ***	−0.64 ***	−0.69 ***
	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
Hispanic	−0.08	−0.07	−0.10	−0.09	−0.09	−0.08	−0.06	−0.08
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Family Characteristics								
Married		0.10 *	0.07	0.07	0.07	0.07	0.05	0.06
		(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Any Children			0.14 ***	0.20 ***	0.16 **	0.19 ***	0.19 ***	0.25 ***
			(0.04)	(0.05)	(0.06)	(0.05)	(0.05)	(0.06)
Children before Tenure				−0.09 *	−0.08	−0.09 *	−0.08	−0.10 *
				(0.05)	(0.05)	(0.05)	(0.04)	(0.05)
Leave Type								
Care for children					0.05			
					(0.04)			
Care for elders						−0.08		
						(0.04)		
Time off Clock							−0.62 ***	
							(0.09)	
Care Volume								−0.07 **
								(0.02)

Table 4. *Cont.*

	1	2	3	4	5	6	7	8
Variables	**Baseline**	**Married**	**Children**	**Before Tenure**	**Child Care**	**Elder Care**	**Time off Clock**	**Total Care**
Career Controls								
Year of PhD	−0.02 ***	−0.02 ***	−0.03 ***	−0.03 ***	−0.03 ***	−0.03 ***	−0.03 ***	−0.03 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Postdoctoral	0.44 ***	0.42 ***	0.38 ***	0.37 ***	0.37 ***	0.37 ***	0.37 ***	0.37 ***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Publications	0.02 ***	0.02 ***	0.02 ***	0.02 ***	0.02 ***	0.02 ***	0.02 ***	0.02 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Field Controls								
Engineering/Math (b)	0.20 ***	0.21 ***	0.18 ***	0.16 ***	0.16 ***	0.15 ***	0.02 ***	0.14 ***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.001)	(0.04)
Measure of Fit								
Likelihood Ratio	539	548	558	556	558	560	614	565
Degrees of Freedom	7	8	9	10	11	11	11	11

(a) Reference group for race and ethnicity is White and Asian faculty; (b) reference group is biology; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.00$.

Table 5. Cox proportional hazards model of time to full professorship: log odds coefficients of best model, by gender.

Variables	Time off Clock	Interaction	Women	Men
Demographic Characteristics				
Woman	−0.18 ***	−0.15 **		
	(0.05)	(0.05)		
Black (a)	−0.64 ***	−0.69 ***	−0.41	−0.81 ***
	(0.12)	(0.12)	(0.22)	(0.14)
Hispanic	−0.06	−0.08	−0.24	−0.02
	(0.11)	(0.11)	(0.23)	(0.13)
Family Characteristics				
Married	0.05	0.05	0.22 *	−0.04
	(0.05)	(0.05)	(0.10)	(0.06)
Any Children	0.19 ***	0.19 ***	0.24 *	0.18 **
	(0.05)	(0.05)	(0.12)	(0.06)
Children before Tenure	−0.08	−0.08	−0.06	−0.08
	(0.04)	(0.05)	(0.11)	(0.05)
Leave Type				
Time off Clock	−0.62 ***	−0.39 ***	−0.90 ***	−0.37 **
	(0.09)	(0.12)	(0.14)	(0.12)
Woman*Time Off Clock		−0.49 ***		
		(0.18)		
Career Controls				
Year of PhD	−0.03 ***	−0.03 ***	−0.01 **	−0.03 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Postdoctoral	0.37 ***	0.38 ***	0.25 **	0.41 ***
	(0.04)	(0.04)	(0.09)	(0.04)
Publications	0.02 ***	0.02 ***	0.02	0.02 ***
	(0.001)	(0.001)	(0.001)	(0.001)
Field Controls				
Engineering/Math (b)	0.02 ***	0.17 ***	0.16	0.17 ***
	(0.001)	(0.04)	(0.09)	(0.04)
Measure of Fit				
Likelihood Ratio	614	621	113	449
Degrees of Freedom	11	12	10	10

(a) Reference group for race and ethnicity is White and Asian faculty; (b) reference group is biology; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

In Table 5, the last two columns estimate the effects separately by gender. As in the model for tenure, the negative effects of race and ethnicity apply to men and not to women, and the positive effects of being an engineer or mathematician are advantageous only for men. We further note that marriage is advantageous for women, but not for men, in timing of promotion to full professor. With respect to our focal analytic interest in gender and leave, women who have taken time off the tenure clock are 60% as likely to earn promotion compared to women who have not (Model 3); men who have taken time off the tenure clock are 30% as likely to earn promotion compared to men who have not (Model 4). Recall that the interactive model (Model 2) showed that women who have not taken leave are 14% less likely to be promoted than men who have not taken leave.

4. Discussion and Conclusions

To summarize our findings, a number of family-related factors affect earning tenure. Caring for children and elders reduces the odds of gaining tenure, and having children pre-tenure reduces the likelihood of tenure. In leave-taking, stopping the tenure clock extends time to tenure for both men and women. That is, both women and men are equally disadvantaged in taking time off the clock; the effect is gender neutral. Promotion to full professor is another matter. Being a woman has a strong negative effect on the likelihood of promotion to full professor, and the effect is not fully mediated by accounting for time taken off the tenure clock. Family characteristics (marriage, children) have less of an effect on promotion to full professor than for tenure. The critical gender divide is the effect on promotion of having taken time off the tenure clock. Women are especially disadvantaged when they used this policy years earlier. Furthermore, the negative effects of race (Black) and ethnicity (Hispanic) operate for men only. Like their white colleagues, Black and Hispanic women are disadvantaged by taking time off the tenure clock, but the direct negative effects of being Black or Hispanic are borne by men.

We set out to evaluate how caregiving affects faculty career trajectories, focusing on the speed at which tenure and promotion to full rank occur. As other research has demonstrated, women are slower to advance. However, as the policy mechanism may predict, we find that the negative effect on women's time to tenure owes to making use of the tenure clock policy prior to tenure. To put it another way, the gendered effect of time is fully mediated here. Furthermore, the effect of taking time off the tenure clock is negative for both men and women in time to tenure. Most striking is that the effects of taking time off the tenure clock persist into the promotion to full professor rank, and that women of any race or ethnicity are especially disadvantaged.

These effects are consequential and complex, with significant bearing on equity and sustainability. Policies creating formal mechanisms to stop the tenure clock are intended to level the playing field for faculty with caregiving responsibilities and those without them. As we have seen, these policies are more likely to be used by women, which, in turn, reflects larger gendered social dynamics in families. However, at the university level, the policies have equitable impacts for women and men in time to tenure. Some scholars have suggested that caregiving leave disproportionately favors men in the timing of tenure. However, we do not find empirical support for that hypothesis.

Our conclusion is that the use of tenure-clock-stopping policies has a gender equitable effect in delaying the award of tenure. From a sustainability perspective, such an outcome is desirable. Policies for equity should have equitable effects, as this one apparently does in the timing of tenure. The debate is not over, however. When we estimate the effects of stopping the tenure clock on attaining the rank of full professor, we find both a negative effect of using the policies and a disproportionate impact on women. Faculty who take time off the tenure clock are disadvantaged after tenure has been attained, usually many years later. In the policy world, this is known as an unintended policy effect. When national funding agencies, professional associations, and universities were drafting and implementing stop-the-clock policies, the intent was to mitigate the negative effect of

caregiving on earning tenure. The policy was not intended to be a career marker with long-lasting effects in the academic life course.

Our findings point to a potential caregiving bias, whereby caregivers continue to be disadvantaged in promotion to full professor. Furthermore, a particular female caregiving bias appears, whereby women caregivers are especially delayed in advancing. A related hypothesis is that caregivers remain active caregivers after the tenure decision. Other mechanisms may be that, compared to men, women take different career strategies and approaches, and/or experience more overt gender discrimination. The data here do not allow us to disentangle the actual mechanisms by which the delay occurs. The data do, however, bring attention to the dynamics of a policy that appears to be solving one issue—equity in timing of tenure—while not addressing, or even exacerbating, another—inequity in the post-tenure life course. Addressing the underlying mechanisms involves new research designs. For now, we can settle for a robust empirical observation about the differential effects of university policies on success, at least according to two major metrics—tenure, and promotion to full professor.

This study is not without other limitations, of course. Ours is a study of faculty in academic science in US universities. Universities in the US are structured differently than those in most other higher education systems. In nations outside of the US, tenure is a civil service designation, unlike tenure in the US. Similarly, full rank as a professor has different meanings in different systems. At the same time, the US higher education system is a significant one, and our findings may be a basis for investigation in other systems, with appropriate changes in the measurement of the key outcome indicators. Tenure and the rank of full professor are ultimately conferred at the university level, and it is reasonable to hypothesize that our findings here apply to other fields within US universities. In future research, we will address the decade after 2012 (the time at which these data were collected). The institutionalization of gender-related policies continues to occur in academia, and its effects merit further attention. A key issue from our study concerns the implications that exist for universal attention to the use of leave policies as relates to women's advancement to the highest academic ranks.

Notably, future research and action on the sustainability of academic research careers need to take a long-term perspective on faculty development that encompasses comprehensive understanding of the roles of caretaking. This is a key implication and recommendation. Furthermore, in an increasingly diverse scientific world, it is essential that research designs support intersectional analysis, and that practical policy impacts be considered in nuanced ways that take account of gender, race, ethnicity, and stage of academic life course. We are hopeful that the assumptions of earlier generations—that women must choose between work and family, for example—will continue to be questioned both conceptually and practically by policies and procedures, and that careers will be structured to meet the needs of diverse generations of students and professionals, and to support the sustainability of vital university systems.

Author Contributions: Conceptualization, methodology, analysis, visualization, writing (original draft preparation, and review and editing): M.F.F. and M.G.; funding: M.G. All authors have read and agreed to the published version of the manuscript.

Funding: The research reported here was funded in part through the National Science Foundation NSF-DRL-0910191 (Julia Melkers, PI, Georgia Institute of Technology; Eric Welch, Co-PI, University of Illinois at Chicago; Monica Gaughan, Co-PI, University of Georgia and Arizona State University). NSF played no role in the design or implementation of the research reported here, and the analysis and conclusions are the authors' own.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board of the Georgia Institute of Technology (protocol code H10180, 6 July 2010).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Information about the research project from which the data derive is available on the NETWISE: Networks of Women in Science and Engineering project webpage https://netwise.gatech.edu/ (accessed on 7 June 2021), Access to the data is governed by the Institutional Review Board of the Georgia Institute of Technology, for human subjects' protection.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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Monica Gaughan is a Professor at the School of Human Evolution and Social Change at Arizona State University. Dr. Gaughan earned a Bachelor of Arts degree (1989) in political science from the New College of Florida, a Master of Public Administration degree (1992) from Syracuse University, and a Master of Arts (1997) and Doctor of Philosophy (1999) in sociology from the University of North Carolina at Chapel Hill. Dr. Gaughan has also held academic appointments at Oglethorpe University, the Georgia Institute of Technology, and the University of Georgia. She served as a Presidential Management Fellow at the U.S. Department of Health and Human Services (1992–1994). Her research focuses on the training, distribution, and migration of scientists and engineers in the global knowledge system. She is particularly interested in how policies and practices affect scientific career development, with a focus on differences in terms of race, ethnicity, gender, socioeconomic status, and national origin.