

Research Article

Career Outcomes for STEM, Social and Behavioral Sciences and Education Doctoral Alumni

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Abstract

Traditionally doctoral students are trained to pursue tenure-track positions in research-intensive institutions. However, a survey of 914 PhD alumni at a public research university in a diverse array of disciplines finds that students move across employment sectors over a 15-year period. This study used a three-tier taxonomy to classify both short- and long-term employment outcomes based on employment sector, career type and job sector for Science, Technology, Engineering and Mathematics (STEM) and Social and Behavioral Sciences and Education (SBSE) doctoral alumni. The study is unique in that demographic information such as race, gender and citizenship status and academic performance measures were examined to gain a deeper understanding of career trajectories. The findings indicate differing career paths based on demographic characteristics, but also finds there is no correlation between academic performance metrics such as GPA and GRE scores and job placements in academia or outside of academia. This has significant implications for doctoral training and suggests that graduate programs must prepare students for both academic and alternative careers, particularly as tenure-track positions and U.S. federal research dollars continue to shrink. This study also adds to a growing body of literature on the need for rigorous data collection, and transparency to help students make informed choices about PhD training and career pathways.

Keywords: Career outcomes, doctoral training, STEM, Social and Behavioral Sciences and Education

Introduction

Graduate study is a high-stress pursuit [1]. Some of this stress results from uncertainty about career outcomes. Academic institutions have traditionally trained and prepared doctoral students for a single career pathway: tenure-track faculty positions. However, today's knowledge-based economy offers doctoral students rich and varied career options, and doctorate holders have the potential to contribute to a broad spectrum of the US workforce. In this paper, we use data from a 15-year survey of Ph.D. alumni from a comprehensive research university to document the diversity of career pathways pursued by PhD students in Science, Technology, Engineering and Mathematics (STEM) fields and in the Social and Behavioral Sciences and Education (SBSE). We separate our examination of STEM and SBSE alumni, as we suspect that the career paths of alumni in these broad disciplinary areas may differ. We also analyze how career outcomes change for different cohorts by age, and how they correlate with demographics and academic performance indicators. This study provides a better understanding of the career trajectories of doctoral alumni, which has significant implications for appropriate training and advising of Ph.D. students. This in turn may lead to higher rates of career satisfaction and well-being for individuals over the course of their careers. Institutional transparency about career outcomes can also encourage students to explore all available career tracks and mitigate some of the stress inherent in the pursuit of a doctoral degree.

New research shows that Ph.D. holders are increasingly migrating to non-academic sectors despite a persistent culture in academia that emphasizes the singular path to success as the professoriate at a research-intensive university. National data sources and the research literature underscore the shift away from academic careers in specific disciplines. For example, only 17.7% of PhDs (in science, engineering and health disciplines) in 2015 had secured tenure-track positions within five years of receiving their degree. This compares to a 25.9% tenure track placement in 2006 and a 27% placement in 1993 [2]. Similarly, the National Science Foundation's Survey of Earned Doctorates (SED) found that 50% of science, engineering and health discipline PhDs are engaged in careers outside of academia within 14 years of graduation [3]. Almost 75% of all biomedical doctoral alumni engage in careers beyond academia, including for-profit, government and non-profit sectors [4,5]. The shift is present, though perhaps less stark, in the Social and Behavioral Sciences. A study of 3000 Social Science graduates who earned their degrees in the United States between 1995 and 1999 found that 77% hoped to obtain tenure-track positions, but only 40% found such positions within a year of earning their degree [6].

The steady exodus away from careers in academia can be attributed in part to a declining number of faculty jobs [7]. It also reflects some students' loss of interest in a lifetime career in academia as they progress through doctoral programs [8–11]. Students may reassess

their opportunities for success in hyper-competitive environments, which place a premium on publications and grants. When students observe the life-work imbalances of their faculty advisers, long postdoctoral training periods, and meager salaries for academics at early stages of their careers, these factors may also contribute to student interest in alternative paths [8]. For these reasons, and because students move between employment sectors in the course of a career, it becomes incumbent upon graduate institutions to inform current and former students about a wide-range of career options [7, 10, 12–14].

The move towards transparency about PhD career outcomes has gained momentum in recent years [13, 15–17], yet, the use of divergent taxonomies prevented aggregation and identification of national trends [18–22]. A unified and replicable taxonomy for the biomedical sciences was developed in 2017 by several groups, including the National Institutes of Health Broadening Experiences in Scientific Training (NIH-BEST) grantee consortium, the Association of American Medical Colleges' Graduate Research Education and Training (AAMC GREAT) group, and Rescuing Biomedical Research (RBR). The consortium proposed a common three-tier taxonomy to standardize PhD career outcomes classifications: Tier 1 includes five employment sectors; Tier 2 comprises five career types; and Tier 3 includes 26 job functions [23], as shown in **S1 Appendix**. This taxonomy is flexible enough to adapt to disciplines beyond biomedical sciences and was used to categorize the 914 alumni in this study.

In addition to improved data collection and transparency about Ph.D. career outcomes, new training models and professional development offerings are crucial to helping students make the transition to work environments and cultures outside academia [10, 12, 24, 25]. The research literature indicates that employers look for transferrable skills such as the ability to work in collaborative teams, strong communication and presentation skills, and project management experience. The literature calls on faculty mentors and the graduate training community to strongly encourage mentees to fully explore myriad career options during their graduate studies [26]. Some also suggest the use of professional nonacademic mentors and successful alumni to provide students with guidance throughout a graduate program [24].

Wayne State University (WSU) is a comprehensive research institution with an enrollment that includes 1,500 doctoral students in 75 doctoral programs. Our PhD alumni work as professors, lead research labs, own consulting firms, teach undergraduates and work in executive management in industry and government. Like other academic institutions, our training models have long been based on the assumption that students would pursue tenure-track faculty positions. To gain a granular understanding of career trajectories, the Graduate School launched the 2015 Alumni Census project to collect employment information of doctoral alumni who graduated over a 15-year window from 1999 to 2014 [18]. Analyzing longitudinal data provided us with a deeper understanding of how our alumnus navigate through the early and middle stages of their careers.

In addition to looking at career changes over time, our study also collected demographic information on doctoral alumni so that

we could better understand how race, gender and citizenship status interact with career outcomes. We also examined key metrics associated with academic performance such as GRE scores, cumulative GPA and time-to-PhD degree completion. Traditionally, strong performance in these metrics was believed to be correlated with securing a tenure-track position at a research institution, while lower performers on these types of measures were perceived as accepting positions outside academia at a higher rate; jobs which have been traditionally viewed as less prestigious.

To provide a short- and long-term snapshot, we used the career of the alumnus at the time of the data collection and “binned” these data in aggregate for alumni based on number of years from graduation (0–5 years; 6–10 years; and 10–15 years post-graduation). These aggregated career outcomes data were then classified according to the unified three-tier taxonomy, and used to ask the following questions: (a) in which employment sectors, career types, and job functions are WSU's alumni engaged; (b) is there a distinction between the types of careers pursued based on gender, race and U.S. citizenship status of alumni; and (c) is there a correlation of career outcomes with academic characteristics such as GRE scores, doctoral GPA, and time-to-PhD degree completion?

To our knowledge, this report is unique. It is the first published research to examine doctoral career paths along with the demographics and academic preparedness of alumni in STEM and SBSE. There exists an abundance of literature on STEM career outcomes; however there is less robust information on SBSE career trajectories. This study attempts to close some of those information gaps and shed light on what we anticipate are divergent pathways. Specifically, we assume that STEM alumni, particularly those in engineering, would pursue jobs in business and industry, while SBSE PhDs would follow more traditional paths securing teaching and research positions in academic settings.

Methods & Materials

Alumni Census Project

In 2015 WSU's Graduate School launched an Alumni Census Project in which the current employment information of 496 STEM and 418 SBSE doctoral alumni who graduated from 1999–2014 were collected, as previously described [18]. The departments included in this study and the numbers of alumni surveyed in each are described in Table 1. The information gathered included a direct survey of alumni to indicate their current job placement, as well as information gathered directly from graduate programs and graduate faculty. Alumni were also asked to answer a series of questions about their career trajectories, including information on their first placement, the length of time they have been with their current employer as well as their various job titles over time to provide a rich view of their career progression. The complete survey is in **S2 Appendix**. Self-reported employment data were validated using alumni institutional websites, federal funding agency and publication records, Google, LinkedIn, and other professional social media sites.

Table 1a. STEM Majors

Departments	College of Engineering	College of Liberal Arts & Sciences	Grand Total
Chemical Engineer & Materials Science	58		58
Civil & Environmental Engineering	24		24
Computer Science	4	74	78
Electrical & Computer Engineering	70		70
Engineering Dean	36		36
Industrial & Manufacturing Engineering	53		53
Mathematics		50	50
Mechanical Engineering	65		65
Physics & Astronomy	1	61	62
Grand Total	311	185	496

Table 1b. SBSE Majors

Departments	College of Education	College of Liberal Arts & Sciences	School of Business	School of Social Work	Grand Total
Administrative & Organizational Studies	54				54
Anthropology		12			12
Business Administration			5		5
Economics		38			38
Political Science		22			22
Psychology		197			197
Social Work				3	3
Sociology		34			34
Teacher Education	4				4
Theoretical & Behavioral Foundations	49				49
Grand Total	107	303	5	3	418

Ethical Approval

This project was conducted with approval from Wayne State University's Institutional Review Board on the Use of Human Subjects, IRB#094013B3E.

Data Reporting and Visualization

All data are reported in aggregate or with identifiable information removed. Data in which a group is below 4% are not reported in order to maintain confidentiality and anonymity of the individual(s).

Demographic characteristics used in the study include gender (men and women); race (Asian, Black, White); and citizenship status (U.S. citizen/permanent resident or non-U.S. citizen). The 496 STEM alumni include 106 women (21.4%) and 390 men (78.6%); 291 Asian (58.7%), 188 White (37.9%) and 17 Black (3.4%) alumni; 119 U.S. citizens/permanent residents (24%) and 377 non-U.S. citizens (76%), as shown in Table 2a. The 418 SBSE alumni include 266 women (63.6%), 152 men (36.4%); 307 White (74.5%), 56 Black (13.6%), 49 Asian (11.9%); 353 U.S. citizens/permanent residents (84.4%), and 65 non-U.S. citizens (15.6%), as shown in Table 2b. Note that we report race data in only three categories because the number of alumni in other race categories falls below our 4% reporting threshold. This reduces the number of SBSE alumni included in analyses that consider race from 418 to 412.

Academic characteristics assessed were (a) GRE-Quantitative and GRE-Verbal scores submitted at the time of graduate admission; (b) cumulative GPA at doctoral graduation; and (c) time to doctoral degree completion. For our analysis, GRE Quantitative scores (GRE-Q) are shown in blocks of scores of 137–145, 146–155, 156–166. GRE-Verbal scores (GRE-V) are shown in blocks of scores of 130–145, 146–155, 156–170. Note that the GRE is not a requirement for admission to all programs at WSU, therefore the numbers in these analyses do not total 496 (for STEM) or 418 (for SBSE). Data are expressed as percent of alumni in each score/year range.

Cumulative GPA at time of doctoral graduation is grouped as blocks of 3.0–3.5 GPA, 3.51–3.75 GPA, 3.76–4.0 GPA; and Time-to-Degree completion (TTD) in blocks of 3.5–5.0, 5.1–6.0, 6.1–7, 7+ years. At WSU, average Time-to-Degree for STEM doctoral students is 6.1 years and 6.9 years for SBSE students.

As we examined our data, we realized that the distributions of alumni in each of the three tiers: Employment Sectors, Career Types and Job Functions, change over time. Since most of these changes were seen in 5 year windows, we have depicted all data in three 5 year windows to visualize employment shifts; i.e., Window 1 (0–5 years); Window 2 (6–10 years); and Window 3 (11–15 years) immediately following graduation. Note that in this manuscript, the trajectory of each alumnus over a 15-year time period is not reported. Rather, the overall alumni aggregate employment data are shown in each time window from years following graduation within each of the three tiers at the specific time of the survey.

Outcome analyses were performed using SPSS version 25 (IBM 2018). Chi-Squared (X^2) analyses with follow-up z tests employing a Bonferroni correction were used to test for significantly different proportions of alumni in different Employment Sectors, Career Types, and Job Functions over time. Since time windows contained different sets of participants, between-subjects analyses were conducted. Multinomial logistic regression analyses were then conducted to test for significant interactions between time windows and demographic characteristics. Singularities in the Hessian matrix due to small sample

sizes in some cells prevented valid multinomial analysis. Because of the Hessian matrix violations, Chi-Squared (X^2) analyses were used to test for significantly different proportions of demographic groups within each tier. As with time windows, post hoc z tests with Bonferroni

corrections were used to test for significant effects if the omnibus Chi-square test was significant. Differences among comparison groups were considered to be statistically significant at $p < .05$.

Table 2a. Gender, race, and citizenship status of 15-year STEM doctoral alumni (n = 496)

	Women	Men	Asian	Black	White	US citizen or Permanent Resident	Non-US Citizen
Total (496)	106	390	291	17	188	119	377
Asian (291)	51	240	291	-	-	21	270
Black (17)	6	11	-	17	-	12	5
White (188)	49	139	-	-	188	86	102
US Citizen or Permanent Resident (119)	36	83	21	12	86	119	-
Non-US Citizen (377)	70	307	270	5	102	-	377

Table 2b. Gender, race, and citizenship status of 15-year SBSE doctoral alumni (n =418)

	Women	Men	Asian	Black	White	US Citizen or Permanent Resident	Non-US Citizen
Total (418)*	266	152	49	56	307	353	152
Asian (49)	31	18	49	-	-	18	31
Black (56)	35	21	-	56	-	48	8
White (307)	195	112	-	-	307	281	26
US Citizen or Permanent Resident (353)	231	122	18	48	281	353	-
Non-US Citizen (65)	35	30	31	8	26	-	65

* Note that we report race data in only three categories because the number of alumni in other race categories fall below our 4% reporting threshold. This reduces the number of SBSE alumni included in analyses that consider race to 412 from 418.

In addition, we conducted multinomial logistic regression analyses to test for significant interactions between combinations of demographic characteristics (e.g., gender, race, and citizenship). However, singularities in the Hessian matrix due to small sample sizes in some cells prevented valid multinomial analysis. Chi-Squared (X^2) analyses were also attempted to examine patterns of career outcomes in isolated subsets of alumni; however, small and $n = 0$ cell sizes for some categories resulted in uninterpretable results. Because the patterns of findings appear to be similar for these small groups, we decided to present analyses on each demographic variable (rather than combinations of variables) to yield robust results that could be used as a basis for future investigations. Thus, the analyses presented here focus on patterns of career outcomes within each demographic group for the entire 15-year window. Logistic regression analyses were used to test whether academic characteristics were associated with Employment Sector outcomes. Significance was determined with a p value $< .05$.

Results

15-year career outcomes of WSU's STEM doctoral alumni

Figure 1 shows overall 15-year STEM doctoral alumni career outcomes. Data are presented by tier in three time windows that build from the center of the circle as follows: 0–5 years; 6–10 years; and 11–15 years. In our overall STEM alumni outcomes, not all employment sectors, career types and job functions were equally represented.

For employment sector (Tier 1), overall across the three time periods we found that STEM alumni were almost evenly split between careers in academia (47.2%) and the for profit sector (48.2%). Only a small percentage go on to work in government (4.2%) or nonprofit (.4%) sectors (Figure 1a).

Tier 2 (Career Type) shows that alumni engage in careers that are discipline related (46.2%), primarily research (23.8%), and primarily teaching (23.4%), with a small percent engaged in further training or education (4.2%) and others in careers not related to discipline (2.4%) (Figure 1b).

Fig 1a. Employment Sector

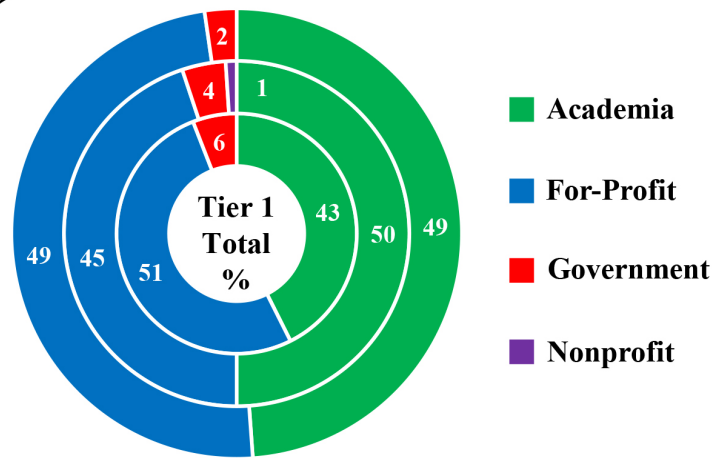


Fig 1b. Career Type

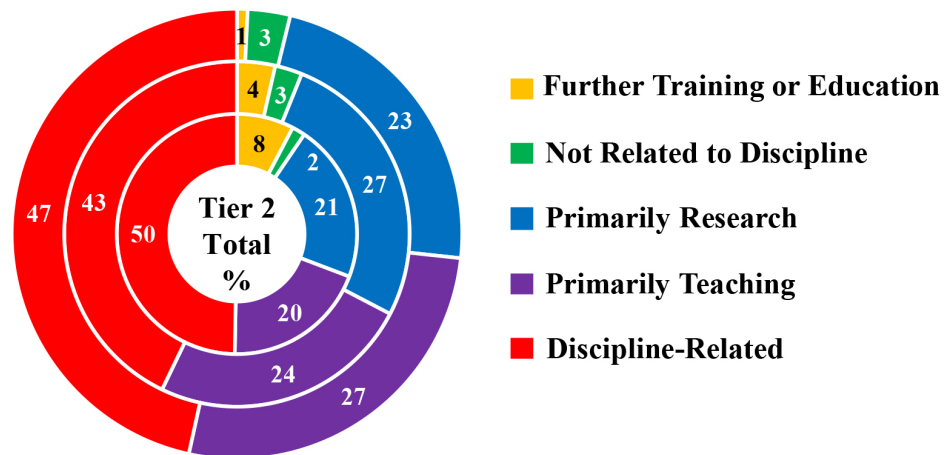


Fig 1c. Job Function

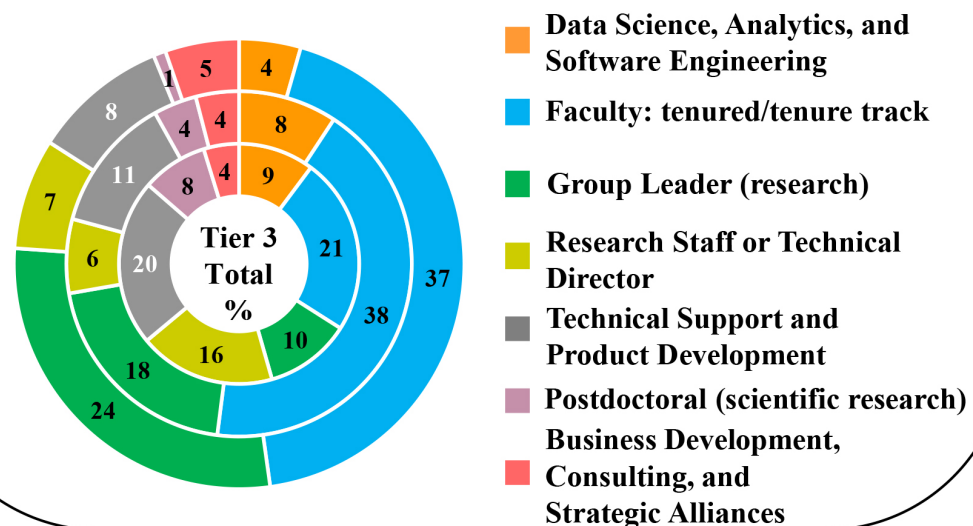


Figure 1. STEM Doctoral Alumni Career Outcomes by Tier

For Tier 3 we find that seven primary job functions describe the work of 87.3% of Wayne State's STEM PhD alumni: faculty (tenured/tenure track) (31.9%), research group leader (16.9%), technical support/product development (13.3%), research staff or technical director (9.7%), and data science, analytics, and software engineering (7.3%), post-doctoral research (4.2%) business development, consulting and strategic alliances (4%) (Figure 1c). The remaining 12.7% of STEM alumni are engaged in other job functions which have fewer than 4% alumni in each.

STEM Demographic Characteristics and Employment Sector (Tier 1)

We analyzed the Tier 1-Employment Sector data as three windows of 5-years each to see if there were significant career shifts over time, or significant differences in career outcome by gender, race or U.S. citizenship status. We find that the pattern of employment sector for STEM alumni did not significantly change over time, $X^2(6, N = 496) = 7.35, p = .29$. However, there was a significant difference between men and women in terms of their sector of employment, $X^2(3, N = 496) = 8.97, p = .03$, with women more likely to hold academic jobs and men more likely to be employed in the for-profit sector, $p < .05$ (Figure 2).

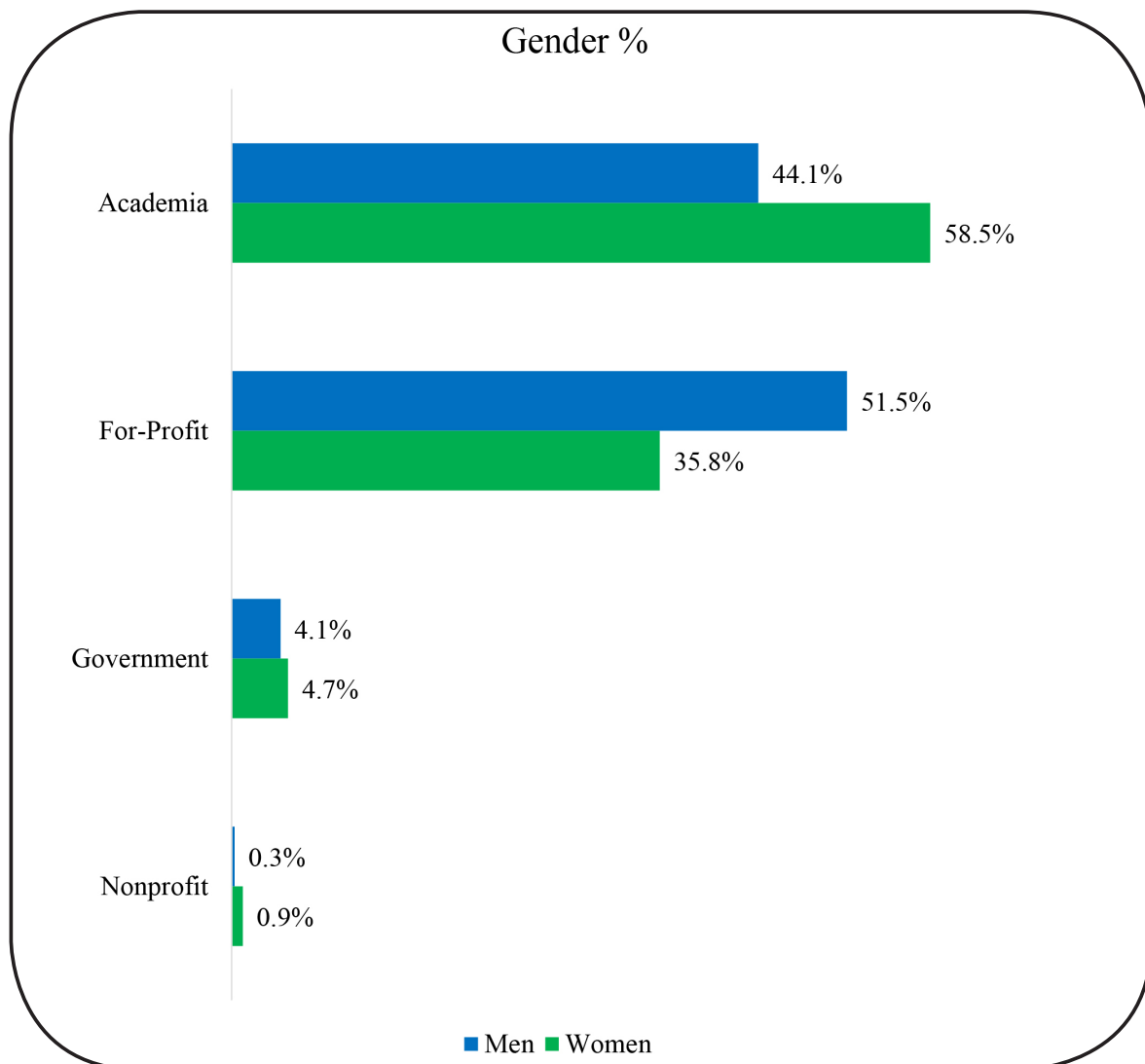


Figure 2. Gender and Employment Sector of STEM Doctoral Alumni

There was also a significant effect of race on employment sector $X^2(6, N = 496) = 19.91, p = .003$. A higher proportion of Asians entered the for-profit sector as compared to Whites ($p < .05$). (Figure 3). There

were no significant differences between U.S. citizen and non-U.S. citizen alumni in the STEM fields, $X^2(3, N = 496) = 1.86, p = .60$.

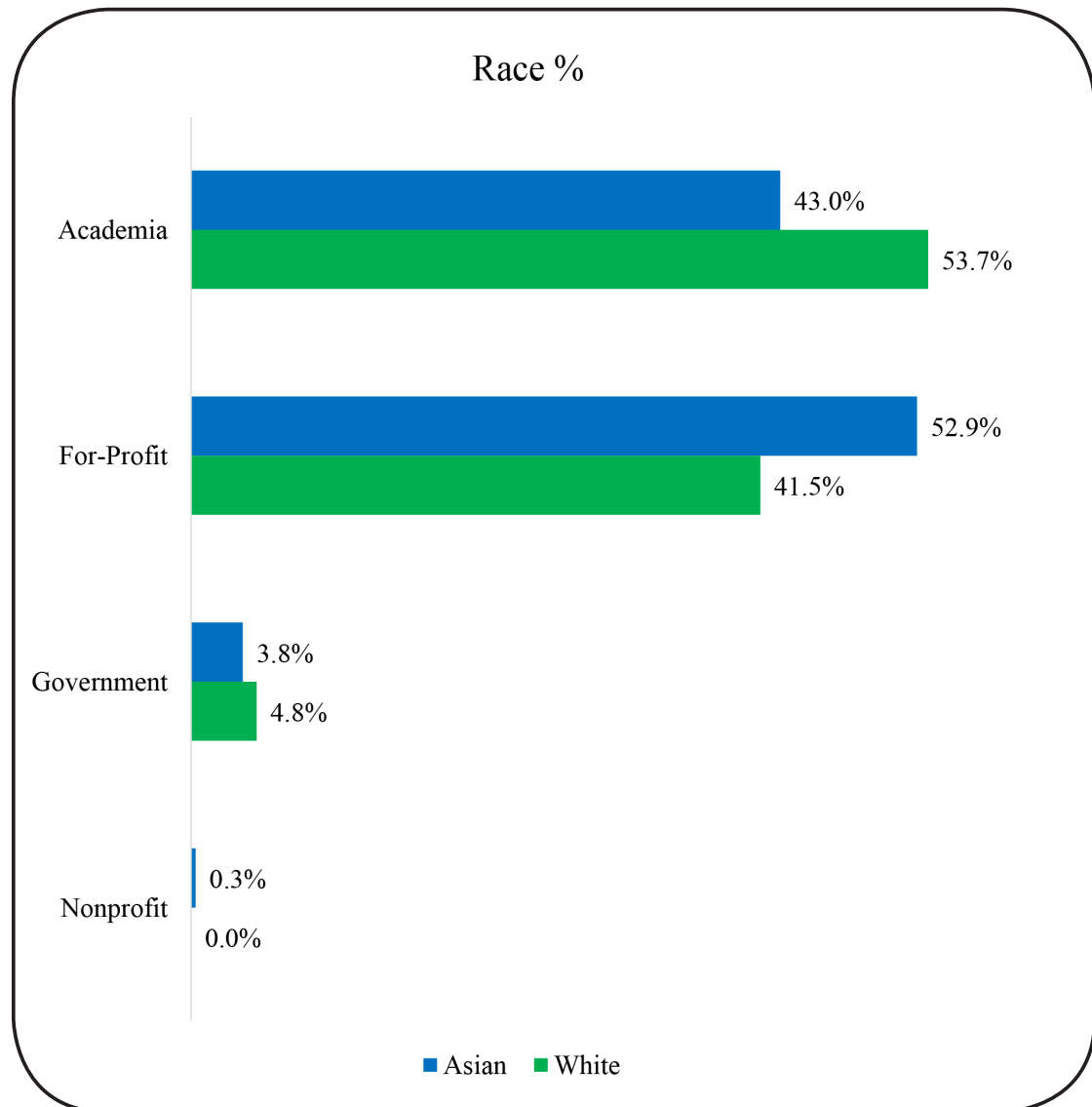


Figure 3. Race and Employment Sector of STEM Doctoral Alumni

STEM Demographic Characteristics and Career Type (Tier 2)

We further analyzed the Tier 2- Career Type data as three windows of 5-years each for total alumni as well as by gender, race, and U.S. citizenship status. As with Tier 1, we find that for STEM alumni, the distribution of career types did not significantly change over time, X^2

(, $N = 496$) = 12.15, $p = .15$. However, men and women differed in their career types, X^2 (4, $N = 496$) = 11.64, $p = .02$. Significantly more women were in primarily teaching careers ($p < .05$), and more men in science-related careers ($p < .05$). (Figure 4). Racial group distributions were similar across Career Types, X^2 (8, $N = 496$) = 6.96, $p = .54$. Career type was not associated with citizenship status, X^2 (4, $N = 496$) = 2.3, $p = .68$.

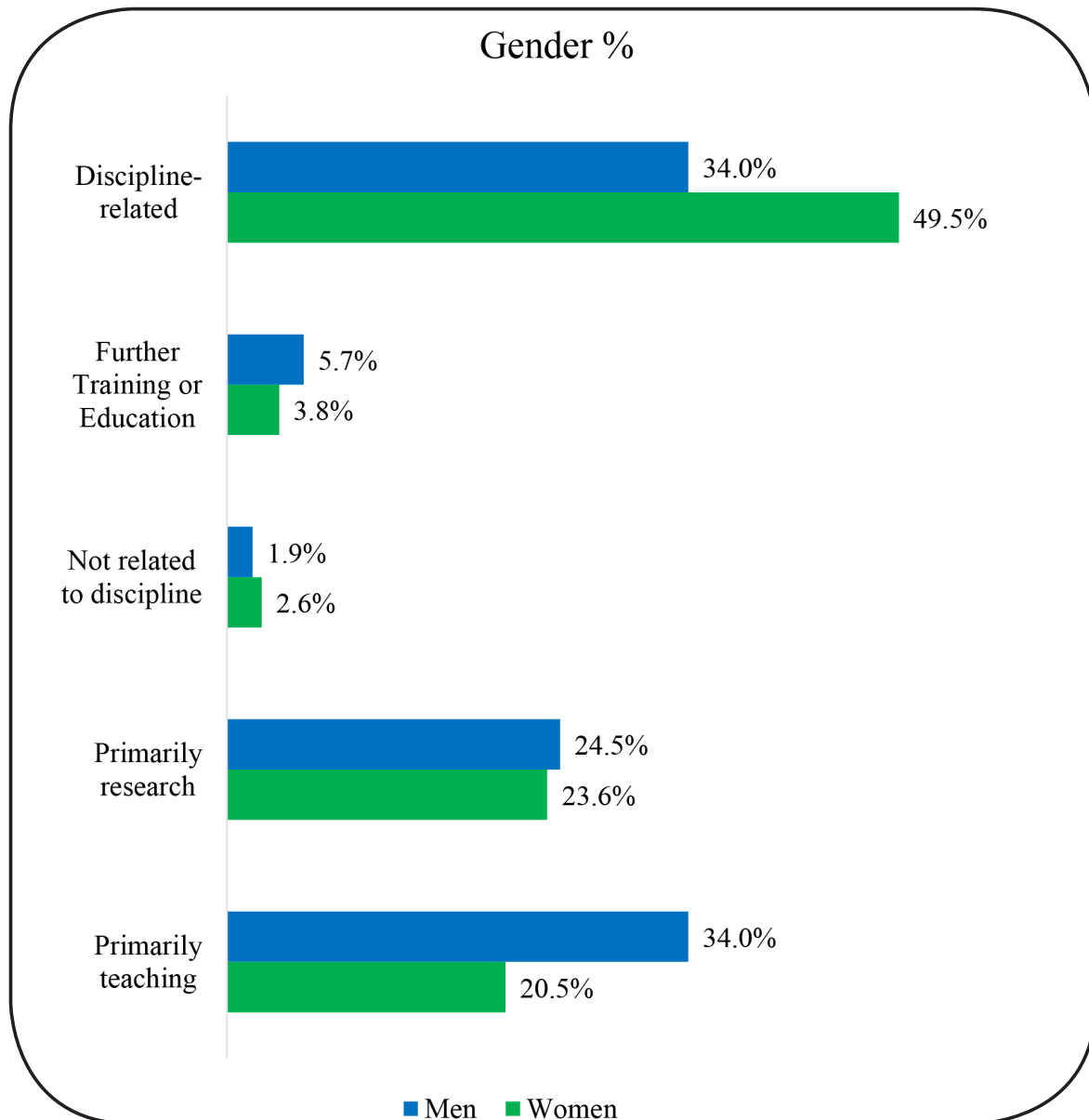


Figure 4. Gender and Career Type of STEM Doctoral Alumni

STEM Demographics and Job Function (Tier 3)

We also analyzed the Tier 3- Job Function data in the same manner as described for employment sector and career type. For this Tier, we found significant changes in the proportions of alumni in different job functions across the different five-year time windows, $X^2(8, N = 392) = 37.38, p = .0001$. Specifically, the proportion of alumni in faculty jobs increased significantly from window 1 (0–5 years) to 2 (5–10 years) ($p < .05$). We believe this shift may reflect a transition where alumni shift from postdoctoral positions or other additional training to faculty positions. Similarly, the number of alumni in group leader (research) jobs increased significantly from window 1 (0–5 years) to 3 (10–15 years) ($p < .05$), whereas the proportion of STEM alumni in data science/technical support and product development jobs declined from window block 1 to 3 ($p < .05$). There was also a

significant decrease in alumni in research staff or technical director jobs from Window 1 to 2 ($p < .05$) (Figure 1c). Again, these shifts can be viewed as part of the expected course of career advancement of Ph.D. holders.

A significant difference was also found between women and men with regard to job function (Figure 5). The significant Chi-square for gender, $X^2(4, N = 392) = 17.58, p = .001$ was accounted for by the fact that women were more likely to hold tenured/tenure track faculty jobs and men were more highly represented in group leader jobs ($p < .05$). (Figure 5). There were no significant racial group differences, $X^2(8, N = 392) = 8.47, p = .39$, or citizenship group differences $X^2(4, N = 392) = 6.29, p = .18$ in job functions.

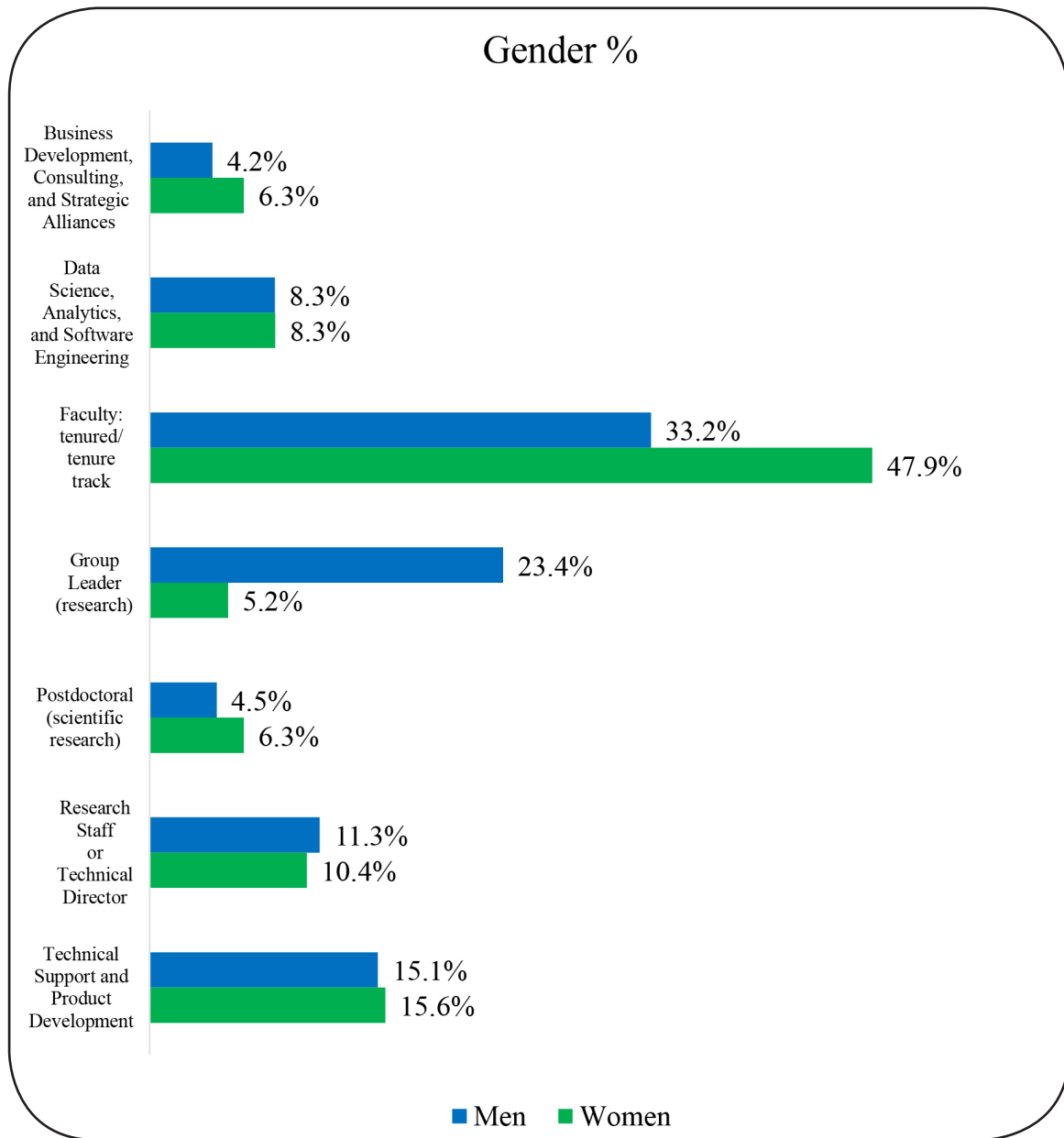


Figure 5. Job Function of STEM Doctoral Alumni by Gender

STEM Academic performance indicators and employment sector

We also examined the association of academic characteristics with the two largest STEM employment sectors: “Academia” and “For-profit.” Participation in other sectors is too small to allow for meaningful comparisons.

There are no statistically significant differences in most of the academic performance indicators examined between alumni who end

up in careers in academia as versus the for-profit sector. There is an equivalent spread of GRE-Quantitative scores, GRE-Verbal scores and cumulative GPA of alumni between these sectors (Figure 6). However, STEM alumni who took longer to complete their degrees were more likely to enter the for-profit sector, $B = .165$, $SE = .049$, $Wald (df = 1) = 11.37$, $p = .001$. A follow-up t-test showed that alumni in the academic sector completed their degrees, on average, in 5.68 years ($SD = 1.68$) whereas alumni in the for-profit sector completed their degrees, on average, in 6.33 years ($SD = 2.30$), $t (471) = 14.88$, $p = .001$.

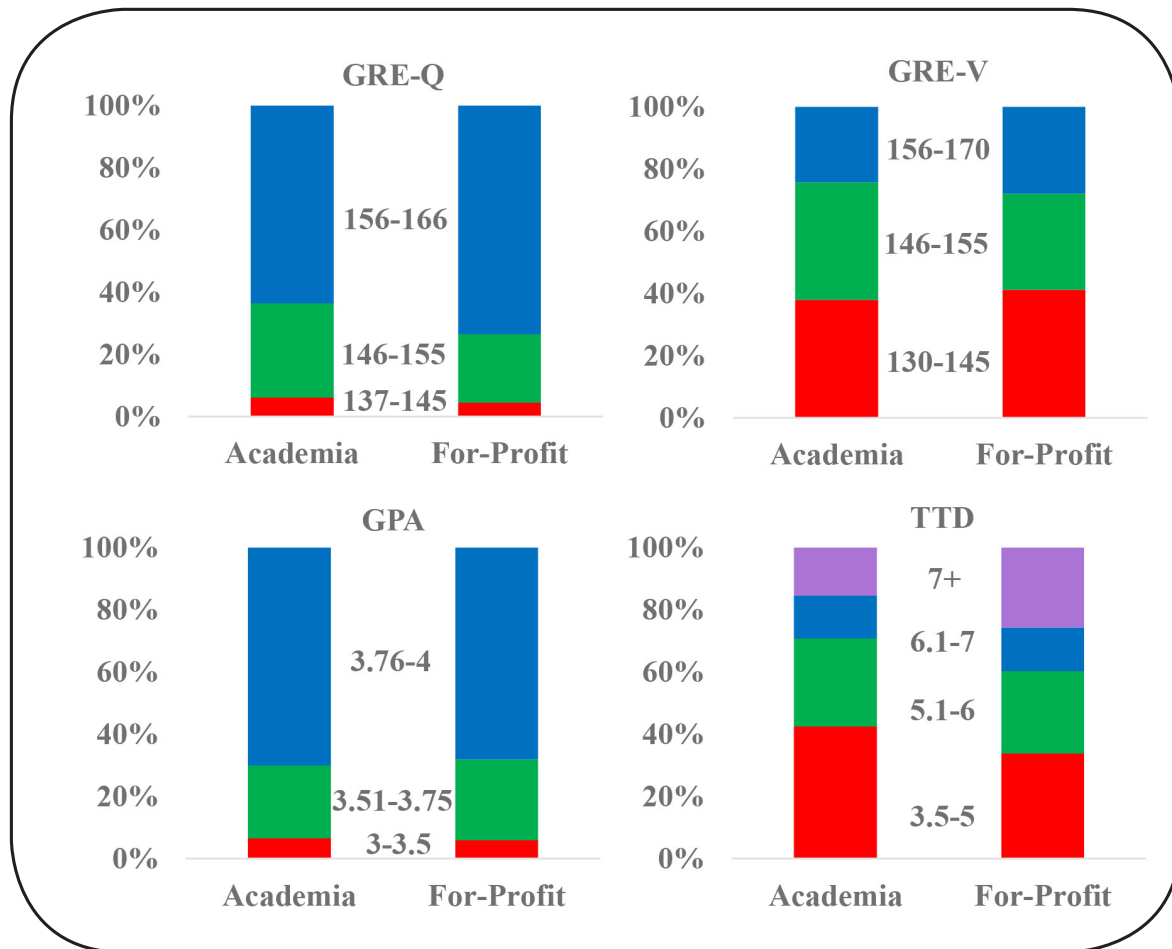


Figure 6. STEM Doctoral Alumni Academic Performance Indicators and Employment Sector

15-year career outcomes of WSU's SBSE doctoral alumni

SBSE alumni outcomes show not all employment sectors, career types, and job functions are equally represented. SBSE alumni data in Tiers 1, 2 and 3 across the three time windows (0–5 years; 6–10 years; and 11–15 years) is summarized (Figure 7).

In Tier 1, we found the majority of SBSE alumni are employed in academia (64.6%) and the for-profit sector (27.5%). The remaining 8.1% work in government (5.0%) and nonprofit (2.9%) sectors (Figure 7a). This is different from STEM alumni, for whom similar percentages worked in academia and the for-profit sector. Still, over a third of SBSE alumni move on to careers outside of academia. Tier-2 (Career Type) shows that alumni engage in careers that are discipline-related (39.2%) and primarily teaching (38.3%). Approximately 18.9% engage in careers that are primarily research and a small percentage in careers not related to their Ph.D. discipline (3.6%) (Figure 7b).

For Tier-3 (Job Functions), we find that seven primary job functions describe the work of 86.1% of WSU's SBSE's alumni: faculty tenure/tenure track (35.9%), healthcare provider (15.1%), administration (11.2%), business development, consulting, and strategic alliances (6.7%), research staff or technical director (6.2%), full-time teaching staff/instructor (6.0%), part-time teaching staff/

adjunct (5.0%) (Figure 7c). The remaining 13.9% of SBSE alumni are engaged in job functions that have fewer than 4% alumni in each.

Demographics Characteristics and Employment Sector (Tier 1)

Approximately 92.1% of SBSE alumni are engaged in either academia or for-profit sectors. For the SBSE alumni, unlike STEM graduates, the pattern of employment sector did not significantly change over time, $X^2(6, N = 418) = 3.96, p = .68$. The percentage of SBSE alumni in academic and for-profit careers appears relatively stable across the three time windows. Note that as discussed earlier, the trajectory of each alumnus over a 15-year time period is not reported. Rather, we show aggregate alumni employment data in each time window grouped by years following graduation. For example, a student who graduated in 2006 would be represented in the 6–10 year block only.

In addition, for SBSE alumni we do not see the same gender and race differences we find for STEM alumni. In SBSE fields, men and women did not significantly differ in employment sector, $X^2(3, N = 418) = 2.11, p = .55$. Racial group distributions were similar across employment sector, $X^2(6, N = 412) = 10.85, p = .09$. Also, as with STEM alumni, employment sector was not associated with citizenship status, $X^2(3, N = 418) = 5.59, p = .13$.

Demographics Characteristics and Career Type (Tier 2)

For SBSE alumni, the majority are split between careers that primarily involve teaching and other discipline-related career types. As in the case of SBSE Tier 1 employment sector, the distribution of career types did not significantly change over time, $X^2 (6, N = 418) = 5.30, p = .51$. There were no significant gender differences in career

types, $X^2 (3, N = 418) = 5.82, p = .12$. Racial group distributions were similar across career types, $X^2 (6, N = 412) = 8.27, p = .22$. Nor was career type associated with citizenship status, $X^2 (3, N = 418) = 4.62, p = .20$. To summarize, career types – whether primarily teaching, primarily research, discipline-related or not related to discipline of study– did not vary for SBSE doctoral alumni with respect to gender, race, or citizenship status.

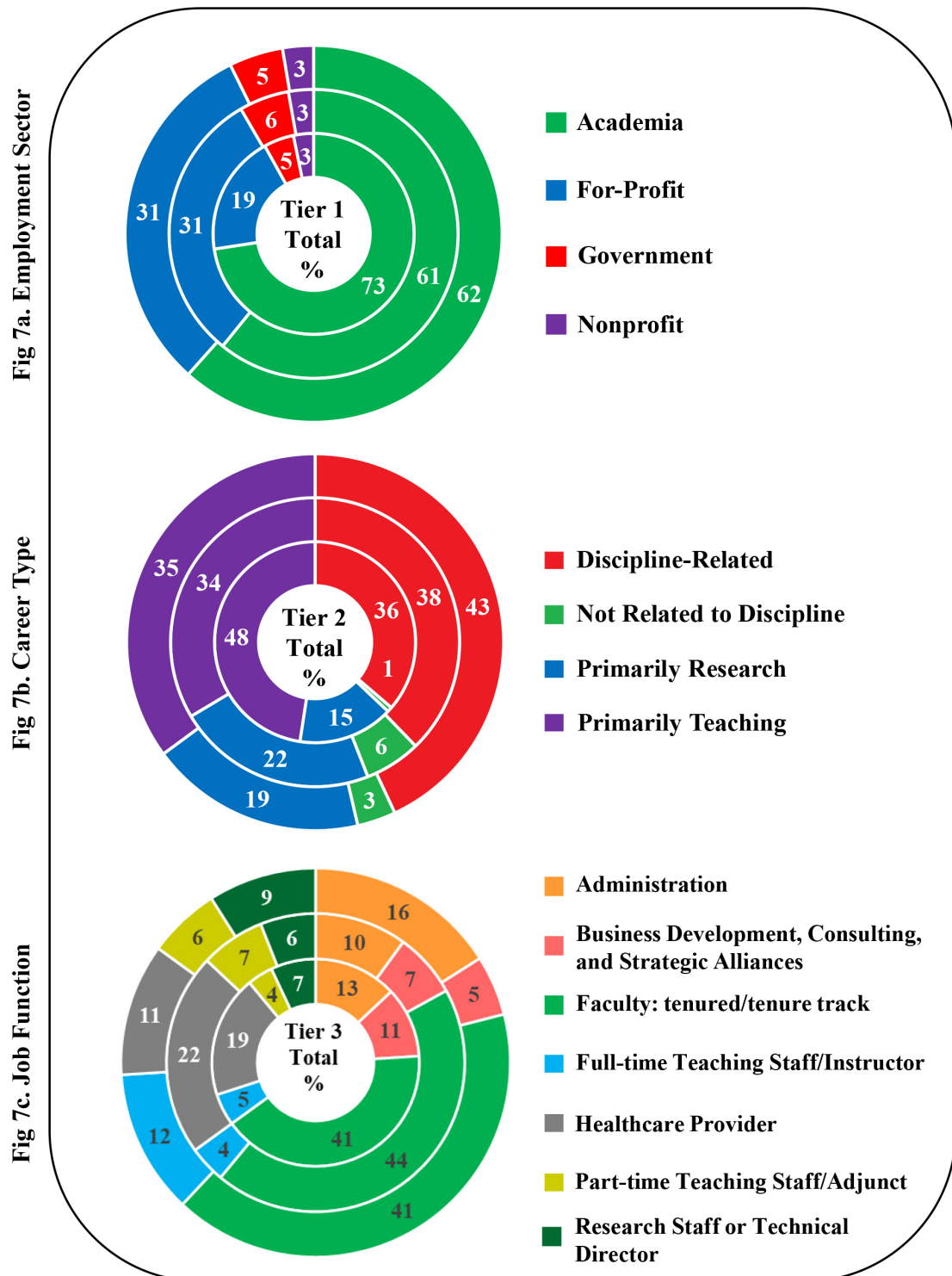


Figure 7. SBSE Doctoral Alumni Career Outcomes by Tier

Demographics Characteristics and Job Function (Tier 3)

For job function, as with employment and career type, we find no statistically significant changes in the proportions of alumni in different job functions over our three time windows, X^2 (12, N =

360) = 13.08 p = .36. However, there was a significant Chi-square for gender, X^2 (6, N = 360) = 13.65, p = .03 in the job function category of healthcare provider. Specifically, our data show that women are more likely to work as health care providers than men. (Figure 8).

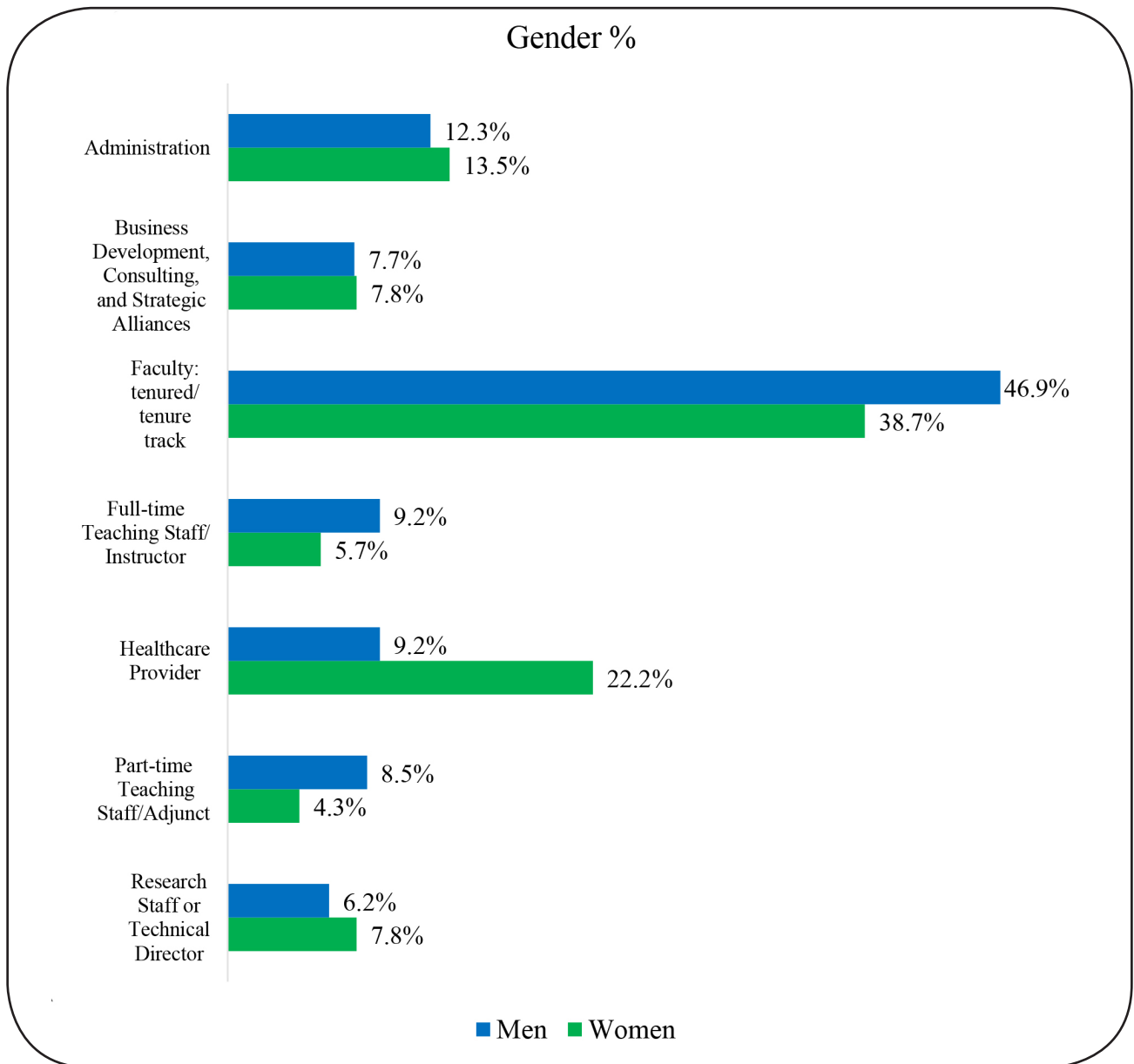


Figure 8. SBSE Doctoral Alumni Job Function by Gender

There were also some significant racial group differences in job functions, X^2 (12, N = 354) = 31.1, p = .002 (Figure 9). White alumni were more likely than Asian alumni to work as healthcare providers. White alumni were also more likely to hold full-time teaching staff/instructor position than Black alumni. Note that Figure 9 depicts the overall percentage of alumni within the seven top job functions with

respect to racial demographics. Although White alumni held 50% of the positions reported for full-time teaching staff/instructor job functions, only 4% of White alumni were represented in this category overall. However, 17% of black alumni are represented in these job functions. There were no significant citizenship group differences in job functions, X^2 (6, N = 360) = 8.35, p = .21.

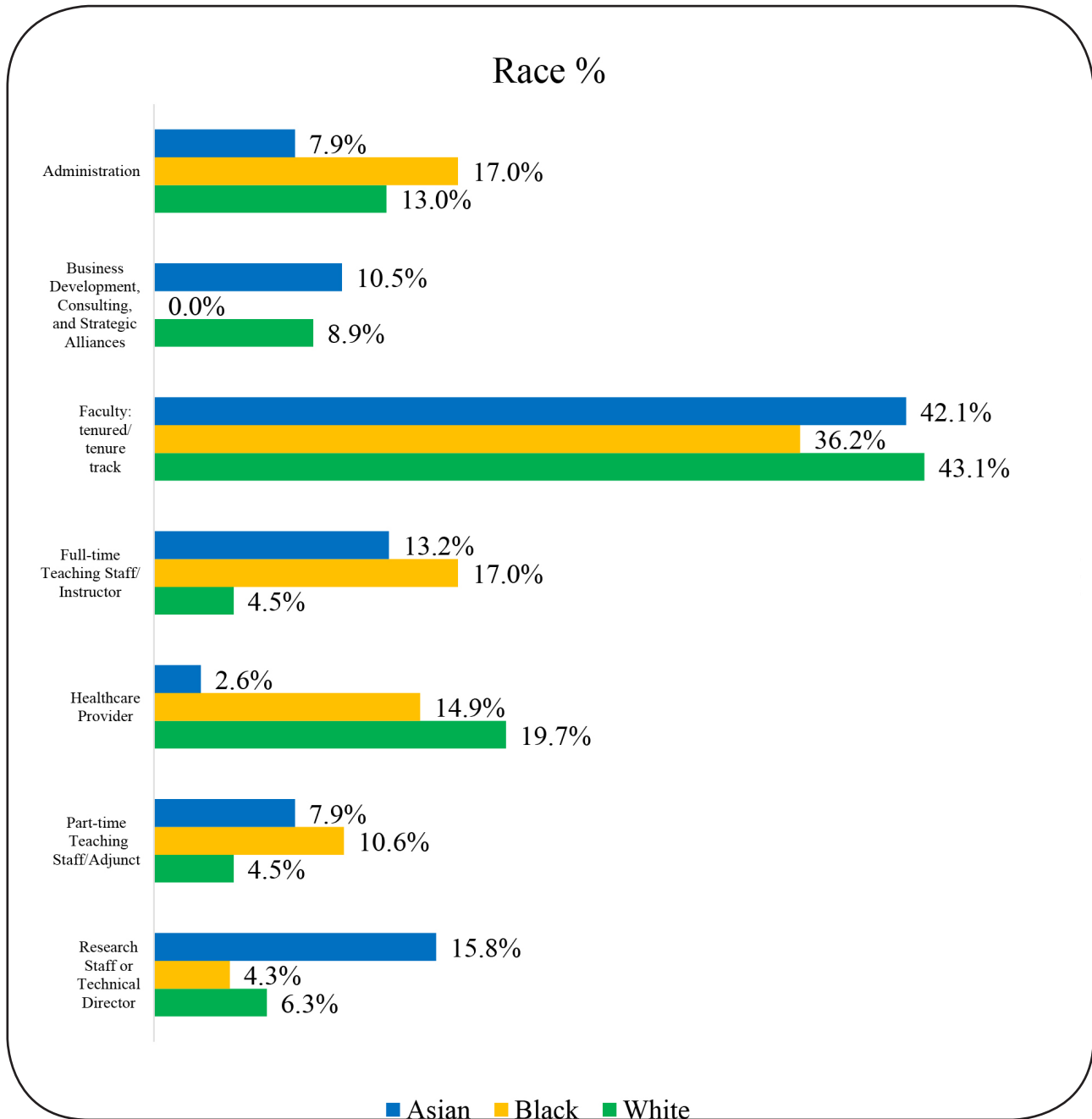


Figure 9. SBSE Doctoral Alumni Job Function by Race

SBSE Academic Performance Indicators and Employment Sector

We examined the association of academic characteristics with career outcomes in only the two largest employment sectors of “Academia” and “For-profit”, since participation in other sectors is too small to allow for meaningful comparisons.

Interestingly, we found no statistically significant differences in any of the academic characteristics examined between alumni in academia and for-profit sectors. An equivalent spread of GRE-Quantitative scores, GRE-Verbal scores, cumulative GPA, and Time-to-Degree completion of alumni between these sectors is shown (Figure 10). Thus, we can conclude that these traditional performance metrics tell us little about what career path our alumni are likely to take.

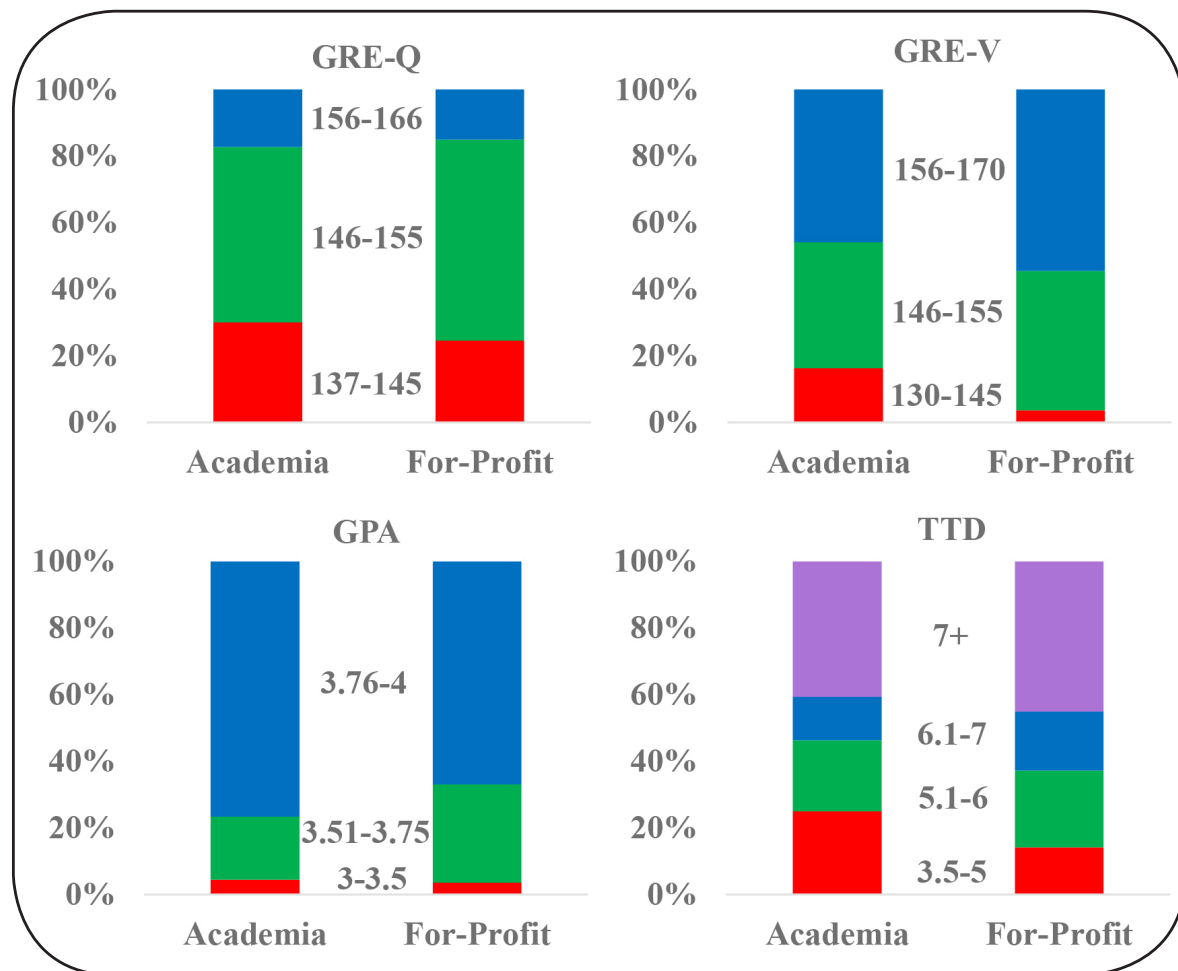


Figure 10. SBSE Doctoral Alumni Academic Performance Indicators and Employment Sector

Discussion

In this paper, we have investigated the 15-year career trajectories of STEM and SBSE doctoral alumni of Wayne State University, a comprehensive research university in Detroit, Michigan. The findings of our study have implications for how higher education institutions approach training and advising for Ph.D. students.

First, our findings confirm exiting studies that show that today's doctoral students pursue diverse career trajectories – not just tenured positions in the academy. This indicates that we should be advising doctoral students in STEM and SBSE fields about diverse career pathways they might pursue after the Ph.D. Universities should take steps to prepare doctoral students for success not just in academia, but in other areas, particularly the for-profit sector.

As suspected, a common theme throughout the data for STEM alumni was the different career paths for men and women. Our findings show that for employment sector and career type, women were more likely to work in academia in primarily teaching roles, while men were more likely to work in the for-profit sector and in science-related positions. This is further reflected in the job function outcomes in which women worked as faculty whereas men pursued positions such as group leader.

The finding that women in STEM fields were more likely to pursue careers in academia is interesting and encouraging. Research has consistently shown that women and minorities are underrepresented in STEM [26]. This trend is reflected in our 15-year Ph.D. alumni data: in STEM fields, the sample included 76% men compared to 24% women (Table 2). The need to increase diversity in STEM fields is an issue that has been identified at both the national level and at Wayne State [27]. Recognizing these disparities, WSU has actively sought to increase the representation of women and minorities in STEM fields through programs such as the NIH BUILD (Building Infrastructure Leading to Diversity) program, Wayne Med Direct and the Postdoctoral to Faculty Transition (PFT) fellowship. WSU provides support and training to current students and early career scholars to produce a pipeline of underrepresented students for doctoral training and faculty positions in a range of disciplines [28].

As expected, the data does suggest that a majority of SBSE alumni follow more traditional pathways with alumni securing academic positions at greater levels than those in STEM disciplines. Overwhelmingly, SBSE alumni are working in academia, in both tenured/ tenure-track positions and non-tenured roles (adjuncts or full-time instructors). We found that White alumni are more likely to hold non-tenure track positions than Asians and Black alumni.

The percentage of SBSE alumni in non-tenured roles can be viewed from a number of different perspectives. On one hand, part-time and adjunct teaching offer less job security and upward mobility than tenured/tenure-track positions. However, some PhDs, such as those embarking on a second career or preferring a part-time position, may view non-tenured positions as offering more flexibility.

In conclusion, both STEM and SBSE students will clearly benefit from early advising about diverse career pathways. There are some statistically significant gender differences and a few differences by race, but, in general, our research demonstrates that Ph.D. students of diverse backgrounds seek a wide array of career pathways. Citizens and non-citizens are equally likely to pursue a variety of career tracks and job functions.

Furthermore, any preconceived notions that graduate schools, graduate program or faculty advisors might hold about who might and might not succeed in the “traditional” tenure/tenure-track academic career based on academic performance metrics should be discarded. Students with higher and lower scores on traditional academic metrics used to evaluate applicants and evaluate student progress to degree show practically no difference in terms of the likelihood that alumni will pursue different types of careers.

For graduate schools, data on the career trajectories of doctorate holders should shape training and advising. For doctoral students and Ph.D. holders, transparency about diverse career pathways can help them to envision and explore career paths that best fit their interests and needs. We hope that attention to these matters will alleviate some of the stress inherent in the pursuit of a Ph.D. and contribute to higher rates of career satisfaction and well-being for doctoral alumni over the course of their careers.

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Appendix S1: Three Tier Taxonomy

Tier 1: Employment Sectors	Tier 2: Career Types	Tier 3: Job Functions
Academia	Primarily Research	Administration
Government	Primarily Teaching	Business Development, Consulting, and Strategic Alliances
For-Profit	Science-related	Clinical Research Management
Nonprofit	Not-related to science	Clinical Services
Other	Further training or education	Data Science, Analytics, and Software Engineering
		Entrepreneurship
		Faculty: non-tenure track
		Faculty: tenured/tenure track
		Faculty: track unclear or not applicable
		Full-time Teaching Staff/Instructor
		Group Leader (research)
		Healthcare Provider
		Intellectual Property and Law
		Part-time Teaching Staff/Adjunct
		Postdoctoral Research
		Regulatory Affairs
		Research Staff or Technical Director
		Sales and Marketing
		Science Education and Outreach
		Science Policy and Government Affairs
		Science Writing and Communication
		Technical Support and Product Development
		Completing further education or training
		Other
		Deceased/retired

Appendix S2

Census_2015

Start of Block: Demographic Block

Q1 Wayne State University Graduate School Alumni Census

Q2 Demographic information on File:

Last Name: `${m://LastName}`

First Name: `${m://FirstName}`

ID: `${e://Field/ID}`

If your name has changed since you graduated, your name while you were at WSU:

`${e://Field/LastName}`

preferred email address: `${m://Email1}`

Current Address: missing

Q3 Graduate Degree Information (if you received more than one WSU degree, the most recent degree will be listed):

Department/Program: `${e://Field/DEPARTMENTDESC}`

Degree Awarded: `${e://Field/DEGREE}`

Degree Date: `${e://Field/ACADEMIC_PERIOD_GRADUATION}`

Q4 Please update the following parts of my contact information: (you will be prompted to provide information for any field you indicate)

☐ name (1)

☐ email address (2)

☐ postal address (3)

☐ department/degree information (6)

☐ nothing to change (4)

Q5 I use LinkedIN to maintain my professional social network?

☐ Yes (1)

☐ No (2)

Q6 I wish to stay connected with WSU through LinkedIN. My profile name is...



Q7 I do not wish to be contacted by WSU in the future (opt out from future mailings or surveys).

☐ True (1)

☐ False (2)

Page Break _____

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = name

Q8 Last Name:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = name

Q9 First Name:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = name

Q10 Middle Name:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = email address



Q11 Preferred email address:

Page Break

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = postal address

Q12 Address Line 1:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = postal address

Q13 Address Line 2:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = postal address

Q14 Address Line 3:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = postal address

Q15 City:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = postal address

Q16 State:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = postal address

Q17 Zipcode:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = postal address

Q18 Country:

Display This Question:

If Please update the following parts of my contact information: (you will be prompted to provide inf... = department/degree information

Q19 Please indicate what is in error about the degree information listed.

Page Break

End of Block: Demographic Block

Start of Block: Short Form

Q20 Short Form Census:

Q21 Current data WSU has on file regarding your employment:

Current Employer: \${e://Field/currentemployer}

At current employer since: **MISSING**

Current Job Title: \${e://Field/currentjobtitle}

In current job title since: **MISSING**

Field in which you work: **MISSING**

Geographic local: **MISSING**

Q22 Is all of the information listed above correct and current?

☐ Yes (1)

☐ No (2)

Q23 Which of the following categories best describes your current employment status?

▼ - (1) ... Other (9)

Q24 Which statement best categorizes the terms of your employment?

▼ - (1) ... Currently employed but seeking employment (8)

Display This Question:

If Is all of the information listed above correct and current? = No

Q25 Current employer

Q26 In what year where you hired by current employer?

▼ - (1) ... 2015 (22)

Q27 Current job title:

Q28 In what year did you assume your current job title?

▼ 1995 (1) ... 2015 (21)

Q29 Which answer best describes the geographical location of employer

▼ Detroit (1) ... other (12)

Q30 Employer category:

▼ - (27) ... other (26)

Q31 If you listed the employer category as other, please elaborate.

Page Break

End of Block: Short Form

Start of Block: Long Form

Q32 Additional Questions for Long Form Census:

Q33 You have been randomly selected to complete the long-form of the PhD alumni census. If you are willing, the additional questions will take about 10 minutes to complete. The longer version asks more detailed questions about how your training at Wayne State prepared you for your first position after graduate school as well as your current position. We will use these data to help us improve our doctoral programs.

Are you willing to complete the longer questionnaire?

- ☐ Yes - I agree to complete the long version (1)
- ☐ No - I would rather stop here (2)

Skip To: End of Block If You have been randomly selected to complete the long-form of the PhD alumni census. If you are wi... = No - I would rather stop here

Page Break

Q34 Were you unemployed and looking for work at any time during 2014?

☐ Yes (1)

☐ No (2)

Q35 Which category best describes your residency status while at Wayne State University?

☐ Native U.S. Citizen (1)

☐ Naturalized U.S. Citizen (2)

☐ Canadian Citizen (3)

☐ permanent resident/green card holder (4)

☐ Student Visa (5)

☐ Spousal Visa (6)

☐ Other visa type (7)

Q36 Which category best describes your current residency status?

- ☐ Native U.S. Citizen (1)
- ☐ Naturalized U.S. Citizen (2)
- ☐ Canadian Citizen (3)
- ☐ Permanent resident/green card holder (4)
- ☐ Student Visa (5)
- ☐ Spousal Visa (6)
- ☐ Other visa type (7)
- ☐ Living or working outside of the U.S. (8)

Page Break

Q37 On a scale of 1 to 5, rate whether you agree or disagree with the following statements:

Q38 I have held ____ employment positions since leaving Wayne State.

▼ 0 (1) ... 10+ (8)

Q39 Immediately after graduate school I...

▼ - (1) ... other (please specify) (11)

Q40 Please specify:

Q41 I held my first position after WSU for ____ year(s).

▼ 0 (1) ... 10+ (6)

Q42 I have been in my current position for ____ year(s).

▼ 0 (1) ... 10+ (6)

Page Break

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
I enjoyed my time in graduate school at Wayne State. (1)	☐	☐	☐	☐	☐
My Ph.D. advisor respected me as a student and a colleague. (2)	☐	☐	☐	☐	☐
My Ph.D. advisor acted in my best interests to help me develop in my field. (3)	☐	☐	☐	☐	☐
The Ph.D. program requirements were clearly explained to me. (4)	☐	☐	☐	☐	☐
The courses I took at WSU provided me with background necessary to perform my research. (5)	☐	☐	☐	☐	☐
The courses I took at WSU provided me with material needed to pass my qualifying exam. (6)	☐	☐	☐	☐	☐
My experience at WSU prepared me well for my first position after graduate school. (7)	☐	☐	☐	☐	☐
My training at WSU prepared me well for my current position. (8)	☐	☐	☐	☐	☐
I would recommend my program at WSU to a friend, colleague or advisee. (9)	☐	☐	☐	☐	☐

Relative to new graduates I met from other Ph.D. programs, my presentation skills were better than theirs, thanks to my experience at WSU. (10)

☐☐☐☐☐

Relative to new graduates I met from other Ph.D. programs, my writing skills were better than theirs, thanks to my experience at WSU. (11)

☐☐☐☐☐

Relative to new graduates I met from other Ph.D. programs, my disciplinary skills were better than theirs, thanks to my experience at WSU. (12)

☐☐☐☐☐

Relative to new graduates I met from other Ph.D. programs, my critical thinking skills were better than theirs, thanks to my experience at WSU. (13)

☐☐☐☐☐

The facilities at WSU were better than those I have had the opportunity to use in my post-Wayne positions. (14)

☐☐☐☐☐

Were I in a position to hire a Ph.D., I would look favorably on a WSU Ph.D. recipient for that position. (15)

☐☐☐☐☐

People in my company/university/place of employment who are in a position to hire new Ph.D. recipients look favorably on WSU alumni such as myself. (16)

☐☐☐☐☐

If I had the opportunity to do it over again, I would still have pursued a Ph.D. in my chosen field. (17)

☐☐☐☐☐

If I had the opportunity to do it over again, I would have still have gotten my Ph.D. from Wayne State? (18)

☐☐☐☐☐

End of Block: Long Form

Start of Block: Submit form

Q43 Please share with the Graduate School anything about your significant achievements or accomplishments since Wayne State?

Q44 The Graduate School is interested in using the alumni network to help mentor new doctoral students through graduate professional development activities. Would you be interested in interacting with current doctoral students or recent alumni through career panels or other related activities?

☐ Yes (1)

☐ No (2)

Q45 Do you have any feedback that you would like shared anonymously with the faculty of your graduate program or the graduate school in general?

Q46 Submit Survey?

☐ Yes (1)

☐ No (2)

End of Block: Submit form
