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Influences to Post-graduation Career Aspirations and Attainment in STEM Doctoral Candidates and Recipients

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ABSTRACT

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As the realities of the academic job market have forced some PhD recipients to accept less-preferable position types, there has been increasing concerns that these students are not prepared for their careers, especially in STEM fields. However, aside from the labor market, few studies have explored the influences on career aspiration and attainment among doctoral degree holders. This study utilized the socialization theory framework to identify aspects of the doctoral education process that are predictive of the likelihood of certain career aspirations among science and engineering doctoral candidates and career attainment among STEM doctoral recipients by utilizing nationally representative datasets: The National Research Council's Assessment of Research Doctorate Programs student questionnaire and the National Science Foundation's Survey of Earned Doctorates. This study identified field of study, research productivity rank of doctoral programs, primary type of finding doctoral students received, level of satisfaction with research experiences, and their sense of belonging within their doctoral program as factors that predict the likelihood of certain career aspirations compared with a career in education. Doctoral candidates' background characteristics that were significant predictors of career aspirations were gender, marital status, dependent status, race, age, and citizenship status. Further, this study identified participant's field of study, the Carnegie Rank of institutions attended, primary type of funding received, length of time to PhD, gender, marital status, dependent status, race, citizenship stats, and age as factors that predict the likelihood of the career outcomes investigated in this study, including doctoral recipients' employment field and primary work activity.

INFLUENCES TO POST-GRADUATION CAREER ASPIRATIONS AND ATTAINMENT IN STEM DOCTORAL CANDIDATES AND RECIPIENTS

by

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TABLE OF CONTENTS

Chapter 1: Introduction **1**
Introduction 1
Statement of the Problem 5
Theoretical Framework 7
Study Rationale 9
Research Questions 14
Contributions 15
Conclusions 16
Chapter 2: Literature Review **18**
Theoretical Framework 18
Context of Graduate Education in STEM Fields 24
Career Aspirations and Outcomes 41
Conceptual Model 46
Chapter 3: Methods, Data, and Analysis 51
Description of Data 52
Description of Data, Research Question 1 53
Data Preparation 59
Analysis 60
Measurements/ Definitions 61
Research Design, Question 1A 71
Research Design, Question 1B 72
Research Design, Question 1C 74
Description of Data, Research Question 2 75
Data Preparation 78
Analysis 80
Measurements/ Definitions 81
Research Design, Question 2A 90
Research Design, Question 2B 92
Research Design, Question 2C 93
Chapter 4: Results, Career Aspirations **96**

Influences to Career Aspirations ... 96
Influences to Academic Career Aspirations ... 104
Influences to Nature of Career ... 114
Chapter 5: Results, Career Attainment ... 125
Influences to Career Attainment ... 125
Influences to Employment Field ... 137
Influences to Primary Work Activity ... 157
Chapter 6: Discussion, Implications, and Future Research ... 172
Discussion ... 172
Implications for Graduate Education ... 167
Limitations of the Research ... 183
Directions for Future Research ... 187
Appendix 1 ... 195
Literature Cited ... 197
***Curriculum vitae* ... 211**

LIST OF ILLUSTRATIVE MATERIALS

Figures

Figure 1: Conceptual model guiding research question1…………………………….………...49

Figure 2: Conceptual model guiding research question 2…………………….………...…50

Figure 3: Schematic representation of data sources…………………………………….52

Tables

Table 1: Dependent variables included in the models to address research question 1…………………………………………………………………………….………..62

Table 2: Independent variables included in the models to address research question 1…………………………………………………….………………………….…..64

Table 3: Sample research rank quartile calculation………………..………………………....66

Table 4: Description of the dependent variables utilized to address research question 2……………………………..………………………………………………...82

Table 5: Independent variables included in models to address research question 2 ………...83

Table 6: Cross-tabulation of nature of career with each nominal level independent variable…97

Table 7: Descriptive statistics of independent variables included in models to address research question 1………………………………………………………………………….99

Table 8: Multinomial logistic regression model of doctoral program experiences on the likelihood of certain academic career aspirations…………………………….……100

Table 9: Cross-tabulation of academic career aspirations and each nominal level independent variable………………………………………………………………………….106

Table 10: Multinomial logistic regression model of doctoral program experiences on the likelihood of certain academic career aspirations……………………………………109

Table 11: Cross-tabulation of nature of career with each nominal level independent variable……………………………………………………….................……...116

Table 12: Multinomial logistic regression model of doctoral experiences on participants' likelihood of certain primary career activities………………………………….……119

Table 13: Frequency and percent of career attainment, employment field, and primary work activity……………………………………………………………………………..126

Table 14: Descriptive statistics of continuous independent variables………………………….127

Table 15: Cross-tabulation of career attainment with each nominal level independent variable……………………………………………………………………...………..128

Table 16: Multinomial logistic regression model of doctoral institution and program characteristics and doctoral experiences on the likelihood of career attainment……….132

Table 17: Cross-tabulation of employment field with each nominal level independent variable……………………………………………………………………………….139

Table 18: Multinomial logistic regression model of effect of doctoral program and institution characteristics, and doctoral experiences on the likelihood of employment in certain fields………………………………………………………………………………….145

Table 19: Cross-tabulation of primary work activity and each nominal level independent variable……………………………………………………………………………….159

Table 20: Multinomial logistic regression model investigating the influences of doctoral program experiences on primary work activity…………………………………………..……164

CHAPTER 1: INTRODUCTION

Introduction

In the United States, 100,000 doctoral students received their degrees from 2005-2009, during that time frame, only around 16,000 new professoriate positions became available (Hacker & Dreifus, 2010). While the lack of academic positions alone may be enough to deter some students from following in the footsteps of their doctoral advisors, 54% of doctoral students surveyed by Golde and Dore (2001) aspire to work in research intensive universities as professors. The majority of these aspirations will never come to fruition, and in fact, many of these PhD holders will feel fortunate to simply be employed, regardless of the institution or type of position. However, aside from the labor market, few studies have explored the influences on career aspirations and attainment among doctoral holders, especially in science and engineering fields (Hill, Corbet & St. Rose, 2010; National Science Foundation, 2011).

Career prospects for PhD recipients are shaped by the current labor market, including the demand for higher education services and the supply of qualified individuals suited for those positions. Toukoushian (2003) outlined some of the significant factors shaping the academic labor market as the "state of the economy, the demand for post-secondary education among high school graduates, and federal support for university research" (p. 264). Additionally, changes in demand in non-academic labor markets also indirectly affect the employment conditions in certain fields.

According to the National Science Foundation's Science and Engineering Indicators (2012), the number of doctoral recipients in the science and engineering fields has increased 29.1% in the years between 1999 and 2006. Further, only slightly more than 25% of doctoral recipients are employed in tenure- track positions 4-6 years after the receipt of their doctorate (NSF, 2012). The number of full-time, tenure-track faculty positions in science and engineering has experienced a 16% decrease over the past 30 years. However, postdoctoral positions, especially at research universities are growing in availability (National Science Foundation, 2011). While the number of post-doctoral training positions is experiencing growth in alignment with the increased number of doctoral recipients, the number of full-time faculty positions is decreasing. This creates a large pool of applicants for every position that becomes available, whether it is a new position or replacing a retiree, which creates a high degree of competition. Due to the fact that many PhDs are unable to attain academic work, many critics are referring to the root of the problem as the overproduction of doctoral recipients (Deresiewicz, 2011).

Some of the increase in doctoral enrollment has been blamed on rhetoric in the public media from the National Science Foundation and other groups that there was an impending "wave of retirement about to sweep through academia, and that the academic job prospects for emerging PhDs had never been brighter. In fact, the economic assumptions that formed on the basis of this prediction were erroneous, and no such wave of retirement took place" (Fiske, 2001, p 381). The perceived job market influences the decision to enter graduate school and may also influence attrition. If students perceive they will not be able to get a job, they may consider the utility (or not) of completing their degree, and depart graduate school early. High rates of attrition (more than 50%) from doctoral studies have been cited as a major issue plaguing doctoral education (Golde, 2005). However, the need for universities to continue to make use of graduate student labor pools may outstrip their desire to decrease rates of attrition. Doctoral recipients in some fields, particularly science and engineering, continue to provide cheap labor in the years following their degree completion. For example, according to the *Science and*

Engineering Indicators 2010, in science, technology, engineering, and mathematics (STEM) fields, approximately 46% of doctoral recipients complete at least one post-doctoral appointment, representing a 12% increase in the total number of post-doctoral positions in recent years (National Science Foundation, 2011). Post-docs continue the tradition of cheap labor in the sciences, with a mean salary of $38,000 in 2011 per year, while providing important research functions for universities.

The funding climate of research, especially in the sciences, has encouraged growth in the market for graduate students, regardless of the status of the academic job market for professors. Graduate students fill important niches for universities, including teaching undergraduate service courses and laboratories, and fulfilling contractual research requirements on grant-funded projects for their doctoral advisors. At a time when many universities are downsizing their tenure-track professor pools (June, 2012), graduate students have become increasingly important as cheap labor, alongside the ranks of adjuncts hired to teach lecture courses. As *The Economist* (2010) points out, graduate students are paid approximately $20,000 to teach courses over 9 months, while the average pay of full professors was $109,000 in 2009.

It is important to consider why so many students are entering graduate school with the hopes of attaining a PhD. Although some students have described their reason for embarking on doctoral studies as personal or professional development, others have cited simply to continue life as a student as their reason (Leonard, Becker, & Coate, 2005; The Economist, 2010). Aside from enjoying student life, career prospects at the time of undergraduate graduation also have a strong influence on this decision (Bedard & Herman, 2008; Fisk, 2011). In the sciences particularly, doctoral students receive a stipend and benefits package to continue their studies, making the continuation of school an economically viable choice for individuals in certain fields (Bedard & Herman, 2008).

Perna (2004) suggests that the decision to enroll in a post-baccalaureate program is a function of sex, race, expected costs and benefits, financial and academic resources, and cultural and social capital. Her study of over 5,000 individuals measured the expected costs and benefits to individuals enrolling in graduate study as the opportunity cost of foregone earnings of typical starting salaries. Participants' marital and parental status was also considered, as this is influential in enrollment decisions. Financial and academic resources, including the amount of undergraduate debt incurred, parental financial support, and academic ability and achievement were also included as influential factors on graduate enrollment. Measures of cultural and social capital measured in this study included parent's highest level of education, perceived levels of career success, quality of life, the value of doing intellectual work, and the Carnegie classification of the participants' bachelor's degree-granting institution. This rank reflects the institutional emphasis on research and graduate education, which may be influential in students' enrollment patterns.

Perna (2004) concludes that measures of social and academic capital are statistically significant indicators of doctoral enrollment, including the Carnegie classification of undergraduate institution attended. Academic capital, as measured by students' ability, was significantly related to the likelihood of enrollment in graduate or professional school. However, the opportunity cost of attending graduate school, as measured by foregone salary was not found to be a significant indicator of enrollment. Perna's (2004) work focused specifically on how gender and race relate to enrollment in graduate school, and did not include measures of students' field of study. However, her sample of over 5,000 individuals likely included individuals in STEM fields. Doctoral enrollment has been shown to vary according to undergraduate major, GPA, gender, race, and the national unemployment rate (Bedard & Herman, 2008).

Statement of the Problem

While the majority of PhD recipients may prefer to work at research intensive universities, the number of academic positions available at such institutions is far less than the number of PhD recipients (Trautmen, 2008; Austin, 2010). Due to the increasing number of doctoral recipients, and decreasing number of full-time faculty positions, more and more PhDs are taking jobs in industry as well as with state and federal governments (National Science Foundation, 2011). As the realities of the academic job market have forced some PhD recipients to accept less-preferred position types, there has been increasing concerns that these students are not prepared for their careers, especially in STEM fields (Austin, 2010).

The concerns about the preparedness of doctoral recipients have resulted in calls to reform the current model of doctoral education, including bolstering the amount and type of preparation that students receive to become effective educators, work in interdisciplinary teams, and effectively problem-solve (Austin, 2010; Grasgreen, 2010). These calls to reform doctoral education have come from varied audiences, increasing the faction of groups involved in discussing the goals, purpose, and success of doctoral programs to include "national organizations, government and private agencies, professional societies, foundations, individual institutions, and individuals inside and outside the academy" (Nyquist, 2002, p. 14). However, there has been little discussion as to whether or not altering the system of doctoral education will also alter the purpose. If the purpose of the PhD system is to prepare a highly skilled workforce that is **not** geared toward academic life in a research oriented university, then such reform efforts may be necessary. However, as little is known about the factors that act to influence post-graduation career aspirations and attainment in doctoral students, it may be premature to alter a system that serves the purpose of creating researchers for the academic marketplace.

The current reform documents concerning doctoral education have concluded that doctoral education should match the aspirations of the degree recipients, respond to the needs of a changing society and academy, provide professional preparation for careers within and outside the academy, increase retention rates, increase the number of women and minorities served, and change the open-ended time to completion policies (Austin, 2010; Nyquist, 2002). The career aspirations of doctoral students tend to change throughout the degree process as students gain experience. Goldsmith, Presley, and Cooley (2002) report that graduate students become less inclined to pursue academic positions over time for several reasons, including “tight competition within the academic job market, better pay in the private sector, and disillusionment with academia” (p. 11). However, this may not necessarily be a problem for the future of the professoriate, as there has yet to be a shortage of professors to fill an academic void; instead this serves as evidence of the market influences on career aspirations.

Recently, the National Research Council (2012) suggested that American research universities are of paramount importance for our nation’s prosperity and security particularly in STEM disciplines. This report followed *Rising Above the Gathering Storm* (2005) and its more recent update (2010), in which the National Academies committee outlined key relationships between our nation’s science and engineering workforce and the American economy. Thus, it is imperative to understand how doctoral program experiences influence career aspirations and attainment in STEM doctoral recipients in order to effectively and appropriately consider reform in doctoral education.

Theoretical Framework

The "disillusionment with academia" among doctoral candidates reported by Goldsmith et al. (2002) may be a function of the socialization process, or the failure to socialize, that students undergo during graduate studies (Sweitzer, 2009). Socialization has become the most common framework utilized to study the experiences of graduate students, and serves as the guiding theoretical framework for this study (Bieber & Worley, 2006). As it pertains to graduate school, socialization theory suggests that students' beliefs and prior experiences influence the experiences they have in graduate school (Weidman, Twale, & Stein, 2001). Through this process, students begin to learn about the academic norms of their discipline, including the culture, values, attitudes, and expectations of faculty in their field (Austin, 2002). Socialization is an integral part of persistence within a field for graduate students, related to degree completion, and potentially career success (Gardner & Barnes, 2007).

The socialization process is discipline specific, as each academic discipline uniquely defines research questions and practices, relationships between teaching and research, and the scholarly production of new knowledge (Austin, 2002; Lois et al., 2007). Faculty members figure prominently in modeling the values and attitudes of being an academic for graduate students, and influence graduate students in their development of a professional identity (Bragg, 1976). Professional identity was defined by Bragg (1976) as "the process of acquiring the values, attitudes and skills of a given profession" (p. 7). The doctoral advisor and other faculty members in the same department act as models for graduate students. They provide important and meaningful examples of success that graduate students may aspire to. Aside from simply modeling the profession of an academic, faculty members are “also perpetuating a legacy or a succession of ideas, methods, and values” in the students they mentor (Tenner, 2004, p. 4).

As graduate students are inducted into the culture of the academy as future professors, it will undoubtedly act to influence students’ experiences in graduate school as well as their post-graduation career aspirations. Through socialization in graduate school, students begin to learn about the academic norms of their discipline, and make decisions about whether to adopt those norms and pursue academic careers in similar institutions or to change fields (Quinn & Litzler, 2009). The institutional culture provides students with ideas about how successful faculty members in that discipline rank aspects of their professional careers, such a research, teaching, and service to the university. Additionally, through socialization at the departmental level and by participating in national meetings, students develop conceptions about how the field ranks the importance of different types of academic positions, such as those at research intensive universities or community colleges. Socialization theory also posits that the greater the degree to which students self-identify with a given role, the more likely they are to accept it. Therefore, the roles that students’ assume during graduate school, such as research and teaching assistantships, and their funding opportunities, such as fellowships or grants, are likely influential in their career aspirations and attainment, however this has yet to be empirically investigated in a comprehensive manner.

Socialization theory, as it has been applied to understanding the experiences of doctoral students, served as the theoretical underpinning for this study. This study was conceived to further understand the impacts of socialization on career aspirations and attainment. This theoretical perspective supported the selection of program and discipline specific independent variables for the statistical models reported herein. Finally, it is through the lens of socialization that the findings have been interpreted.

Study Rationale

Although several studies have been completed to assess how some factors contribute to post-graduation career aspirations and attainment, no comprehensive inquiries have been completed. Much of the previous research in the field of graduate student socialization has been completed through qualitative research, utilizing relatively small samples of doctoral students within a small number of programs and institutions (i.e. Holley, 2011; Mendoza, 2007; Wegner, 2010). As I describe in subsequent chapters, I utilized this research to identify aspects of doctoral education that have been described as significant to the socialization of doctoral students or to the career outcomes of doctoral recipients. Many of these studies investigated how a single aspect of doctoral students (such as their gender) or their program experiences (such as the type of funding they received) was significant to either their socialization or their career outcomes.

Specifically, single factors that have been identified as influential in career attainment are prestige of PhD-granting department, gender, ethnicity, and number of pre-graduation publication rates (Cognard-Black, 2004; Fox, 2000; Fox & Colatrella, 2006; Hill et al., 2010; Kuck, Marzabadi, Nolan & Buckner, 2004; Long & Fox, 1995). Kuck et al., (2004) also investigated the interaction between PhD granting department prestige and gender in academic chemistry positions at the top 50 ranked Chemistry departments. They found that, even at top-ranked institutions, female graduates attain tenure track positions at a lower rate than do male graduates.

The influence of gender and minority status in academic career aspirations and attainment has also been investigated (Fox, 2000; Fox & Colatrella, 2006; Hill et al., 2010; Kuck et al., 2004; Long & Fox, 1995). Although the percentage of women and minorities who receive doctorates in science and engineering fields has been on the rise since the 1970's, the rate of hiring of female faculty members has not increased at the same pace (Kuck et al., 2004, Nerad, 2004). Long and Fox (1995) assessed historical differential attainment in scientific careers across gender and minority groups, finding that women and minorities are underrepresented in academic careers compared with the number of doctoral recipients in those categories. Additionally, they show that the number of female and minority faculty at research universities tends to be lowest, while higher numbers of female and minority faculty can be found at comprehensive and liberal arts colleges, where fewer resources are available to contribute to scholarly productivity (Long & Fox, 1995; Morrison, Rudd, & Nerod, 2011).

Measures of socialization, such as department climate, including career satisfaction of faculty members and educational history, have yet to be studied as influential in career attainment of STEM doctoral students on a large scale. Several qualitative studies have investigated how socialization during graduate school influences career aspirations (Barry & Tillotson, *in review;* Goldsmith et al., 2002; Helland, 2010). These studies have concluded that the socialization that occurs during graduate school is influential in espoused career aspirations. Additionally, as Hall and Burns (2009) assert, many doctoral mentors prepare students to enter positions similar to the ones the mentor's currently hold. Since doctoral degrees are not offered at many institution types, this translates into preparation for a research-oriented career that may include some teaching responsibilities. However, it remains unclear whether or not socialization factors, such as department climate, faculty career satisfaction, and time faculty devote to various aspects of their academic careers, are influential in career attainment of the graduate students within their departments.

As Fisk (2011) points out, quality matters. “Although there is ample evidence that the current mechanisms for ranking graduate programs are limited and problematic, there is nevertheless a high correlation between the overall ranking of a program and the employment outcomes of its alumni” (p. 381). The prestige of the university or program attended is important in terms of employment, funding acquisition, and initial enrollment in doctoral studies (Goldsmith, Presley, & Cooley, 2002; Perna, 2004).

Previous studies have investigated the influence of PhD granting department prestige on academic career attainment (Baldi, 1995; Burris, 2004; Cognard-Black, 2004; Long, 1978; Long, Allison, & McGinnis, 1979). These studies conclude that the prestige of the PhD granting department is influential in academic hiring decisions, and highly correlated with the prestige of the department where doctoral recipients obtain their initial job. In fact, Burris (2004) investigated the career networks of doctorate holders from all 94 U.S. news and World Reports ranked sociology programs. She found that graduates from the top five ranked departments account for roughly one-third of all faculty hires in all 94 departments. The top 20 departments account for roughly 70 percent of the total. Those who do not graduate from top 20 departments are rarely hired at top 20 departments and almost never hired at top five departments. Similar findings were reported for Chemistry professors graduating from and populating the top 50-ranked Chemistry programs (Kuck et al., 2004).

The type of funding received as part of the graduate education has been reported as influential in doctoral persistence and espoused career aspirations (DeAngelis, 1997; Gemme, 2005). The type of funding received, such as a research or teaching assistantship, research fellowship, or research grants also impacts the type of training received during graduate education, as they determine the primary activities that a student will engage in for at least 20 hours per week. Teaching assistantships during graduate school are often viewed as less prestigious than research positions, including research assistantships and fellowships (Austin, et al., 2009). Within the academy, teaching has been historically defined as a secondary focus, falling behind research for both faculty and graduate students because teaching is often viewed as time taken away from research (Addy & Blanchard, 2010). Research productivity, often measured in terms of publications, is the yard-stick by which career success is measured in the academic sciences (Olssen & Peters, 2005). Therefore, those students with additional opportunities to conduct research and publish may experience preference in obtaining academic jobs.

Gemme (2005) investigated how external funding contributes to post-graduation career choice in doctoral students. Her study targeted graduate students who work on research projects with highly-qualified research professionals from outside academia. These students work as part of cooperative research agreements between industry and the university. Her research included a sample of 162 science and engineering doctoral students and recent graduates. Students within her study who had received some sort of non-academic (private) funding for their research were more likely to aspire to working within the private sector. The research education experienced by these students was in closer alignment with the private sector which provided funding, than the university setting. These students tended to report different experiences in terms of research and teaching training than their peers who did not receive non-academic funding.

DeAngelis (1997) investigated the effects of funding type (assistantship, grants, loans) on doctoral persistence. Her results indicated that graduate assistantships alone do not significantly impact student persistence, however the receipt of additional grants in combination with the graduate assistantship does. Grants fund doctoral research projects, and may act to increase the students' feeling of accountability towards completing their research and their degree. As noted by Gemme (2005), receiving this type of funding may also influence students' post-graduation career choices. Additionally, the receipt of research grants by doctoral students is perceived as more prestigious than assistantships, which may also contribute to students' career aspirations. In addition to individual research grant funding, the total amount of grants received by a university or program acts to confer a degree of prominence and status to the institution and grant recipients. The funding status of research programs is considered in their U.S. News and World Report Ranking status, which contributes to the perceived level of prestige associated with certain schools, degrees, or programs (Morse & Flanagan, 2011).

Some PhD recipients intentionally choose to work at institutions where teaching is ranked of higher importance than research, and others will end up there because there are not openings available at research-intensive institutions (Trautman, 2008). Still others will find employment in the private sector, government, and non-profit firms. However, there is only one model currently available to prepare graduate students. As a result, more research is needed to understand how graduate training, including the areas of graduate student socialization, research and teaching experiences, educational history, PhD department prestige, and student demographic characteristics influence the post-graduation career aspirations and attainment of doctoral recipients.

Research Questions

This study investigated the following research questions:

1. *A. Is there a relationship between science and engineering doctoral candidates' graduate school experiences and their espoused career aspirations in the four broad categories of education, industry, government, and other?*

   B. Is there a relationship between science and engineering doctoral candidates' graduate school experience and the types of academic institutions at which they aspire to work?

   C. Is there a relationship between science and engineering doctoral candidates' graduate school experiences and the nature of career activities they aspire to engage in?

2. *A. Is there a relationship between the STEM PhD recipients' institutional and program experiences and the attainment of initial post-graduation employment?*

   B. Is there a relationship between STEM PhD recipients' institutional and program experiences and the nature of career activities they intend to engage in?

   C. Is there a relationship between STEM PhD recipients' institutional and program experiences and their initial post- graduation employment field?

In order to address these research questions, this study utilized program-level data from the National Research Council's Assessment of Research-Doctorate Programs and student-level data from the National Research Council's Assessment of Research-Doctorate Programs and the National Science Foundation's Survey of Earned Doctorates. The program-level data was collected in 2005-2006 and both student-level datasets were collected during the 2005-2006 academic year. As explained in more detailed in subsequent chapters, program-level data is merged with student-level data, then a series of multinomial logistic regression modeling are estimated that examine how program characteristics are related to science and engineering student/STEM Ph.D. recipient career aspirations and attainment controlling for other student-level characteristics.

Contributions

The current study sought to add to and extend the current literature concerning post-graduation career attainment in STEM doctoral students in several ways. Primarily, my goal was to develop and test models of career aspirations in science and engineering doctoral candidates, and initial career attainment in STEM doctoral recipients utilizing broad, nationally representative samples. These models allow for the investigation of factors that have been previously found to be influential in career aspiration and attainment, such as gender, ethnicity, and funding received. Additionally, I investigated institutional level variables, such as department culture, rank, and faculty research productivity influence career attainment, as well controlled for PhD recipient demographic characteristics and educational history data.

This study is unique in several ways. First, it makes use of the newest ranking system of research doctorate programs. The ranking system published by the National Research Council's Assessment of Research-Doctorate Programs is a novel ranking system that presents ranks in terms of 90% confidence intervals. I developed a method, further described in Chapter 3, to preserve the nature of the confidence intervals while allowing me to utilize these rankings of doctoral programs to predict the likelihood of doctoral candidates' career aspirations and doctoral recipients' career attainment patterns. Thus, I merged the data related to doctoral programs with the National Research Council's questionnaire of doctoral candidates in an effort to address research question 1. Further, I also matched the program-level ranking data from the National Research Council's Assessment of Research-Doctorate Programs with the National Science Foundation's Survey of Earned Doctorates in an effort to address research question 2. The creation of these two student-level datasets, including a detailed description of how the student-level data was matched with the program-level data is described in Chapter 3. This use of this novel ranking system, as well as the merging of this program-level ranking data with the student-level data represents a methodological contribution of this study.

Although previous research has described doctoral candidate career aspirations and/or attainment patterns (Cognard-Black, 2004; Golde & Dore, 2001; NSF, 2011, 2012; Rudd et al., 2010; Sauermann & Roach, 2012; Sweitzer, 2009), this research represents the first time that predictive modeling has been used to account for the relationship between doctoral student experiences as their career outcomes. Further, this research utilized a broad, nationally representative sample that includes representation from a variety of STEM fields, in contrast to previous research in this area that was limited to a few fields of study (Rudd et al., 2010; Sauermann & Roach, 2012). Finally, this research contributes to the literature concerning doctoral student socialization by identifying factors that are significant in predicting the likelihood of certain career aspirations and career attainment patterns across a multitude of doctoral programs and fields of study. This contrasts previous research in the field of doctoral student socialization that focused on relatively small samples of students within a limited number of programs (Bieber & Worley, 2006; Gardner, 2007, 2008, 2010; Gemme, 2005; Golde, 2005; Haley, 2006; Mendoza, 2007; Sallee, 2011; Sweitzer, 2009).

Conclusions

The outcomes of this study will inform those parties interested in reforming doctoral education, including faculty, administrators, and funding agencies, particularly regarding the factors that are influential in post-graduation career attainment for STEM doctoral recipients. This knowledge will be critical in the reform process to ensure that future training of STEM doctoral students includes meaningful learning experiences necessary to meet the needs of both future STEM faculty and those who choose to work in fields outside academia. While many calls to reform have cited inadequate career preparation as an on-going problem in doctoral education, few studies have investigated factors that contribute to career attainment, and of those studies, many have focused on academic careers only (Cognard-Black, 2004).

Additionally, information provided from this study may assist professors as they council new students to reach their career goals. This type of mentoring may help decrease the rate of doctoral student attrition and ultimately may help reduce new faculty attrition (Golde, 2005, Hill et al., 2010). Attrition from doctoral studies as well as faculty careers can be very costly to institutions, who have invested significant time and resources in individuals. Career satisfaction has been cited as a major cause of attrition in new faculty (Hill et al., 2010). However, more thoroughly understanding factors that influence career aspirations and attainment may help to alleviate some issues of attrition if better "fits" between students, faculty, and institutions can be identified (Hill et al., 2010; Trower & Chait, 2002).

CHAPTER 2: LITERATURE REVIEW

This study draws on a diverse body of literature, primarily from the broad fields of sociology and education, to provide the context and background information. First, I will outline the theoretical framework guiding this study. The chapter will continue with a discussion of the context of graduate training in higher education and academic careers, and conclude with a discussion of the previous research that serves as background literature for this research.

Theoretical Framework

This study, which focuses on career aspirations and attainment in Science, Technology, Engineering, and Mathematics (STEM) doctoral candidates and recipients, draws primarily upon socialization theory. Socialization theory is currently the most widely used framework to study the experiences of doctoral students within their graduate programs, and posits that that students' beliefs and prior experiences influence the experiences they have in graduate school, and that these experiences result in identity formation (Weidman, Twale, & Stein, 2001; Austin, 2002). Socialization occurs throughout an individual's lifetime, and includes a variety of socializing agents, including parents, siblings, and teachers (Grusec & Hastings, 2007). In the case of this study, I contend that the socialization that occurs during graduate school influences the career aspirations and attainment of STEM doctoral candidates and recipients.

The process of socialization that occurs during graduate studies exposes students to the disciplinary and academic norms of their field of study, including the culture, values, and expectations of faculty in the field (Austin, 2002). Socialization is an integral part of persistence within a field for graduate students, related to degree completion, and potentially academic career success (Gardner & Barnes, 2007). Austin (2010) contends that students are socialized (and thus prepared) for academic careers *only*.

Several models of graduate student socialization have been proposed (Gardner, 2010; Tinto, 1993; Weidman, Twale, & Stein, 2001). Weidman, Twale and Stein (2001) proposed a theoretical model, including four stages in the socialization process: anticipatory, formal, informal, and personal. They define this process as developmental and reflecting different "states of identity" (p. 11) acquisition. The anticipatory stage includes the time preceding a students' formal enrollment in doctoral study, when students form conceptions about their upcoming role in graduate school. In the formal stage of socialization, students enter graduate school and receive some formal instruction from a professional authority. The normative expectations for the student are clearly defined and documented, and there is generally consensus among socializing agents, such as faculty and other students. During the informal stage of socialization, students learn about informal role expectations by observing acceptable behavior in other students and responding accordingly. During the personal stage, students form a professional identity as a scholar, merging their previous self-concept or reconciling any inconsistencies with their previous personal and professional identities.

Weidman, Twale, and Stein (2001) also identify three core elements that are integral to the socialization process of students. The first of these core elements is *knowledge acquisition*. The students must gain information about the normative expectation for their discipline, with increasing specificity as they progress through their degree program. This knowledge allows graduate students to develop an evolving professional identity as they achieve milestones in their academic career. The second core element in the socialization process is *investment*. At each of the outlined stages of socialization, the student must invest in their program, discipline, and career goals in order to successfully assimilate. Without the students' investment in these processes, socialization cannot be achieved. The third core element is *involvement* on the part of the student. Involvement with professors and more experienced students can provide insight to the graduate student about the professional norms of the discipline. Weidman, Twale and Stein describe these core elements as interrelated in the process of socialization and professional identity formation in graduate students.

Gardner (2010) proposed an empirically derived model of doctoral student socialization, based on her previous research (2007; 2008). Gardner's three phase framework of socialization is related to student transitions during their program and intended to account for developmental changes that occur within an individual related to their relationships with others. Phase 1 includes the anticipatory stage. This is the time leading up to the students' enrollment in doctoral study and includes their first few months. This phase is characterized by students "settling into their roles as doctoral students" (p. 64), and in this process they form initial conceptions of the role of doctoral student. Phase II includes the time from which the student begins their program to the initial phases of their candidacy. This time is generally characterized by completing coursework and candidacy exam preparation, as well as integration into their program. This integration occurs through interactions with peers, faculty members, assuming the role of their assistantship. The final phase of socialization, Phase III includes the candidacy stage of doctoral study, which is focused on dissertation research and future career plans. This phase is characterized by the students' changing relationship with faculty and peers as they develop towards being a professional.

Gardner (2007, 2008) also proposed five factors related to doctoral student socialization, and the relatedness of these factors to her proposed model (2010). She described these factors as emergent themes from interviews with several groups of doctoral students. The first group consisted of chemistry and history doctoral students from one Land-grant institution (2007). The second group included doctoral students from chemistry and history from another institution, a prestigious public university (2008). These students were also self-reported as “not fitting the mold of graduate school” and included students of color, students with families, part-time students, and older students (p. 126). The third group of students that Gardner used in the development of the relatedness of her model to the factors that influence doctoral socialization included 60 doctoral students from five disciplines at one research-extensive university (2010).

The five factors that impact doctoral student socialization, as described by Gardner (2007, 2008, 2010) are ambiguity, balance, independence, development, and support. The students in these studies experienced ambiguity in regards to their program, how to advance in their programs, and the direction of their research. Issues of balance for graduate students were in relation to managing research and teaching responsibilities, in addition to their personal lives and coursework, including the prioritization of each of these items. The idea of independence as part of the socialization process emerged when doctoral students referred to the nature of the mentoring relationship they have with their research advisors. Gardner (2007) referred to the development aspect of socialization as “grooming” for the professional career (p. 734). This grooming was specifically related to taking on the role of the researcher during graduate studies. The final factor Gardner identified as important to the socialization process was support, including faculty and peer support. Gardner (2010) suggests that these factors influencing socialization are related to her proposed three-phase model of socialization in that at each transition from one phase to another, students experience ambiguity in regards to the expected role and obligations of that phase. Ambiguity regarding navigating program requirements shifts to ambiguity regarding research. Students must figure out how to balance these new responsibilities, and look to faculty and peers for models on the appropriate norms as well as support. Students experience increasing independence and development of their researcher identity as they progress from phase I to III.

Professional identity was defined by Bragg (1976) as “the process of acquiring the values, attitudes and skills of a given profession (p. 7). The socialization of members of a given profession has been identified as important to the process of developing a professional identity (Weidman, Twale, & Stein, 2001; Austin, 2002). Reybold (2003) equated graduate student socialization with their professional identity formation, and stressed the importance of elucidating a professional identity as a whole. He suggests that focusing research on the identity formation within the spheres of an academic position (i.e. teaching or research) fails to present the complexities of faculty identities with regard to all aspects of their positions. However, due to the current norms of graduate school, generally focused on development of proficient researchers, the professional identity development of graduate students is also focused on their researcher identities, and less on teaching identities. Additionally, professors tend to identify themselves as professionals in their discipline but not in the teaching of that discipline (Rushkin et al., 1997).

How professors and graduate students self- identify is only one aspect of their identity (Kaufman & Feldman, 2004). Identities also include aspects that are defined by social interactions and that could not exist without the other parties. In their study of college student identity formation during the undergraduate experience, Kaufman and Feldman (2004) found that students develop new self-identities related to knowledgeability, occupation, and cosmopolitanism. These areas of self-identity were related to social interactions with peers in similar situations, i.e. college classmates, but also related to societal views of college graduates. Thus, according to Kaufman and Feldman, college students develop a self-identity related to being knowledgeable; have certain career expectations As a result of their education, and a sense of worldliness. Although not investigated in their study, these domains of self-identity are also likely to be present in changes in graduate students' self-identity as they progress to post-graduate careers.

This study seeks to empirically determine the influences of these processes on career aspirations and attainment at two points during the doctoral education, candidacy and immediately after graduation. The candidacy stage of doctoral study was described by Weidman, Twale, and Stein (2001) and Gardner (2010) and the final stage of their respective models. This stage of doctoral study, as described in both models is related to scholarly development and preparation for the academic career. Additionally, Austin (2002, 2010) describes graduate school generally as socialization for the academic career. Therefore, these two points of doctoral study were selected to provide snapshots of how aspects of doctoral study can be influential in the career aspirations and attainment patterns of STEM doctoral candidates and recipients, respectively.

I utilized the socialization theory framework, previous research in the area of doctoral student socialization, and literature related to the career aspiration and attainment patterns of doctoral recipients to identify aspects of the doctoral education process that could be influential to career aspirations and attainment within STEM fields. These aspects of doctoral education, including the type of funding received, institutional culture, relationship with doctoral mentor, research productivity of the faculty, and student support services will be reviewed and described below as part of the current context of graduate education.

The Context of Graduate Education in STEM Fields

Doctoral education in the natural sciences has historically followed an apprenticeship model. Students learn to conduct research, at first heavily supervised and as they progress, they become capable of conducting independent research to produce new scientific knowledge (Feldman et al., 2009). Graduate students rely primarily on their doctoral advisors for guidance in conducting research, but also depend on more experienced graduate students and post-doctoral research associates in their laboratory groups to learn specific techniques.

Research- focused science departments have a distinct and shared culture that acts to provide a group identity and contributes to the research productivity of the faculty (Bland, Weber-Main, Lund, & Finstad, 2004). Within this culture of university science, teaching has been historically defined as a secondary focus, falling behind research for both faculty and graduate students (Addy & Blanchard, 2010). The relationship between research productivity and conceptions of teaching has been investigated and researchers have concluded that research activity often bears little influence on teaching performance (Prosser, Martin, & Trigwell, 2007 and references therein). Research productivity, especially in terms of grant money awarded and number of publications, is often used as the measure of success for university scientists.

Doctoral education in the sciences, where research productivity is at the forefront, provides the context for the socialization process of doctoral students. This process is influenced by numerous factors, including background characteristics, such as gender and race. Additionally, the types of training and funding that students' receive are also likely to be influential in this process, as well as a students' doctoral advisor. The doctoral advisor has been described as the primary socialization agent within the doctoral education process (Bieber &

Worley, 2006; Lois et al., 2007; Golde, 2000). As each institution and program varies in their department norms for doctoral education, program features, such as departmental prestige and student support services, are likely to be influential in doctoral student socialization (Ehrenberg, Zuckerman, Groen, & Bruckner, 2009). In the sections that follow, I describe the aforementioned aspects of doctoral education in an effort to provide context for the variables selected for inclusion in this study.

Funding the Doctoral Education

Doctoral students in STEM fields typically do not pay tuition for their graduate degrees. Financial assistance in the form of teaching or research assistantships, fellowships, or grants, comes from a variety of sources including private industry, government, and the doctoral granting institution. Doctoral students may fund their education by holding one of the aforementioned funding types, or through some combination. The rates of funding vary by institution and field of study, as well as by the type of funding received.

Recently, *The Chronicle of Higher Education* conducted a survey of graduate student pay and benefits (June, 2008). The survey revealed that student pay and benefits vary widely by institution, and sometimes even by department within the same institution. The amount of salary that graduate students receive from their institution also depends on the type of assistantship. For example, the average pay rate for research assistants in Biology in 2008-2009 was $18,270, while teaching assistants in the same field received an average of $16,368 in salary for the same time period. Teaching assistants in other fields, such as English and History, received approximately $3000 less than Biology teaching assistants over the same funding period.

While each institution and field of study defines their disciplinary norms in terms of common funding types for doctoral students, fellowships and grants from sources outside the doctoral granting institution are considered to be the most prestigious. These types of funding generally offer greater wages than teaching and research assistantships, and are also awarded through competition. For example, in 2002 the National Science Foundation's Graduate Research Fellowship Program (GRFP) received 5000 proposals and funded 900 fellowships (Goldsmith, Presley, & Cooley, 2002). The number of applicants has continued to grow in the past decade, with over 9000 applicants received in 2009, while the number of funded fellowships remains close to 1000 (https://www.nsfgradfellows.org/about_the_program). These fellowships provide up to three years of funding, with an annual stipend of $30,000, along with an education allowance to pay for tuition and fees. The fellowships are also portable, allowing recipients to study at the institution of their aspirations.

Students, who receive funding through the NSF GRFP, report numerous advantages, including the financial support, acknowledgement as a good students, and assistance in job attainment (Goldsmith et al., 2002). In the field of economics, for example, almost twice as many GRFP recipients had attained tenure track appointments as their peers. Additionally, fellows report the benefit of flexibility- either to pursue research of interest because funding is secured or to pursue research instead of devoting time to teaching responsibilities.

In addition to providing funding for doctoral education, research and teaching assistantships, as well as grants and fellowship programs, provide important training opportunities for doctoral students. As noted earlier, doctoral education in STEM fields primarily serves the purpose of preparing academic researchers through an apprenticeship model. Thus, the type of work that doctoral students do to receive their funding represents an important part of the training received. Typically, assistantships require approximately a 20-hour per week commitment, and may or may not be related to a students' doctoral dissertation research (Nettles & Millet, 2006; Luft et al., 2004). The experiences that doctoral students have as part of the funding they receive plays an important role in their socialization to the academic career, especially in regards to disciplinary norms related to the value of teaching and research.

The type of funding received may also be linked to the quality of student or the quality of the training experiences (Goldsmith et al., 2002; National Research Council, 2010). Teaching assistantships, which are viewed as the least prestigious types of funding, typically go to those students who are perceived to have lower potential for research. This academic stratification system of funding doctoral students is likely to have implications on students' self-efficacy and confidence in their research and teaching abilities, as well as their career aspirations and attainment. Bandura, Barbaranellil, Caprara, and Partorelli, (2001) described how individual's feelings of self-efficacy with perceived career related tasks is related to exposure to a given field and subsequent career aspirations. Thus, it is possible that students who fund their doctoral education with teaching assistantships have more exposure to teaching and more confidence in this area, and as a result would aspire to a career that focuses on teaching. Additionally, funding has been linked to students' time-to-degree and completion rates. Students who receive fellowships or research assistantships have higher completion rates and shorter times-to-degree than those who receive teaching assistantships (Ehrenberg & Mavos, 1992).

However, a recent study by Feldon, Peugh, and Timmerman et al. (2011) reports that teaching during graduate studies actually improves students' abilities to formulate testable hypotheses and design valid experiments. The researchers compared research proposals at the beginning and end of an academic year between two groups of graduate students, those who teach as some part of their responsibilities, and those who do not. They found, after statistically controlling for differences in quality within the student populations, that the group of students who taught during the academic year had significantly greater improvements within their research proposals. They measured the quality of these research proposals in terms of "setting the context for a study, framing testable hypotheses, attention to validity and reliability of methods, experimental design, appropriate selection of data for analysis, presentation of data, data analysis, basing conclusions on data, identifying limitations, and effective use of the primary literature" (p. 1038).

More recently, financial support from private industry for graduate student fellowships and assistantships in STEM fields has increased (National Science Foundation, 2011). Mendoza (2007) investigated the connection between academic capitalism and doctoral student socialization into the academic profession. His study, focused within one engineering department at a Research I institution with heavy research funding from industry, employed a qualitative case study methodology focusing on ethnographic interviews with 20 doctoral students. Through analysis, these students were grouped by socialization stage following Tinto's (1993) model (pre and post candidacy), and whether or not they received funding from industry in their laboratory group. Although students did not perceive either industry or academia as more prestigious, students believed that working in industry prior to academia was preferable in order to gain experience in managing both people and finances. Overall, students reported industrial funding as positive, stating that it fosters a supportive learning environment and could be beneficial in attaining a job in industry upon degree completion.

Mendoza (2007) noted that those students who were exposed to industrial funding, and those that receive their funding from government sources are socialized differently. Those students exposed to industry funding believe that faculty members' research is not constrained by funding, in contrast to those students who receive government funding. This study was inconclusive as to whether or not receiving funding from industry influenced students' career or research interests. However, Gemme (2005) noted that doctoral students who receive funding from industry are more likely to aspire to work in the private sector.

Funding has also been linked to doctoral student satisfaction (Nettles, 1990; Barnes & Randall, 2011). Students who receive funding through grants and other sources of external funding tend to be more satisfied with their degree progress than students who are funded through teaching assistantships. Additionally, Nettles (1990) reports that receipt of a teaching or research assistantship also increases contact with faculty members, initiating a working relationship which could potentially develop into a positive interpersonal relationship between faculty and students.

The types of funding that students receive as part of their doctoral education has important implications on the doctoral experience. As described above, limited research has described how funding sources can influence career decisions (Gemme, 2005; Goldsmith et al., 2002; Mendoza, 2007). The graduate assistantship represents a significant opportunity for students to participate in research or teaching, and have implications for degree completion and time-to-degree (Ehrenberg & Mavos, 1992). I suggest that the type of assistantship primarily utilized to fund doctoral studies will affect the socialization experiences of doctoral students, and in turn affect their career aspirations and attainment patterns.

Doctoral Research Advisors

The term “mentor” is often used to describe any supportive relationship (Mertz, 2004). As such, the literature discussing the benefits of “mentoring” is widespread, but not cohesive because the definition of mentoring varies widely (Healey & Welchert, 1990; Mertz, 2004). Healey and Welchert (1990) define mentoring “to be a dynamic, reciprocal relationship in a work environment between an advanced career incumbent (mentor) and a beginner (protégé) aimed at promoting the career development of both” (p. 17). Further, they suggest that the goal of mentoring for the protégé is identity transformation from subordinate to self-directing colleague. However, goals may vary by participant in some relationships, causing dissatisfaction and potentially unsuccessful mentoring (Pleegar & Mertz, 1994). Therefore, it is unclear whether all doctoral advisors serve the function of mentor to their doctoral students. For the purposes of the proposed study, although mentoring relationships may in fact exist between doctoral students and their dissertation research supervisors, I will discuss these research supervisors as “advisors.” According to Schlosser, Knox, Moskovitz, and Hill (2003), “advising refers to a positive or negative relationship in which guidance may or may not be provided with regard to professional skill development (p. 3).

Doctoral advisors are chosen by students at various times during their degree progress, depending on the field of study (Zhao, Golde, & McCormick, 2005). In some fields, such as Ecology, the advisor is chosen prior to enrollment, whereas in molecular biology it is more common for first year students to undergo a series of laboratory rotations where they work for various advisors before making their choices. Of course, the advisors must also agree to accept a student into their laboratory or working group. Acting as a doctoral advisor is associated with a great deal of responsibility, since students are expected to enter the same field as the advisor, and advisors are expected to mentor high quality individuals (Tenner, 2004; Dodson, Fernyhough, & Holman, 2006).

Doctoral advisors have been shown to exert influence on various doctoral degree processes of their advisees. In her review, Barnes (2010) outlines these processes to include students' socialization processes and postgraduate options (Lovits, 2001), satisfaction (Holland, 1998), and providing opportunities to participate in research projects, including publishing and conference presentations (Cheatham & Phelps, 1995). Additionally, graduate advisors have been shown to influence student productivity (measured in publication rates) and time to graduation (Ehrenberg et al., 2007). Ehrenberg et al. (2007) investigated various program features as they relate to students' time-to-degree and graduation completion rates in the social sciences fields. They found that the relationship students have with their doctoral advisor is a significant factor in lessening students' time-to-degree and increasing graduation rates. Although Ehrenberg et al. (2007) investigated relationships between advisors and graduate students within social science fields, I suggest that their findings have important implications for doctoral students in the natural sciences as well. Thus, it is important to investigate how the nature of the relationship between doctoral candidates and their advisors influences the likelihood of career aspirations in a variety of fields.

Advisors contribute to their students' socialization processes as their primary point of contact for research development and the program or department (Austin, 2002; Barnes & Austin, 2009; Golde, 2005; Pole, Sprokkereef, Burgess, & Larkin, 1997; Tinto, 1993; Weidman et al., 2001). Doctoral advisors assume a role of power of their advisees, controlling many aspects of their educational experiences and serving as the "gatekeeper" to the profession (Heinrich, 1995).

Pole, Sprokkereef, Burgess, and Larkin (1997) investigated the expectations and experiences of doctoral students and their supervisors in science and engineering. Their research revealed that early career doctoral students claimed to know little about the process of obtaining a PhD, including the role of the supervisor. Students expected their supervisors to help them find focus in their dissertation research, playing an active role in the process. However, this expectation was not mirrored in the supervisors, who believed that students should have internal motivation in the development of research questions. The variation in expectations between supervisors and doctoral students can be a source of discontentment within the doctoral degree process for students, as well as a source of attrition (Barnes, 2010; Barnes & Randall, 2011; Golde, 2005).

Students also utilize their advisors and other faculty in the department to develop conceptions of faculty life (Austin, 2002). Many expectations about academic positions are forged during graduate school, although Bieber and Worley (2006) suggest that these ideas are often incomplete. In their study of graduate student perceptions of faculty life, Bieber and Worley report that graduate students only formed conceptions about aspects of faculty life that were observable. Graduate students did not discuss faculty life with mentors or other faculty members, and therefore formed their conceptions by observation. The authors report that these conceptions are resistant to change, and did not change over the course of graduate school for their participants. They suggest that this results in a disconnect in what graduate students perceive as aspects of an academic career and the realities that they will encounter. Students in this study entered graduate school with strong orientations toward teaching, and because these orientations did not change, the authors concluded that these students were unsuccessfully socialized into the research culture of their institutions.

As described above, doctoral advisors serve as the main socializing agents for their advisees. The relationship between doctoral advisors and students can be a source of discontentment within doctoral studies, and has been cited as a source of attrition (Barnes, 2010; Barnes & Randall, 2011; Golde, 2005). Several authors have suggested that students who drop-out of graduate school do so as a result of their failure to socialize (Bieber & Worley; Sweitzer, 2009; Tinto, 1993). Thus, it is important to investigate the nature of the relationship between doctoral advisors and graduate students. As faculty members provide important models of academic life, I suggest that the relationship between doctoral advisors and their students will have implications on doctoral candidate career aspirations.

Gender and the Doctoral Education

Morrison, Rudd, and Nerod (2011) outlined several challenges that women in academia face, including demanding careers during family formation (Jacobs, 2004), hiding pregnancies and timing children's birth (Armenti, 2004), and that women's family roles may interfere with academic success (Mason & Goulden, 2002, 2004; Wolf-Wendel & Ward, 2006). These issues influence the experiences and expectations of women in graduate school, and as they progress through the academic pipeline. Even though the number of women who receive doctoral degrees overall closely matches that of men, women experience decreased representation in academic positions, especially in higher ranks (Mason & Goulden, 2002).

The increased participation of women in pursuit of doctoral degrees has led to an interest in determining how gender is related to doctoral degree progress (Maher, Ford, & Mamrick, 2005). In order to investigate how gender is related to degree completion, Maher et al. (2005) surveyed doctoral degree recipients from Stanford's School of Education, conducted separate analyses for male and female respondents, and then compared the significant results between the genders. They report that degree progress of both male and female participants was positively influenced by a strong commitment to finish in a timely manner, feelings of adequacy to navigate degree requirements, and having dissertation research proceed as planned. This study also identified the absence of several constraining factors as significant to time-to-completion rates for both genders. These factors included the "absence of lacking a plan, desire to maintain student benefits, erratic university funding, child care responsibilities, marital problems, poor mentoring, time consuming RA-TA positions, and of not being able to locate a suitable dissertation topic" (p. 12).

For female participants, Maher et al. (2005) found that 40% of variance in degree completion time could be explained by factors relating directly to navigating the academic system, such as advisor choice, achieving funding, and dissertation research preparedness. Additionally, but not surprisingly, women who had the shortest times-to-degree, also reported fewer non-academic constraints such as marital or family concerns. For male students, 60% of the variance in degree completion was related to internal motivation to complete in a timely manner, absence of funding issues, and the absence of marital or parental concerns.

Sallee (2011) considered how doctoral socialization within a discipline may be gendered. She focused her analysis on male graduate students studying Mechanical and Aerospace Engineering. She suggests that students' experiences are related to adopting masculine values through the socialization process, such as valuing "competition, hierarchy, and the objectification of women, in order to succeed in the discipline" (p. 189). The variation in the socialization process may influence career decisions. McClintock-Comeaux (2007) investigated the role of doctoral experiences and family status in the career choices of female doctoral students at the

University of Maryland. She identified career choice as the decision whether or not to enter the pool of tenure-track faculty. For those who decide to pursue academic careers, she identified institution types as research I universities, liberal arts universities or colleges, and community colleges. Her study determined that marriage was a significant negative predictor in pursuit of a research I university or liberal arts university, and parenting was a not significant predictor in these career aspirations. Additionally, her study revealed that faculty role models and positive relationships with research advisors are associated with intent to pursue academic positions, particularly in liberal arts institutions. However, as this study only investigated the influences of department experiences on career choice for female graduate students with children, further study of gendered career choices related to doctoral experiences is warranted.

Morrison et al. (2011) investigated the gendered effects of marriage and parenting on academic career at the transition from PhD to tenure-track job. They utilized event history analysis to observe the effects of marriage and parenting separately for a cohort of men and women social science PhDs who have moved into tenure track positions at similar rates, at equally prestigious universities, and earn the same amounts of money. They find that women in their sample achieve tenure-track positions at a significantly faster rate than their male counterparts. However, when controlling for labor market status, that significant effect disappeared. The labor market status was defined as either in graduate school or the academic labor market, or in the private sector of the labor market. Men were more likely than women to hold positions in the private sector. Their study also found no evidence of women experiencing a marriage penalty when entering the tenure-track, but did find that women who parent young children take approximately 30% longer to transition to tenure than other women. The authors conclude that women are suffering a parenting penalty. Their study also showed that male PhD recipients experience a stronger benefit of quick time-to-degree than women in the transition to tenure-track positions.

The research presented here links gender to the doctoral experience, and subsequently to participants' career outcomes, primarily in social science fields (Mason & Goulden, 2002; Maher et al., 2005; Morrison et al., 2011). In certain STEM fields, such as engineering and physics, the number of female doctorate holders in still significantly less than males (NSF, 2011). However, in the life sciences, females now represent close to half of all doctoral recipients (NSF, 2011). As Sallee (2011) noted, it is particularly important to investigate the socialization experiences of female doctoral students in male dominated fields. As such, I investigate gender as it relates to the career aspirations and attainment patterns of STEM doctoral candidates and recipients.

Racial and Ethnic Diversity

Ethnic and racial minorities are currently underrepresented as science and engineering doctoral students (Einaudi, 2011). However, in recent years, there has been a substantial increase in the population of racial and ethnic minorities enrolled in graduate studies, more than doubling over the past 10 years (NSF, 2012). The United States Department of Education (2005) identified increasing representation of minority groups in STEM fields as a policy priority.

Millet and Nettles (2006) outlined four aspects of doctoral education as "most important" to the student experiences, including "being a research assistant, having a mentor, publishing an article, and completing the doctoral degree" (p. 262). Subsequently, they focus their inquiry on how students of racial and ethnic minorities, specifically Hispanic students in STEM programs experience these critical aspects of doctoral education. In relation to the research assistantships, they found that Hispanic students are not disadvantaged compared to White students in science and engineering fields. There were also no differences observed in whether or not students had a mentor. Overall, Hispanic students reported a lower rate of research productivity (measured as conference presentations, publications in peer-reviewed journals, publication of a chapter in an edited book, or publication of a book). Within STEM fields, the rates of participation in research productivity were similar between groups. Hispanic students were less successful than White students in degree completion; however, race was only a significant predictor of degree completion for those enrolled engineering programs.

Nettles (1990) investigated differences in the experiences of Black, White, and Hispanic doctoral students at 4 large research intensive or extensive public universities. Significant differences between the racial groups were revealed in four areas: full-time enrollment, social involvement, perceptions of racial discrimination, and amount of time devoted to studying. Hispanic students were most likely to attend graduate school full-time, the most socially involved, and devoted more time to studying among the groups studied. Black students perceived higher levels of racial discrimination than the other groups, and White students perceived the least amount of racial awareness and were least socially involved of the doctoral students investigated. This study also revealed that a larger percentage of Black and Hispanic students received fellowships or loans to fund their studies, while the majority of White students received teaching or research assistantships. Black doctoral students were most likely to rely on personal resources and loans to fund their doctoral education. Of particular interest to the present study, Black students were significantly less likely than their White or Hispanic counterparts to be science majors in graduate school.

In a qualitative study of 40 students at two institutions in the fields of Chemistry and History, Gardner (2008) found that the socialization experiences of minority students vary from that of White students. Gardner suggested that lack of “fitting the mold” of graduate school is a clear player influencing doctoral attrition for minority students (p. 127). Included in this population are women, part-time students, older students, and students with families, or those students who are not young, white, single males. The background differences contributed to students’ socialization processes, playing a role in students’ overall satisfaction with their program as well as their ability to effectively integrate. For 12 of her participants, their lack of “fitting the mold” resulted in attrition from their doctoral programs. Gardner suggests that future research is needed in the area of socialization of minority doctoral students, specifically investigated differences across larger geographic areas and among a greater number of institutions.

The socialization experiences of doctoral students is related to their race (Gardner, 2008), the decision to enroll in doctoral studies (Nettles, 1990), and the type of funding received during doctoral studies (Millet & Nettles, 2006). Further, the persistence of doctoral students has also been linked to their race (Millet & Nettles, 2006). Subsequently, racial differences among doctoral students could be influential in their career aspirations and outcomes.

Institutional Culture and Prestige

Institutional classifications, rankings, and categorizations often serve as measures of institutional prestige (McCormick & Zhao, 2005). These rankings and classifications, found in publications such as *U.S. News and World Report* and the National Research Council’s recent ranking of research-based doctoral programs are often used as indicators of institutional or program quality (Keith, 1999; National Research Council, 2010). These rankings serve to assist students' in their academic choice, and serve as justification for resource allocation (Goldberger, Maher, & Flattau, 1995; McCormick & Zhao, 2005).

Doctoral program rankings may be utilized to signify applicant quality when graduates apply for positions in academia (Keith, 1999). In fact, Burris (2004) investigated the career networks of doctorate holders from all 94 U.S. news and World Reports ranked sociology programs. She found that graduates from the top five ranked departments account for roughly one-third of all faculty hires in all 94 departments. The top 20 departments account for roughly 70 percent of the total. Those who do not graduate from top 20 departments are rarely hired at top 20 departments and almost never hired at top 5 departments. Similar findings were reported for Chemistry professors graduating from and populating the top 50-ranked Chemistry programs (Kuck, Marzabadi, Nolan & Buckner, 2004).

Several studies have documented the relationship between doctoral department prestige, and the prestige of subsequent academic employment (Baldi, 1995; Bedeian, Cavazsos, Hunt, & Jaunch, 2010; Burris, 2004; Cognard-Black, 2004; Hagstrom & Hargens, 1968; Long, 1978; Long, Allison, & McGinnis, 1979; McGinnis, Allison & Long, 1982). Doctoral department prestige is often measured by the reputation of the institution according to institution rank, the publication record of the faculty, and the amount of grant money won. Further, institutional prestige is also measured by selectivity of admission, and ranking systems such as U.S. News and World Report. These studies conclude that prestige of PhD granting department is influential in academic hiring decisions, and highly correlated with the prestige of the department where doctoral recipients obtain their initial job. Additionally, Bedeian et al. (2010) show that department prestige interacts with perceived quality of publications such that those who attended more prestigious programs gained more job placement benefits from their publications.

Research productivity of the faculty, in terms of both publication rates and citation rates is often used as a measure of departmental or program prestige (Barnett, Danowski, Feeley, & Stalker, 2010; Morse & Flannagan, 2011; Goldsmith, Presley, and Cooley, 2002; Perna, 2004). Additionally, in their study of career changes between academic institutions, Allison and Long (1990) reported the relationship between department affiliation and research productivity in faculty. They found that research productivity often comes into alignment with academic institutional norms after career changes. In other words, upward mobility is often followed by an increase in publication and citation rates, while downward mobility is followed by a decrease in productivity. This serves as evidence of departmental culture and normative behavior on research productivity.

Gardner (2010) specifically investigated the relationships between institutional culture, prestige, and doctoral student socialization. Her qualitative study focused on interviews with 38 faculty and 60 doctoral students within one research extensive university. While the faculty members in the study were found to be striving to increase the rankings, and subsequently the level of prestige of their institution, the students resisted. Gardner noted that the resistance of these students is problematic in terms of their anticipatory socialization for the academic career. The desire of the faculty to increase the level of prestige resulted in an increased focus on research productivity and a high rate of faculty turnover, which was cited as a reason for high rates of student attrition. Additionally, as discussed earlier, there is limited mobility of students from lower-ranked doctoral programs to higher-ranked academic careers, which means that these doctoral students, if they attain academic employment, will be working at similar institutions (Burgess, 2004). Barnes and Randall (2011) suggest that more research addressing the career preparation and attainment of doctoral students who attend less prestigious or smaller institutions is necessary.

Doctoral granting department and institution have been clearly linked to the employment outcomes of their graduates (Baldi, 1995; Bedeian, Cavazsos, Hunt, & Jaunch, 2010; Burris, 2004; Cognard-Black, 2004; Hagstrom & Hargens, 1968; Long, 1978; Long, Allison, & McGinnis, 1979; McGinnis, Allison & Long, 1982). The majority of this research follows graduates along a typical academic career path (Cognard-Black, 2004). However, as noted earlier, only approximately 25% of doctoral recipients are able to gain employment as a tenure-track professor at a four-year college or university (NSF, 2012). Thus, understanding how measures of program and institutional prestige, such as research activity of the faculty impact the career outcomes of graduates is essential.

Career Aspirations and Outcomes

Very little research has focused on the forces that shape individuals' decisions to pursue academic careers (Lindholm, 2004). Models of career choice, more generally, have been developed. Astin (1984) outlined a model of career choice that considers work motivation, expectations, socialization, and the structure of the opportunity. Within this model, Astin recognizes that individuals are motivated to work in order to meet three basic needs: survival, pleasure, and contribution. The choices that individuals make in terms of their career are based on expectations of the accessibility of other forms of work, and the ability to satisfy the three basic needs. These expectations are influenced by socialization experiences with family, school, and work, as well as the perceived structure of the opportunity. Astin also notes that these expectations can be modified by changes in the structure of the opportunity, which can lead to changes in career choice.

In her review of the literature, Healey (2007) outlines two independent types of career decisions relevant to prospective faculty: choice of discipline and choice of academic career. The choice of discipline often occurs early in undergraduate students' careers as they decide on a major (Lindholm, 2004). However, the pathway to the professoriate is often less direct, and can follow a variety of routes (Bowen & Schuster, 1997).

Linholm (2004) conducted a retrospective qualitative study with 36 faculty members in four departments at one public, research intensive university. She found that academics are attracted to academic work because of the autonomous nature, enjoyment of the work, and the attractiveness of working in an academic environment. In her participants, the desire to become an academic was shaped by childhood experiences, undergraduate and graduate training, as well as perceptions of competence. Linholm also notes that professors in her study described the process of becoming an academic as either intentional or accidental. The latter case described their experiences as serendipitous leading to academic employment.

McGinnis, Allison, and Long (1982) investigated the influences to attaining a postdoctoral training position among 557 biochemists, and how the postdoctoral training position influenced further academic employment. In determining factors that are influential to attaining a postdoctoral appointment, the authors identified the undergraduate institution's selectivity, prestige of the doctoral department, doctoral advisor's prestige (as measured by citation rates), publications, marital status, and age at which the doctorate was received. The authors only included male doctoral recipients in their sample due to low numbers of female biochemists during the sampling frame. They found that those persons from undergraduate institutions with high degrees of selectivity, prestigious doctoral departments, and with prestigious doctoral advisors (as measured by their research productivity) were most likely to receive a postdoctoral position. Surprisingly, their study did not reveal a link between pre-doctoral publication or citation rate and the attainment of a postdoctoral training position.

McGinnis et al. (1982) also explored the relationship between the postdoctoral position attained and the first faculty position attained, if this was in an academic field (N=348). Although postdoctoral training was not significant in their investigation, there was a relationship between the postdoctoral department prestige and the academic position attained. The authors suggest that the department prestige of the postdoc can act to replace the effect of doctoral department prestige in academic employment, and therefore may play a critical role in future employment. Additionally, the authors found that those scientists who attain postdoc positions are more likely to work in research intensive academic fields later in their careers, and tend to have higher rates of publication. It should be noted that at the time this study was conducted (PhD graduates in the early 1960s), the authors report that academic positions were “relatively plentiful” and lacking a postdoctoral training position was not a barrier to gaining academic employment (p. 718).

More recently, Rudd, Picciano, Nerad, and Cerny (2010) investigated the influence of postdoctoral training on prestige and time in academic careers. Their study focused on the postdoctoral training appointments of PhD recipients in biochemistry and mathematics. In contrast to the early 1960’s, when McGinnis et al. (1982) conducted their research, the postdoc is now seen as a mandatory first step in academic employment (Rudd et al., 2010). Their study used the 1995 National Research Council’s ranking of research-based doctoral programs

(Goldberger et al., 1995) as a measure of prestige, and utilized multinomial logistic regression techniques to address their research questions related to the prestige of the postdoctoral appointment and the subsequent academic career. Their analysis controlled for PhD granting department prestige, time to degree, number of publications during graduate school, retrospective evaluation of program quality, time spent in postdoctoral position, gender, marital and parental status, and ethnicity.

The prestige ranking of the PhD granting department was related to the likelihood of academic employment for students in biochemistry (Rudd et al., 2010). Students from higher ranked programs were more likely to achieve tenure- track academic positions. However, in mathematics there was no difference observed between program rank and likelihood of academic employment. Additionally, the program rank of the PhD department was also related to the rank of the achieved postdoctoral appointment, with those graduates from higher-ranked institutions also attaining higher-ranked postdoctoral appointments. The authors conclude that the PhD institution rank is an important indicator in determining the likelihood of a faculty career in a research university or top-ranked department.

Rudd et al.'s (2010) study also showed that marriage and children are negatively associated with the likelihood of attaining a prestigious academic position. Their study revealed that women with children are less likely to enter or remain in faculty careers, possibly reflecting that marriage and motherhood track women away from faculty careers. In their large, comprehensive study of 8,000 doctoral students in the University of California system, Mason, Goulden, and Frasch (2009) documented how many doctoral students view the incompatibility between academic and family life. Nearly all of the doctoral students in their sample (84% of women and 74% of men) expressed concerns about the family- friendliness of their choice.

Although female doctoral holders in science and engineering fields have increased in recent years, “the proportions of women at rank of full professor remain meager to limited” (Fox & Colatrella, 2006, p. 1). Fox and Stephen (2001) investigated how the career preferences, prospects, and realities of young scientists varied in the mid-1990s in five academic fields: chemistry, computer science, electrical engineering, microbiology, and physics. Career preferences were indicated by participants as “academic with emphasis upon research, academic with emphasis upon teaching, and nonacademic” (p. 111). Participants ranked their career prospects on a scale of 1-4, where 1 indicated poor, and 4 indicated excellent. This research combined data from a mailed survey distributed during 1993-1994, where participants reported their career prospects and preferences. The employment data for participants was gleaned from the 1993 NSF Survey of Doctoral Recipients.

Participants indicated preferences for nonacademic or academic research careers over teaching. These findings varied for women compared to men, and by field of study. Preferences for nonacademic careers were highest in chemistry and electrical engineering, and did not differ by gender. However, preferences for academic careers that focused in research were higher for men, while preference for academic careers that focused on teaching were higher for women. Fox and Stephen (2001) suggest that these reported preferences may be related to gender role expectations. The actual career attainment varied for men and women according to field. Women experienced higher rates of unemployment in each field. Additionally, higher proportions of women in electrical engineering were hired at research universities, while in physics higher proportions of men were employed at research universities. Women were more likely than men to have jobs teaching at academic institutions, while in nearly every field, men were paid more for the same job. The authors suggest that the career attainment findings may be linked to career preference by field and gender, ultimately suggesting that women are left with the employment "left-overs" (p. 119).

Correll (2001) also supports that individuals act on gender-differentiated perceptions when making career decisions. She argues that shared cultural beliefs about gender and ability to perform certain tasks bias individuals' perceptions of their competence. This perception of competence is then influential in career choice, a notion also supported by Bandura's theory of self-efficacy in career choice (Bandura, Barbaranelli, Caprara, & Partorelli, 2001). In addition to perceptions of competence, students may not feel supported in their decisions to pursue employment outside the academic sector, which may also influence their career preferences. Barnes and Randall (2011) found that doctoral students are not satisfied with the support they receive to pursue careers outside of academia. Their study used data from the 2000 National Association of Graduate and Professional School's survey of 32,000 doctoral students.

In summary, very little is known about what drives the career choices of doctoral recipients, and the career aspirations of doctoral candidates. This limited body of research has been limited to a small number of fields (Rudd et al., 2010), and much of it has focused specifically on the effects of postdoctoral training on academic employment (Long et al., 1979; McGinnis et al., 1986). Research related to career aspirations and attainment patterns has often been reported in terms of the percent of the population that either aspires to or attains a certain career (Golde & Dore, 2001; NSF 2012; Sauermann & Roach, 2012).

Conceptual Model

Two conceptual models were developed for the purposes of this study. The first model, Figure 1, suggests the relationships between doctoral candidates' graduate school experiences and their career aspirations. The second model, Figure 2, suggests the relationships between doctoral recipients' graduate school experiences and their career attainment patterns. These models were guided by the literature related to doctoral student socialization and the survey instruments that were selected for analysis. The first model and subsequent analysis utilizes the student questionnaire of the National Research Council's Assessment of Research- Doctorate Programs. The second model was developed from the National Science Foundation's Survey of Earned Doctorates. It should be noted that two models were developed because two independent samples of data were utilized for this analysis. A thorough description of these survey instruments can be found in Chapter 3.

This study investigated the relationship between doctoral candidates' graduate school experiences and their career aspirations and the nature of career activities they hope to engage in once they have graduated from their doctoral program (Figure 1). The conceptual model used to guide this inquiry was directed by the literature related to doctoral student experiences, with particular regard to their socialization experiences during graduate study and the survey instruments that were selected for analysis. The independent variables included in this study are listed under the Background Characteristics, Program Characteristics, and Graduate Experiences sections. The dependent variables in this analysis are listed under Career Aspirations, Nature of Career Activities, and Academic Career Aspirations. These variables are operationalized in Chapter 3.

The focal independent variables for this analysis are the Program Characteristics and Graduate Experiences. These variables represent the socialization experiences of doctoral candidates within their doctoral program. Doctoral candidates' background characteristics are influential in their doctoral experiences (Gardner, 2008; Millet & Nettles, 2006; Nettles, 1990;

Sallee, 2011). The influence of background characteristics on doctoral experiences in indicated with an arrow linking these boxes. I hypothesize that doctoral candidates' experiences within their program will influence the likelihood of their career aspirations and the nature of career activities they aspire to engage in. Participants academic career aspirations represent an in-depth analysis of these individuals who selection the broad field of education as their career aspiration.

This study also explored the relationship between graduate school experiences and initial career attainment at the time of graduation (Figure 2). Again, the focal variables of this investigation were the Program Characteristics and Graduate Experiences. These variables were selected based on relevant literature in the area of doctoral student socialization and the survey instrument selected. The arrows between the boxes indicate a hypothesized relationship between the variables. The National Science Foundation's Survey of Earned Doctorates does not include any measures of doctoral recipients' satisfaction or feelings of belonging within their graduate experience, but does include information concerning the educational history of participants. This model also accounts for participants' background characteristics. The dependent variables for this analysis are Career Attainment, Primary Career Activity, and Employment Field. A thorough description of the variables can be found in Chapter 3.

Figures 1 and 2 outline the conceptual models that form the basis for this study.

Figure 1

Conceptual model guiding research question 1.

[redacted]

Figure 2

Conceptual model guiding research question 2

[redacted]

CHAPTER 3: METHODS, DATA, AND ANALYSIS

This chapter describes the methods used to address the research questions outlined in this study. As such, this chapter focuses on describing the data sets utilized, how these data sets were matched, and providing a description of the analysis that was carried out. The chapter continues with a description of the dependent and predictor variables, and the independent variables included as controls in these models.

This study utilized the socialization theory framework to identify aspects of the doctoral education process that could be influential in predicting career aspirations among STEM doctoral candidates. These aspects of doctoral education include the type of funding received, relationship with doctoral advisor, research productivity of the faculty, and student support services (Austin, 2002; Barnes & Austin, 2009; Barnes, 2010; Barnes & Randall, 2011; Ehrenberg et al., 2009; Geme, 2005; Golde, 2000; Golde, 2005; Goldsmith et al., 2002; National Research Council, 2010; Nettles, 1990; Pole et al., 1997; Tinto, 1993; Weidman et al., 2001). Additionally, the role of students' background characteristics including gender, race/ethnicity, marital status, and dependent status will be investigated (Maher, Ford, & Mamrick, 2005; Nettles, 1990; Gardner, 2008; Salee, 2010).

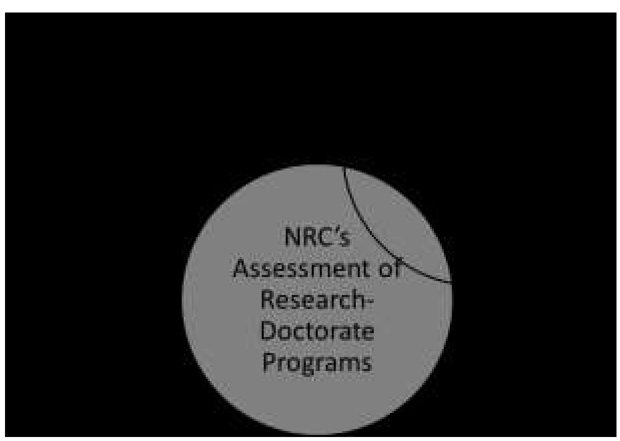
The aforementioned aspects of doctoral education were identified as influential in the socialization and success of doctoral students (Austin, 2002; Barnes & Austin, 2009; Barnes, 2010; Barnes & Randall, 2011; Ehrenberg et al., 2009; Geme, 2005; Golde, 2000; Golde, 2005; Goldsmith et al., 2002; National Research Council, 2010; Nettles, 1990; Pole et al., 1997; Tinto, 1993; Weidman et al., 2001). Thus, it is the aim of this study to test how these aspects of doctoral education are influential in the career aspirations of doctoral candidates. While these measures do not directly measure the socialization of doctoral students, they are intended to provide documentation of the aspects of doctoral education that are influential in predicting career aspirations. The potential identification of significant factors will provide key information to future scholars interested in pursuing this line of research and have implications for how STEM graduate programs may be redesigned to better support the needs of all doctoral students.

Description of Data

Broadly, this study explores the relationship between graduate school experiences and post-graduation career aspirations and attainment among STEM doctoral candidates and recipients respectively, by utilizing data from the National Research Council's Assessment of Research- Doctorate Programs (ARDP) and the National Science Foundation's Survey of Earned Doctorates (SED). These data were collected during the 2005-2006 academic year at institutions of higher education across the United States. Figure 3 provides a schematic representation of the data sources used in this study.

Figure 3

Schematic representation of the data sources utilized.



The National Research Council's Assessment of Research-Doctorate Program (ARDP) ranking system was used in conjunction with two additional data sources: the NRC student questionnaire and the NSF's Survey of Earn Doctorates. The ARDP program rating information was collected in 2005-2006, and therefore reflects the program characteristics experienced by the students in the NRC student questionnaire and the NSF Survey of Earned Doctorates. Using these three datasets, I created two, independent datasets to complete this research. The first dataset included the NRC student questionnaire and the ARDP rankings, which is used to address the first set of research questions. The second dataset included the NSF Survey of Earned Doctorates and the ARDP program rankings, which is used to address the second set of research questions. In order to create the two student-level datasets containing program-level characteristics, I created a crosswalk to link the ARDP rankings to the NRC student questionnaire and the NSF survey respectively. This crosswalk was possible because each of the student-level datasets contain the same institution and field of study codes that are used in the ARDP data. These common variables enable me to link the two different student-level datasets with the program-level characteristics. The NRC student questionnaire also includes the same program codes as the program ranking data. These crosswalks are described below in reference to each broad research question.

Research Question 1: Career Aspirations

This section focuses on exploring aspects of doctoral education that are influential in predicting career aspirations of science and engineering doctoral candidates. Specifically, data collected by the ARDP student questionnaire was combined with broader program ranking data and analyzed to address how program experiences influence the likelihood of certain career aspirations of doctoral candidates. A description of the ARDP, including a discussion of the student questionnaire follows.

National Research Council Assessment of Research Doctorate Programs

The Assessment of Research Doctorate Programs was conducted by the National Research Council in the 2005-2006 academic year to develop a ranking system for research doctoral programs in the United States, to allow for comparisons to be made across similar programs. The committee formed was tasked with creating a measure of quality to rank various programs and in doing so, measured research activity of faculty, student support and outcomes, and the diversity of the academic environment. The diversity of the academic environment measured the racial diversity of faculty and staff within the program. Additionally, a summary measure of program quality was created that included the aforementioned measures. Ultimately, the assessment covered doctoral programs in 61 fields at 222 institutions across the United States.

Doctoral-granting institutions were recruited for participation and asked to make financial contributions to the assessment. Institutional participation was voluntary. Data were collected during the 2005-2006 academic year. Disciplinary inclusion in the study was determined by the number of PhD's produced in the five years prior to 2004-2005. All fields of study included produced at least 500 PhDs during the five-year timeframe and are housed in at least 25 different universities. The fields of study included in the ARDP were based upon the National Science Foundation's Doctoral Records file. The following STEM fields of study were included (http://sites.nationalacademies.org/PGA/Resdoc/PGA_044521):

- Life Sciences
    - Biochemistry, Biophysics, and Structural Biology

  - Cell and Developmental Biology
  - Ecology and Evolutionary Biology
  - Public Health
  - Genetics and Genomics
  - Immunology and Infectious Disease
  - Biology/Integrated Biology/ Integrated Biomedical Sciences
  - Kinesiology
  - Microbiology
  - Neuroscience and Neurobiology
  - Nursing
  - Pharmacology, Toxicology and Environmental Health
  - Physiology
  - Animal Science
  - Entomology
  - Food Science
  - Forestry and Forest Science
  - Nutrition
  - Plant Science
  - Bioinformatics
  - Biotechnology
  - Systems Biology
- Physical Sciences and Mathematics
  - Applied Mathematics
  - Astrophysics and Astronomy
  - Chemistry
  - Computer Science
  - Earth Sciences
  - Mathematics
  - Oceanography, Atmospheric Sciences and Meteorology
  - Physics
  - Statistics and Probability
- Engineering
  - Aerospace Engineering
  - Biomedical Engineering and Bioengineering
  - Chemical Engineering
  - Civil and Environmental Engineering
  - Electrical and Computer Engineering
  - Material Science and Engineering
  - Mechanical Engineering
  - Operations Research, Systems Engineering and Industrial Engineering
  - Computational Engineering
  - Information Science
  - Nanoscience and Nanotechnology
  - Nuclear Engineering

The ARDP also included several non-STEM fields in Social and Behavioral Science and Arts and Humanities. As this dissertation was focused specifically on STEM fields, only these rankings were included in this study.

The ARDP defined programs to enroll students, have designated faculty, develop curricula for doctoral study, and recommend students for the award of a doctoral degree. Programs were included if they had produced at least five PhD recipients in the five years prior to 2005-2006. Each university chose which of their programs to include based on these criteria. Ultimately, over 5000 research doctorate programs were included in the assessment.

Five separate questionnaires were designed and distributed to collect data for this assessment. These included an *institutional questionnaire, program questionnaire, faculty questionnaire, student questionnaire,* and *rating questionnaire.* An Institutional Coordinator at each university assisted with the data collection procedures, by completing the institutional questionnaire, and naming each of the programs at the university that met the NRC guidelines for inclusion. Each of these programs was then sent the program questionnaire, which included questions about students, faculty, characteristics of their program, and named a list of faculty and students. Individual faculty were then contacted to complete the faculty survey. They provided information concerning their educational and work history, grants, publications, and characteristics important to doctoral program quality. Advanced students, those who had been admitted to candidacy, in English, chemical engineering, economics, physics, and neuroscience were contacted to complete the student questionnaire. These programs of study were chosen to represent both natural science and social science disciplines to pilot the student questionnaire. This questionnaire included items pertaining to student educational background, research experiences while in the program, program practices they had experienced, and post-graduation plans. Finally, the rating questionnaire was distributed to a stratified sample of those faculty who had completed the faculty questionnaire to provide ratings of programs in their field.

The ARDP provides ranking data in three broad categories, as well as an overall ranking range. These categories, also called dimensional measures, are: research activity, student support and outcomes, and diversity of the academic environment. The dimensional measures were weighted based upon the faculty survey responses for each program. Faculty were asked questions pertaining to faculty quality, student characteristics, and program characteristics, indicating characteristics in each category that they believe is important to program quality. This portion of the survey had an 86% response rate, allowing for the calculation of weights based upon the number of faculty in a given field that provided information. These weights were then used to create dimensional measures of research activity, student support and outcomes, and diversity of the academic environment.

The dimensional measure related to *research activity* relates to various ways to measure scholarly productivity, including publications, citations, the percent of faculty holding research grants, and recognition of scholarship. This dimension was most closely related to overall measures of program quality. The *student support and outcomes* measure combined data on the percent of fully-funded first year students, the percent of students completing their degree in a given time period reasonable to that field of study, time to degree, placement in academic positions, and whether or not a program collects data about the employment outcomes of its graduates. The *diversity of the academic environment* measure included the percent of faculty and students who are from underrepresented minority groups, and the percent of faculty and students who are female and the percent of international students. These dimensional measures were combined into a single measure to create an overall program rating. Ranges for program quality, as opposed to a numerical rank, were created in two ways: using direct measures from survey responses and creating a regression-based rating. Both of these measures were standardized by weights through calculations carried out 500 times with different sets of faculty responses included in each calculation to account for variability in rater opinion and statistical error. A sample of how these program quality ratings were obtained is provided in *A guide to the methodology of the National Research Council Assessment of Doctorate Programs* (2010).

Data collected through the NRC's Assessment of Research Doctorate Programs were cleaned and checked for accuracy. Institutions with incomplete data were contacted and asked to supply the missing information in both 2007 after the initial data collection period and again in 2008. During this process, 298 programs submitted new data, or confirmed their existing data, 66 programs did not update their data because of unavailability or non-response, and 23 programs requested to be removed from the study. NRC also conducted internal checks on the data and identified three sources of possible error in their study: classification errors, data collection errors, and omission of field-specific measures of scholarly productivity.

National Research Council Student Questionnaire

Items from the NRC student questionnaire were utilized in conjunction with the overall assessment rankings, warranting further discussion of this instrument. This questionnaire was administered to 16,439 doctoral candidates in chemical engineering, physics, neuroscience, economics, and English. The overall response rate was 70.5%. For the purposes of this study, only those student responses in the targeted STEM fields: chemical engineering, physics, and neuroscience, will be included (N=6350, response rate = 72%). Institutions identified doctoral candidates as those students who had passed their qualifying examinations.

- Of interest to the present study, candidates were asked to indicate their post-graduation plans in terms of the nature of work they hoped to engage in and their career aspirations. Both of these items were measured twice, as students were asked to indicate their preferences retrospectively at the time they entered the program and at the time of survey administration. The nature of work candidates hope to engage in was indicated in terms of primary and secondary activities, including research and development, teaching, management or administration, professional services to individuals or other. Career aspirations were indicated as the type of employer that the candidate believes he or she will work for upon graduation. These employers included:Education
    - US 4 year college or university other than medical school
    - US medical school
    - US affiliated research institute
    - US community college or technical institute
    - US preschool, elementary, middle, secondary school or system
    - Non-U.S. educational institution
- Government
    - Foreign government
    - U.S. federal government
    - U.S. state government
    - U.S. local government
- Private Sector
    - Not-for-profit instituion
    - U.S. based industry or business (for profit)
    - Non-U.S. based industry or business (for profit)
- Other
    - Sef-employed
    - Other- specify

This questionnaire also included items related to doctoral experiences, including candidates' relationship with their doctoral mentor concerning their career goals and dissertation research. Additionally, candidates indicated their overall satisfaction with their program related to teaching by the faculty, dissertation supervision, research experiences, program curriculum, and overall program quality. Candidates also indicated their primary source of funding, research productivity in terms of publications, and their background characteristics including gender, marital status, dependent status, year of birth, citizenship status, and racial background.

Data Preparation

Data collected by the NRC ARDP was obtained from one of the primary researchers. This dataset included 10,819 doctoral candidates from English, economics, physics, chemical engineering, and neuroscience. As described above, these fields were selected by the NRC committee as representative fields. For the purposes of this study, which is focused exclusively on STEM fields, responses from doctoral candidates in neuroscience, physics, and chemical engineering were included (N=6350). Those individuals who did not report a career choice (N= 24) were deleted using listwise deletion. Those individuals who did not report their background characteristics gender, marital status, dependent status, and race were deleted using listwise deletion (N=237). The remaining sample (N= 6089), was utilized in the current study. Those individuals who selected an educational career choice (N= 3242) represented a subset of this dataset, and were analyzed to further understand predictors of academic career aspirations.

In order to create a crosswalk to link the student- level questionnaire data with the broader program ranking data, individual program numbers assigned by the ARDP were utilized. This information was present in both the individual response data and the program ranking data. Participant response data was obtained through an agreement with one of the primary researchers that conducted the ARDP. Program ranking data is publically available, and was accessed through the NRC ARDP website (http://sites.nationalacademies.org/PGA/Resdoc/). Thus, this common measure between the two datasets provided a simple way to link the individual doctoral candidate response data with their program ranking data. In the following sections, I describe the analyses utilized and hypotheses tested in this research.

Analysis

This research utilized multinomial logistic techniques. Logistic regression is a useful way to study social phenomena that are discrete and categorical rather than numeric and continuous (Pampel, 2000). Logistic regression can be used to model the likelihood of non-ordered events occurring, such as attaining an academic position or a position in private industry while accounting for independent variables, such as gender and race (Agresti & Finlay, 1999). Multinomial logistic regression is used when more than two categorical dependent variables exist, such as modeling career attainment within the three categories of education, government, and private industry. Crosstabulation with chi square analysis was used to investigate the association between the independent and dependent variables prior to regression analysis. Measures of central tendency were computed for age and scholarly productivity. In the following sections, an analysis plan regarding the specification of regression models, the hypotheses tested, and a brief discussion of the dependent and independent variables is outlined with respect to each research question.

Measurements/ Definitions

I examine several dependent variables in this study. In the first set of analyses, I assess a nominal- level dependent variable to assess the likelihood of doctoral candidates' career choice. I further investigate doctoral candidates' academic career choices, which serves as the nominal dependent variable in a second set of analyses. The dependent and independent variables included in this study are further described and operationalized below.

Dependent variables

Career aspirations. For the purposes of this study, career aspirations were operationalized as the type of institution where doctoral candidates expect to attain employment after the completion of their degree. These career expectations were measured in four broad categories: education, government, private sector, and other. Doctoral candidates were asked to reflect on their career aspirations at the time they entered their degree programs, and also to indicate their preferences at the time of survey completion. Doctoral candidates' aspirations at the time of the NRC survey administration were utilized as their career choice in the present study. The career aspiration category, education, was the reference category. As Table 1 shows, 53.2 % of the population indicated an educational career aspiration, 8.1 % indicated government, 35.3 % indicated industry, and 3.3% indicated other.

Table 1

Dependent variables included in models to address research question1 (N= 6089)

Concept and Variable	Measures	Percent of Population (N=6089)
Career Aspiration[n]	0=Education	53.2%
	1=Government	8.1%
	2=Industry	35.3%
	3=Other	3.3%
Academic Career Aspiration[h,n,o,q]	0= U.S. four-year College or University	23.0%
	1=Medical School	6.2%
	2= Research Institute	17%
	3=Community College/ k-12	1.8%
	4=Non U.S. Educational Institution	5.3%
Nature of Career[n]	0= Research & Development	75.1%
	1=Teaching	
	2=Management/	10.9%
	Administration	4.9%

3=Professional Service to Others	4.0%
4= Other	5.1%

Note. In each variable, 0 serves as the reference category. All variables were dichotomously coded to be entered in to the regression models.
[h]Fox & Stephan, 2001; [n]Golde & Dore, 2001; [o]Haley, 2007; [q]Lindhom, 2004

Academic career aspirations. Academic Career Aspirations were indicated as part of the NRC student questionnaire in the following categories: U.S. 4 year college or university other than medical school; U.S. medical school; U.S. affiliated research institute; U.S. community college or technical institute; U.S. preschool, elementary, middle, secondary school or system; Non-U.S. educational institution. The categories, U.S. community college or technical institute and U.S. preschool, elementary, middle, secondary school or system, were combined into one category due to low representation. U.S. 4- year college or university other than a medical school served as the reference category. Of participants who selected an academic career, 43.2% indicated a four-year college or university, 11.7 % indicated a medical school, 31.9 % indicated a research institute, 3.3 % indicated a community college or k-12, and 9.9 % indicated a non-U.S. educational institution (Table 1).

Nature of career. Doctoral candidates indicated the nature of work they hope to engage in at the time of questionnaire administration. For the purposes of this study, these will serve as the nature of doctoral candidates' careers. Students indicated this in the following categories: research and development, teaching, management or administration, professional service to others, or other goal. Research and development will serve as the reference category for this analysis. Slightly more than three-quarters of the population selected research and development as their primary career objective. Teaching represented 10.9 %, management or administration represented 4.9 %, professional service to others was indicated by 4% of respondents, and 5.1% indicated other as their career goal.

Independent Variables

Table 2 outlines the independent variables that were included in this analysis. The coding scheme and percent of the population represented by each category is included. Each variable is also described in the sections that follow.

Table 2

Independent variables included in models to address research question 1 (N=6089)

Concept and Variables	Measures	Percent of Population (N=6089)
Background Characteristics		
Gender[p,r,bb]	0=Male	70.4%
	1= Female	29.6%
Race[j,v,y]	0= White	55.8%
	1=Hispanic	4.7%
	2=Asian	36.5%
	3=Other	4.2%
Citizenship	0= U.S. Citizen	55.2%
	1=Non U.S. Citizen	44.8%
Marital Status[j]	0= Not Married	53.8%
	1= Married	46.2%
Dependent Status[,j.s,w]	0= No Children	85.2%
	1= Children	14.2%
Age[j].	Continuous	N/A
Program Characteristics		
Research Productivity of the Faculty	0= 1st Quartile	32.8%
	1= 2nd Quartile	47.7%
	2= 3rd Quartile	13.3%
	3= 4th Quartile	4.3%
	4= Missing Rank	1.8%
Student Support and Outcomes	0= 1st Quartile	13.2%
	1= 2nd Quartile	55.3%
	2= 3rd Quartile	24.4%
	3= 4th Quartile	5.6%

(continued)

	4= Missing Rank	1.5%
Graduate Experiences		
Field of Study[a,l,j]	0= Neuroscience	22.6%
	1= Physics	51.7%
	2= Chemical Engineering	25.7%
Funding Received[c,k,u,y]	0= Fellowship	17.2%
	1=Research Assistantship (RA)	22.6%
	2= Teaching Assistantship (TA)	5.2%
	3= Multiple Funding Sources	17.6%
	4=TA and RA	
	5=Fellowship, TA, and RA	18.7%
Satisfaction with Research Experiences[b,d,l]	Scale calculated by summing responses to relation with doctoral advisor, feedback on research, and satisfaction with research & dissertation supervision	N/A
Satisfaction with Program	Scale calculated by summing responses to satisfaction with overall program quality, satisfaction with teaching of the faculty and program curriculum	N/A
Feelings of Belonging[j]	0= Not at all	0=6.9%
	1=somewhat	1=40.1%
	2= a lot	2=53.0%
Scholarly Productivity[f]	Continuous, capped at 50	N/A

Note. In each variable, 0 serves as the reference category. All independent variables with more than two categories were dichotomously coded to be entered in to the regression models.

[a]Austin, 2002; [b]Barnes, 2010; [c]Barnes & Randall, 2011;[d]Bieber & Worley, 2006; [f]Cognard-Black, 2004;[i]Gardner 2007;[j]Gardner, 2008; [k] Gemme, 2005; [l]Golde, 2000; [p]Kuck et. al, 2004; [r]Long & Fox, 1995; [s]Mclintock-Comeaux, 2007 ; [u]Mendoza, 2007[w ;] Morrison, et. al, 2011 ; [v]Nettles & Millet, 2006; [y]Nettles, 1990; [bb]Sallee, 2011

Program characteristics. These measures, related to doctoral granting programs, were collected as part of the NRC ARDP. Several doctoral programs can exist within the same department at one university. For example, programs in Ecology/ Evolution and Molecular Biology may both be housed in same Biology Department. These different programs would be ranked separately according to the measures outlined below. The methods used to construct the standardized ranges were described earlier in this chapter.

Research activity. Research activity was reported by program faculty. The dimensional measure related to *research activity* relates to various ways to measure scholarly productivity, including publications, citations, the percent of faculty holding research grants, and recognition of scholarship. This dimension was most closely related to overall measures of program quality. This measure is reported by NRC as a 90% confidence interval range for each program. These ranges were categorized into quartiles in order to preserve as much of the range as possible, and coded as a series of dichotomous variables. Programs that did not receive a research productivity regression range were coded as "missing". For the majority of programs that participated in the study, the regression range reported was greater than one quartile. These programs were coded into the quartile that represented the majority of the range, where 0= highest quartile rank and 3= lowest quartile rank. If two quartiles were equally represented, the higher quartile was used for the purposes of this study. The majority rule was used for the current study to try and best capture the rank of each program. Table 3 provides an example of how the quartile ranks were calculated. For the research ranks presented in the ARDP, the scores ranged 1-224. These ranks were divided into 56 point quartiles (1-56, 57-113, 114-170, and 171-224). For example, the Ecology program at the University of Massachusetts at Amherst ranged from 45-87 in their research rank. The majority of this range falls within the second quartile, 57-113, and thus a score of 1 was assigned.

Table 3

Sample research rank quartile calculation.

Institution	Program	R5	R95	Rank Quartile Code
University of Massachusetts, Amherst	Ecology	45	87	1
Syracuse University	Algebra	33	77	0

Student support and outcome rating. The *student support and outcomes* measure combined data on the percent of fully-funded first year students, the percent of students completing their degree in a given time period, time to degree, placement in academic positions, and whether or not a program collects data about the employment outcomes of its graduates. This information was reported by faculty and program administrators. This measure is reported by NRC as a 90% confidence interval range for each program. These ranges were categorized into quartiles, and coded as a series of dichotomous variables in the same fashion as the research ranks described above. Those programs that did not receive a student support services regression rank range were coded as "missing". For the majority of programs that participated in the study, the regression range reported was greater than one quartile. These programs were coded into the quartile that represented the majority of the range. If two quartiles were equally represented, the higher quartile was used for the purposes of this study. The majority rule was used for the current study to try and best capture the rank of each program. Table 2 presents the percent of the total population represented by each quartile.

Field of study. The three fields of study represented by the NRC ARDP were dichotomously coded. Neuroscience doctoral candidates comprised 22.6%, physics doctoral candidates comprised 51.7%, and chemical engineering doctoral candidates comprised 25.7% of the total population (Table 2).

Program Experiences. These measures are related to doctoral candidate experiences within their doctoral program. These data were collected as part of the NRC ARDP, and will be utilized in an effort to answer the first research question.

Satisfaction with Research Experiences. This scaled variable was created by summing several responses related to doctoral candidates' satisfaction with their research experiences within their doctoral program. Cronbach's alpha was calculated to determine the reliability of this scale. The calculated value, 0.785, indicates strong internal reliability for this scale. A description of each questionnaire item follows:

- Relationship with doctoral mentor. Candidates were asked to characterize their overall relationship with their doctoral mentor on a scale from 1-5, with 1 indicating a distant or hostile relationship (2.3%), 2 indicating a negative relationship (5%), 3 indicating a neutral relationship (15.8 %), 4 indicating a positive relationship (29.2%) and 5 indicating a highly supportive relationship (47.7%).
- Feedback on research. Respondents indicated whether or not they received *timely feedback* and *helpful feedback*. These responses were dichotomously coded as 0 indicating "no", and 1 indicating "yes". The majority of individuals indicated receiving both timely and helpful research feedback. These were entered as two separate variables into the regression models.

- Satisfaction with research experiences and dissertation supervision. Questionnaire respondents indicated their level of satisfaction with several features of their doctoral programs on a 3-point likert scale. These were coded as 0 indicating not satisfied, 1 indicating satisfied, and 2 indicated very satisfied.

Satisfaction with doctoral program. This scaled variable was created by summing responses to three questions where doctoral candidates indicated their level of satisfaction with the overall quality of their doctoral program, the program's curriculum, and the quality of teaching of the faculty within their program on a 3-point likert scale. These responses were coded as 0 indicating not satisfied, 1 indicating satisfied, and 2 indicating very satisfied. The Cronbach's alpha value calculated for this scale indicates strong internal reliability (α=0.778).

Scholarly productivity. The number of publications completed during doctoral studies was reported by candidates in four categories on the NRC ASRDP student questionnaire: refereed articles, book chapters, book reviews, and book or edited volumes. The total from all categories was summed and capped at 50.

Primary funding type received. The type of primary funding received during the doctoral program was reported by candidates in fourteen separate categories. Respondents were directed to indicate up to three categories. The following categories were utilized regarding the NRC ARDP data: fellowship (reference category) (17.2%), research assistantship (RA) (22.6%), teaching assistantship (TA) (5.2%), multiple funding sources (17.6%), TA & RA (18.7%), and fellowship, TA, & RA (18.8%) (Table 2). The "multiple funding sources" category included those individuals who indicated funding their doctoral education through employer reimbursement, personal/spouse savings, other assistantships, foreign government assistance, and those who indicated any combination of funding types that was not included as a stand-alone category.

Feelings of belonging. Doctoral candidates indicated their feelings of belonging within their doctoral programs on a scale of 1-3, with 1 representing not at all (6.9%), 2 representing "somewhat" (40.1%), and 3 representing "a lot" (53.0%) (Table 2).

Background Characteristics. Several background characteristics were indicated by participants on the NRC ARDP (Table 2). These included:

Gender. Gender was reported as male or female. Male, coded as 0, was the reference category and represents 70.4% of the population. Female was coded as 1.

Marital status. Participants indicated their *marital status* in 6 categories that included married, living in a marriage- like relationship, widowed, divorced, separated, and never married. The categories "married" and "living in a marriage-like relationship" were combined and coded as 1 (46.2%). All other categories, including single, divorced, and widowed, were combined and served as the reference category, coded as 0. Respondents indicated whether or not they are responsible providing financial support for dependents.

Dependent status. Their *dependent status* was coded such that 0 represented no dependents (85.2%) and 1 represented having dependents (14.8%).

Age. Participants' age was reported as respondent's birth year, which was converted into their age at the time of survey by subtracting the birth year from the year the questionnaire was completed.

Citizenship status. Participants' *citizenship status* was indicated in four categories, including U.S. citizen since birth, naturalized, non-U.S. citizen with a permanent visa, or non-U.S. citizen with a temporary visa. The first two categories were combined into "U.S. citizen", represented by 0 (55.2%), and the second two categories were combined into a "non- U.S. citizen" category, represented by 1 (44.8%).

Race. Race was reported as Hispanic, American Indian or Alaska Native, Native Hawaiian or Pacific Islander, Asian, Black or African American, and White. For the purposes of this study, an "other" category was created due to low representation in many of the categories by combining American Indian or Alaska Native, Native Hawaiian or Pacific Islander, and Black or African American. The "other" category was also used to code individuals who indicated more than one race. The majority of respondents (55.8%) are White, 36.5% are Asian, 4.7 % are Hispanic, and 4.2 % were coded as "other".

Research Question 1A: Is there a relationship between science and engineering doctoral candidates' graduate school experiences and their career aspirations, when controlling for background characteristics?

A multinomial logistic regression model was specified using data collected by the NRC ARDP student questionnaire and program quality ratings. This analysis investigated the effects of doctoral program experiences and programs ratings on the likelihood of certain espoused career aspirations. I include program characteristics rank data related to research productivity of the faculty and student support services offered. Measures of doctoral candidates' program experiences include their field of study, primary type of funding received, feedback received on their research, satisfaction with their doctoral program, and their scholarly productivity while in graduate school. I controlled for doctoral candidates' background characteristics, including gender, age, citizenship status, marital status, and dependent status. SPSS version 19 was utilized to complete the analysis.

The hypotheses tested by this model follow.

The overarching hypothesis tested by this model is:

H_1 Doctoral candidates' experiences within their doctoral programs and the characteristics of these programs have an effect on the likelihood of an academic career aspiration in relation to government, industry, or other career choices.

The following hypotheses are related to each independent variable investigated in the model.

- Doctoral candidates in programs with higher measures of research productivity are more likely to aspire to academic employment than government, industry or other.
- Doctoral candidates in programs with higher measures of student support are more likely to aspire to academic employment than government, industry, or other.
- Doctoral candidates who are satisfied with their doctoral program are more likely to aspire to academic employment than government, industry, or other.
- Doctoral candidates who indicate they belong in their program are more likely than those who indicate otherwise to aspire to academic employment than government, industry, or other careers.
- Doctoral candidates who have higher measures of scholarly productivity during graduate school are more likely to aspire to academic careers than government, industry, or other.
- Doctoral candidates who fund their studies primarily through grants and fellowships are more likely to aspire to academic careers than government, industry, or other career paths.

- Controlling for background characteristics will alter the relationship between program characteristics and experiences and candidates' espoused career choice.
    - Men are more likely than women to aspire to academic careers than government, industry, or other careers.
    - Whites are more likely than non-whites to aspire to academic careers than government, industry, or other careers.
    - Individuals who are not married are more likely than those that are married to aspire to academic careers than government, industry, or other careers.
    - Individuals who do not have dependents are more likely than those who have dependents to aspire to academic careers than government, industry, or other careers.

- U.S. citizens are more likely than non- U.S. citizens to aspire to academic careers than government, industry, or other careers.
- Younger students are more likely than older students to aspire to academic careers than government, industry, or other careers.

Research Question 1B: Is there a relationship between science and engineering doctoral candidates' graduate school experiences and their espoused academic career aspirations, when controlling for background characteristics?

A multinomial logistic regression model was specified to investigate the relationship between doctoral candidates' program characteristics, experiences, and the likelihood of a specific academic career aspiration. Academic career aspirations, described above, served as the nominal-level dependent variable for this investigation. Only those individuals who indicated an academic career aspiration were included in this investigation (N=3242). Measures of doctoral program characteristics included research productivity and student support services. Measures of doctoral candidates' experiences included their field of study, primary type of funding received, feedback received on their research, satisfaction with their doctoral program, and their scholarly productivity while in graduate school. I controlled for doctoral candidates' background characteristics, including gender, age, citizenship status, marital status, and dependent status. A full list of independent variables included in this analysis are listed in Table 2.

The overarching hypothesis tested by this model is:

H_2: Doctoral candidates' experiences within their doctoral programs and the characteristics of these programs have an effect on the likelihood of aspiring to work at a college or university in relation to other types of academic employment.

The following hypotheses related to each of the independent variables investigated are tested:

- Doctoral candidates in programs with higher measures of research productivity are more likely than candidates in programs with lower measures

of research productivity to aspire to a U.S. 4 year college or university other than medical school more so than other types of academic employment.
- Doctoral candidates in programs with higher measures of student support are more likely than those in programs with lower measures of student support services to aspire to a U.S. 4 year college or university other than a medical school more so than other types of academic employment.
- Doctoral candidates who are satisfied with their research experiences are more likely than those who report a negative relationship to aspire to a U.S. 4 year college or university other more so than a medical school than other types of academic employment.
- Doctoral candidates who are satisfied with their doctoral program are more likely than individuals who are not satisfied to aspire to a U.S. 4 year college or university other more so than a medical school than other types of academic employment.
- Doctoral candidates who have achieved higher measures of scholarly productivity during graduate school are more likely than those with lower scholarly productivity to aspire to employment at a U.S. 4 year college or university more so than other types of academic employment.
- Doctoral candidates who fund their studies primarily through grants and fellowships are more likely than those who fund their education through other means to aspire to a U.S. 4 year college or university other more so than a medical school than other types of academic employment.

Research Question 1C: Is there a relationship between the primary nature of career activity that science and engineering doctoral candidates' desire and their graduate school experiences, controlling for background characteristics?

A multinomial logistic regression model was specified to investigate the relationship between doctoral candidates' program features, experiences within graduate school, and the likelihood of desiring a certain nature of career (N= 6089). Prior to regression analysis, crosstabulation with chi-square testing was conducted to determine if a significant relationship exists between the nominal level independent variables (Table 2) and the dependent variable. Nature of career, outlined above, served as the nominal-level dependent variable for this analysis. The overarching hypothesis tested by this model is:

H_3: Doctoral candidates' experiences within their doctoral programs and the characteristics of these programs have an effect on the likelihood of aspiring to a career primarily in research and development in relation to teaching, management/ administration, professional service to others, or other activities.

The following hypotheses related to the independent variables are tested in this model:

- Doctoral candidates in programs with higher measures of research productivity are more likely than candidates in programs with lower measures of research productivity to aspire to a career in research and development than other types of career activities.
- Doctoral candidates in programs with higher measures of student support are more likely than those in programs with lower measures of student support services to aspire to a career in research and development than other career activities.
- Doctoral candidates who are satisfied with their research experiences are more likely than those who are not to aspire to a career in research and development than other career activities.
- Doctoral candidates who are satisfied with their doctoral program are more likely than individuals who are not satisfied to aspire to a career in research and development than other career activities.
- Doctoral candidates who have achieved higher measures of scholarly productivity during graduate school are more likely than those with lower scholarly productivity to aspire to a career in research and development than other career activities.
- Doctoral candidates who fund their studies primarily through grants and fellowships are more likely than those who fund their education through other means to aspire to a career in research and development than other career activities.

Research Question 2: Career Attainment

Program rank data provided by the Assessment of Research-Doctorate Programs (NRC, 2010) was combined with data collected by NSF's Survey of Earned Doctorates. These data were analyzed to investigate the likelihood of post-graduation career attainment in light of doctoral program experiences. This section provides a description of the Survey of Earned Doctorates (SED), the procedures that were used to prepare and match the datasets, and continues with a description of the dependent and predictor variables, and the independent variables included as controls in these models.

NSF Survey of Earned Doctorates (SED)

The National Science Foundation (NSF) began collecting data on the number and characteristics of research doctoral degree recipients in 1957-1958 (www.nsf.gov). The Survey of Earned Doctorates is a census, whereby all individuals receiving research doctoral degrees during a certain academic year (for example, 2003-2004) from U.S. accredited institutions of higher education are asked to participate. NSF defines research doctoral degrees, most commonly the PhD, as requiring the completion of an "original intellectual contribution in the form of a dissertation or equivalent project of work". Each graduate school is responsible for administering the SED to their graduates and submitting completed forms to NSF. The SED collects information on participants' education, demographic characteristics, as well as their post-graduation plans, including the academic institution of the baccalaureate and doctorate, field of study, sex, and sources of financial support during graduate studies.

The SED is administered to doctoral degree recipients in three ways: self-administered paper surveys, Web-based surveys, and computer assisted telephone interviews. The U.S. Department of Education's Integrated Post-secondary Data System (IPEDS) coding frame is used for the U.S. institutions where doctoral recipients earn their undergraduate or master's degrees. A coding manual for those students who earned doctoral degrees in other countries was also developed by the U.S. Department of Education.

For the purposes of this study, data from the 2006 SED, collected from July 1, 2005- June 30, 2006 were utilized. This data collection cycle corresponds with the data collected by the

National Research Council Assessment of Research Doctorate Programs described in the following section, and this it is likely that the survey respondents experienced the programs as they are represented by ARDP. The SED collects data on the following:

- Academic Institution of the doctorate
- Baccalaureate-origin institution
- Birth year
- Race/ethnicity
- Citizenship
- Sex
- Field of degree
- Educational history
- Type of funding received during doctoral studies
- Marital status/dependent status
- Type of academic institution awarding the doctorate
- Post-graduation plans (work, postdoc, other training)
    - Primary and secondary work activities
    - Source and type of financial support for postdoc/research
    - Location and type of employer

During the 2006 survey cycle, data on 45,596 research doctorate recipients were collected in all fields, representing a 92% response rate overall (Hoffer, Hess, Welch & Williams, 2007). Individual item response rates for items included in the current study were also reported by Hoffer et al., 2007. STEM doctoral recipients represent approximately 24,400 respondents of the 2006 survey cycle. NSF describes the SED as a census, whereby there is no sampling variability. Measurement error and data recording error are reported as less than 1% for the SED (http://www.nsf.gov/statistics). Missing values within the dataset are not imputed by NSF.

These data were obtained through a licensing agreement with the National Science Foundation. While the majority of these data are publicly available, in order to merge the data, blinded, individual level data were required. These two data sets have not been previously merged by other researchers. The 1995 NRC rankings of research based doctoral programs have been used in conjunction with other large-scale data sets collected by NSF (Rudd et al., 2010).

This study utilized the most recent ranking data which makes use of regression modeling and is reported in 90% confidence interval ranges, as discussed earlier is this chapter. Previous iterations of the NRC ranking data relied on a numeric ranking of programs (Goldsmith et al., 1995).

Data Preparation

A crosswalk provided by NSF was utilized to match data provided by the Survey of Earned Doctorates and program ranking data available from the ARDP. The crosswalk provides the institution identification number and the best-matching SED field code and label for each NRC program (Appendix 1). The ARDP also reports the institution identification number and a field of study for each program. The ARDP utilized the same code numbering system for institution numbers and fields of study as the SED.

As noted in Appendix 1, there were some fields of study without a direct match, and other fields that could be matched to more than one field code (for example, biology could be matched to “molecular biology”, “ecology”, or “cellular biology”). The research team that was tasked with creating the crosswalk selected only one field code per program; which may fail to represent the interdisciplinary nature of some programs as well as include all of the fields of study that doctoral recipients may have reported.

The initial merge of the two datasets using the crosswalk provided by NSF resulted in a match in less than 50% of cases. There are several reasons for the low match rate using the initial crosswalk. First, the ARDP researchers were instructed to only match 1 field of study to each ranked program. However, doctoral recipients may have selected a similar field, and because the entry codes did not match, a program was not assigned. Second, it remains unclear if students’ selected their field of study based on the topic of their dissertation, their department, program, or by some other method. Thus, the matching of these two datasets based on the field of study and institution attended by doctoral recipients is a limitation of the present research.

In order to match as many cases as possible to an appropriate doctoral program, a supplementary crosswalk was created. I utilized doctoral recipients' field of study as reported on the Survey of Earned Doctorates and doctoral granting institution to link these two datasets. I was able to utilize these two pieces of information to try and link individual respondents to specific programs. First, I investigated whether or not and individual's institution participated in the ARDP. If their institution did not participate, I assigned a "not ranked" score for the research rank quartile and the students support services quartile. Then, I utilized participants' reported field of study to match individuals to programs. I researched individual doctoral granting program's informational websites to accurately match fields to programs. This resulted in several fields of study that could be linked to a single program at an institution. For example the fields, Cell Biology, Microbiology, and Molecular Biology could all be linked to the same Biology program within a single institution.

In cases where a potentially interdisciplinary field was selected, such as "engineering physics", which could fall in either a physics or engineering department, I researched university and program websites to determine the best match. If it remained unclear after this research was completed, I assigned a "not ranked" score. This method allowed me assign an appropriate program or "not ranked" score to all of the individuals in the present study.

The ARDP ranking data for research productivity and student support services were utilized. These data are presented as 90% confidence ranges. As described in more detail earlier in this chapter, I assigned quartiles to these rank ranges.

Although the SED has high individual question response rates, missing responses to individual questions ranged from 0.8% to 5.1%. Additionally, while the NRC Assessment of Research Doctorate Programs is quite comprehensive, providing data for over 5000 doctoral programs, it is possible that some of the doctoral recipients in the sample graduated from non-ranked programs. Missing NRC rank data were assigned a "non-ranked" category, allowing for comparison between ranked and non-ranked programs.

Missing data in any of the dependent variables, definite career attainment, employment field, and primary career activity were not included in the analysis. This resulted in three different sample sizes for each model depending on the number of missing cases in the respective dependent variable. Those individuals who indicated that they had no definite career prospects, did not plan to work or study, or were negotiating with one or more employer (N= 6452) were not included in the analysis of employment field (N= 15431). A further 970 cases were removed from the analysis of primary career activity due to missing data (N= 14461)

Missing data in the independent variables ranged from 0.8% to 5.1%. In nominal level categorical independent variables with less than 5% missing cases, mode imputation was utilized. These variables, with the original percent of missing cases in parentheses, included: primary source of funding (3.9%), junior college indicator (2.8%), additional professional degree (2.8%), marital status (2.8%), number of dependents (3.9%), and race (0.8%). Mean imputation was used for the 3.6% of missing cases on the length of time to Ph.D. variable. For the nominal independent variable, baccalaureate field, a “missing data” category was created for the 5.1% of cases that did not include data. A large percentage of cases, 31.4%, did not include information for their master’s degree field of study. Many of these cases likely did not complete a master’s degree; however I had no way to differentiate between individuals who did not complete a master’s degree compared with those individuals who simply did not report a field of study. Thus, I created a “missing” variable and included all of the appropriate cases.

Analysis

Crosstabulation with chi square analysis was utilized to determine if a relationship exists between the nominal level independent and dependent variables. Following, multinomial logistic regression models were utilized in this analysis. As mentioned previously, logistic regression is a useful statistical technique with categorical dependent variables. In the following sections, I operationalize the variables included in this study, outline an analysis plan regarding the specification of regression models, and provide the hypotheses tested by these models.

Measurements/ Definitions

Several dependent and independent variables are tested in this study. These variables are operationalized and further described below.

Dependent Variables.

Post-graduation Career Attainment. For the purposes of this study, post-graduation career attainment was measured by participants’ indication of their career plans following graduation. Those participants who responded that they had made a definite commitment for employment are considered to have attained a job, while those individuals who indicated that they had no definite prospects were considered to not have attained a job. Participants indicated their status in the following categories: returning to pre-doctoral employment (13.1 %), signed a contract (57.4%), negotiating with one or more employers (9.6%), and other (19.9) (Table 4). The other category included those individuals were seeking employment, not planning to work, or chose the "other" option on the survey. Those PhD recipients who reported either returning to pre-doctoral employment or signed a contract were considered to have achieved career attainment (70.5%). Thus, these two categories were combined for the purposes of this analysis.

Post-graduation Career Field. Those individuals, who were considered to have attained a position, indicated the career field where they will be employed (15831). The following categories were utilized: U.S. four-year college/ university (27.1%), Medical School (11.4%), Industry (25.1%), Research Institute (12.9%), Other (9.2%), Foreign employment (6.9%), and U.S. Government (7.5%). Table 4 shows the percent of the total population of doctoral recipients who reported their post-graduation employment fields in the aforementioned categories.

Primary Career Activity. Participants indicated their primary and secondary work activities. Only the primary work activities are utilized in this study to gain a sense of what participants will be doing in their initial post-graduation employment. The following categories were utilized: Research & Development (50.8%), Teaching (7.7%), and Administration/ Professional Service to Others (5.8%).

Table 4

Description of the dependent variables utilized to address research question 2 (N=21,883).

Concept	Measurement	Percent of Population (N= 21,883)
Career Attainment	0= Definite Career Attainment	70.5%
	1= Negotiating	9.6%
	2= Other	19.9%
Employment Field[1f]	0= U.S. Four-year College or University	19.1%
	1= Medical School	8.0%
	2= Industry	17.7%
	3= Research Institute	9.1%
	4= Other	6.5%
	5= Foreign Employment	4.9%
	6= U.S. Government	5.3%
Primary Work Activity[1,2,h]	0= Research and Development	50.8%
	1= Teaching	7.7%
	2= Administration/ Professional Service to Others	7.6%

Notes: In each variable, 0 serves as the reference category. All variables with more than two categories were dichotomously coded to be entered in to the regression models. Only individuals who reported definite career attainment were included in the analysis of employment field and primary work activity. Individuals who did not report a value for employment field or primary work activity were removed from the respective analysis.

[1]29.5% of the population were not included in this sample. These individuals were coded as "Logical skip" in the data provided by NSF because they indicated that they: were negotiating but did not have a signed contract, were seeking a position with no definite prospects, pursuing another full time degree program, no plan to work or study (family commitment) (N=15431)

[2]An additional 4.4% of the total population were not included in this sample because they did not report a value for their primary career activity (N=14461)

[f]Cognard-Black, 2004; [h]Fox & Stephan, 2001

Independent Variables

Table 5 presents the independent variables that are included in these analyses. The following sections describes further how these variables were operationalized in the present study.

Table 5

Independent variables included in the models to address research question 2 (N=21,883).

Concept and Variable	Measures	Percent of Population (N=21,883)
Background Characteristics		
Gender[p,r,bb]	0= Male	64.8%
	1= Female	35.2%
Age[j]	Continuous	N/A
Race[j,v,y]	0= White	51.3%
	1= Hispanic	4.4%
	2= Asian	38.7%
	3= Other	5.6%
Marital Status[j]	0=Not Married	38.9%
	1= Married	61.1%
Dependent	0= No	81.0%
Status[j,s,w]	1= Yes	19.0%
Citizenship Status[x]	0=Non U.S. Citizens	49.5%
	1= U.S. Citizens	50.5%
Educational History		
Junior College	0= No	88.9%
	1= Yes	11.1%
Baccalaureate	0= Research University, Very High	26.7%
Institution Rank[aa]	1= Research University, High	6.0%
	2= All other Institution Types	18.6%
	3= Non U.S. Institution	44.9%
	4= Missing	3.8%
B.A. Field of	0= Biological/ Biomedical Science	21.4%
Study	1= Agriculture/ Natural Resources	3.8%
	2=Health Science	5.9%
	3=Mathematics	5.8%
	4=Chemistry	10.4%
	5= Geological/ Earth Sciences	2.6%
	6= Physics	7.0%
	7= Engineering	28.9%
	8= Computer & Information	3.7%
	Sciences	5.4%
	9= Non Science B.A.	5.1%
	10= Missing	
Master's	0= Research University, Very High	35.7%
institution Rank	1= Research University, High	7.7%
	2= All Other Institution Types	5.6%
	3= Non U.S. Institution	19.6%

	4= Missing or No M.A.	31.4%
Master's Field of Study	0= Biological Sciences	9.9%
	1= Agriculture/ Natural Resources	3.5%
	2=Health Sciences	6.5%
	3=Mathematics	4.9%
	4=Chemistry	4.4%
	5=Geological/Earth Sciences	2.8%
	6=Physics	4.1%
	7=Engineering	25.1%
	8=Computer & Information Sciences	5.0%
		2.5%
	9=Non Science M.A.	
	10=Missing/No MA	31.2%
Doctoral Institution Rank[e,t]	0= Research University, Very High	80.6%
	1= Research University, High	12.8%
	2=Other	6.6%
Program Characteristics		
Research Productivity of the Faculty	0= 1^{st} Quartile	49.6%
	1= 2^{nd} Quartile	30.7%
	2= 3^{rd} Quartile	4.9%
	3= 4^{th} Quartile	0.5%
	4= Missing Rank	14.4%
Student Support and Outcomes	0= 1^{st} Quartile	48.0%
	1= 2^{nd} Quartile	30.8%
	2= 3^{rd} Quartile	6.0%
	3= 4^{th} Quartile	0.8%
Graduate Experiences		
Field of Study[a,I,j,m]	0= Biological Sciences	31.7%
	1= Agriculture/ Natural Resources	4.3%
	2=Health Sciences	7.9%
	3=Mathematics	5.7%
	4=Chemistry	9.4%
	5=Geological/Earth Sciences	4.1% (continued)
	6=Physics	5.0%
	7=Engineering	30.1%
	8=Computer & Information Sciences	6.1%
Funding Received[c,k,u,y]	0=Fellowships/Grants	29.6%
	1=Teaching Assistantships	13.4%
	2=Research Assistantships	41.0%
	3=Other Sources of Funding	16.1%
Length of Time to PhD[g]	Continuous	N/A

Note. In each variable, 0 serves as the reference category. All independent variables with more than two categories were dichotomously coded to be entered in to the regression models.

[a]Austin, 2002; [c]Barnes & Randall, 2011; [e]Burris, 2004; [g]Ehernberg & Mavos, 1992; [i]Gardner 2007;[j]Gardner, 2008; [k] Gemme, 2005; [m]Golde, 2005; [p]Kuck et. al, 2004; [r]Long & Fox, 1995; [t]McCormick & Zhao, 2005; [s]Mclintock-Comeaux, 2007 ; [u]Mendoza, 2007[w]Morrison, et. al, 2011; [x]National Research Council, 2012 ; [v]Nettles & Millet, 2006; [y]Nettles, 1990 [bb]Sallee, 2011

Program and Institutional Characteristics. These measures, related to doctoral granting programs, were collected as part of the NRC ARDP. The methods used to construct the rank ranges are discussed earlier in this chapter.

*Research activity***.** Research activity was reported by program faculty. The dimensional measure related to *research activity* relates to various ways to measure scholarly productivity, including publications, citations, the percent of faculty holding research grants, and recognition of scholarship. This dimension was most closely related to overall measures of program quality. This measure is reported by NRC as a standardized regression coefficient. These regression coefficients are presented in a 90% confidence interval range for each program. These ranges were categorized into quartiles, and coded as a series of dichotomous variables. Programs that did not receive a research productivity regression range were coded as "missing". For the majority of programs that participated in the study, the rank range reported was greater than one quartile. These programs were coded into the quartile that represented the majority of the range. If two quartiles were equally represented, the higher quartile was used for the purposes of this study. The majority rule was used for the current study to try and best capture the rank of each program (Table 3).

Student support and outcome rating. The *student support and outcomes* measure combined data on the percent of fully-funded first year students, the percent of students completing their degree in a given time period, time to degree, placement in academic positions, and whether or not a program collects data about the employment outcomes of its graduates. This information was reported by faculty and program administrators. This measure is reported by NRC as a 90% confidence interval of the rank range. These ranges were categorized into quartiles, and coded as a series of dichotomous variables. Those programs that did not receive a student support services regression rank range were coded as “missing”. For the majority of programs that participated in the study, the rank range reported was greater than one quartile. These programs were coded into the quartile that represented the majority of the range. If two quartiles were equally represented, the higher quartile was used for the purposes of this study. The majority rule was used for the current study to try and best capture the rank of each program.

PhD Field of Study. Participants reported their specific field of study within the STEM fields targeted in this study. These fields were then condensed into the following groups based on the frequency of participants and the categories of fields of study as provided by NSF: Agricultural Sciences/ Natural Resources (4.3%), Biological/ Biomedical Sciences (27.4%), Health Sciences (7.9%), Mathematics (5.7%), Astronomy & Atmospheric Sciences (1.4%), Chemistry (9.4%), Geological & Earth Sciences/ Ocean & Marine Sciences (2.6%), Physics (5.0%), Engineering (30.1%), and Computer & Information Sciences (6.1%) (Table 5).

PhD Institution Carnegie Rank. The Carnegie Rank of doctorate-granting institutions were measured in the following categories for the purposes of this study: Research University- Very High Activity (80.6%), Research University- High Activity (12.8 %), Doctoral/ Research University (1.8%), Medical School or Research Institute (3.4 %), and Other (1.4 %). The Other category included Master’s and Baccalaureate granting institutions. The categories Doctoral/

Research University, Medical Schools or Research Institute, and Other were combined into one "Other Institution Types" variable that constituted 6.6% of the population (Table 5).

Program Experiences.

Primary Funding Type Received. Survey respondents indicated the primary type of funding they received throughout their doctoral education. Participants were limited to indicate only 1 of 14 categories. Participants chose from: fellowships/ scholarships, grants, teaching assistantship, research assistantship, other assistantship, traineeship, internship/clinical residency, loans (from any source, personal savings, personal earnings during graduate school, spouse/ partner/ family earnings or savings, employer reimbursement, spouse/ family earnings, foreign government, and other. These categories were condensed based on frequencies and to maintain consistency among various aspects of this study into: Fellowships and Grants (29.6 %), Teaching Assistantships (13.4%), Research Assistantships (41.0%), and Other Sources of Funding (16.1%) (Table 10). Fellowships and Grants served as the reference category (Table 5).

Length of Time to PhD. This variable was calculated by subtracting the year participants started their PhD from the year it was completed. Descriptive statistics are presented in table 7.

Background Characteristics. Several descriptors of doctoral recipients' background characteristics are included as independent variables in this study. These include:

Gender. Gender was reported as male or female. Males represent 64.8% of the population, while female doctoral recipients represent 35.2%.

Marital Status. Doctoral recipients' marital status was reported as singe, married, living in a marriage like relationship, divorced, or widowed. These categories were condensed into married or living in a marriage-like relationship and single. The single category includes those individuals who are divorced or widowed (Table 5).

Dependent Status. Individuals reported the number of dependents under the age of 5. For the purposes of this study, dependent status was coded dichotomously as 0 representing those who do not have dependents (81%), and 1 representing individuals who do have dependents (19%) (Table 5).

Age. Participants reported their date of birth. Their age at the time of survey administration was calculated. Descriptive statistics are presented in Table 7.

Citizenship Status. Participants' citizenship status was coded dichotomously. Non- U.S. citizens were coded as 0 (49.5%) and U.S. citizens were coded as 1 (50.5%) (Table 5).

Race. For the purposes of this study, participants' race was measured as White (51.3%), Hispanic (4.4%), Asian (38.7%), or Other (4.8%). The Other category included individuals who reported their race as Black or African American, American Indian or Alaska Native, and Native Hawaiian or Pacific Islander. White served as the reference category (Table 5).

Educational History. Participants' educational history was operationalized for the purposes of this study using measures of participants' Bachelors and Masters institutions and field of study (Table 5).

Junior College Indicator. This variable measures which participants attended a junior or community college during their educational history. The majority of participants in this study (88.9%) did not attend a junior college.

Baccalaureate Carnegie Rank. The Carnegie Rank of participants' baccalaureate institution was measured in the following categories: Research University- Very High Activity (26.7%), Research University- High Activity (6.0%), Doctoral/Research University (2.1%), Master's Institution (8.1%), Baccalaureate Institution (7.8%), Non U.S. Institution (44.9%), and Missing Rank (3.8%). For the purposes of this analysis, doctoral/ research universities, master's institutions, and baccalaureate institutions were condensed into an "other institution types" variable (18.6%).

Baccalaureate Field of Study. Baccalaureate fields of study were indicated by participants. These fields were condensed into the following groups: Agricultural Sciences/ Natural Resources (3.8%), Biological/ Biomedical Sciences (21.4%), Health Sciences (5.9%), Mathematics (5.8%), Astronomy/ Atmospheric Sciences and Earth Sciences (2.6%), Chemistry (10.4%), Physics (7.0%), Engineering (28.9%), Computer and Information Science (3.7%), Other Fields (5.4%), and Missing Field (5.1%) (Table 5).

Master's Carnegie Rank. The Carnegie Rank of participants' Master's institution was measured using the following categories: Research University- Very High Activity (35.7%), Research University- High Activity (7.7%), Doctoral/Research University (1.6%), Master's Institution (2.9%), Bachelors or Associates Institution (1.1%), Non U.S. Institution (19.6%), and no Master's or Missing Data (31.4%). In order to remain consistent across measures of educational history, an "other institution types" variable was created. This category included doctoral/ research, master's, and bachelors' institutions (Table 5).

Master's Field of Study. Those participants who completed a Master's degree indicated their field of study. These fields were condensed into groups following the guidelines set forth by NSF. These categories include: Agricultural Sciences/ Natural Resources (3.5%), Biological/ Biomedical Sciences (9.9%), Health Sciences (6.5%), Mathematics (4.9%), Astronomy/ Atmospheric Sciences and Earth Sciences (2.8%), Chemistry (4.4 %), Physics (4.1%), Engineering (25.1%), Computer and Information Science (5.0%), Other Fields (2.7%), and No Master's or Missing (31.2%) (Table 5).

Research Question 2A: Is there a relationship between the STEM PhD recipients' program characteristics and experiences and their initial post-graduation employment, controlling for background characteristics?

A multinomial logistic regression model was specified to address this research question. The nominal- level variable, career attainment, served as the dependent variable. Career attainment, as described above, was measured in three categories: definite career plans, negotiating with one or more employers, and other. Prior to regression modeling, crosstabulation with chi square testing was conducted to determine if a relationship exists between the nominal level independent variables and the dependent variable. This analysis investigated the potential influence of doctoral program characteristics and experiences on the likelihood of post-graduation career attainment at the time of survey administration. Doctoral program characteristics were measured by programs' research productivity rank and student support services rank. Additionally, I controlled for doctoral institutions' Carnegie rank. Doctoral experiences were measured by PhD recipients' field of study, the type of funding they received to primarily fund their doctoral studies, and the length of time to PhD. I controlled for participants' educational history, including their previous fields of study (where applicable), and the Carnegie ranks of institutions they previously received degrees from. I also included a measure of whether or not they attended a junior college. In addition, I controlled for PhD recipients' background characteristics, including their gender, marital status, whether or not they have children, race, citizenship status, and age. A full list of independent variables can be found in table 5.

The overarching hypothesis tested by this model is:

H_4: Doctoral institution and program characteristics and PhD recipients' experiences within these programs has an effect on the likelihood of definite career attainment in comparison to negotiating or other.

The following hypotheses were tested in regard to each of the independent variables included in this model:

- PhD recipients from programs with higher measures of research productivity are more likely to attain a position than those in lower ranking programs.
- PhD recipients from programs with higher measures of student support will be more likely to attain a position than those in lower ranking programs
- PhD recipients from institutions that are ranked as Very High Research activity are more likely than those from lower ranked institutions to attain a position.
- PhD recipients who fund their doctoral studies through fellowships are more likely to attain a position than those individuals who fund their studies through teaching /research assistantships or by other means.
- Controlling for PhD field of study will not alter the relationship between doctoral program experiences and initial career outcomes.
- Men are more likely than women to have definite career attainment at the time of survey administration.
- White PhD recipients are more likely than other races to have definite career attainment.
- U.S. citizens are more likely than non-citizens to have definite career attainment.
- Older recipients are more likely than younger recipients to have definite career attainment.
- Married recipients are more likely than non- married individuals to have achieved definite career attainment.
- Participants who attended Master's institutions ranked as Very High research activity are more likely than those who attended lower ranked institutions to attain a position.
- Participants who attended a Bachelor's institution ranked as Very High research activity are more likely than those who attended a lower ranked institution to attain a position.

Research Question 2B: Is there a relationship between STEM PhD recipients' institutional and program characteristics and experiences and the nature of their primary career activity?

A multinomial logistic regression model was specified to test the relationship between doctoral institutional and program characteristics and the likelihood of certain career activities. The nominal level dependent variable, career activity, was measured in the following categories:

research and development, teaching, and administration/ professional service to others (Table 4). Institutional characteristics were measured as Carnegie Rank. Measures of program included the research and student support services rank, length of time to PhD, and the primary type of funding doctoral recipient's utilized to fund their studies. I controlled for doctoral recipients' educational history, including the Carnegie Rank and field of study for their previous degrees. I also controlled for participants' background characteristics, including their gender, marital status, dependent status, race, citizenship status and age. A full list of independent variables included in this model can be found in Table 5.

The following overarching hypothesis was tested by this model:

H_5: Doctoral institution and program characteristics and PhD recipients' experiences within these programs influences the likelihood of doctoral recipients engaging in research and development in relation to teaching or administration/professional service to others .

In regard to each of the independent variables included in this model, the following hypotheses were tested:

- PhD recipients from programs with higher measures of research productivity are more likely to report research and development as their primary career activity compared with graduates from lower ranking programs.
- PhD recipients from programs with higher measures of student support services are more likely to report research and development as their primary career activity compared with graduates from lower ranking programs.
- PhD recipients from institutions with Carnegie Ranks of Very High are more likely than graduates from lower ranking institutions to report research and development as their primary career activity.
- PhD recipients who complete their degree in a shorter period of time are more likely than those individuals who take longer to report research and development as their primary career activity.
- Participants who complete PhDs in Agriculture, Health Science, Mathematics, and Astronomy/Geology are less likely to report research and development as their primary career activity than their peers who complete degrees in other fields.

- PhD recipients with an educational history that includes Carnegie ranks of Very high research activity from their master's and bachelor's institutions are more likely to report research and development as their primary career activity compared with individuals who attended lower ranking institutions.
- Men are more likely than women to report research and development as their primary career activity.
- Whites are more likely than non-whites to report research and development as their primary career activity.
- U.S. citizens are more likely than non- citizens to report research and development as their primary career activity.
- Married individuals are more likely than non-married individuals to report research and development as their primary career activity.
- PhD recipients who do not have dependents are more likely than those that do to report research and development as their primary career activity.
- Younger PhD recipients are more likely than older participants to report research and development as their primary career activity.

Research Question 2C: Is there a relationship between STEM PhD recipients' institutional and program experiences and their initial post- graduation employment field?

A multinomial logistic regression model was specified to investigate the relationship between STEM PhD recipients' institutional experiences and their initial post-graduation employment. Employment field served as the nominal-level dependent variable in this model, measured in the following categories: U.S. four year college or university, industry, medical school, research institute, other, foreign employment, and U.S. government. U.S. four-year college or university served as the reference category (Table 4). The measure of institutional characteristics was Carnegie Rank. Doctoral program characteristics were measured as research and student support services ranks. Doctoral program experiences included length of time to PhD, primary source of funding, and field of study. I controlled for doctoral recipients' background characteristics, including their gender, marital status, dependent status, race, citizenship, and age (Table 5). Prior to regression analysis, crosstabulation with chi square testing was conducted to determine if a relationship exists between the nominal level independent variables and the dependent variable.

The overarching hypothesis tested by this model is:

H_6: Doctoral institution and program characteristics and experiences influence the likelihood of certain initial post-graduation employment fields.

The specific hypotheses tested in regards to each of the independent variables are outlined below.

- PhD recipients from programs with higher measures of research productivity are more likely to achieve employment in U.S. four year colleges or universities than participants from lower ranked programs.
- PhD recipients from programs with higher measures of student support services are more likely to achieve employment in U.S. four year colleges or universities than participants from lower ranked programs.
- PhD recipients from institutions whose Carnegie Rank is Very High are more likely to achieve employment in U.S. four year colleges or universities than participants from lower ranked institutions.
- PhD recipients who receive PhDs in Biology will be more likely than recipients in any other field to obtain a position at a Medical School.
- PhD recipients in Chemistry, Engineering, and Computer Science will be more likely than participants in all other fields to obtain a position in Industry.
- Participants who attended a Master’s institution ranked as Very High research activity are more likely than those who attended lower ranked institution to obtain a position at a U.S four-year college or university.
- Participants who attended a bachelor’s institution ranked as Very High research activity are more likely than those who attended a lower ranked institution to obtain a position at a U.S. four-year college or university.
- Men are more likely than women to obtain a position at a U.S. four-year college or university.
- Participants who are unmarried are more likely than married participants to obtain a position at a U.S. four-year college or university.
- Participants who do not have dependents are more likely than those who have dependents to obtain a position at a U.S. four-year college or university.
- U.S. citizens are more likely than non-citizens to obtain a position at a U.S. four-year college or university.
- White participants are more likely than non-whites to obtain a position at a U.S. four year college or university when compared with other employment options.

CHAPTER 4: RESULTS, CAREER ASPIRATIONS

In this chapter, I will share the results of a series of regression analyses that examined the effects of doctoral candidates' program experiences on the likelihood of certain career aspirations. These results have been organized in terms of the dependent variable in each model. I present the appropriate descriptive statistics related for each model, followed by the regression analysis.

Influences to Career Aspirations

As noted in Table 1, the majority (53.2%) of doctoral candidates in this study indicated their preference for employment in the education sector. The majority of doctoral candidates also indicated their preference to participate in research and development as their primary career activity (Table 1). These analyses focus on the aspects of doctoral studies that may act as determinants of the likelihood of this career choice.

Table 2 presents a basic description of the sample of doctoral candidates that were included in this study. The majority of doctoral students (51.7%) studied Physics, while 22.6% studied Neuroscience, and 25.7% identified with the field of Chemical Engineering. The majority of these individuals are male (70.4%), White (55.8%), U.S. citizens (55.2%), unmarried (53.2%) and do not have dependents (85.2%). The 2^{nd} quartile of research productivity of the faculty and student support services represents the majority of doctoral programs. Twenty-two percent of doctoral candidates reported funding their doctoral studies primarily through research assistantships. This category of funding had the highest representation among the funding options selected by participants. Further, the majority of doctoral candidates (53%) reported high feelings of belonging within their doctoral program.

Pearson Chi-square analysis was conducted to determine if a relationship exists between the dependent variable, career aspirations, and the nominal independent variables included in this study (Table 6). The results of these analyses show that there is a significant relationship between career aspirations and field of study (χ^2= 133.035, $p<0.001$), research productivity quartile (χ^2= 31.305, $p=0.002$), student support services quartile (χ^2= 26.927, $p=0.008$), primary funding type (χ^2= 89.580, $p<0.001$), dependent status (χ^2=8.226, $p=0.042$), race (χ^2=90.651, $p<0.001$), citizenship (χ^2=78.101, $p<0.001$), and feelings of belonging (χ^2=44.840, $p<0.001$) (Table 6). Several independent variables were not significantly related to career aspirations, including marital status, and gender ($p>0.05$) (Table 6). Descriptive statistics for the continuous independent variables, age and scholarly productivity, and the scales related to doctoral candidates' program experiences are presented in Table 7.

Table 6

Cross-tabulation of doctoral candidates' career aspirations and each independent variable

	Career Aspiration					
Independent Variable	**Education**	**Government**	**Industry**	**Other**	**Total (N)**	**Chi-square**
Field of Study						133.035***
Neuroscience	60 %	7.7 %	29.4 %	2.9 %	1376	
Physics	56.6 %	8.6 %	32.3 %	3.5 %	3147	
Chemical Engineering	42.5 %	7.7 %	46.8 %	3.1 %	1566	
Research Productivity Quartile						31.305**
1	56.6 %	6.5 %	34.7 %	3.3 %	2000	
2	53.4 %	8.2 %	35.3 %	3.2 %	2907	
3	49.8 %	10.6 %	36.9 %	2.7 %	812	
4	45.9 %	12.0 %	36.7 %	5.4 %	259	
Missing	50.5 %	10.8 %	34.2 %	4.5 %	199	
Student Support Services Quartile						26.927**
1	61.1 %	7 %	29.2 %	2.7 %	804	
2	51.9 %	8.5 %	36.3%	3.3 %	3364	
3	52.1 %	7.9 %	36.3 %	3.8 %	1483	
4	52.6 %	7.9 %	37.4 %	2.1 %	340	
Missing	53.6 %	10.3 %	33.0 %	3.1 %	97	
Primary Funding Type						89.580***
Fellowship	59.6 %	7.8 %	30.0 %	2.7 %	1045	
RA	49.9 %	7.1 %	40.8 %	2.1 %	1376	
TA	64.0 %	5.0 %	26.2%	4.7 %	317	
Multiple Funding Types	49.4 %	10.8 %	35.0 %	4.9 %	1069	
RA & TA	53 %	7.5 %	36.6 %	3.0 %	1138	
Fellowship, RA & TA	52.3 %	8.8 %	35.3 %	3.6 %	1144	
Feelings of Belonging						44.840***
Not at all	43.2 %	12.4 %	38.5 %	5.9 %	421	
Somewhat	51.4 %	8.2 %	36.6 %	3.8 %	2442	
A lot	56.0 %	243 %	34.0 %	2.5 %	3226	
Gender						3.665
Male	52.8 %	8.1 %	36.0 %	3.1 %	4284	
Female	54.3 %	8.3 %	33.7 %	3.7 %	1805	
Race						90.651***
White	54.2 %	9.7 %	32.5 %	3.5 %	3399	
Hispanic	57.5 %	9.1 %	31.0 %	2.4 %	287	
Asian	51.9 %	5.3 %	40.1 %	2.7 %	2225	

Other	46.5%	11.0 %	36.2 %	6.3 %	254	
Citizenship Status						78.101***
Non U.S. Citizen	54.4 %	4.8 %	37.8 %	2.9 %	2730	
U.S. Citizen	52.3 %	10.8 %	33.3 %	3.5 %	3359	
Marital Status						4.208
No	61.96%	8.9%	41.83%	3.5%	2816	
Yes	45.7%	7.45%	29.76%	3.1%	3273	
Percent of Total	**53.2%**	**8.1 %**	**35.3 %**	**3.3 %**	**6089**	

*= p<0.05, **=p<0.01, ***=p<0.001.

Table 7

Descriptive statistics of continuous independent variables included in the analysis to address research question 1.

Variable	Minimum	Maximum	Mean (S.E.)	Std. Deviation	Variance
Age	21	60	28.26 (0.051)	4.015	16.124
Satisfaction with Research	1	11	8.57 (0.032)	2.463	6.066
Satisfaction with Program	0	4	2.72(0.014)	1.120	1.254
Scholarly Productivity	0	50	8.47(0.093)	7.291	53.157

A multinomial logistic regression model was calculated to investigate the influence of doctoral program characteristics and experiences on the likelihood of certain career aspirations (N=6089). Table 8 presents this multinomial logistic regression model. The dependent variable for this model was the nominal variable career aspiration, including the categories education, government, industry, and other. Education served as the reference category for this analysis. The analysis of model fit indicates that this model is significant (χ^2= 530.194, p<0.001).

Table 8

Multinomial logistic regression model of doctoral program experiences influence on the likelihood of certain career aspirations.

Independent Variable	Intended Career Aspirations[a]					
	Government		**Industry**		**Other**	
Field	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}
Neuroscience (reference)						
Physics	0.111(0.130)	1.118	0.105(0.077)	1.111	0.244 (0.199)	1.276
Chemical Engineering	0.422(0.152)	1.525**	0.775(0.086)	2.170***	0.463 (.232)	1.589*
Research Productivity Rank						
1st Quartile (reference)						
2nd Quartile	0.407(0.120)	1.502***	0.072(0.066)	1.075	-0.01 (0.172)	0.990
3rd Quartile	0.913(0.164)	2.492***	0.208(0.10)	1.231*	-0.011 (0.27)	0.989
4th Quartile	1.042(0.237)	2.834 ***	0.217(1.56)	1.232	0.632 (0.333)	1.882
Missing Rank	2.063(0.888)	7.860*	0.915(0.665)	2.497	2.081 (0.911)	8.009*
Student Support Services Rank						
1st Quartile (reference)						
2nd Quartile	0.327(0.158)	1.386*	0.328(0.090)	1.380***	0.276 (0.243)	1.317
3rd Quartile	0.223(0.176)	1.250	0.414(0.10)	1.512***	0.440 (0.263)	1.553
4th Quartile	0.116(0.267)	1.124	0.384(0.153)	1.468*	-0.290 (0.465)	0.748
Missing Rank	-1.100(0.961)	0.333	-0.446(0.707)	0.640	-1.886 (1.101)	0.152
Funding Type						
Fellowship (reference)						
RA	0.238(0.177)	1.269[c]	0.144(0.102)	1.160[c]	-0.128 (0.295)	0.881[d]
TA	-0.526(0.302)	0.605[bde]	-0.660(0.161)	0.517[bde]***	0.245 (0.361)	1.278
Multiple Funding Sources	0.327(0.166)	1.386[ce]*	0.249(0.103)	1.283[c]*	0.606 (0.254)	1.833*
TA and RA	0.288(0.181)	1.334[c]	0.099(0.104)	1.104[c]	0.153 (0.286)	1.165
Fellowship, TA, & RA	0.346(0.167)	1.414[c]*	0.268(0.1)	1.308[c]**	0.386 (0.261)	1.471

(continued)

	Government		Industry		Other	
	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}
Doctoral Experiences						
Satisfaction with Overall Program	0.092(0.054)	1.097	0.065(0.032)	1.067*	0.042 (0.08)	1.043
Research Experiences	-0.042(0.024)	0.959	-0.093(0.014)	0.911***	-0.110 (0.034)	0.895***
Sense of Belonging	-0.281(0.091)	0.755**	-0.088(0.055)	0.916	-0.32 (0.135)	0.726*
Scholarly Productivity	0.005(0.007)	1.005	-0.007(0.004)	0.993	-0.008 (0.011)	0.992
Demographics						
Male (reference)						
Female	-0.004(0.109)	0.996	-0.107(0.064)	0.899	0.105 (0.161)	1.111
Not married (reference)						
Married	0.013(0.107)	1.013	0.033(0.062)	1.034	0.208 (0.158)	1.231
No Children (reference)						
Children	0.263(0.149)	1.301	-0.011(0.093)	0.989	-0.263 (0.233)	0.769
White (reference)						
Hispanic	0.083(0.226)	1.087	-0.056(0.142)	0.945	-0.424 (0.403)	0.654
Asian	0.047(0.146)	1.048	0.332(0.078)	1.394***	-0.018 (0.207)	0.982
Other	0.427(0.224)	1.532	0.364(0.148)	1.440*	0.771 (0.291)	2.161**
US citizen (reference)						
Non U.S. Citizen	-1.033(0.146)	0.356***	-0.139(0.078)	0.870	-0.153 (0.20)	0.858
Age	-0.006(0.012)	0.994	-0.052(0.009)	0.950***	0.019 (0.017)	1.019
Model Fit	χ^2		*df*		*p*	
Likelihood ratio test	530.194		81		0.000***	

[a] Education served as the reference category.[b] indicates a significant difference from RA ($p<0.05$), [c] indicates significant difference from TA ($p<0.05$),[d] indicates a significant difference from multiple funding sources ($p<0.05$), [e] indicates a significant difference from TA and RA ($p<0.05$), * indicates $p<0.05$, ** indicates $p<0.01$, *** indicates $p<0.001$.

Compared to the reference group neuroscience doctoral candidates, chemical engineering doctoral candidates were significantly more likely to aspire to government, industry or other career paths ($p<0.01$) (Table 8). Chemical engineering students were 1.5 times more likely to indicate government rather than education ($p<0.01$), 2.17 times more likely to aspire to industry than education ($p<0.001$), and 1.59 times more likely to aspire to other careers than education ($p<0.05$) in relation to neuroscience students. Physics doctoral candidates did not statistically differ from neuroscience candidates in their career aspirations.

The research productivity rank quartile of doctoral candidates programs was a significant determinant of the likelihood of aspiring to a career in government as opposed to education ($p<0.05$). Individuals in programs ranked in the 2nd quartile were 1.5 times more likely than their peers in 1st quartile ranking programs to aspire to a career in government rather than education ($p<0.001$). Individuals in programs with a 3rd quartile ranking were 2.5 times more likely than their peers in 1st quartile ranking programs to aspire to a career in government and 1.2 times more likely to aspire to a career in industry than education ($p<0.001$, $p<0.05$ respectively). Those individuals who were enrolled in 4th quartile ranking programs were 2.8 times more likely to indicate a government career aspiration in relation to those enrolled in 1st quartile ranking programs. Finally, individuals enrolled programs that did not report at rank for research productivity differed were significantly more likely to indicate a government or other career aspiration than education ($p<0.05$).

Program's student support services rank was influential in the likelihood of a doctoral candidate indicating their aspiration of a career in industry in relation to education for ranked programs ($p<0.01$). Individuals in programs ranked in the 2nd quartile were 1.39 times more likely to aspire to a career in government or industry than education when compared to individuals in 1st quartile ranked programs ($p<0.05$). Individuals in lower ranking programs were even more likely to indicate a desire to work in industry compared with education. Individuals in 3rd quartile ranked programs were 1.5 times more likely to aspire to careers in industry, while those in 4th quartile ranked programs were also 1.5 times more likely ($p<0.05$). Individuals in programs that were not ranked as part of the NRC ARDP study did not differ significantly in their career aspirations than those in 1st quartile ranked programs.

The primary type of funding received by doctoral candidates was significantly related to their career aspirations in some cases. Individuals who reported funding their doctoral studies with a teaching assistantship were less likely to indicate an industry career aspiration over education than their peers who funded their studies primarily through a fellowship ($p<0.001$). Further, those individuals who funded their doctoral studies through multiple means, often including personal savings, loans, employer grants, foreign government assistance, as well as a combination of other sources, were significantly more likely to aspire to government, industry, or other careers than education when compared with the reference category, those who funded their studies with fellowships ($p<0.05$). Finally, individuals who indicated funding their studies primarily through a combination of fellowships, teaching assistantships, and research assistantships were more likely to indicate government or industry as a career aspiration than the reference category ($p<0.05$, $p<0.01$, respectively). Doctoral candidates who funded their studies primarily through research assistantships or research and teaching assistantship did not differ significantly in their career aspirations from those who funded their studies through fellowships and grants. Supplementary analysis concerning the type of funding received indicates that several other significant relationships among the funding types and doctoral candidates' career aspirations. The results of this analysis are available upon request.

Certain aspects of doctoral experiences were influential in the likelihood of certain career aspirations by doctoral candidates. Participants' positive research experiences were associated with a decreased likelihood of indicating career aspirations in industry or other compared with education ($p<0.001$). Doctoral candidates' who indicated their higher satisfaction with their doctoral program were more likely to indicate their aspirations for a career in industry instead of education ($p<0.05$). Finally, a candidate's sense of belonging in their doctoral program decreased the likelihood that they would aspire to government over education ($p<0.01$). Participants' scholarly productivity was not significant in predicting the likelihood of career aspirations.

Participant's race, citizenship status, and age influenced the likelihood of certain career aspirations. Individuals who indicated Asian race were 1.4 times more likely to choose a career in industry than education when compared with White participants ($p<0.001$). Those individuals who were categorized in the Other race groups were significantly more likely to aspire to industry ($p<0.05$) or other ($p<0.01$) careers than education when compared with White participants. U.S. citizens were less likely to choose a career in government than non U.S. citizens ($p<0.001$). Background characteristics that were not significant include gender, marital status, dependent status, and being of Hispanic descent.

Influences to Academic Career Aspirations

The majority of participants in this study indicated their expectation to work in the academic realm (Table 1). Of those 3242 participants, 43.2 % indicated that they aspire to work at a four year college or university other than a medical school (Table 1). This analysis focuses on the factors that may be influential in predicting the likelihood of participants' academic career aspirations.

The relationship between the nominal independent variables and the dependent variable, academic career aspirations was investigated using Pearson Chi-square analysis (Table 9). Several independent variables are significantly related to academic career aspirations. These include, field of study (χ^2= 77.686, p<0.001), research productivity quartile (χ^2= 52.81, p<0.001), student support services quartile (χ^2= 53.395, p<0.001), primary funding type (χ^2=403.386, p<0.001), feelings of belonging (χ^2=75.851, p<0.001), gender (χ^2=57.515, p<0.001), race (χ^2=182.857, p<0.001), and citizenship (χ^2= 440.225, p<0.001). The nominal independent variables that do not have a significant relationship with academic career aspirations are dependent status and marital status.

Table 9

Cross-tabulation of academic career aspirations and each nominal level independent variable.

	Academic Career Aspiration						
Independent Variable	**Four year college**	**Medical School**	**Research Institute**	**Community College or K-12**	**Non U.S. Institution**	**Total (N)**	**Chi-square**
Field of Study							77.686***
Neuroscience	37.2 %	18.3%	32.3%	2.9 %	9.3%	826	
Physics	45.0 %	11.1%	31.2%	3.7%	9.0%	1751	
Chemical Engineering	45.7 %	5.1%	33.2%	2.7%	13.2%	665	
Percent of Total Population	43.2 %	11.7%	31.9%	3.7 %	9.9%	N= 3242	
Research Productivity Quartile							52.810***
1st	47.3	13.2	28.8	2.0	8.6	1112	
2nd	40.0	11.9	33.3	3.7	11.1	1551	
3rd	42.6	8.9	37.7	5.0	9.9	404	
4th	49.6	1.7	34.5	5.0	9.2	119	
Missing	37.5	19.6	37.5	0	5.4	56	
Student Support Services							53.395***
1st	42.8	11.2	33.0	2.8	10.2	491	
2nd	44.9	11.4	30.3	3.3	10.2	1748	
3rd	40.3	14.8	33.2	3.3	8.4	773	
4th	42.5	0.6	37.4	5.6	14.0	179	
Missing	34.6	21.2	38.5	0	5.8	52	
Primary Funding Type							403.386***
Fellowship	39.5	27.1	24.7	3.2	5.5	623	
RA	39.9	6.8	39.3	1.3	12.7	687	
TA	40.4	2.5	36.0	7.4	13.8	203	
Multiple Funding Types	41.5	19.5	24.1	4.2	10.8	528	(continued)
Independent	**Four year**	**Medical School**	**Research**	**Communi**	**Non U.S.**	**Total (N)**	**Chi-square**

Variable	college		Institute	ty College or K-12	Institution		
TA and RA	44.6	2.2	38.1	3.4	11.8	603	
Fellowship, TA &RA	51.7	7.2	30.1	3.5	7.5	598	
Feelings of Belonging							75.858***
Not at all	42.3	12.1	21.4	10.0	13.2	182	
Somewhat	41.6	11.8	31.7	4.0	10.8	1255	
A lot	44.3	11.6	33.1	2.0	9.0	1805	
Gender							57.515***
Male	44.9	9.4	31.9	2.7	11.1	2262	
Female	39.2	17.0	17.0	4.7	7.2	980	
Race							182.857***
White	49.1	13.1	26.5	3.8	7.5	1843	
Hispanic	41.2	9.7	30.3	3.3	9.7	3077	
Other	45.8	18.6	22.0	6.7	6.8	118	
Asian	34.0	8.9	42.0	2.0	13.1	1154	
Marital Status							6.960
Single	41.8	12.0	32.4	3.0	10.8	1745	
Married	44.8	11.4	31.3	3.7	9.0	1497	
Dependent Status							8.774
No	43.6	11.8	31.9	3.0	9.8	2756	
Yes	40.7	11.3	32.1	5.1	10.7	486	
Citizenship Status							440.225***
US Citizen	53.1	16.3	22.6	4.4	3.6	1756	
Non US Citizen	31.4	6.3	42.9	2.0	17.4	1486	
Percent of Total Population	43.2 %	11.7%	31.9%	3.7 %	9.9%	N= 3242	

* indicates $p<0.05$, ** indicates $p<0.01$, *** indicates $p<0.001$.

A multinomial logistic regression model was calculated to investigate the influence of the independent variables on the likelihood of participants indicating certain academic career aspirations (N=3242). The dependent variable for this model was the nominal level variable academic career aspirations, including the categories U.S. four year college or university other than a medical school, medical school, research institute, K-12 or community college, and non U.S. institution. U.S. four year college or university served as the reference category for this analysis. This regression model is presented in Table 10. The analysis of model fit indicates that this model is significant (χ^2= 960.380, $p<0.001$).

Table 10

Multinomial logistic regression model of doctoral program experiences on the likelihood of certain academic career aspirations.

Independent Variable	Academic Career Aspirations[a]							
	Medical School		**Research Institute**		**Community College/ k-12**		**Non U.S. Institution**	
Field	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}
Neuroscience (reference)								
Physics	-0.374 (0.141)	0.688**	-0.189 (0.111)	0.828	0.096 (0.272)	1.101	-0.148 (0.173)	0.863
Chemical Engineering	-0.986 (0.222)	0.373***	-0.369 (0.132)	0.696**	-0.360 (0.351)	0.698	-0.189 (0.193)	0.828
Research Productivity Rank								
1st Quartile (reference)								
2nd Quartile	0.187 (0.138)	1.206	0.154 (0.099)	1.166	0.648 (0.268)	1.911*	0.172 (0.153)	1.187
3rd Quartile	0.108 (0.228)	1.114	-0.033 (0.152)	0.966	0.716 (0.362)	2.047*	-0.170 (0.238)	0.844
4th Quartile	-1.237 (0.740)	0.290	0.034 (0.235)	1.035	0.503 (0.529)	1.653	-0.243 (0.377)	0.784
Missing Research Rank	-16.12 (0.454)	9.943***	-1.237 (1.175)	0.290	-15.42 (5190.6)	1.994	-17.26 (5526.5)	3.192
Student Support Services Rank								
1st Quartile (reference)								
2nd Quartile	0.009 (0.182)	1.363	-0.121 (0.126)	0.886	0.047 (0.321)	1.049	-0.028 (0.193)	0.972
3rd Quartile	0.310 (0.199)	1.363	0.047 (0.142)	1.048	-0.076 (0.359)	0.927	-0.062 (0.224)	0.940
4th Quartile	-2.556 (1.032)	0.078*	0.047 (0.220)	1.048	0.264 (0.487)	1.302	0.230 (0.319)	1.259
Missing Support Rank	16.96 (000)	23395112	1.357 (1.224)	3.884	0.03 (5432.2)	1.031	16.73 (5526.5)	18573761

Independent Variables	Medical School		Research Institute		Community College/ K-12		Non U.S. Institution	
Funding Type								
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**
Fellowship (reference)								
RA	-1.269	0.281^{de}***	-0.012	0.989	-0.851	0.427	-0.119	0.888
	(0.209)		(0.152)		(0.446)		(0.248)	
TA	-2.116	0.120^{d}***	-0.177	0.837	0.390	1.476^{b}	-0.270	0.763
	(0.168)		(0.216)		(0.440)		(0.324)	
Multiple Funding Sources	-0.266	0.766^{bce}	-0.148	0.863	-0.322	0.724	0.339	1.403^{bce}
	(0.168)		(0.161)		(0.352)		(0.256)	
TA and RA	-2.523	0.08^{be}***	-0.236	0.790	-0.176	0.838	-0.429	0.651^{d}
	(0.318)		(0.155)		(0.373)		(0.254)	
Fellowship, TA, & RA	-1.462	0.232^{de}***	-0.263	0.769	-0.191	0.826	-0.434	0.648^{d}
	(0.202)		(0.150)		(0.345)		(0.256)	
Doctoral Experiences								
Research Experiences	0.067	1.069*	-0.017	0.983	-0.110	0.896*	-0.008	0.992
	(0.032)		(0.022)		(0.045)		(0.033)	
Satisfaction with Overall Program	-0.215	0.806***	-0.095	0.909*	-0.105	0.90	-0.096	0.908
	(0.067)		(0.048)		(0.111)		(0.073)	
Sense of Belonging	-0.014	0.996	0.145	1.156	-0.593	0.570**	-0.129	0.879
	(0.119)		(0.086)		(0.185)		(0.131)	
Scholarly Productivity	0.022	1.022**	0.014	1.014*	-0.049	0.952*	-0.005	0.995
	(0.008)		(0.006)		(0.021)		(0.01)	
Demographics								
Male (reference)								
Female	0.418	1.519***	0.177	1.193	0.727	2.070***	-0.154	0.858
	(0.129)		(0.096)		(0.219)		(0.157)	
Not married (reference)								
Married	-0.248	0.780	-0.175	0.840	-0.062	0.940	-0.308	0.735*
	(0.134)		(0.093)		(0.232)		(0.145)	
No children (reference)								
Children	-0.002	0.998	-0.076	0.927	0.421	1.523	-0.011	0.989
	(0.199)		(0.136)		(0.297)		(0.201)	(continued)

Independent Variables	**Medical Schools**	**Research Institutes**	**Community College/**	**Non-U.S. Institution**

	β (SE)	e^{β}	β (SE)	e^{β}	K-12 β (SE)	e^{β}	β (SE)	e^{β}
White (reference)								
Hispanic	-0.386 (0.303)	0.680	-0.044 (0.204)	0.957	0.146 (0.476)	1.158	0.13 (0.274)	1.139
Other	0.274 (0.281)	1.135	-0.244 (0.254)	0.784	0.731 (0.426)	2.076	-0.453 (0.416)	0.636
Asian	0.282 (0.173)	1.326	0.103 (0.116)	1.109	-0.092 (0.322)	0.912	-0.360 (0.161)	0.698*
U.S. citizen (reference)								
Non U.S. Citizen	0.098 (0.183)	1.102	1.152 (0.017)	3.165***	-0.370 (0.314)	0.691	-2.422 (0.186)	11.53***
Age	0.42 (0.017)	1.043*	0.006 (0.012)	1.006	0.074 (0.02)	1.071***	-0.008 (0.019)	0.992

Model Fit	χ^2	***Df***	***p***
Likelihood ratio test	960.380	108	0.000***

[a] 4 year Colleges and Universities other than Medical Schools served as the reference category. [b] indicates a significant difference from RA ($p<0.05$), [c] indicates significant difference from TA ($p<0.05$),[d] indicates a significant difference from multiple funding sources ($p<0.05$), [e] indicates a significant difference from TA and RA ($p<0.05$) * indicates $p<0.05$, ** indicates $p<0.01$, *** indicates $p<0.001$

Participant's field of study was influential in predicting the likelihood of certain academic career aspirations. Doctoral candidates completing their degree in Physics are significantly less likely to pursue a career at a medical school ($p<0.01$) than a four year college or university compared with doctoral candidates in Neuroscience. Not surprisingly, doctoral candidates in Chemical Engineering are also significantly less likely to pursue careers at medical schools ($p<0.001$) or research institutes ($p<0.01$) than four year colleges or universities when compared with doctoral candidates in Neuroscience. Additionally, doctoral candidates in Chemical Engineering are also less likely than their colleagues in Neuroscience to aspire to careers at research institutes compared with 4-year colleges or universities ($p<0.01$).

Doctoral program characteristics were influential in doctoral candidates' academic career aspirations in certain instances. Individuals in the 2^{nd} and 3^{rd} quartile of research productivity rank are twice as likely to aspire to work in K-12 or community colleges compared four year colleges or universities ($p<0.05$). Those individuals who are in programs who are not ranked are significantly less likely to aspire to work at medical schools than four year colleges or universities ($p<0.001$). Individuals enrolled in 4^{th} quartile ranked programs did not differ significantly from those in 1^{st} quartile ranked programs. Individuals in doctoral programs with 4^{th} quartile student support rankings are less likely to aspire to work at a medical school than four year colleges or universities ($p<0.05$). Otherwise, student support services rankings were not influential in predicting academic career aspirations.

The primary type of funding that doctoral students utilize is influential in predicting the likelihood of participants aspiring to work at a medical school compared with four year colleges or universities. Doctoral candidates who fund their doctoral studies with research assistantships, teaching assistantships, RA and TA, and fellowships TA & RA are all significantly less likely to aspire to work at a medical school ($p<0.001$) than a four year college or university when compared with those individuals who fund their studies primarily through fellowships. Individuals who funded their doctoral education through multiple funding sources did not differ significantly in academic career aspirations than those that funded their studies through fellowships. Supplemental analysis of doctoral candidates' primary source of funding revealed that those who fund their studies with teaching assistantships or research assistantships vary significantly from those who fund their studies through multiple funding types in their likelihood to aspire to work at a medical school. Further results of this supplemental analysis are available upon request.

Several doctoral experiences reported by doctoral candidates were significant predictors in the likelihood of certain academic career aspirations. Participants who were more satisfied with their research experiences were more likely to aspire to work at a medical school than a four year college or university ($p<0.05$). These individuals were also significantly less likely to aspire to work in K-12 schools or community colleges ($p<0.05$). Satisfaction with the doctoral program curriculum was negatively related to the likelihood of aspiring to work at a medical school or research institute compared with a four year college or university ($p<0.05$). Thus, more satisfied individuals are less likely to aspire to work at a medical school or research institute. Participants' sense of belonging in their doctoral programs is important in predicting the likelihood of aspiring to work in K-12 schools or community colleges. Those individuals who report a sense of belonging are significantly less likely to expect to work in K-12 schools or community colleges when compared to four year colleges or universities. Finally, individual's scholarly productivity during graduate studies significantly relates to their academic career aspirations. Higher rates of scholarly productivity are associated with an increased likelihood to aspire to work at a medical school ($p<0.01$) or research institute ($p<0.05$), and a decreased likelihood of aspiring to work at in the K-12 sector or community college ($p<0.05$).

Certain demographic characteristics of participants were also significantly related to the likelihood of certain academic career aspirations. Female doctoral candidates were 1.5 times more likely than male candidates to report the desire to work at a medical school ($p<0.001$) and 2 times more likely than males to report the desire to work in K-12 schools or community colleges ($p<0.01$) compared with four year colleges or universities. Individuals who reported being married or living in a marriage-like relationship were less likely to aspire to a non U.S. educational institution ($p<0.05$). Non U.S. citizens were 3 times more likely than U.S. citizens to report the desire to work at a research institute ($p<0.001$) and 11.5 times more likely to choose a non-U.S. educational institution ($p<0.001$). Further, Asian individuals were less likely than White individuals to choose a non U.S. educational institution. Older doctoral candidates were more likely to express their desire to work at a medical school ($p<0.05$) and K-12/community colleges ($p<0.05$). The demographic characteristics that were not significant in predicting the likelihood of academic career aspirations were dependent status and being of Hispanic or Other race.

Influences to Nature of Career

The nature of career that doctoral candidates desire was measured by asking participants the primary career activity they intend to engage in upon completion of their degree. The majority of participants in this study indicated that they would prefer to engage in research and development (Table 1). This analysis focuses on the aspects of doctoral education that may be influential in predicting the likelihood of the nature of doctoral candidates' careers.

Crosstabulation analysis with Pearson Chi-square tests were conducted to determine if a relationship exists between the independent variables and the nominal-level dependent variable, nature of career. Several independent variables have a significant relationship with nature of career. These include: field of study (χ^2= 24.390, p= 0.002), research productivity quartile (χ^2=31.259. p=0.012), primary funding type received (χ^2=100.173, $p<0.001$), feelings of belonging (χ^2=86.875, $p<0.001$), gender (χ^2= 45.353, $p<0.001$), race (χ^2=148.661, $p<0.001$), dependent status (χ^2=14.513, p=0.006), and citizenship status (χ^2= 180.601, $p<0.001$) (Table 11). The nominal level independent variables that do not have a significant relationship with career objective are student support services rank and marital status.

Table 11

Cross-tabulation of nature of career with each nominal level independent variable.

	Nature of Career						
Independent Variable	**Research & Devel.**	**Teaching**	**Management/ Admin**	**Professional Service**	**Other**	**Total (N)**	**Chi-square**
Field of Study							24.390**
Neuroscience	74.2%	10.6%	4.8%	4.6%	5.8%	1376	
Physics	74.6%	12.2%	4.4%	3.8%	5.1%	3147	
Chemical Engineering	76.9%	8.6%	6.1%	3.9%	4.5%	1566	
Research Productivity Quartile							31.259*
1st	73.8%	10.5%	6.1%	3.7%	6.1%	2000	
2nd	76.5%	10.2%	4.3%	4.2%	4.7%	2907	
3rd	74.1%	13.3%	4.7%	4.3%	3.6%	812	
4th	71.4%	15.1%	4.2%	4.2%	5.0%	259	
Missing	77.5%	9.9%	2.7%	2.7%	7.2%	111	
Student Support Services Rank							16.122
1st	75.9%	11.1%	5.3%	3.5%	4.2%	804	
2nd	75.1%	10.6%	4.8%	4.0%	5.5%	3365	
3rd	74.8%	10.7%	5.1%	4.8%	4.7%	1483	
4th	73.8%	4.4%	4.4%	3.5%	3.6%	340	
Missing	79.4%	9.3%	3.1%	1.0%	7.2%	97	
Primary Funding Type							100.173***
Fellowship	73.0%	11.2%	4.4%	5.2%	6.2%	1045	
RA	79.3%	7.7%	6.0%	3.7%	3.3%	1376	
TA	72.9%	17.4%	2.5%	5.0%	2.2%	317	
Multiple Funding Types	70.7%	12.7%	6.0%	4.5%	6.1%	1305	

(continued)

Independent Variable	Research & Devel.	Teaching	Manageme nt/ Admin	Professio nal Service	Other	Total (N)	Chi-square
TA and RA	79.6%	79.6%	3.3%	2.7%	4.4%	1138	
Fellowship, TA &RA	72.7%	72.7%	5.1%	3.7%	6.8%	908	
Feelings of Belonging							86.875***
Not at all	61.8%	13.1%	8.1%	7.1%	10.0%	421	
Somewhat	72.4%	12.3%	5.2%	4.7%	5.4%	2442	
A lot	78.9%	9.5%	4.2%	3.1%	4.2%	3226	
Gender							45.353***
Male	77.3%	10.1%	4.9%	3.5%	4.3%	4284	
Female	69.9%	12.9%	5.0%	5.3%	6.9%	1805	
Race							148.661***
White	71.8%	14.2%	4.2%	3.9%	5.9%	3451	
Hispanic	71.3%	11.4%	6.0%	5.4%	6.0%	317	
Other	64.4%	12.3%	9.2%	8.0%	6.1%	163	
Asian	81.7%	5.5%	5.6%	3.7%	3.6%	2157	
Marital Status							12.560
Single	74.4%	10.6%	5.2%	4.6%	5.2%	3273	
Married	76.0%	11.3%	4.6%	4.5%	3.4%	2816	
Dependent Status							14.513**
No	74.4%	10.9%	5.1%	4.2%	5.4%	5189	
Yes	79.0%	11.0%	3.8%	2.8%	3.4%	900	
Citizenship Status							180.601***
US Citizen	69.2%	15.1%	5.1%	4.3%	6.3%	3359	
Non US Citizen	82.3%	5.7%	4.7%	3.7%	3.6%	2730	
Percent of Total Population	75.1%	10.9%	4.9%	3.9%	4.5%	N=6089	

* indicates p<0.05, ** indicates p<0.01, *** indicates p<0.001.

A multinomial logistic regression model was calculated to determine the influence of these independent variables on the likelihood of participants' nature of career. The dependent variable for this analysis was the nominal level variable nature of career, including the categories research and development, teaching, management/administration, professional service to others, and other. Table 12 presents the results of this regression model. Analysis of model fit indicated that this model is significant (χ^2=560.652, $p<0.001$).

Table 12

Multinomial logistic regression model of doctoral experiences on participants' likelihood of certain primary career activities

Independent Variable	Nature of Career[a]							
	Teaching		**Management/Admin**		**Professional Service**		**Other**	
Field	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}
Neuroscience (reference)								
Physics	0.083 (0.112)	1.087	-0.120 (0.164)	0.887	-0.140 (0.17)	0.870	-0.178 (0.152)	0.837
Chemical Engineering	-0.129 (0.136)	0.879	0.226 (0.177)	1.254	-0.068 (0.198)	0.935	-0.011 (0.181)	0.989
Research Productivity Rank								
1st Quartile (reference)								
2nd Quartile	0.007 (0.101)	1.007	-0.302 (0.136)	0.740*	0.147 (0.156)	1.158	-0.157 (0.134)	0.854
3rd Quartile	0.373 (0.143)	1.452**	-0.163 (0.210)	0.850	0.274 (0.228)	1.315	-0.282 (0.228)	0.754
4th Quartile	0.549 (0.209)	1.4731**	-0.094 (0.339)	0.91	0.447 (0.350)	1.564	0.193 (0.318)	1.213
Missing Research Rank	1.233 (0.81)	3.432	-17.23 (0.623)	3.266***	1.78 (0.825)	5.932*	0.634 (1.087)	1.884
Student Support Services Rank								
1st Quartile (reference)								
2nd Quartile	-0.028 (0.131)	0.973	-0.092 (0.181)	0.912	0.127 (0.216)	1.136	0.278 (0.195)	1.321
3rd Quartile	-0.069 (0.146)	0.934	0.063 (0.203)	1.065	0.321 (0.233)	1.379	0.154 (0.220)	1.166
4th Quartile	0.288 (0.213)	1.334	0.060 (0.333)	1.062	0.114 (0.374)	1.121	0.320 (0.355)	1.377
Missing Support Rank	-1.371 (0.890)	0.254	16.64 (0)	170.100	-2.889 (1.312)	0.055*	-0.188 (1.168)	0.828

(continued)

Independent Variable	Teaching		Management/Admin		Professional Service		Other	
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**
Funding Type								
Fellowship (reference)								
RA	0.088 (0.156)	1.092[c]	0.265 (0.214)	1.303[c]	-0.287 (0.226)	0.750	-0.414 (0.219)	0.661
TA	0.785 (0.202)	2.192[b]***	-0.516 (0.410)	0.597[b]	-0.010 (0.323)	0.990	-0.823 (0.422)	0.439
Multiple Funding Sources	0.013 (0.148)	1.013[c]	0.601 (0.207)	1.824[c]**	-0.059 (0.215)	0.943	0.045 (0.194)	1.046[bc]
TA and RA	0.292 (0.155)	1.339[c]	-0.205 (0.243)	0.814[bd]	-0.592 (0.252)	0.553[d]*	-0.105 (0.215)	0.901
Fellowship, TA, & RA	0.271 (0.141)	1.312[c]	0.166 (0.216)	1.181[d]	-0.199 (0.221)	0.820	0.259 (0.187)	1.295[bc]
Doctoral Experiences								
Research Experiences	-0.034 (0.02)	0.966	-0.118 (0.028)	0.889***	-0.081 (0.03)	0.922**	-0.061 (0.028)	0.941*
Satisfaction with Overall Program	-0.03 (0.046)	0.970	0.012 (0.066)	1.012	-0.026 (0.071)	0.974	-0.034 (0.064)	0.967
Sense of Belonging	-0.171 (0.078)	0.843*	-0.208 (0.113)	0.812	-0.348 (0.121)	0.706**	-0.319 (0.108)	0.727**
Scholarly Productivity	-0.010 (0.007)	0.990	0.013 (0.008)	1.014	0.014 (0.009)	1.014	0.002 (0.008)	1.002
Demographics								
Male (reference)								
Female	0.344 (0.092)	1.411***	0.033 (0.134)	1.034	0.440 (0.14)	1.544**	0.477 (0.125)	1.612***
Not married (reference)								
Married	0.033 (0.092)	1.033	-0.026 (0.131)	0.974	-0.289 (0.145)	0.749*	-0.014 (0.127)	0.986
No children (reference)								
Children	-0.017 (0.138)	0.983	-0.138 (0.208)	0.871	-0.404 (0.240)	0.667	-0.480 (0.217)	0.625 *
White (reference)								

(continued)

Independent Variables	**Teaching**		**Management/ Admin**		**Professional Service**		**Other**	
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**
Hispanic	0.026 (0.202)	1.026	0.410 (0.279)	1.506	0.393 (0.274)	1.481	0.143 (0.268)	1.154
Other	-0.031 (0.212)	0.965	0.977 (0.243)	2.657***	0.454 (0.288)	1.575	0.144 (0.277)	1.155
Asian	-0.487 (0.131)	0.614***	0.503 (0.163)	1.653 **	-0.032 (0.180)	0.968	-0.185 (0.167)	0.831
U.S. citizen (reference)								
Non U.S. Citizen	-1.028 (0.127)	0.358***	-0.339 (0.164)	0.713*	-0.177 (0.178)	0.838	-0.488 (0.165)	0.626 **
Age	0.025 (0.011)	1.025*	-0.092 (0.022)	0.912***	0.013 (0.018)	1.013	0.022 (0.016)	1.022

Model Fit	**χ^2**	***df***	***P***
Likelihood ratio test	560.652	108	0.000***

[a] Research and Development served as the reference category. [b] indicates a significant difference from RA ($p<0.05$), [c] indicates significant difference from TA ($p<0.05$),[d] indicates a significant difference from multiple funding sources ($p<0.05$), [e] indicates a significant difference from TA and RA ($p<0.05$)* indicates $p<0.05$, ** indicates $p<0.01$, *** indicates $p<0.001$

Participants' field of study was not significantly related to the likelihood of certain career activities. Individuals in programs ranking in the 2^{nd} quartile of research productivity were less likely than those in 1^{st} quartile ranked programs to aspire to a career in management or administration. Additionally, candidates in 3^{rd} and 4^{th} quartile ranked programs were 1.5 times more likely to indicate teaching as their primary career activity in lieu of research and development ($p<0.05$). Finally, those individuals in programs that were unranked were less likely to aspire to a career in management or administration ($p<0.001$) and more likely to aspire to a career in professional service to others ($p<0.05$). Students support services ranking of doctoral programs were generally not significant predictors of the nature of doctoral students' careers.

The primary type of funding received by doctoral candidates to fund their degrees was influential in predicting the likelihood of certain primary career activities. Those who held teaching assistantships were more than twice as likely as those who held fellowships to state that teaching was their primary objective ($p<0.001$), and were less likely to report other career activities in comparison to research and development. Individuals who funded their degrees through multiple funding sources were more likely to aspire to careers with a high degree of management or administrative responsibilities than research and development ($p<0.01$). Holding a teaching and research assistantship position was associated with a decreased likelihood of aspiring to a career activity of professional service to others compared to research and development ($p <0.05$). Funding types that were not significantly different from those who funded their doctoral studies with fellowships were research assistantships, and those that held the combination of fellowships, teaching assistantships, and research assistantships. Supplemental analysis of differences among funding types revealed several areas of significance. Those doctoral candidates who funded their doctoral studies through teaching assistantship varied significantly from those who funded their doctoral studies with all other funding sources in their likelihood to aspire to careers in teaching. Further details of this analysis are available upon request.

Only two aspects of doctoral experiences proved to be significant in predicting the nature of doctoral candidates' careers in relation to research and development. These were participants' satisfaction with research experiences, and their sense of belonging ($p<0.05$). A positive research experience was associated with a decreased likelihood of the career objective management or administration, professional service to others, or other career activities in comparison to research and development ($p<0.05$). Individual's with a positive sense of belonging were less likely to aspire to teaching, professional service to others or other career objectives ($p<0.05$).

Certain background characteristics were influential in predicting the likelihood of participants' nature of career. Female doctoral candidates were 1.4 times more likely than male candidate to report teaching as their primary career activity ($p<0.001$). Additionally, female candidates were 1.5 and 1.6 times more likely to aspire to professional service to others ($p<0.01$) or other career objectives ($p<0.001$) than males, respectively. Those candidates who are married were less likely than unmarried candidates to aspire to professional service to others, while those who have children were less likely to aspire to other career activities than research and development ($p<0.05$). Individuals of Asian and Other races differed significantly from White participants in their likelihood of aspiring to careers in teaching and management/administration rather than research and development. Those in the Other category were 2.7 times more likely than White participants to desire careers with the primary objective of management or administration rather than research and development ($p<0.001$). Asian participants were less likely than white participants to desire careers in teaching ($p<0.001$) and more likely to desire careers in management or administration ($p<0.01$). An individual's citizenship status was also important in predicting the likelihood of career activities compared with research and development. U.S. citizens were less likely to report teaching ($p<0.001$), management/administration ($p<0.05$), and other ($p<0.01$) as their primary career objective compared with research and development. Finally, older individuals were 1.024 times more likely to state that teaching is their primary career objective ($p<0.05$). Older individuals were also significantly less likely to report management/ administration as their primary career objective compared with research and development ($p<0.001$).

CHAPTER 5: RESULTS, CAREER ATTAINMENT

In this chapter, I will describe the results of several regression analyses that investigated the effects of doctoral institution and program characteristics and PhD recipients' experiences within those programs on the likelihood of initial post-graduation career attainment. First, I will present the descriptive statistics associated with each model, followed by the results of the regression analysis. These results are presented according to dependent variable.

Career Attainment

As noted in Table 5, the majority of participants in this study (70.5 %) achieved definite career attainment at the time of survey administration. The analyses presented here focus on investigating how differences in doctoral program rank and student experiences within those doctoral programs influence the likelihood of definite career attainment compared with negotiating with one or more employers or other. The "other" category includes individuals who reported no plans to work, those pursuing other advanced degrees, or other plans, such as starting their own business.

The population of STEM doctoral recipients included in this study was 64.8% males and 35.2% females (Table 5). The majority of these individuals are White (51.3%), followed by Asian (38.7%), Other (5.6%), and Hispanic (4.4%). The majority of this population is married (61.1%) with no dependents (81.0%). There are slightly more U.S. citizens (50.5%) than non-U.S. citizens (49.5%). Only 11.1% of doctoral recipients reported attending a junior college during their educational history. Information regarding participants' field of study for their bachelors, masters, and doctoral degrees can be found in Table 5.

Table 13

Frequency and percent of career attainment, employment field, and primary work activity.

Career Attainment	**Frequency (N)**	**Percent of Population**
Returning to Pre-doctoral Employment	2862	13.1%
Definite Commitment	12564	57.4%
Negotiating with Potential Employers	2101	9.6%
Other/ Missing	4356	19.9%
Total	**21883**	**100%**
Employment Field		
U.S. 4 year college/ university	4180	27.1%
Medical School	1754	11.4%
Industry	3871	25.1%
Research Institute	1986	12.9%
Other	1424	9.2%
Foreign Employment	1064	6.9%
U.S. Government	1152	7.5%
Total	**15431**	**100%**
Primary Work Activity		
Research and Development	11121	76.9%
Teaching	1681	11.6%
Administration/ Professional Service to Others	1659	11.5%
Total	**14461**	**100%**

Measures of central tendency are presented in Table 14 for the two continuous variables included in this analysis, age and length of time to PhD. Crosstabulation analysis with Pearson Chi-square testing was utilized to determine if a significant relationship exists between the nominal-level dependent variable, career attainment, and the independent variables in this study. Of the doctoral institution and program characteristics measured in this study, only the PhD Institution Carnegie Ranks was significantly related to definite career attainment ($\chi^2= 28.795$, $p<0.001$; Table 15). The research productivity and student support services quartile ranks were not significantly related to career attainment. PhD recipients' primary source of funding ($\chi^2=135.851$, $p<0.001$) and field of study ($\chi^2= 150.645$, $p<0.001$) were both related to participants' career attainment status.

Table 14

Measures of central tendency for the independent variables.

Variable	**Minimum**	**Maximum**	**Mean (S.E.)**	**Std. Deviation**	**Variance**
Age	22	75	32.48 (0.039)	5.787	33.49
Length of time to Phd	1	35	5.9 (0.016)	2.40	5.74

The measures of educational history for participants' bachelors and master's degrees are significantly related to career attainment (Table 15). These include the Carnegie Rank of master's institutions (χ^2= 60.530, p<0.001), master's field of study (χ^2= 144.982, p<0.001), Carnegie Ranks of bachelor's institution (χ^2=152.880, p<0.001), and bachelor's field of study (χ^2= 115.854, p<0.001). Junior college attendance is not related to career attainment. Several measures of participants' background characteristics were significantly related to career attainment status. These include: gender (χ^2= 36.656, p<0.001), race (χ^2= 150.297, P<0.001), and citizenship status (χ^2=134.960, p<0.001). Marital status and dependent status were not significantly related to career attainment.

Table 15

Cross-tabulation of career attainment with each nominal level independent variable.

Independent Variable	Definite Career Attainment	Career Attainment Negotiating	Other/ Missing	Total (N)	Chi-square
PhD Field of Study					150.645***
Agricultural Sciences/ Natural Resources	67.7%	8.1%	24.2%	950	
Biological/ Biomedical Sciences	72.0%	9.5%	18.5%	5986	
Health Sciences	74.7%	10.3%	15.0%	1723	
Mathematics	75.9%	7.2%	16.9%	1254	
Chemistry	70.6%	8.4%	21.0%	2051	
Geological/ Earth Sciences/Atmospheric Sciences	75.7%	8.8%	15.5%	893	
Physics	71.5%	9.0%	19.5%	1090	
Engineering	66.0%	10.7%	23.2%	6591	
Computer & Information Sciences	72.6%	9.9%	17.5%	1345	
PhD Institution Carnegie Rank					28.795***
Research University- Very High Activity	70.7%	9.6%	19.6%	17637	
Research University- High Activity	67.1%	10.0%	23.0%	2808	
All other institution types	74.2%	8.7%	17.1%	1438	
Research Productivity Quartile					13.991
1	71.4%	9.4%	19.2%	10858	
2	69.5%	9.8%	20.7%	6715	
3	68.0%	9.3%	22.7%	1062	
4	69.9%	9.7%	20.4%	103	
Missing	70.1%	10.0%	19.8%	3145	
Student Support Services Quartile					
1	70.7%	9.7%	19.6%	10511	5.956
2	70.6%	9.3%	20.0%	6730	
3	68.7%	9.3%	22.0%	1313	
4	71.2%	8.7%	20.1%	184	
Missing	70.1%	10.0%	19.8%	3145	

(continued)

Independent Variable	Definite Career Attainment	Negotiating	Other/ Missing	Total (N)	Chi-square
Primary Funding Type					136.851***
Fellowships/ Grants	72.3%	9.9%	17.8%	6488	
Teaching Assistantships	66.3%	9.8%	23.9%	2937	
Research Assistantships	68.2%	10.3%	21.6%	8962	
Other Sources of Funding	76.6%	7.2%	16.2%	3516	
M.A. Field of Study					144.982***
Agricultural Sciences/ Natural Resources	67.5%	9.3%	23.2%	767	
Biological/ Biomedical Sciences	72.1%	8.7%	19.2%	2175	
Health Sciences	76.4%	9.5%	14.2%	1427	
Mathematics	75.6%	7.6%	16.8%	1066	
Chemistry	68.4%	8.9%	22.7%	960	
Geological/ Earth Sciences/Atmospheric Sciences	74.0%	8.8%	17.2%	615	
Physics	72.5%	8.9%	18.6%	898	
Engineering	65.4%	10.8%	23.8%	5499	
Computer & Information Sciences	71.3%	9.8%	18.9%	1089	
Non Science M.A.	73.6%	7.5%	18.9%	550	
Missing/ No M.A.	71.7%	9.7%	18.6%	6837	
M.A. Institution Carnegie Rank					60.530***
Research University- Very High	70.6%	9.9%	19.5%	7807	
Research University- High	69.8%	10.3%	20.0%	1694	
Other Institution Types	74.8%	8.4%	16.8%	1223	
Non U.S. Institution	67.0%	9.3%	23.7%	4279	
Missing or no M.A.	71.9%	9.6%	18.5%	6880	
B.A. Field of Study					115.854***
Agricultural Sciences/ Natural Resources	70.4%	8.7%	20.8%	835	

Independent Variable	Definite Career Attainment	Negotiating	Other/ Missing	Total (N)	Chi-square
Biological/ Biomedical Sciences	71.6%	9.4%	19.1%	4683	
Mathematics	76.2%	8.1%	15.7%	1265	
Chemistry	71.2%	8.5%	20.3%	2281	
Geological/ Earth Sciences/Atmospheric Sciences	72.0%	9.6%	18.4%	565	
Physics	71.4%	8.9%	19.7%	1521	
Engineering	66.4%	10.7%	22.9%	6317	
Computer & Information Sciences	72.3%	10.1%	17.7%	815	
Non Science B.A.	74.0%	8.1%	17.9%	1185	
Missing	68.1%	11.7%	20.1%	1124	
BA Institution Carnegie Class					152.880***
Research University- Very High	73.9%	9.2%	16.9%	5838	
Research University- High	73.1%	9.1%	17.8%	1322	
Other Institution Types	74.3%	9.0%	16.7%	4060	
Non U.S. Institution	68.8%	10.0%	23.2%	9830	
Missing	13.0%	11.6%	21.1%	833	
Junior College Attendance					0.896
No	70.4%	9.6%	20.0%	19462	
Yes	71.3%	9.5%	19.2%	2421	
Gender					36.656***
Male	71.7%	9.6%	18.7%	14180	
Female	68.3%	9.6%	22.1%	7703	
Race					150.297***
White	73.4%	9.7%	16.9%	11220	
Hispanic	69.3%	10.9%	19.8%	190	
Asian	66.9%	9.2%	23.8%	8478	
Other	69.6%	10.0%	20.4%	250	
Citizenship Status					134.960***
Non U.S. Citizen	67.1%	10.0%	22.9%	10838	
U.S. Citizen	73.8%	9.2%	17.0%	11045	
Marital Status					4.136
No	70.0%	10.1%	19.9%	8522	
Yes	70.8%	9.3%	19.9%	13361	
Dependent Status					0.947
No	70.6%	9.6%	19.8%	177724	

Yes	70.2%	9.4%	20.4%	4159
Percent of Total	**70.5%**	**9.6%**	**19.9%**	**21883**

A multinomial logistic regression analysis was calculated to investigate the effect of these independent variables on the likelihood of definite career attainment. The dependent variable for this model was career attainment, including the categories: definite career attainment, negotiating with one or more employer, and other. The "other" category included those individuals who indicated their intent to pursue another full-time degree, those who do not intend to work or study, and those who indicated other on the survey. Definite career attainment served as the reference category. Table 16 presents the results of this regression analysis. The analysis of model fit indicated that this model is significant (χ^2= 672.495, p<0.001).

Table 16

Multinomial logistic regression model of doctoral institution and program characteristics and doctoral experiences on the likelihood of career attainment.

Independent Variables	**Career Attainment**[a]			
	Negotiating		**Other**	
PhD Field	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**
Biological Sciences (reference)				
Agriculture	-0.24 (0.181)	0.786	0.303 (0.120)	1.354*
Health Science	0.324 (0.146)	1.383*	-0.054 (0.118)	0.947
Mathematics	-0.488 (0.206)	0.614*	-0.084 (0.150)	0.920
Astronomy/Geology	-0.284 (0.202)	0.753	-0.412 (0.159)	0.662**
Chemistry	-0.2 (0.136)	0.819	0.093 (0.099)	1.097
Physics	-0.161 (0.186)	0.851	0.053 (0.137)	1.055
Engineering	-0.025 (0.122)	0.976	0.117 (0.091)	1.125
Computer Science	-0.112 (0.187)	0.894	-0.336 (0.144)	0.715*
Research Productivity Rank				
1st Quartile (reference)				
2nd Quartile	0.076 (0.055)	1.079	0.081 (0.041)	1.084*
3rd Quartile	0.068 (0.0015)	1.071	0.184 (0.082)	1.202*
4th Quartile	0.0154(0.351)	1.167	0.219 (0.261)	1.245
Missing Rank	0.130 (0.081)	1.139	0.095 (0.061)	1.1
Student Support Services Rank				
1st Quartile (reference)				
2nd Quartile	-0.41 (0.055)	0.96	-0.013 (0.041)	0.987
3rd Quartile	-0.195 (0.278)	0.822	-0.159 (0.197)	0.853
Funding Type				
Grant/Fellowship (reference)				
TA	0.136 (0.083)	1.146	0.341 (0.061)	1.406[c]***
RA	0.042 (0.063	1.043	0.079 (0.048)	1.082[b]
Other Funding Types	-0.423 (0.085)	0.0655[b,c]***	-0.284 (0.063)	0.753[b]***
PhD Carnegie Rank				
Very High (reference)				
High	0.067 (0.083)	1.069	0.159 (0.06)	1.173**
Other Institution Types	-0.135 (0.113)	0.874	-0.113 (0.085)	0.893
Length of Time to PhD	-0.027 (0.012)	0.974*	0.018 (0.008)	1.018*
Masters Field				
Biological Sciences (Reference)				
Agriculture	0.321 (0.205)	1.378	0.154 (0.144)	1.166
Health Science	-0.115 (0.174)	0.891	-0.184 (0.138)	0.832
Mathematics	0.048 (0.201)	1.05	-0.005 (0.148)	0.995
Astronomy/Geology	0.058 (0.236)	1.06	0.184 (0.179)	1.202
Chemistry	0.217 (0.169)	1.242	0.134 (0.12)	1.144

(continued)

Independent Variables	Negotiating		Other	
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**
Physics	0.069 (0.199)	1.071	0.081 (0.146)	0.922
Engineering	0.236 (0.131)	1.267	0.025 (0.097)	1.289**
Computer Science	0.133 (0.204)	1.142	0.354 (0.154)	1.425*
Non-science MA	-0.107 (0.2)	0.899	0.107 (0.14)	1.113
No Master's or Missing	0.422 (0.217)	1.524	0.346 (0.162)	1.413*
Master's Carnegie Rank				
Very High				
High	0.038 (0.105)	1.038	-0.127 (0.08)	0.881
Other Institution Types	-0.136 (0.121)	0.873	-0.14 (0.091)	0.869
Non U.S. Institution	-0.155 (0.076)	0.856*	-0.009 (0.054)	0.991
Missing	-0.330 (0.205)	0.719	-0.223 (0.154)	0.8
Bachelor's Field				
Biological Sciences (Reference)				
Agriculture	-0.089 (0.168)	0.915	-0.197 (0.12)	0.821
Health Science	-0.105 (0.137)	0.901	-0.330 (0.108)	0.719**
Mathematics	0.044 (0.172)	1.045	-0.287 (0.131)	0.751*
Astronomy/Geology	0.191 (0.21)	1.211	0.108 (0.16)	1.114
Chemistry	-0.08 (0.127)	0.923	-0.117 (0.093)	0.89
Physics	0.014 (0.155)	1.014	0.036 (0.115)	1.037
Engineering	0.074 (0.119)	1.077	-0.043 (0.089)	0.958
Computer Science	0.096 (0.189)	1.101	-0.105 (0.145)	0.901
Non-science BA	-0.134 (0.133)	0.875	-0.133 (0.098)	0.875
Missing	0.123 (0.158)	1.131	-0.197 (0.124)	0.821
Bachelor's Carnegie Rank				
Very High				
High	-0.033 (0.111)	0.967	0.043 (0.084)	1.044
Other Institution Types	0.006 (0.075)	1.006	0.011 (0.058)	1.012
Non U.S. Institution	0.218 (0.114)	1.243	0.246 (0.085)	1.279**
Missing	0.272 (0.182)	1.313	0.345 (0.141)	1.413*
Junior College				
No (Reference)				
Yes	0.078 (0.079)	1.081	0.157 (0.06)	1.170**
Demographics				
Male (reference)				
Female	0.119 (0.053)	1.126*	0.368 (0.038)	1.444***
Not married (reference)				
Married	-0.109 (0.052)	0.896*	-0.071 (0.039)	0.931
No Children (reference)				
Children	0.03 (0.066)	1.031	0.019 (0.048)	1.02
White (reference)				
Hispanic	0.107 (0.113)	1.113	0.108 (0.089)	1.115
Asian	-0.2 (0.065)	0.819**	0.247 (0.049)	1.281***
Other	0.108 (0.109)	1.114	0.23 (0.083)	1.258
Not a US citizen (reference)				

(continued)

Citizenship	-0.054 (0.107)	0.948	-0.002 (0.08)	0.998**
Age	0.004 (0.005)	1.004	0.022 (0.004)	1.022***
Model Fit	χ^2	***Df***		***P***
Likelihood ratio test	672.495	168		0.000

[a] Definite Career Attainment served as the reference category. * indicates p<0.05, ** indicates p<0.01, *** indicates p<0.001
[b]TAs are significantly different from RAs and Other Funding types (p<0.05)
[c]RAs are significantly different from Other Funding Types (p<0.05)

Two measures of program characteristics and institutional characteristics were significantly related to the likelihood of definite career status. Participants graduating from 2nd and 3rd quartile programs in terms of their research productivity rank were 1.08 and 1.2 times more likely than those in 1st quartile ranked programs to indicate other career status, respectively ($p<0.05$). PhD recipients from institutions ranked as high research activity as opposed to very high research activity were 1.2 time more likely to indicate other career attainment status instead of reporting definite career plans ($p< 0.01$).

Engaging in certain fields of study influenced the likelihood of definite career attainment compared with those individuals were reported their status as negotiating or other. PhD recipients in the field of health sciences were 1.4 times more likely than their peers in the biological sciences to indicate that they were negotiating with one or more employers instead of having firm career plans ($p<0.05$). Further, PhD recipients in mathematics fields were 60 % more likely than their peers in the biological sciences to have definite career plans instead of negotiating with one or more employers ($p<0.05$). Several fields of study, agriculture, astronomy/geology, chemistry, physics, engineering, and computer science, did not influence the likelihood of negotiating with one or more employers compared with PhD recipients in the biological sciences. PhD recipients in agriculture are 1.3 times more likely than PhD recipients in the biological sciences to report other as their career status compared with those that have definite career plans ($p<0.05$). Participants in the fields of astronomy/geology and computer science are less likely to report a career status of other than definite career plans when compared with PhD recipients in biology ($p<0.05$).

Participants' primary type of funding was influential in predicting the likelihood of their career attainment status. PhD recipients who funded their doctoral studies through other sources were less likely than those who funded their doctoral studies through fellowships to be negotiating or other instead of having definite career plans ($p<0.001$). Individuals who funded their doctoral studies through teaching assistantships were 1.4 times more likely than those who funded their studies with fellowships to report Other as opposed to having definite career attainment ($p<0.001$). As noted in Table 16, there were also significant differences among the funding types. The results of this analysis are available upon request.

The length of time to degree was a significant predictor in this model. Long time to degree was significantly related to the likelihood of definite career attainment ($p<0.05$). Individuals who took longer to complete their degrees were 0.974 times less likely to report that they were negotiating with several employers rather than having definite career plans. However, those PhD recipients who took longer amounts of time to complete their degrees were 1.01 times more likely to report Other as their career attainment ($p< 0.05$).

PhD recipients who completed master's degrees in engineering, computer science or who did not complete a master's degree were at least 1.3 times more likely than those individuals who completed a master's degree in biology to select Other as their career attainment in relation to definite career attainment ($p<0.05$). The other fields of study, agriculture, health science, mathematics, astronomy/ geology, chemistry, physics, and non-science fields were not significant predictors of the likelihood of the Other career. No fields of study were significantly different from the reference category concerning the likelihood of negotiating with employers compared with those who are either returning to pre doctoral employment or those with a signed contract. Master's institution Carnegie Rank was significantly related to career attainment for those individuals who attended institutions outside the United States. These individuals were 85.6 % less likely to be negotiating a contract compared with individuals who attended institutions who were ranked as Very High research activity ($p<0.05$).

Those participants who obtained a bachelor's degree in health science or mathematics were more likely than their colleagues who obtained a bachelor's degree in biology to have definite career attainment than Other. However, those individuals who attended Non-U.S. institutions or were missing for the Carnegie Rank of their bachelor's institution were 1.3 and 1.4 times more likely to report Other career attainment compared with definite career attainment, respectively ($p<0.05$). Attendance of a junior college also increased the likelihood of participants selecting Other career attainment ($p<0.01$).

Certain background characteristics were significant in predicting the likelihood of career attainment. Female doctoral recipients were 1.2 times more likely than male doctoral recipients to be negotiating ($p<0.05$) and 1.4 times more likely to report Other career attainment ($p<0.001$) compared to definite career attainment. Those doctoral recipients who are married are less likely to be negotiating instead of having definite career attainment ($p<0.05$) compared with unmarried PhDs. Dependent status was not a significant predictor of career attainment. Only the Asian race indicator significantly predicted career attainment in this model, among the racial categories investigated. Asian PhDs were more likely to have definite career attainment than be negotiating compared to their White peers ($p<0.01$), and also 1.2 times more likely to report Other ($p<0.001$)

than definite career attainment compared with their White peers. Participants' age and citizenship status also significantly predicted the likelihood of Other career attainment. U.S. citizenship decreased the likelihood of reporting Other compared definite career attainment relative to non U.S. citizens by 0.998 times ($p<0.01$). Older PhD recipients were 1.02 times more likely to report Other career attainment relative to younger participants ($p<0.001$).

Employment Field

I investigated the employment field for those participants who indicated definite career attainment (N=15426). While many individuals (27.4%) indicated that they would be employed at U.S. four-year colleges or universities, several other employment fields were also represented (Table 13). In addition to four-year colleges and universities, participants indicated their employment in medical schools, industry, research institutes, Other, foreign employment, or the U.S. government. This analysis focused on elucidating the relationship between doctoral institution and program characteristics and experiences and the field of employment of STEM PhD recipients.

Cross-tabulation with Pearson Chi-square analysis was calculated to determine if a relationship exists between the nominal level dependent variable, employment field and each of the independent variables in this study (Table 17). All independent variables in this study are significantly related to employment field. These include: PhD field of study (χ^2=4821.304, $p<0.001$), PhD institution Carnegie Rank (χ^2= 328.45, $p<0.001$), research productivity rank quartile (χ^2=106.9, $p<0.001$), student support services rank quartile (χ^2=96.769, $p<0.001$), primary funding type (χ^2= 1990.678, $p<0.001$), MA field of study (χ^2= 3027.203, $p<0.001$), MA institution Carnegie Rank (χ^2=1127.70, $p<0.001$), BA field of study (χ^2=3459.250, $p<0.001$), BA institution Carnegie Rank (χ^2= 1442.64, $p<0.001$), junior college attendance (χ^2=161.473, $p<0.001$), gender (χ^2=300.193, $p<0.001$), race (χ^2=953.340, $p<0.001$), citizenship status (χ^2= 1426.992, $p<0.001$), marital status (χ^2=121.626, $p<0.001$), and dependent status (χ^2= 27.563, $p<0.001$).

Table 17

Cross-tabulation of employment field with each nominal level independent variable.

	Employment Field								
Independent Variable	**Four year college**	**Medical School**	**Industry**	**Research Institute**	**Other**	**Foreign Employ.**	**U.S. Government**	**Total (N)**	**Chi-square**
PhD Field of Study									4821.304***
Agricultural Sciences/ Natural Resources	35.3%	1.6%	15.7%	10.4%	10.9%	13.5%	12.6%	643	
Biological/ Biomedical Sciences	23.9%	30.5%	7.8%	16.3%	10.6%	4.0%	6.9%	4311	
Health Sciences	35.2%	12.9%	9.2%	9.9%	15.9%	6.8%	10.1%	1287	
Mathematics	44.5%	2.9%	16.8%	12.0%	6.5%	12.7%	4.5%	952	
Chemistry	32.9%	4.5%	25.6%	17.0%	7.3%	4.7%	8.0%	1448	
Geological/ Earth Sciences/Atmospheric Sciences	36.1%	0.3%	12.3%	18.0%	10.5%	8.9%	13.9%	676	
Physics	29.5%	4.0%	18.7%	16.7%	7.4%	6.8%	12.3%	779	
Engineering	18.8%	2.8%	49.0%	9.2%	7.4%	6.8%	5.9%	4353	
Computer & Information Sciences	28.2%	1.3%	43.5%	7.7%	7.3%	8.3%	3.7%	977	
PhD Institution Carnegie Rank									328.45***
Research University- Very High Activity	27.5%	10.6%	26.1%	12.9%	8.6%	7.1%	7.1%	12476	
Research University- High Activity	27.5%	8.1%	23.7%	13.0%	11.5%	7.3%	8.9%	1883	

(continued)

Independent Variable	Four year college	Medical School	Industry	Research Institute	Other	Foreign Employ.	U.S. Government	Total (N)	Chi-square
All other institution types	21.9%	25.8%	15.7%	12.7%	11.8%	3.2%	8.9%	1067	
Research Productivity Quartile									
1	26.9	11.2	26.2	12.9	8.9	7.2	6.6	7761	
2	27.6	10.2	26.1	12.8	8.7	6.8	7.9	4669	
3	28.5	10.8	21.5	15.2	10.0	5.1	8.9	722	
4	38.9	16.7	12.5	12.5	5.6	6.9	6.9	72	
Missing	25.8	14.4	20.5	12.3	11.3	6.5	9.2	2207	
Student Support Services Quartile									96.769***
1	26.9	10.9	26.3	12.7	9.0	7.2	6.9	7435	
2	28.0	11.2	25.2	13.1	8.5	6.7	7.2	4756	
3	26.8	8.3	24.6	14.1	10.6	6.2	9.3	902	
4	30.5	11.5	29.0	14.5	3.1	6.9	4.6	131	
Missing	25.8	14.4	20.5	12.3	11.3	6.5	9.2	2207	
Primary Funding Type									1990.678***
Fellowships/ Grants	26.5%	22.0%	16.5%	13.1%	7.9%	6.3%	7.6%	4679	
Teaching Assistantships	37.3%	5.8%	22.8%	13.6%	6.4%	9.0%	5.1%	1946	
Research Assistantships	26.1%	6.7%	35.1%	14.5%	5.3%	6.1%	6.2%	6109	
Other Sources of Funding	23.1%	7.5%	19.1%	8.3%	22.2%	8.1%	12.0%	2692	
M.A. Field of Study									3027.203***
Agricultural Sciences/ Natural Resources	34.9%	3.1%	16.0%	9.5%	10.4%	14.3%	11.8%	518	

(continued)

Independent Variable	Four year college	Medical School	Industry	Research Institute	Other	Foreign Employ.	U.S. Government	Total (N)	Chi-square
Biological/ Biomedical Sciences	26.5%	23.7%	7.4%	18.3%	11.3%	5.4%	7.5%	1568	
Health Sciences	34.1%	15.5%	8.0%	11.6%	13.9%	7.2%	9.8%	1090	
Mathematics	43.5%	4.0%	18.9%	11.3%	6.1%	10.8%	5.5%	806	
Chemistry	31.5%	6.7%	26.6%	17.7%	7.0%	4.0%	6.5%	657	
Geological/ Earth Sciences/Atmospheric Sciences	35.4%	0.2%	13.0%	18.9%	10.8%	9.0%	12.7%	455	
Physics	27.8%	4.1%	21.8%	18.6%	7.5%	8.9%	11.2%	651	
Engineering	18.7%	2.2%	48.3%	10.1%	7.3%	7.4%	6.0%	3596	
Computer & Information Sciences	27.6%	1.4%	45.2%	9.0%	5.8%	7.6%	3.4%	776	
Non Science M.A.	34.3%	10.1%	15.1%	10.1%	16.3%	4.2%	9.9%	405	
Missing/ No M.A.	26.2%	19.6%	18.5%	12.9%	9.6%	5.6%	7.5%	4904	
M.A. Institution Carnegie Rank									1127.70***
Research University- Very High	27.3%	6.5%	31.3%	11.4%	8.7%	6.0%	8.9%	5512	
Research University- High	31.2%	5.1%	23.4%	10.4%	12.1%	7.7%	10.1%	1182	
Other Institution Types	35.7%	11.4%	14.3%	10.8%	13.9%	3.5%	10.5%	916	
Non U.S. Institution	23.8%	8.7%	28.7%	17.2%	7.0%	11.8%	2.8%	2868	
Missing or no M.A.	26.1%	19.9%	18.5%	13.0%	9.5%	5.5%	2.4%	4949	

(continued)

Independent Variable	Four year college	Medical School	Industry	Research Institute	Other	Foreign Employ.	U.S. Government	Total (N)	Chi-square
B.A. Field of Study									3459.250***
Agricultural Sciences/ Natural Resources	34.9%	5.4%	14.6%	11.2%	8.3%	13.3%	12.2%	588	
Biological/ Biomedical Sciences	25.4%	27.1%	8.1%	15.0%	12.1%	3.8%	8.5%	3351	
Health Sciences	30.3%	17.7%	10.3%	14.3%	13.3%	8.1%	5.8%	976	
Mathematics	42.0%	4.3%	17.0%	11.4%	7.2%	12.8%	5.4%	964	
Chemistry	30.1%	9.8%	25.0%	15.8%	6.8%	4.4%	8.2%	1625	
Geological/ Earth Sciences/Atmospheric Sciences	36.1%	1.5%	16.0%	15.2%	8.6%	8.8%	13.8%	407	
Physics	28.8%	4.1%	23.3%	15.7%	7.2%	9.4%	11.4%	1086	
Engineering	20.1%	3.5%	47.1%	9.3%	7.3%	7.1%	5.7%	4197	
Computer & Information Sciences	26.5%	14.2%	47.2%	8.7%	6.5%	6.5%	3.4%	589	
Non Science B.A.	33.9%	14.6%	10.8%	12.2%	15.1%	5.1%	8.3%	877	
Missing	23.5%	14.2%	22.8%	17.2%	8.6%	8.5%	5.1%	766	
BA Institution Carnegie Class									1442.64***
Research University- Very High	29.4%	15.3%	20.7%	9.5%	10.6%	4.25	10.4%	4313	
Research University- High	30.5%	10.8%	17.6%	9.9%	14.7%	3.1%	13.4%	967	
Other Institution Types	33.7%	13.5%	14.7%	12.6%	10.7%	3.2%	11.6%	3020	
Non U.S. Institution	22.4%	7.7%	33.9%	15.2%	6.9%	10.8%	3.1%	6568	
Missing	23.4%	14.1%	24.3%	17.9%	8.2%	8.2%	3.9%	560	

(continued)

Independent Variable	Four year college	Medical School	Industry	Research Institute	Other	Foreign Employ.	U.S. Government	Total (N)	Chi-square
Junior College Attendance									161.473***
No	26.6%	11.2%	26.0%	13.0%	9.0%	7.3%	6.8%	13700	
Yes	30.9%	12.5%	17.8%	11.9%	10.5%	3.5%	12.7%	1726	
Gender									300.193***
Male	26.2%	9.9%	29.0%	12.3%	8.3%	7.3%	6.9%	10164	
Female	28.8%	14.2%	17.5%	14.0%	10.9%	6.1%	8.5%	5262	
Race									953.340***
White	31.1%	12.0%	18.4%	12.2%	10.3%	6.3%	9.8%	8236	
Hispanic	23.2	11.4	18.8	11.4	9.5	17.7	8.0%	665	
Asian	22.0	10.2	36.6	14.1	7.1	6.3%	3.7%	5676	
Other	25.5	12.6	18.1	12.9	12.5	8.7	6.9	854	
Citizenship Status									1426.992***
Non U.S. Citizen	22.6%	8.3%	33.1%	15.3%	6.9%	11.0%	2.9%	7270	
U.S. Citizen	31.1%	14.1%	17.9%	10.7%	11.3%	3.3%	11.5%	8156	
Marital Status									121.626***
No	25.5%	11.2%	24.0%	12.0%	12.1%	7.8%	7.3%	5966	
Yes	28.1%	11.5%	25.8%	13.4%	7.4%	6.3%	6.9%	9460	
Dependent Status									27.563***
No	27.4%	11.4%	24.8%	12.8%	9.7%	6.7%	7.4%	12507	
Yes	25.8%	11.4%	26.4%	13.4%	7.2%	7.9%	7.8%	2919	
Percent of Total	**27.1%**	**11.4%**	**25.1%**	**12.9%**	**9.2%**	**6.9%**	**7.5%**	**15426**	

A multinomial logistic regression model was specified to investigate the effect of the identified independent variables on the likelihood of certain employment fields. Table 18 presents the results of this regression analysis. Employment field served as the nominal level dependent variable. U.S. four-year colleges or universities served as the reference category.

Table 18

Multinomial logistic regression model of effect of doctoral program and institution characteristics, and doctoral experiences on the likelihood of employment in certain fields.

Independent Variable	Employment Field[a]											
	Medical School		**Industry**		**Research Institute**		**Other**		**Foreign Employment**		**U.S. Government**	
PhD Field	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}
Biological Sciences (reference)												
Agriculture	-2.589 (0.36)	0.075***	0.395 (0.192	1.484*	-0.532 (0.197)	0.587**	-0.185 (0.207)	0.831	0.346 (0.236)	1.413	0.158 (0.208)	1.171
Health Science	-1.159 (0.165)	0.314***	0.077 (0.188)	1.08	-0.912 (0.179)	0.402***	-0.131 (0.176)	0.877	0.091 (0.239)	1.096	-0.159 (0.211)	0.853
Mathematics	-2.345 (0.307)	0.096***	-0.110 (0.202)	1.116	-0.608 (0.219)	0.544**	-0.502 (0.261)	0.605	0.42 (0.258)	1.523	-0.582 (0.307)	0.559
Astronomy/Geology	-3.902 (0.747)	0.02***	-0.139 (0.222)	0.87	-0.28 (0.205)	0.755	0.058 (0.239)	1.059	0.338 (0.286)	1.403	0.426 (0.227)	1.531
Chemistry	-2.148 (0.182)	0.177***	0.443 (0.142)	1.558**	-0.277 (0.144)	0.758	-0.292 (0.183)	0.746	0.052 (0.229)	1.053	0.019 (0.188)	1.019
Physics	-1.964 (0.305)	0.14***	0.15 (0.192	1.162	-0.523 (0.203)	0.593*	-0.157 (0.252)	0.855	0.669 (0.255)	1.952**	0.571 (0.238)	1.771*
Engineering	-1.621 (0.184)	0.198***	1.336 (0.133)	3.802***	-0.69 (0.154)	0.502***	-0.057 (0.171)	0.944	0.353 (0.199)	1.423	0.246 (0.187)	1.279
Computer Science	-2.451 (0.391)	0.086***	0.916 (0.18)	2.5***	-1.28 (0.25)	0.278***	-0.208 (0.243)	0.812	0.607 (0.265)	1.835*	-0.646 (0.31)	0.629
Research Productivity Rank												
1st Quartile (reference)												
2nd Quartile	0.012 (0.075)	1.012	-0.054 (0.056)	0.947	-0.039 (0.066)	0.962	-0.072 (0.077)	0.931	-0.105 (0.085)	0.901	0.182 (0.081)	1.2*
3rd Quartile	0.125 (0.155)	1.133	-0.257 (0.121)	0.773	0.094 (0.131)	1.099	0.026 (0.154)	1.026	-0.442 (0.195)	0.643*	0.238 (0.16)	1.269
4th Quartile	-0.158	0.854	-0.253	0.776	-0.245	0.783	-0.815	0.443	0.02	1.02	-0.187	0.829

(continued)

Independent Variables	Medical School		Industry		Research Institute		Other		Foreign Employment		U.S. Government	
	(0.404)		(0.409)		(0.407)		(0.558)		(0.513)		(0.506)	
	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}	β (SE)	e^{β}
Missing Rank	0.192 (0.109)	1.212	-0.04 (0.089)	0.961	0.061 (0.101)	1.063	-0.043 (0.693)	0.957	0.042 (0.128)	1.043	0.131 (0.117)	1.14
Student Support Services Rank												
1st Quartile (reference)												
2nd Quartile	-0.03 (0.073)	0.97	0.02 (0.056)	1.02*	-0.06)	0.942	-0.075 (0.076	0.928	-0.001 (0.084)	0.999	-0.113 (0.081)	0.893
3rd Quartile	-0.295 (0.360)	0.744	0.153 (0.262)	1.165	-0.102 (0.299)	0.903	-1.066 (0.547)	0.344	0.239 (0.4)	1.270	-0.645 (0.459)	0.525
Funding Type												
Grant/Fellowship (reference)												
TA	-0.957 (0.122)	0.384***	-0.098 (0.087)	0.907	-0.306 (0.096)	0.736***	-0.284 (0.122)	0.753*	-0.464 (0.121)	0.629***	-0.351 (0.131)	0.704**
RA	-0.581 (0.083)	0.559[b]***	0.153 (0.066)	1.165[b]*	-0.052 (0.074)	0.950[b]	-0.297 (0.093)	0.743***	-0.685[b] (0.098)	0.504***	0.057 (0.092)	1.059
Other Funding Types	-0.373 (0.106)	0.689[b][c]***	0.362 (0.088)	1.436[b]***	-0.081 (0.102)	0.922[b]	1.382 (0.095)	3.981[bc]***	0.261 (0.116)	1.298[b][c]*	0.594 (0.106)	1.182[bc]***
PhD Carnegie Rank												
Very High (reference)												
High	0.180 (0.118)	1.197	0.092 (0.09)	1.097	0.109 (0.099)	1.115	0.220 (0.109)	1.246*	-0.133 (0.127)	0.876	0.23 (0.12)	1.259
Other Institution Types	0.542 (0.121)	1.719***	0.415 (0.129)	1.515***	0.208 (0.133)	1.231	0.173 (0.141)	1.189	-0.483 (0.213)	0.617*	0.332 (0.154)	1.394*
Length of Time to PhD	-0.002 (0.016)	0.998	0.03 (0.012)	1.03*	-0.004 (0.015)	0.996	0.013 (0.013)	1.013	-0.045 (0.02)	0.956*	0.02 (0.013)	1.02
Masters Field												
Biological Sciences (Reference)												

(continued)

Independent Variables	Medical School		Industry		Research Institute		Other		Foreign Employment		U.S. Government	
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**
Agriculture	-0.360 (0.318)	0.698	0.22 (0.232)	1.246	-0.349 (0.142)	0.705	0.083 (0.247)	1.086	0.274 (0.275)	1.316	-0.108 (0.247)	0.898
Health Science	0.331 (0.183)	1.392	-0.141 (0.229)	0.868	0.113 (0.568)	1.120	-0.476 (0.207)	0.621*	0.168 (0.269)	1.183	0.023 (0.244)	1.023
Mathematics	0.015 (0.287)	1.016	0.238 (0.207)	1.269	-0.288 (0.218)	0.750	-0.366 (0.265)	0.693	-0.473 (0.258)	0.623	0.206 (0.299)	1.228
Astronomy/Geology	-2.012 (1.051)	0.134	0.111 (0.26)	1.117	0.229 (0.236)	1.257	0.261 (0.278)	1.298	-0.087 (0.325)	0.917	-0.096 (0.265)	0.909
Chemistry	0.045 (0.224)	1.046	0.237 (0.18)	1.267	-0.140 (0.175)	0.870	0.08 (0.230)	1.083	-0.67 (0.296)	0.512*	0.015 (0.241)	1.015
Physics	0.322 (0.324)	1.380	0.428 (0.211)	*1.534	0.422 (0.211)	1.525	0.28 (0.265)	1.323	-0.268 (0.272)	0.765	0.138 (0.241)	1.148
Engineering	-0.547 (0.205)	0.579**	0.463 (0.154)	1.589**	0.411 (0.165)	1.508*	0.105 (0.182)	1.111	0.122 (0.214)	1.129	0.2 (0.201)	1.222
Computer Science	-0.38 (0.431)	0.684	0.358 (0.204)	1.431	0.374 (0.263)	1.453	-0.446 (0.279)	0.64	-0.209 (0.297)	0.811	-0.193 (0.351)	0.824
Non-science MA	0.153 (0.223)	1.165	0.139 (0.215)	1.149	-0.094 (0.218)	0.910	-0.219 (0.213)	0.804	-0.621 (0.32)	0.537	-0.018 (0.243)	0.982
No Master's or Missing	-0.38 (0.256)	0.684	0.088 (0.244)	1.092	-0.119 (0.250)	0.888	0.178 (0.286)	1.195	-0.019 (0.333)	0.981	0.044 (0.332)	1.045
Master's Carnegie Rank												
Very High												
High	-0.56 (0.172)	0.571***	-0.289 (0.122)	0.749**	-0.329 (0.131)	0.720	-0.173 (0.135)	0.841	0.213 (0.157)	1.237	-0.296 (0.143)	0.744*
Other Institution Types	-0.256 (0.146)	0.774	-0.562 (0.129)	0.570***	-0.346 (0.137)	0.708	-0.193 (0.136)	0.824	-0.484 (0.213)	0.616*	-0.421 (0.146)	0.656**
Non U.S. Institution	-0.019 (0.120)	0.981	-0.370 (0.077)	0.691***	-0.047 (0.09)	0.954	-0.064 (0.116)	0.938	0.215 (0.106)	1.240*	-0.457 (0.155)	0.633**
Missing	0.619 (0.253)	1.857*	0.123 (0.218)	1.131	0.071 (0.241)	1.074	-0.078 (0.274)	0.925	0.222 (0.31)	1.248	-0.176 (0.315)	0.838

(continued)

Independent Variables	Medical School		Industry		Research Institute		Other		Foreign Employment		U.S. Government	
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**
Bachelor's Field												
Biological Sciences (Reference)												
Agriculture	-0.620 (0.224)	0.538 **	-0.038 (0.189)	0.962	-0.269 (0.185)	0.764	-0.775 (0.211)	0.461***	0.216 (0.226)	1.241	-0.064 (0.194)	0.938
Health Science	0.027 (0.144)	1.027	0.301 (0.172)	1.352	0.091 (0.152)	1.095	-0.087 (0.165)	0.917	0.283 (0.210)	1.328	-0.832 (0.21)	0.435***
Mathematics	-0.330 (0.244)	0.719	-0.107 (0.178)	0.898	-0.258 (0.19)	0.772	-0.427 (0.220)	0.652	0.289 (0.232)	1.336	-0.423 (0.244)	0.655
Astronomy/Geology	-0.380 (0.484)	0.684	0.393 (0.233)	1.482	-0.369 (0.227)	0.692	-0.718 (0.267)	0.488**	0.193 (0.308)	1.213	-0.043 (0.244)	0.958
Chemistry	0.082 (0.139)	1.086	0.393 (0.139)	1.481 **	-0.045 (0.138)	0.956	-0.514 (0.173)	0.598**	0.061 (0.223)	1.063	-0.019 (0.173)	0.981
Physics	-0.328 (0.242)	0.721	0.202 (0.165)	1.224	-0.135 (0.173)	0.873	-0.637 (0.210)	0.529**	0.178 (0.233)	1.195	-0.097 (0.201)	0.908
Engineering	-0.077 (0.167)	0.926	0.342 (0.132)	1.408 **	-0.280 (0.146)	0.755	-0.305 (0.161)	0.737	0.073 (0.195)	1.076	-0.247 (0.175)	0.781
Computer Science	-0.780 (0.441)	0.458	0.447 (0.182)	1.564 *	-0.097 (0.245)	0.908	-0.186 (0.265)	0.830	-0.195 (0.287)	0.823	-0.223 (0.328)	0.8
Non-science BA	0.063 (0.137)	1.065	-0.153 (0.158)	0.858	0.005 (0.143)	1.005	-0.166 (0.146)	0.847	0.123 (0.213)	1.131	-0.604 (0.171)	0.547***
Missing	0.306 (0.16)	1.359	0.514 (0.157)	1.671 ***	0.293 (0.058)	1.34	-0.146 (0.186)	0.864	0.169 (0.437)	1.184	-0.120 (0.215)	0.887
Bachelor's Carnegie Rank												
Very High												
High	-0.186 (0.138)	0.831	-0.015 (0.116)	0.985	0.103 (0.447)	1.109	0.211 (0.126)	1.235	-0.422 (0.217)	0.656	0.214 (0.128)	1.239
Other Institution Types	-0.206 (0.084)	0.814 *	-0.075 (0.076)	1.261	0.202 (0.084)	1.224*	-0.1 (0.089)	0.905	-0.262 (0.131)	0.770	0.013 (0.088)	1.013
Non U.S. Institution	-0.033	0.968	0.232	0.928	0.560	1.751*	0.097	1.101	0.138	1.148	0.042	1.043

	(0.151)		(0.113)	*	(0.135	**	(0.154)		(0.163)		(0.183)	
Missing												

(continued)

Independent Variables	**Medical School**		**Industry**		**Research Institute**		**Other**		**Foreign Employment**		**U.S. Government**	
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**	**β (SE)**	**e^{β}**
Junior College												
No (Reference)												
Yes	-0.084 (0.097)	0.919	0.045 (0.085)	1.046	0.126 (0.094)	1.134	-0.081 (0.1)	0.922	-0.142 (0.151)	0.867	0.148 (0.094)	1.16
Demographics												
Male (reference)												
Female	-0.206 (0.066)	0.814 **	-0.134 (0.056)	0.874 *	0.019 (0.061)	1.02	0.025 (0.07)	1.025	-0.127 (0.082)	0.881	0.147 (0.076)	1.158
Not married (reference)												
Married	-0.058 (0.069)	0.944	0.045 (0.054)	1.046	-0.005 (0.063)	0.995	0.627 (0.071)	0.534** *	-0.393 (0.082)	0.675** *	-0.172 (0.077)	0.842*
No Children (reference)												
Children	0.223 (0.087)	1.249 *	0.026 (0.066)	1.026	0.072 (0.076)	1.075	0.007 (0.096)	1.007	0.247 (0.099)	1.28*	0.23 (0.094)	1.259*
White (reference)												
Hispanic	0.098 (0.159)	1.103	0.2 (0.134)	1.221	-0.013 (0.149)	0.987	0.162 (0.162)	1.176	0.534 (0.145)	1.706** *	0.269 (0.17)	1.309
Asian	0.452 (0.093)	1.572 ***	0.524 (0.069)	1.689 ***	0.002 (0.08)	1.002	0.211 (0.143)	1.235*	-0.788 (0.093)	0.455** *	0.214 (0.115)	1.238
Other	0.288 (0.141)	1.334 *	0.129 (0.129)	1.138	0.244 (0.135)	1.276	0.21 (0.143)	1.234	0.11 (0.17)	1.116	0.257 (0.149)	1.293
Not a US citizen (reference)												
Citizenship	-0.075 (0.139)	0.928	-0.055 (0.108)	0.946	-0.367 (0.126)	0.693* *	0.03 (0.145)	1.03	-1.747 (0.155)	0.174** *	0.983 (0.174)	2.673***
Age	-0.018 (0.007)	0.982 *	-0.034 (0.006)	0.967 ***	-0.008 (0.007)	0.992	0.001 (0.006)	1.001	0.012 (0.008)	1.012	0.019 (0.006)	1.019**
Model Fit	χ^2		***Df***		***P***							
Likelihood ratio test	7699.001		336		0.000							

[a] U.S. four-year colleges and universities served as the reference category. * indicates $p<0.05$, ** indicates $p<0.01$, *** indicates $p<0.001$
[b]indicates that TAs are significantly different ($p<0.05$); [c]indicates that RAs are significantly different ($p<0.05$)

Participants' field of study for their PhD affected the likelihood of their employment field when compared with the reference group of biological sciences. Participants in all other fields of study were less likely to be employed at a medical school compared with a four-year college or university ($p<0.001$) (Table 18). Those who hold PhDs in agriculture or chemistry were 1.5 times more likely than those in biological sciences to be employed in industry instead of a college or university ($p<0.05$). PhD recipients in engineering and computer science were 3.8 and 2.5 times more likely than their peers in biological sciences to be employed in industry rather than colleges or universities, respectively ($p<0.001$). Participants' whose field of study was agriculture, health science, mathematics, physics, engineering, and computer science were less likely than their peers who received degrees in biology to work at a research institute than a college or university ($p<0.05$). Participants whose field of study was physics or computer science were nearly twice as likely as PhD holders in biology to gain foreign employment as to become employed at a U.S. college or university ($p<0.05$). Finally, physics PhDs were also 1.7 times more likely than biology PhD holders to become employed by the U.S. government compared with colleges or universities ($p<0.05$).

The research productivity rank of doctoral programs was a significant predictor of the likelihood of foreign and U.S. government employment in certain cases. PhD recipients who complete their degrees third quartile ranked programs were 64% less likely to gain foreign employment compared with graduates from 1st quartile ranked programs ($p<0.05$). Those individuals who graduated from programs ranked in the 2nd quartile were 1.2 times more likely than those who graduated from 1st quartile ranked programs to be employed by the U.S. government ($p<0.05$). Participants did not vary in their likelihood of employment in medical schools, industry, research institutes, or other fields according to their research productivity rank.

PhD recipients who graduated from 2nd quartile ranked programs in student support services were 1.02 times more likely than individuals who graduated from 1st quartile ranked programs to be employed in industry compared with colleges or universities. Participants did not vary in their likelihood of employment field according to the student support services rank of their doctoral program in other instances.

Participants' primary source of funding was a significant predictor of the likelihood of participants' employment field. Compared to participants who funded their doctoral studies with grants/ fellowships, those who funded their degrees with teaching assistantships were 0.38 times less likely to be employed at a medical school ($p<0.001$), 0.73 times less likely to be employed at a research institute ($p<0.001$), 0.753 times less likely to be employed in other fields ($p<0.05$), 0.629 times less likely to achieve foreign employment ($p<0.001$), and 0.704 times less likely to be employed by the U.S. government ($p<0.01$) compared with four-year colleges and universities. Primarily funding doctoral studies through a teaching assistantship was not significantly related to achieving employment industry compared with a four- year college or university.

Participants who funded their doctoral studies through research assistantships were 0.559 times less likely to be employed at medical schools, 0.743 times less likely to be employed in other fields, and 0.504 times less likely to be employed in a foreign country ($p<0.001$) compared with individuals who funded their studies through grants and fellowships. Primarily funding doctoral studies with research assistantships compared with grants/fellowships was associated with a 1.165 times increase in the likelihood of employment in industry rather than colleges and universities ($p<0.05$). Funding doctoral studies through research assistantships did not significantly differ from grants/fellowships in the likelihood of employment at research institutes or the U.S. government compared with four-year colleges and universities. Supplemental analysis of participants' primary type of funding revealed that teaching assistants vary in their likelihood to be employed in medical schools, industry, research institutes, and the U.S. government when compared to research assistants ($p<0.05$). Teaching assistants are also significantly different in every category in their likelihood of employment field when compared to those who used other sources of funding ($p<0.05$). Research assistants also significantly differed from those who funded their doctoral studies through other sources in their likelihood of employment in industry, other, foreign employment, and the U.S. government ($p<0.05$). Results of this analysis are available upon request.

Compared with those who fund their doctoral studies through grants/fellowships, PhD recipients who utilize other sources of funding differed significantly in their likelihood of employment at medical schools, industry, other fields, foreign employment, and the U.S. government compared with U.S. four-year colleges and universities. These individuals were 0.689 times less likely to be employed at a medical school ($p<0.001$), while they were 1.4 times more likely to be employed in industry ($p<0.001$), 3.9 times more likely to be employed in other fields ($p<0.001$), 1.3 times more likely to be employed in a foreign country ($p<0.05$), and 1.2 times more likely to be employed by the U.S. government ($p<0.001$) than those who funded their doctoral studies primarily through grants/ fellowships.

PhD recipients who attended institutions ranked as having high research activity were 1.2 times more likely than those who attended institutions ranked as very high research activity to work in other fields ($p<0.05$). Individuals who attended other types of institutions differed significantly from those whose institution was ranked as very high research activity in their likelihood of employment at medical schools, industry, foreign countries, and the U.S.

government ($p<0.05$). These individuals were 1.7 times more likely to be employed at medical schools ($p<0.001$), 1.5 times more likely to be employed in industry ($p<0.001$), 0.617 times less likely to be employed in a foreign country ($p<0.05$) and 1.4 times more likely to be employed by the government ($p<0.05$) compared with four-year colleges and universities.

Length of time to PhD influenced the likelihood of employment in industry and in foreign countries. Longer time to PhD was associated with an increased likelihood of employment in industry ($p<0.05$) and a decreased likelihood of foreign employment ($p<0.05$) compared with four-year colleges and universities. Length of time to PhD did not significantly impact the likelihood of employment at medical schools, research institutes, Other, or the U.S. government in relation to colleges and universities.

Certain educational history variables were significant in predicting the likelihood of employment field. Those PhD recipients who received a master’s degree in health sciences were 62.1 % less likely than those who received a master’s degree in biological sciences to obtain a career in other fields compared with four-year colleges and universities ($p<0.05$). PhD holders who have a master’s degree in physics are 1.53 more likely than those with master’s in biology to work in industry ($p<0.05$). Having a master’s degree in engineering was associated with a 57.9 % decrease in the likelihood of working at a medical school ($p<0.01$), 1.6 times increase in the likelihood of working in industry ($p<0.001$), and a 1.5 times increase in the likelihood of working at a research institute ($p<0.05$) compared with the reference category.

The Carnegie Rank of master’s institutions was a significant predictor of the likelihood of employment at medical schools, industry, foreign countries, and the U.S. government. Compared to graduates from institutions that were ranked as having very high research activity, graduates from institutions that were ranked as having high research activity were less likely to be employed at a medical school ($p<0.001$), in industry ($p<0.01$), or the U.S. government ($p<0.05$). Graduates who attended other institution types were also less likely than their peers who attended institutions ranked as very high research activity to become employed in industry ($p<0.001$), foreign countries ($p<0.05$), or the U.S. government ($p<0.01$) compared with U.S. four year colleges and universities. Participants who received master's degrees from institutions located in other countries were 0.691times less likely to gain employment in industry ($p<0.001$) and 0.633 times less likely than those who received master's degrees from institutions ranked as very high research activity to gain employment in the U.S. government ($p<0.01$). However, these individuals were 1.2 times more likely to gain employment in a foreign country ($p<0.05$).

Participants' field of study for their bachelor's degree was a significant predictor of the likelihood of employment in medical schools, industry, other fields, and the U.S. government. Compared to the reference group who have a bachelor's degree in the biological sciences, PhD recipients who completed a bachelor's degree in agriculture are less likely to be employed at a medical school ($p<0.001$) or in other fields ($p<0.001$). Those that completed degrees in health sciences were 0.435 times less likely than those that hold a bachelor's degree in biology to work for the U.S. government ($p<0.001$). A bachelor's degree in astronomy/geology was associated with a decreased likelihood of gaining employment in other fields compared ($p<0.01$). Compared with those who hold a bachelor's degree in biology, those who hold a bachelor's degree in chemistry, physics, engineering, computer science, or who were missing in reporting their field of study were at least 1.4 times more likely to work in industry than a four-year college or university ($p<0.05$). Chemistry and physics bachelor's degree holders were less likely than biology bachelor's degree holders to obtain employment in other fields ($p<0.01$). Finally, those who hold non-science bachelor's degrees are less likely than those who hold degree in biology to work for the U.S. government ($p<0.001$).

Participants who attended an institution for their undergraduate studies that was ranked as very high research activity did not vary from those who attended an institution that was ranked as high research activity in their likelihood of employment field. Those who attended other institution types were 0.814 times less likely than those in very high ranked institutions to work at a medical school ($p<0.05$), and 1.2 times more likely to work at a research institute ($p<0.05$) compared with four-year colleges or universities. Further, those who attended non- U.S. institutions were significantly more likely to work in industry ($p<0.05$) or research institutes ($p<0.001$) than their colleagues who attended institutions ranked as very high research activity. Junior college attendance was not a significant predictor in this model.

Participants' background characteristics were significant in predicting the likelihood of certain employment fields. Female participants were more than 0.80 times less likely than their male counterparts to be employed at a medical school ($p<0.01$) or in industry ($p<0.05$) compared with four-year colleges and universities. Married individuals are more likely than non-married individuals to gain employment in other fields ($p<0.001$), while they are less likely to gain employment in foreign countries ($p<0.001$) or the U.S. government ($p<0.05$). PhD recipients who reporting having children were 1.3 times more likely than those that did not to obtain positions at medical school or in foreign countries compared with U.S. four- year colleges and universities ($p<0.05$).

Compared with White individuals, Hispanic participants were 1.7 times more likely to gain employment in foreign countries rather than U.S. four-year colleges and universities

($p<0.001$). Asian individuals were 1.6 times more likely than white PhD holders to gain employment at a medical school or in industry ($p<0.001$). These individuals are also 1.2 times more likely to report other career fields instead of U.S. four year colleges or universities ($p<0.05$), and 44.5% less likely to gain employment in a foreign country ($p<0.001$). Further, those who reported membership in the Other race category were 1.3 times more likely than White participants to work at a medical school than at a four-year college or university ($p<0.05$). PhD holders in the current study who are U.S. citizens were less likely than non-citizens to gain employment at a research institute ($p<0.01$) or in a foreign country ($p<0.001$) compared with U.S. four-year colleges or universities. These individuals were also more than twice as likely as non- citizens to gain employment in the U.S. government than a four-year college or university ($p<0.001$). Finally, older participants in this study were less likely than younger participants to gain employment at a medical school ($p<0.05$) or in industry ($p<0.001$) in relation to a college or university.

Primary Work Activity

Of participants who reported their primary work activity (N= 14, 461), the majority indicated a career in research and development (76.9%). This represents more than half of the total population of STEM PhD recipients included in the current study (Table 9). The remaining participants reported that their initial work activities would consist mostly of teaching or administration/ professional service to others. This analysis focused on elucidating the relationship between doctoral program and institution characteristics, doctoral program experiences, and these primary work activities.

Crosstabulation with Pearson Chi-square analysis was calculated to determine if a significant relationship exists between the nominal- level dependent variable, primary work activity and the independent variables in this study (Table 19). A significant relationship exists between the following independent variables and primary work activity: PhD field of study (χ^2= 1349.476, p<0.001), PhD institution Carnegie Rank (χ^2= 244.58, p<0.001), research productivity rank quartile (χ^2==246.336, p<0.001), student support services rank quartile (χ^2=230.457, p<0.001), primary funding type (χ^2=1148.406, p<0.001), master's field of study (χ^2=1262.874, p<0.001), master's institution Carnegie Rank (χ^2= 804.323, p<0.001), bachelor's field of study (χ^2= 942.390, p<0.001), bachelor's institution Carnegie Rank (χ^2=589.369, p<0.001), attendance of junior college (χ^2=84.464, p<0.001), gender (χ^2= 99.622, p<0.001), race (χ^2=316.46, p<0.001), citizenship status (χ^2=429.441, p<0.001), marital status (χ^2= 41.536, p<0.001), and dependent status (χ^2= 18.462, p<0.001).

Table 19

Cross-tabulation of primary work activity and each nominal level independent variable.

Independent Variable	Primary Work Activity Research and Development	Teaching	Professional Service to Others/ Administration	Total (N)	Chi-square
PhD Field of Study					1349.476***
Agricultural Sciences/ Natural Resources	67.6%	15.7%	16.7%	592	
Biological/ Biomedical Sciences	80.7%	6.5%	12.8%	3988	
Health Sciences	46.5%	31.4%	22.0%	1180	
Mathematics	65.7%	29.8%	4.5%	909	
Chemistry	86.1%	8.3%	5.6%	1385	
Geological/ Earth Sciences/Atmospheric Sciences	78.5%	13.9%	7.6%	647	
Physics	86.4%	7.5%	6.1%	736	
Engineering	80.9%	6.7%	12.4%	4112	
Computer & Information Sciences	76.0%	16.6%	7.5%	912	
PhD Institution Carnegie Rank					244.58***
Research University-Very High Activity	79.1%	10.0%	10.9%	11738	
Research University-High Activity	69.2%	19.7%	11.0%	1749	
All other institution types	64.1%	16.4%	19.5%	974	
Research Productivity Quartile					246.336***
1	74.9	9.5	10.6	7279	
2	78.0	11.5	10.5	4385	
3	77.2	13.0	9.7	667	(continued)

Independent Variable	Research and Development	Teaching	Professional Service to Others/ Administration	Total (N)	Chi-square
4	72.1	23.5	4.4	68	
Student Support Services Quartile					230.457***
1	78.2	10.7	11.1	6985	
2	79.8	10.4	9.8	4463	
3	80.9	9.6	9.5	844	
4	85.8	9.4	4.7	127	
Missing	64.2	18.3	17.5	2062	
Primary Funding Type					1148.406***
Fellowships/ Grants	77.4%	8.6%	14.0%	4473	
Teaching Assistantships	68.8%	24.2%	7.0%	1893	
Research Assistantships	86.3%	6.1%	7.6%	5946	
Other Sources of Funding	57.0%	22.1%	20.9%	2149	
M.A. Field of Study					1262.874***
Agricultural Sciences/ Natural Resources	69.9%	14.1%	16.0%	482	
Biological/ Biomedical Sciences	82.4%	8.8%	8.8%	1455	
Health Sciences	47.5%	31.9%	20.6%	1021	
Mathematics	65.8%	29.5%	4.8%	774	
Chemistry	86.3%	8.0%	5.7%	628	
Geological/ Earth Sciences/Atmospheric Sciences	76.3%	14.6%	9.1%	438	
Physics	86.6%	7.5%	5.9%	614	
Engineering	80.1%	7.6%	12.3%	3409	
Computer & Information Sciences	76.8%	15.9%	7.3%	728	
Non Science M.A.	49.6%	28.3%	22.1%	353	
Missing/ No M.A.	81.6%	6.5%	11.9%	4559	

(continued)

Independent Variable	Research and Development	Teaching	Professional Service to Others/ Administration	Total (N)	Chi-square
M.A. Institution Carnegie Rank					
Research University-High	64.2%	22.8%	13.0%	1089	
Other Institution Types	49.9%	32.5%	17.6%	843	
Non U.S. Institution	85.6%	8.5%	5.9%	2721	
Missing or no M.A.	81.3%	6.7%	12.0%	4601	
B.A. Field of Study					942.390***
Agricultural Sciences/ Natural Resources	71.0%	14.6%	14.4%	548	
Biological/ Biomedical Sciences	79.5%	7.2%	13.3%	3082	
Health Sciences	54.6%	29.6%	15.7%	915	
Mathematics	67.4%	26.7%	5.9%	921	
Chemistry	83.5%	7.5%	9.0%	1548	
Geological/ Earth Sciences/Atmospheric Sciences	74.4%	15.6%	10.0%	391	
Physics	85.5%	7.1%	7.3%	1024	
Engineering	80.5%	7.4%	12.1%	3964	
Computer & Information Sciences	79.9%	14.1%	6.0%	553	
Non Science B.A.	59.9%	22.5%	17.5%	794	
Missing	82.4%	8.3%	9.3%	721	
BA Institution Carnegie Class					589.369***
Research University-Very High	74.6%	9.1%	16.3%	4015	
Research University-High	70.0%	16.9%	13.1%	881	
Other Institution Types	65.3%	19.9%	14.8%	2833	
Non U.S. Institution	84.4%	8.9%	6.7%	6208	(continued)

Independent Variable	**Research and Development**	**Teaching**	**Professional Service to Others/ Administration**	**Total (N)**	**Chi-square**
Missing	80.7%	9.4%	9.9%	524	
Junior College Attendance					84.464***
No	78.1%	11.0%	11.0%	12808	
Yes	68.0%	16.7%	15.3%	1653	
Gender					99.622***
Male	79.2%	9.9%	11.0%	9512	
Female	72.5%	15.0%	12.5%	4949	
Race					316.45***
White	72.3%	14.3%	13.4%	7728	
Hispanic	73.4	14.3	12.3	616	
Asian	84.9	6.9	8.2	5353	
Other	69.8	15.3	14.9	764	
Citizenship Status					429.441***
Non U.S. Citizen	84.4%	8.7%	6.9%	6875	
U.S. Citizen	70.1%	14.3%	15.6%	7586	
Marital Status					41.536***
No	79.5%	9.5%	11.0%	5311	
Yes	75.4%	12.9%	11.7%	9150	
Dependent Status					18.462***
No	77.4%	11.4%	11.6%	11635	
Yes	75.1%	13.9%	11.0%	2826	
Percent of Total	**76.9%**	**11.6%**	**11.5%**	**14461**	

A multinomial logistic regression model was calculated to determine the influence of doctoral program and institution characteristics and experiences on the likelihood of certain primary work activities. The results of this analysis are presented in Table 20. Primary work activity served as the nominal level dependent variable in this study, measured as research/development, teaching, and administration/professional service to others. The analysis of model fit indicates that this model is significant ($\chi^2 = 2813.69$, $p<0.001$).

Table 20

Multinomial logistic regression model investigating the influences of doctoral program experiences on primary work activity.

Independent Variable	Primary Work Activity[a]			
	Teaching		**Professional Service to Others/ Administration**	
PhD Field	β (SE)	e^{β}	β (SE)	e^{β}
Biological Sciences (reference)				
Agriculture	0.736 (0.193)	2.087***	0.314 (0.182)	1.368
Health Science	0.672 (0.164)	1.957***	0.466 (0.154)	1.594**
Mathematics	1.148 (0.201)	3.151***	-0.432 (0.263)	0.649
Astronomy/Geology	0.618 (0.228)	1.855**	-0.764 (0.255)	0.466**
Chemistry	0.344 (0.184)	1.41	-0.941 (0.173)	0.39***
Physics	0.587 (0.254)	1.798*	-0.387 (0.245)	0.679
Engineering	0.087 (0.176)	1.091	0.013 (0.142)	1.013
Computer Science	0.695 (0.217)	2.004***	-0.293 (0.238)	0.746
Research Productivity Rank				
1st Quartile (reference)				
2nd Quartile	0.132 (0.07)	1.141	0.045 (0.067)	1.046
3rd Quartile	0.132 (0.138)	1.141	-0.047 (0.145)	0.954
4th Quartile	0.487 (0.354)	1.628	-1.075 (0.618)	0.341
Missing Rank	0.193 (0.095)	1.213*	0.277 (0.09)	1.319**
Student Support Services Rank				
1st Quartile (reference)				
2nd Quartile	-0.045 (0.07)	0.956	-0.063 (0.067)	0.939
3rd Quartile	-0.152 (0.332)	0.859	-0.621 (0.436)	0.537
Funding Type				
Grant/Fellowship (reference)				
TA	0.922 (0.089	2.515***	-0.173 (0.109)	0.841
RA	-0.227 (0.086)	0.797[b]**	-0.402 (0.075)	0.669[b]***
Other Funding Types	0.282 (0.093)	1.326[bc]**	0.2 (0.085)	1.221[bc]*

Independent Variables	Teaching		Professional Service to Others/ Admin.	
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**
PhD Carnegie Rank				
Very High (reference)				
Other Institution Types	-0.002 (0.128)	0.998	0.214 (0.112)	1.238
Length of Time to PhD	-0.017 (0.011)	0.983	0.029 (0.10)	1.029**
Masters Field				
Biological Sciences (Reference)				
Agriculture	-0.06 (0.232)	0.942	0.484 (0.217)	1.623*/
Health Science	0.466 (0.191)	1.594*	0.534 (0.186)	1.706**
Mathematics	0.412 (0.201)	1.510*	0.318 (0.264)	1.374
Astronomy/Geology	0.183 (0.262)	1.201	0.761 (0.281)	2.141**
Chemistry	0.059 (0.227)	1.061	0.459 (0.233)	1.582*
Physics	0.041 (0.271)	1.042	0.402 (0.27)	1.495
Engineering	0.379 (0.189)	1.461*	0.619 (0.157)	1.858***
Computer Science	0.407 (0.239)	1.502	0.55 (0.268)	1.733*
Non-science MA	0.544 (0.196)	1.724**	0.899 (0.193)	1.545***
No Master's or Missing	-0.051 (0.272)	0.951	0.435 (0.250)	1.545
Master's Carnegie Rank				
Very High				
High	0.346 (0.111)	1.413**	0.078 (0.124)	1.081
Other Institution Types	0.655 (0.112)	1.926***	0.156 (0.123)	1.169
Non U.S. Institution	-0.077 (0.101)	0.926	-0.275 (0.109)	0.760*
Missing	-0.018 (0.253)	0.982	0.021 (0.237)	1.021
Bachelor's Field				
Biological Sciences (Reference)				
Agriculture	0.424 (0.186)	1.529*	0.082 (0.177)	1.085
Health Science	0.612 (0.15)	1.844***	-0.047 (0.149)	0.954
Mathematics	0.319 (0.178)	1.376	-0.135 (0.214)	0.874
Astronomy/Geology	0.213 (0.234)	1.237	0.232 (0.251)	1.262
Chemistry	0.02 (0.174)	1.02	0.357 (0.138)	1.429*

(continued)

Independent Variables	Teaching		Professional Service to Others/ Admin.	
	β (SE)	**e^{β}**	**β (SE)**	**e^{β}**
Physics	-0.286 (0.207)	0.752	-0.176 (0.188)	0.838
Engineering	0.159 (0.159)	1.172	0.134 (0.136)	1.143
Computer Science	0.261 (0.217)	1.299	-0.286 (0.255)	0.751
Non-science BA	0.332 (0.139)	1.394*	-0.023 (0.131)	0.977
Missing	-0.281 (0.185)	0.755	-0.218 (0.162)	0.804
Bachelor's Carnegie Rank				
Very High				
High	0.185 (0.123)	1.203	-0.330 (0.12)	0.719**
Other Institution Types	0.568 (0.082)	1.766***	-0.505 (0.132)	0.999
Non U.S. Institution	0.229 (0.144)	1.258	-0.001 (0.074)	0.603***
Missing				
Junior College				
No (Reference)				
Yes	-0.006 (0.087)	0.994	-0.087 (0.082)	0.917
Demographics				
Male (reference)				
Female	0.374 (0.064)	1.453***	-0.03 (0.062)	0.971
Not married (reference)				
Married	0.096 (0.068)	1.1	-0.017 (0.062)	0.983
No Children (reference)				
Children	0.279 (0.074)	1.322***	-0.049 (0.076)	0.952
White (reference)				
Hispanic	0.121 (0.135)	1.129	0.094 (0.136)	1.098
Asian	-0.544 (0.089)	0.58***	0.112 (0.084)	1.118
Other	-0.055 (0.129)	0.946	0.036 (0.123)	1.037
Not a US citizen (reference)				
Citizenship	0.25 (0.133)	1.284	0.342 (0.124)	1.408**
Age	0.057(0.005)	1.058***	0.042 (0.006)	1.043***

(continued)

Model Fit	χ^2	***Df***	***p***
Likelihood ratio test	2813.69	112	0.000

[a] Research and development served as the reference category.[b] indicates significant difference from TA (p<0.05), [c] indicates significant difference from RA (p<0.05). * indicates significance at the p<0.05 level. ** indicates p<0.01, *** indicates p<0.001.

Participants' PhD field of study was significant in predicting the likelihood of primary work activity. Several fields of study were associated with an increased likelihood of teaching as the primary work activity compared with research and development. In relation to PhD recipients in biological sciences, those that hold PhDs in agriculture ($p<0.001$), health sciences ($p<0.001$), mathematics ($p<0.001$), astronomy/geology ($p<0.01$), physics ($p<0.05$), and computer science ($p<0.05$) are at least 1.8 times more likely to report teaching as their primary work activity. Health science PhDs are 1.6 times more likely than their peers in biological sciences to report professional service to others/administration as their primary work activity in lieu of research and development ($p<0.01$). Those that hold PhDs in astronomy/geology or chemistry are less likely than those that hold PhDs in biology to report professional service to others/administration as their primary work activity ($p<0.01$).

The research productivity rank of doctoral programs was only a significant predictor for those participants who attended unranked programs ($p<0.05$). Attending an unranked program increased the likelihood of teaching by 1.2 times ($p<0.05$), and the likelihood of professional service to others/ administration by 1.3 times ($p<0.01$) compared with those individuals who attended 1st quartile ranked programs. The student support services rank of doctoral programs was not a significant predictor in this model. The Carnegie rank of participants' doctoral granting institution was significant in predicting the likelihood of a career in teaching as opposed to research and development. Participants who attended an institution that was ranked as having high research activity were 1.3 times more likely than individuals who attended an institution ranked as having very high research activity to report a career in teaching ($p<0.01$).

The primary type of funding that participants' utilized by PhD recipients had a significant impact of the likelihood of certain primary work activities. Utilizing teaching assistantships instead of grants/fellowships was associated with a 2.5 times increase in the likelihood of teaching compared with research/development ($p<0.001$). Those that used research assistantships to fund their doctoral studies were less likely than those that used grants/ fellowships to report teaching or professional service to others/administration as their primary work activity ($p<0.001$). PhD recipients who utilized other sources to fund their doctoral studies were 1.3 and 1.2 times more likely to report career in teaching ($p<0.01$) and professional service to others ($p<0.05$), respectively. Longer times to PhD were associated with an increased likelihood of participants reporting a career in professional service to others/administration compared to research and development ($p<0.01$).

Participants with master's degrees in health science, mathematics, engineering, and non-science fields were at least 1.5 times more likely than their peers who hold master's degrees in biology to report teaching as their primary work activity ($p<0.05$). PhD recipients who hold master's degrees in agriculture, health science, mathematics, chemistry, engineering, computer science, and non-science fields are at least 1.6 times more likely than those who hold master's degrees in biology to report professional service to others/ administration as their primary work activity as opposed to research and development ($p<0.05$). The Carnegie rank of master's granting institutions was a significant predictor in this model. Those individuals who attended an institution ranked as high or Other were significantly more likely than individuals who attended an institution ranked as very high research activity to report teaching as their primary career activity ($p<0.01$). Further, those who attended a non-U.S. institution were significantly less likely to report professional service to others than research and development compared with their peers who attended institutions ranked as having very high research activity ($p<0.05$).

Certain bachelor's fields of study were associated with an increased likelihood of teaching or professional service to others relative to research and development compared with those who hold bachelor's degrees in biology. PhD recipients who hold a bachelor's degree in agriculture, health science, and non-science fields are at least 1.5 times more likely than individuals who hold bachelor's degrees in biology to report teaching as their primary work activity ($p<0.05$). Those who hold a bachelor's degree in chemistry are 1.4 times more likely to report professional service to others/ administration as their primary work activity as opposed to research and development ($p<0.05$). The Carnegie rank of bachelor's institutions significantly predicted the likelihood of primary work activity. Those individuals who attended other institution types were 1.8 times more likely than those who attended institutions ranked as having very high research activity to report their primary career activity as teaching rather than research and development ($p<0.001$). Those who attended institutions ranked as high research activity or non U.S. institutions were 0.60 times less likely to report professional service to others/ administration than research and development when compared with those individuals who attended institutions ranked as very high research activity ($p<0.01$).

Certain background characteristics were significant in predicting the likelihood of primary work activity. Female PhD recipients were 1.5 times more likely than male recipients to obtain positions in teaching compared with research and development ($p<0.001$). PhD recipients with dependents were also 1.3 times more likely than those without children to report teaching as their primary work activity compared with research and development ($p<0.001$). Marital status was not a significant predictor of primary work activity. Participants that identified as Asian were 0.58 times less likely than white participants to report careers in teaching ($p<0.001$). 0lder participants were 1.05 times more likely to report careers in teaching compared with research and development ($p<0.001$). U.S. citizens were 1.5 times more likely than non-citizens to indicate a career in professional service to others/administration ($p<0.01$). Older participants were also 1.04 times more likely than younger participants to indicate a career in professional service to others/ administration ($p<0.001$).

CHAPTER 6: DISCUSSION, IMPLICATIONS, and FUTURE RESEARCH

In this chapter, I discuss the results of the multinomial logistic regression analyses. I highlight how this study contributes to the current knowledge base in doctoral student career outcomes. This is followed by the implications for doctoral program reform, limitations of the present research, and directions for future research.

Discussion

Overall, the results of this analysis suggest that doctoral program characteristics and the experiences of doctoral students during graduate studies are influential in predicting the likelihood of career aspirations and attainment in STEM doctoral candidates and recipients, including the nature of work they pursue. This study identified field of study, the research productivity rank of their doctoral programs, the primary type of finding doctoral students received, their level of satisfaction with research experiences, and their sense of belonging within their doctoral program as factors that predict the likelihood of certain career aspirations compared with a career in education (Tables 8, 10, 12). Doctoral candidates' background characteristics that were significant predictors of career aspirations were gender, marital status, dependent status, race, age, and citizenship status (Tables 8, 10, 12). Further, this study identified participant's field of study, the Carnegie Rank of institutions attended, primary type of funding received, length of time to PhD, gender, marital status, dependent status, race, citizenship stats, and age as factors that predict the likelihood of the career outcomes investigated in this study (Tables 16, 18, 20).

Participants' career aspirations and attainment were influenced by their field of study (Tables 8, 10, 12, 16, 18, 20). This finding is consistent with previous research (Golde & Dore, 2001). In their survey of doctoral students, Golde and Dore found that interest in academic faculty careers varied by discipline. Although the majority of students in their study, as well as in the present study, aspired to academic careers, Golde and Dore (2004) point out that certain fields of study are more likely to have close ties with industry. For example, in fields such as engineering and biomedical sciences, doctoral recipients are more likely to aspire to, and find work in industry than in fields such as mathematics or physics. Thus, the disciplinary differences in career aspirations and attainment observed in the present study are not surprising. The socialization experience of doctoral students occurs within the context for their specific discipline (Becher & Trowler, 2001; Gardner, 2010). In this study, the career aspirations of doctoral candidates in neuroscience, chemical engineering, and physics varied along disciplinary lines. Chemical engineering doctoral candidates were more likely than their peers in neuroscience or physics to aspire to work outside the broad field of education (Table 8). This field of study may be versatile in terms of the types of opportunities available to graduates. It is also possible that degree recipients in chemical engineering perceive that there are more options that are easily accessible to them outside of the academy.

The types of academic institutions that doctoral candidates aspire to work at were also influenced by their field of study. Doctoral students in chemical engineering and physics were less likely to report the desire to work at a medical school compared with their peers in neuroscience (Table 10). Again, the opportunities available at a medical school for students in chemical engineering or physics may be extremely limited or non-existent. This inquiry into doctoral student’s career aspirations was limited to only three fields of study. Future research should include a broader variety of STEM fields to more fully investigate the influence of discipline on career aspirations.

In terms of career attainment, doctoral recipients who completed degrees in the health sciences were less likely than their peers in biology to have definite career attainment (Table 16). Health sciences, as defined by the National Science Foundation survey codes, included fields such as environmental health, health systems administrations, public health, nursing science, and speech language pathology. Some of the fields of study herein, like health systems administration for example, may fundamentally differ from other STEM fields in terms of the types of employment available, and thus in the timing of that employment. These data were included in the analysis as they are included as a sub-category of life sciences in the National Science Foundation's definition (2010). The career attainment of doctoral recipients was only recorded at the time their degree was completed. While the details of most academic hires are ironed out well in advance of a new academic year, this may not always hold true for positions in industry or other venues. It is possible that significant difference between Health Science and Biology doctoral recipients in their career attainment pattern is a reflection of timing of non-academic positions.

For participants in this study, the research productivity rank of their doctoral program was significant in predicting the likelihood of their career aspirations (Tables 8, 10, 12). Attending a lower ranked program was associated with an increased likelihood of aspiring to a career outside of education (Table 8). Within the broad field of education, participants who attended a lower ranked program in research productivity were more likely to aspire to teach in K-12 schools or community colleges (Table 10). Further, attendants of programs ranked in the 3^{rd} and 4^{th} quartile for research productivity were more likely than their peers in 1^{st} quartile ranked programs to aspire to careers in teaching as opposed to research and development (Table 12). It is possible that the culture within these doctoral programs that were ranked lower for research productivity of the faculty included a culture that placed a greater importance on teaching than research, however this warrants further investigation.

Research productivity of the faculty, in terms of both publication rates and citation rates are often used as measures of departmental or program prestige (Barnett, Danowski, Feeley, & Stalker, 2010; Morse & Flannagan, 2011; Goldsmith, Presley, and Cooley, 2002; Perna, 2004). The research productivity rank of doctoral programs was also a significant predictor of the likelihood of career attainment in the Other category, which included individuals who did not plan to work or study, those pursuing another advanced degree, and those with alternative plans, such as starting their own business (Table 16). Individuals who attended a program ranked in the 2^{nd} or 3^{rd} quartile of research productivity were more likely to report attainment within the Other category. Further, individuals who attended a program ranked in the 2^{nd} quartile of research productivity were also more likely to report a career in industry compared with those in 1st quartile ranked programs (Table 18). These results support previous research that concludes there is a high correlation between the prestige of the doctoral granting department and the employment outcomes of the graduates (Baldi, 1995; Burris, 2004; Cognard-Black, 2004; Fiske, 2011; Long, 1978; Long, Allison, and McGinnis 1979, Rudd et al., 2010). In the current study, individuals who attended lower ranked programs and institutions in terms of their research productivity were less likely to aspire to and obtain a career in academic research (Tables 12, 20).

The Carnegie Rank of institutions is a measure of research productivity of the faculty as well as the amount of money in research grants obtained by the institution. In this study, the Carnegie Rank of doctoral institutions was significantly related to career attainment in medical schools, industry, U.S. government, and other fields, as well as predicting the likelihood of careers in teaching (Tables 18, 20). Attending a doctoral institution ranked as High Research Productivity was associated with an increased likelihood of engaging in teaching as the primary career activity and obtaining a career in other fields (Table 20). Attending an institution for doctoral studies that was categorized in the Other Carnegie Rank category, including Doctoral Universities increased the likelihood of careers at medical schools, industry, and the U.S. government (Table 18). Further, the Carnegie Rank of the bachelor's and master's institutions was significant in predicting the likelihood of career attainment. Individuals who attended programs ranked lower than Very High Research Activity for their master's degree were less likely to report careers in medical school, industry, foreign countries, and the U.S. government (Table 18). Attendees of institutions categorized in the Other Carnegie Rank category were more likely than their peers to obtain careers in teaching (Table 20). The cultures of these institutions that vary in Carnegie Rank also likely vary in terms of the training of their doctoral recipients.

The educational history of doctoral recipients is an important predictor of the types of careers that doctoral recipients attain, as well as the primary work activity that they will engage in during those careers (Tables 18, 20). The socialization process occurs throughout the lifetime of an individual, including during the completion of their undergraduate degree (Grusec & Hastings, 2007). While the current literature exploring the socialization of graduate students focuses implicitly on the period of time that spans doctoral studies, the research presented here indicates that this body of literature may be deficient. The educational experiences of individuals during the undergraduate and master's studies are influential in the choice to enroll in doctoral studies (Perna, 2004). Further, the experiences of individuals during these studies could significantly influence career aspirations. For example, individuals who attended a smaller, teaching-focused institution for their undergraduate studies may subsequently aspire to and obtain a position at a similar teaching-focused institution. The causal mechanisms of these relationships were not explored in the present research; however, future research should investigate how educational history of doctoral recipients influences their career outcomes.

It has been well documented that teaching is regarded as a second-tier profession within the academy (Addy & Blanchard, 2010; Luft et al., 2004; Shannon, Twale, & Moore, 1998). Luft et al. (2004) point out that “faculty members often do not consider teaching to hold the prestige or marketability of a well-established and productive research agenda” (p. 214). As such, faculty members may be less supportive of doctoral students who intend to enter the field of teaching, as opposed to furthering their research legacy (Tenner, 2004). Participants from top-ranked institutions in research productivity may have been more likely to aspire to careers in research in order to please their research advisors. It is also possible that participants from these lower ranked programs in research productivity perceive themselves to be less competitive in the academic marketplace, and thus have alternative career aspirations.

In each model investigated as part of this study, participants’ primary type of funding received was a significant predictor of career outcomes (Tables 8,10,12,16,18,20). The experiences that doctoral students have as part of their funded graduate position plays an important role in their socialization to the academic career, especially in regards to disciplinary norms related to the value of teaching and research (Mendoza, 2007). Gemme’s (2005) work demonstrated that the receipt of funding from industry increased the likelihood of doctoral students’ aspirations to work in industry. In this study, the receipt of a research assistantship increased the likelihood of a career in research, while the receipt of a teaching assistantship increased the likelihood of a career in teaching (Table 20). The type of funding received by doctoral students has been linked to the quality of student and the quality of the training experiences (Goldsmith et al., 2002; National Research Council, 2010), and doctoral student satisfaction (Nettles, 1990; Barnes & Randall, 2011). Future research should more fully investigate the role of graduate funding opportunities in the socialization and career outcomes of doctoral students, while controlling for measures of student quality.

Funding doctoral studies primarily with a teaching assistantship as opposed to a fellowship was also positively related to aspiring to a career in teaching (Table 12). Holding a teaching assistantship, compared with a research assistantship or fellowship, increases doctoral students' exposure to teaching as a profession. Students with more exposure to teaching may identify with this role and choose to pursue teaching as a career path. Although others have suggested that these students have failed to socialize to the norms of the academy (Quinn & Lizter, 2009; Sweitzer, 2009), these students may be identifying with the dominant role that they play during graduate studies.

Doctoral student socialization in this study was measured by doctoral candidates' sense of belonging within their program, their satisfaction with their program and research experiences. I hypothesized that doctoral candidates who had a positive sense of belonging within their doctoral programs would be more likely to aspire to normative academic careers. The normative academic career includes a focus on research and development within a U.S. four-year college or university. The findings of this study support my hypothesis: participants' sense of belonging within their doctoral program increased the likelihood of aspiring to a career in education, at a four-year college or university that primarily consists of research and development (Tables 8,10,12). Similar results were observed concerning participants' satisfaction with their research experiences and their satisfaction with their program.

Having a positive sense of belonging in one's doctoral program decreased the likelihood of aspiring to a career in teaching (Table 12). Thus, these students who aspire to careers in teaching have a sense that they don't belong within their doctoral programs. These doctoral candidates have become aware of the academic norms in their field, and are choosing to pursue academic careers with a focus on teaching as opposed to research (Quinn & Litzler, 2009). A positive sense of belonging within one's doctoral program decreased the likelihood of aspiring to a career in government or Other career, K-12/community colleges, administration/professional service to others, and Other career activities (Table 12). In summary, a positive sense of belonging within one's doctoral program increases the likelihood of normative academic career aspirations, affirming the relationship between the role of socialization within doctoral studies and academic career aspirations (Sweitzer, 2009).

Gardner (2008) suggests that doctoral students who "do not fit the mold" of graduate studies are less satisfied with their doctoral experiences (p. 130). In her research, she identified underrepresented students, based on the diversity of their background characteristics, including gender, race and age, and lifestyle (i.e. having children) as contributing to their feelings of not belonging. Only doctoral candidates' feelings of belonging were measured as part of this study. Although not investigated, it is possible that that is a link between the doctoral candidates' and recipients' background characteristics in this study and their feelings of belonging within their doctoral programs. In this study, being female was associated with an increased likelihood of aspiring to an academic career in a medical school and K-12/ community college settings (Table 10). Further, being female was also associated with aspiring to a career that primarily focused on teaching or other career tasks (Table 12). Older students were also more likely than younger students to aspire to careers in medical schools and K-12/ community colleges.

Older students in the present study were more likely to attain positions in the U.S. government and less likely to attain positions in medical schools or industry (Table 18). Further, older students were more likely to attain careers focused on teaching or professional service to others/administration compared with research and development (Table 20). As Gardner (2008) suggests, it is possible that these older individuals may not have strong feelings of belonging within their doctoral programs, and thus have alternative socialization experiences as a result, which in turn influences their career aspiration and attainment patterns. Rudd et al. (2010) report that older individuals in their study of academic careers are less likely to obtain faculty positions of any type, although the career aspirations of older individuals could not explain the relationship they discovered. The results of this research are inconsistent with those presented by Rudd et al. However, it should be noted that their data included only two fields of study, biochemistry and mathematics, while this research was much broader in scope of fields. As noted earlier, disciplinary differences were associated with variation in career attainment patterns in this study, and may explain the difference observed between these results and those of Rudd et al.

The doctorate is a research-focused degree. Doctoral candidates' research experiences are central to their socialization within their discipline and profession (Quinn & Litzler, 2009). For participants in this study, positive research experiences were associated with academic career aspirations. Positive research experiences were statistically linked to careers in education over industry or Other (Table 8), medical schools over U.S. four year colleges and universities (Table 10), and careers focused on research and development over administration or other career activities (Tables 12). It is evident from these results that there is a clear link between the research experiences of doctoral candidates and their career aspirations, extending the literature on the role of doctoral student socialization. These research experiences include a focus on the relationship between doctoral students and their research advisors. Previous research has shown that doctoral advisors play a key role in the socialization of their doctoral students, including persistence in graduate programs, and that the relationship between doctoral students and their advisors plays an important role in student satisfaction (Barnes, 2010; Barnes & Randall, 2011; Golde, 2005; Pole, Sprokkereef, Burgess, & Larkin, 1997).

Gender has been linked to career aspirations and doctoral student socialization (Morrison, Rudd, & Nerod, 2011; Sallee, 2011). Similar to results of the present study, Fox and Stephan (2001) also report that women prefer academic careers in teaching significantly more than male PhDs in science and engineering fields. Fox and Stephan (2001) suggest that the career preferences revealed in their study may also be reflective of PhDs expectations or what is expected to be available to them. Women may report that they prefer a career in teaching because they perceive that this is the only option available to them. Correll (2001) contends that individuals act on gender-differentiated perceptions when making career decisions. She argues that shared cultural beliefs about gender and ability to perform certain tasks bias individuals' perception of their competence. This perception of competence is then influential in career choice (Bandura, Barbaranelli, Caprara, & Partorelli, 2001). Thus, the women and older students in this study may be aspiring to what others perceive as career "left-overs" because they view themselves as less competent to fulfill other roles or because they don't see themselves as fitting the mold of normative academic positions in research (Gardner, 2008).

The career attainment pattern of female and minority doctoral recipients varied from those of males and White individuals in the present study. Women were more likely than men to attain positions focused on teaching compared with research and development (Table 20). Women were also more likely than men to be negotiating with one more employer and to report career attainment in the other category (Table 16). Considering it is more common for women than men to stay home with children, it is not surprising that more women than men reported career attainment in the other category, which includes no plans to work or study. Women were less likely than men to achieve positions in medical schools or industry. In this study, female participants were more likely than male participants to aspire to work at medical schools (Table 10). While women were more likely to aspire to and attain careers in teaching (Table 20), the inconsistency in the career aspiration and attainment patterns of women with specific regard to employment in medical schools raises an important question. How do the career attainment patterns of doctoral recipients align with their career aspirations? While this research utilized two independent samples of doctoral candidates and recipients, future longitudinal research should investigate this link. Alignment between career aspirations and attainment may lead to higher job satisfaction.

When compared with White doctoral recipients, Asian doctoral recipients were more likely to attain positions in medical schools, industry, and other fields (Table 18). Asian individuals were also less likely than their White peers to attain foreign employment or careers in teaching. Individuals in the other race category were also more likely than their White peers to obtain positions at medical school, while Hispanic individuals were more likely than their White peers to obtain foreign employment. These results support previous research that suggests that minority doctoral students are less likely to enter the academic workplace (Hill, Castillo, Ngu, & Pepion, 1999).

Length of time to degree has been associated with doctoral student persistence (Ehrenberg & Mavos, 1992) and a decreased likelihood of becoming a professor (Rudd et al., 2010). In their retrospective study of the impacts of post-doctoral positions on faculty career trajectories, Rudd et al. (2010) investigated faculty members' experiences during doctoral studies on their academic career trajectories for biochemistry and mathematics professors with particular attention to the prestige of academic appointments. They found that longer times to degree were associated with a decreased likelihood of obtaining a faculty position, and that the negative impact was even greater on the chances of obtaining a prestigious faculty position. Rudd et al. defined prestigious academic positions to be within Research I universities at highly ranked departments according to the National Research Council's 1982 ranking system.

In this study, long time to PhD was associated with an increased likelihood of definite career attainment (Table 16), career attainment in the Other category (Table 16), a career in professional service to others/ administration compared with research and development (Table 20), and an increased likelihood of employment in industry rather than a U.S. four year college or university (Table 18). Increased time to PhD was also associated with a decreased likelihood of employment in foreign countries (Table 18). Considering normative academic values, longer times to PhD were associated with less prestigious position types in this research. However, other measures of prestige, such as salary, may reveal that these industry and positions in professional service to others are actually quite prestigious. Future research should explore this avenue of measuring career prestige.

Implications for Graduate Education

As concerns have been raised over the preparedness for varied career options for doctoral recipients in STEM fields within an exceedingly tight academic marketplace, alternative career aspirations of doctoral students deserve attention (Austin, 2010). American prosperity and security has been linked to our research universities, particularly the research and development that occurs within science and engineering fields (National Research Council, 2012). In their recent publication, *Research Universities and the Future of America: Ten Breakthrough Actions Vital to Our Nation's Prosperity and Security,* the National Research Council suggests that ties between universities and industry be strengthened to increase the capacity of doctoral recipients to fill workforce gaps in industry (2012). In the research presented here, those individuals who graduated from lower ranked programs in research productivity were more likely to aspire to and attain careers in industry and government. If our nation's security really does rest on the haunches of our doctoral science and engineering workforce, then we need to alter the perception of acceptability of research careers in government and industry for graduates of highly ranked doctoral programs.

For doctoral programs, this could include increased career counseling for doctoral students to help increase their awareness of alternative careers to the academy. Increased funding ties with industry, as highlighted in the National Research Council's recent publication will also help to increase doctoral students' and their mentors' awareness of research and development opportunities in industry. Mentoring programs that match doctoral students with appropriate mentors both inside and outside of the academic workplace based on their career aspirations could also assist doctoral recipients in reaching their career goals, and act to increase doctoral students feeling of belonging within graduate school.

In this study, participants who were unsatisfied with their research experiences during doctoral studies or felt like they didn't belong in their doctoral program aspired to careers outside of U.S. four-year colleges and universities, including industry, other careers, and careers that focus on teaching, administration, or other career tasks. Increasing doctoral student satisfaction with their research experiences during graduate studies, and their feelings of belonging in their doctoral programs, may act to change career aspirations. It is important to note that diverse career aspirations within the population of doctoral recipients should be fostered and developed. Not every doctoral recipient will gain employment in a college or university setting due to the availability of these positions, and feelings of not belonging in doctoral studies may be a result of varied career aspirations as suggested by Sweitzer (2009) or attributed to diversity in doctoral students' background characteristics or familial status as suggested by Gardner (2008).

Further measures to increase feelings of belonging within doctoral studies could be addressed at the level of each doctoral program. In this study, the measure of student support and outcomes was a significantly related to career aspirations in industry (Table 8). Individuals who attended programs ranked in the 2nd, 3rd, or 4th quartile in student support services were more likely than their peers in 1st quartile ranked programs to aspire to careers in industry than education. This gross measure of student support services measured the percent of students who were fully funded in their first year, the percent of students within a program that completed their degree within a certain time frame, and whether or not the department collects employment data following graduation. Many doctoral programs include orientation sessions, peer mentoring networks, preparing future faculty programs, and other programs aimed at providing either formal or informal support for doctoral students. Including these types of programs for doctoral students may increase their feelings of belonging within their program, and thus impact their career goals. Although this study did not include measures of this type of student support services, doctoral program designers would significantly benefit from a large scale investigation of the influences of these types of programs on doctoral student outcomes.

The changing demographic of U.S. doctoral degree holders to include more foreign nationals was also addressed by the National Research Council's recent call to action (2012). In this study, non U.S. citizens were more likely to aspire to work at foreign educational institutions and research institutes than U.S. citizens. Further, individuals who received funding from other sources, including foreign governments were more likely to obtain positions in foreign countries. The structure of the funding received by doctoral recipients clearly influences their career attainment patterns. Funding for doctoral degree programs may even include stipulations for post-graduation employment. The National Research Council prioritized changing the recruitment and retention policies of foreign nationals that earn their PhDs in STEM fields to increase American competitiveness in attracting and retaining these individuals. Doctoral programs may need to consider the type of funding offered to outstanding foreign doctoral students to increase the likelihood of their subsequent employment in the United State following the completion of their degree.

The identification of factors significant to predicting doctoral student career aspirations and attainment has important implications for recruiting and retaining doctoral students. Approximately 50% of matriculated doctoral students fail to graduate (Golde, 2005; Tinto, 1993), which often results in a financial loss to institutions and programs that have invested significant amounts of money to fund assistantships for these individuals (Hill et al., 2010). Current reform documents concerning doctoral education have concluded that doctoral education should match the aspirations of the degree recipients, respond to the needs of a changing society and the academy, provide professional preparation for careers within and outside the academy, increase retention rates, increase the number of women and minorities served, and change the open-ended time to completion policies (Austin, 2010; Nyquist, 2002). Thus, the recruitment of doctoral students into programs needs to focus on matching available program features and funding opportunities to student’s career aspirations. Further, future doctoral students may benefit from the redesign of programs to include more opportunities for students to explore research and teaching experiences to determine their optimum career aspirations and fit, as student's experiences during their doctoral studies clearly impacts the likelihood of certain career paths.

This research identifies factors significant in the career aspirations and attainment of doctoral candidates and recipients in STEM fields. This information can be utilized by doctoral programs to conduct their own research on the various program features available at their institution that may be impacting the career outcomes of their doctoral recipients. The results of that research can then be used to inform program change and developments in institutional-level support for doctoral students to increase the ability of doctoral students to meet their career goals. Finally, these innovations can then be shared across institutions, strengthening the capabilities of American research universities to meet the growing needs for our science and engineering workforce.

Limitations and Contributions of the Present Research

The limitations encountered in this study are related to the choice of data utilized and the use of explanatory models. The data analyzed in this study was constrained by the survey instruments utilized to collect that data. In the Assessment of Research- Doctorate Programs, the National Research Council collected data on several measures of doctoral student socialization, although this was not their explicit purpose. The National Science Foundation's Survey of Earned Doctorates does not include measures of socialization per se. However, as this research was guided by socialization theory, proxies for doctoral recipients' socialization were identified based on prior research. This serves as a limitation in the present study. Future research would benefit from the further investigation of how these proxies act in the socialization of doctoral recipients in STEM Fields.

The study of career aspirations in this investigation was limited to the context of three fields of study, neuroscience, chemical engineering and physics. It is clear from prior research that socialization occurs within the context of a specific discipline, so although there are six thousand doctoral candidates in this study, the results are not necessarily generalizable to all STEM fields (Gardner, 2007, 2008; Golde, 2005, Lovitts, 2001). The National Research Council determined the fields of study to collect the student level data as part of their assessment program.

This research was completed by creating a series of multinomial logistic regression models. In order to complete this analysis, several categories of independent variables were combined in order draw comparisons across models. Although this was most statistically appropriate for the analysis, it did not allow for the investigation of categories that included lower levels of representation in the data, such as individuals who identified themselves as Native American. Further, although the creation of statistical models is very useful to make broad generalizations, it is impossible to include all measures that could be influential in the socialization of doctoral students into their discipline and profession. Even the comprehensive models presented here raised new questions and avenues for future research which will be addressed in detail below.

This dissertation represents several major contributions to the literature concerning doctoral recipient career aspiration and attainment patterns. First, the models created represent the first time that measures of graduate experiences have been used to predict the likelihood of career aspiration and attainment patterns. Much of the previous research that reports information related to career aspiration and attainment patterns report the percentages of individuals who aspire to or attain certain positions (ie NSF, 2012; Saurmann & Roach, 2012). Thus the creation of these models that account for many variables focused on the doctoral experience simultaneously represent a significant contribution. While other research has utlized institution level ranking data (Rudd et al., 2010), program rank data from previous iterations of the NRC assessment programs (Burris, 2004), and predoctoral publication rates (Cognard-Black, 2004), this research presents a novel approach to linking the graduate experience to career aspiration and attainment patterns.

This research also presents a novel approach to utilizing the newest ranking data of research doctorate programs. The National Research Council's Assessment of Research-Doctorate Programs presents their new ranking system as 90% confidence interval ranges. While this presented a challenge to utlizing the data for the purposes of this study, it also presents a more accurate portrayal of program's true rank thank previous iterations (NRC, 2010). The development of the quartile system provides a way to utilize this ranking system while preserving as much of the confidence interval system as possible. This represents an additional contribution of this research.

Further, the crosswalk created linking the Assessment of Research-Doctorate Programs to the Survey of Earned Doctorates as part of this study represents a signifcant contribution of this research. These two data sources have not been previously linked. The creation of the crosswalk will allow for subsequent analysis of data concerning doctoral recipients and the influences of their program rank on their career outcomes. As a result, this aspect of my research signifies the potential for future research.

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Directions for Future Research

This research provides valuable insight into the factors that influence career aspirations and attainment of STEM doctoral candidates and recipients. However, it also brings to light several new questions to be explored and new directions for research to build upon the foundation presented here.

The scope of this research included only science and engineering fields. However, the career aspirations and attainment patterns of doctoral students in all fields are of current concern (Taylor, 2012). This research could be expanded to include an investigation of more fields of study, including those outside of science and engineering. Since socialization varies significantly along disciplinary lines (Gardner, 2008; Golde, 2005), a thorough investigation of the influences of socialization on the career aspirations and attainment patterns of doctoral recipients in a variety of fields is warranted.

Further, this research did not investigate the causal mechanisms of the factors that were identified as significant to the career aspirations and attainment patterns of STEM doctoral candidates and recipients. In order to provide further explanation of these factors, I suggest that this study be followed by in-depth qualitative inquiry into the features identified as statistically significant. Cresswell (2009) describes this research method as a sequential mixed methods inquiry. The purpose of such a study would be to utilize qualitative interviews, focus groups, and participant observations to probe significant factors by further exploring aspects of doctoral student socialization with a smaller sample of doctoral students within specific STEM programs across several institutions. Following this research with a qualitative study would provide rich explanatory data to add to and extend this research.

Future research should investigate the potential links between the background characteristics of doctoral candidates and their subsequent career aspirations. As Gardner (2008) suggests, demographic characteristics of doctoral students play a significant role in their socialization experiences. The research presented here also supports that participant career aspirations and attainment patterns varied along demographic boundaries. Thus, future research should investigate the interaction between participant's career aspirations and demographic variables.

Previous research has suggested that there is a link between the type of funding received by doctoral students to fund their education and the quality of the student (Goldsmith et al., 2002; National Research Council, 2010). Lott, Gardner, and Powers (2009) provide evidence that higher GRE scores decrease the likelihood of attrition from doctoral studies. GRE scores are currently used as a measure of student quality. There is also a link between receipt of funding and persistence in graduate studies (Perna, 2004). The research presented here suggests that there is also a link between the type of funding used to underwrite doctoral studies and career aspiration and attainment patterns. Future research should more fully investigate the relationship between student quality and the type of funding received, and then potentially control for measures of student quality when conducting research of this type.

There are also potentially several interactions between the demographic variables included in this research that were not explored during this study because they were beyond the scope of this project. In their research exploring the importance of completing a postdoctoral appointment to subsequent academic careers, Rudd et al. (2010) investigated the interaction between gender and marriage, and gender and children because the effects of both marriage and children vary for men and women. Investigating such interactions may provide more insight into the effects of these demographic variables on the career aspiration and attainment patterns investigated in this study.

Several programs now exist at various institutions to provide orientation, mentorship, training, and social interactions for graduate students. Future research concerning the socialization of doctoral students and their career aspiration and attainment patterns would benefit from the large-scale evaluation of these programs. This data would help to provide a clearer picture of how these programs influence the socialization of doctoral students.

One of the major limitations of this study was the lack of direct measures of socialization of doctoral recipients in STEM fields. Including such measures in future research would allow for a stronger connection to be drawn between the socialization that occurs during graduate study and the career attainment patterns of doctoral recipients. As I suggested earlier, a subsequent investigation into the socialization that occurs during undergraduate and master's educational experiences, and how these experiences influence the career outcomes and aspirations of doctoral recipients would greatly expand the current knowledge base surrounding the socialization experiences of doctoral students.

In their investigation of recipients of the National Science Foundation's graduate research fellowship, Goldsmith, Presley, and Cooley (2002) report that career aspirations of doctoral students tend to change during their time in graduate school due to disillusionment with academia. Although this study did not investigate how career aspirations change over the course of graduate study, this line of research would inform another aspect of how socialization that occurs during graduate study effects the career aspirations of doctoral students. A longitudinal study, including an event history analysis, would provide a deeper understanding of the temporal nature of doctoral experiences, and how they subsequently impact career aspiration and attainment patterns.

Future research could also compare the career aspirations of doctoral students to their career attainment patterns. Attrition from faculty careers, particularly for women and underrepresented groups has been described as a leaky-pipeline (Committee on Maximizing the Potential of Women in Academic Sciences and Engineering, 2006). Although many women are graduating with doctoral degrees, and entering the academic pipeline, they are not persisting or advancing to high-ranking academic positions. Marriage and family have been identified as reasons why women chose to leave their academic positions (Mason & Goulden, 2002, 2004; Wolf-Wendel & Ward, 2006). Attrition from faculty positions has also been attributed to dissatisfaction with academic life (Hill et al., 2010). I suggest that if there is alignment between career aspirations and attainment, career satisfaction may increase, and subsequently decrease the amount of attrition from faculty careers.

Appendix 1

M E M O R A N D U M

TO: Mark Fiegener, Emilda Rivers and Nirmala Kannankutty, NCSES

FROM: Brianna Groenhout and Mary Ann Latter, NORC

CC: Vincent Welch, Jr., and Steve Schacht, NORC

DATE: July 9, 2012

RE: Draft NRC-SED Crosswalk

This draft memo provides an overview of the NRC-SED field/program-to-DRF field crosswalk developed by NORC staff at the request of NCSES, with no involvement from NRC. In this memo we explain the process by which we developed the crosswalk, including a description of the information sources and matching criteria. We also mention some caveats that a researcher should take into consideration when using this crosswalk.

Information Sources and Matching Criteria

NCSES provided NORC with the NRC Program List containing the Program ID, Broad Field, Field, Institution Name, and Program Name, as well as a list of all SED fine fields that were selected by NRC for mapping to the Doctorate Records File (DRF). NCSES tasked NORC with adding to the NRC Program List:

1) the IPEDS ID of each institution,
2) the best-matching DRF field codes and labels for each NRC Field/Program, drawing only from the NRC-selected fields listed in the crosswalk document provided by NRC.
3) a dictionary defining each column in the updated Program List. This memo discusses the second step in detail.

In order to identify the best-matching DRF code from the NRC-selected list, NORC staff first and foremost used the NRC Program Name, as it was more specific, per NCSES instructions. However any DRF code we picked for the Program Name had to be listed under the respective NRC Field name on the crosswalk document provide by NRC. In the course of creating the file we felt it was necessary to make three changes to the original crosswalk document due to omissions in the original crosswalk. These changes were: (1) added NRC field “Biology/Integrated Biology/Integrated Biomedical Science” and then added the “biological sciences, general” (189) code under the new field, (2) added an “other languages and literature” (769) code under the NRC field of “Language, society and culture” and (3) moved “archeology (733) under NRC field of “History of art, architecture and archeology”.

For some fields without a direct match, NORC staff referenced on-line sources for more information about the closest related fields or other names for the same field. For a limited number of programs with very general NRC Program and Field names, NORC also attempted to find more information about a program from the institution's website. For most NRC Programs NORC staff were able to identify a single SED field to adequately map to the NRC Program. However, there were some cases where multiple codes could fit, however since we were instructed to select only one code, we selected the code matching the first field that appeared in the name (i.e. NRC Program "pharmacology **and** toxicology" and DRF code 180 "pharmacology" was selected). Researchers should be aware of these interdisciplinary fields when using this file.

The only exception to the "one DRF field per NRC Program" rule is the NRC Program of "plant pathology" under the NRC Field of "plant sciences". There are two DRF codes for "plant pathology", code 030 and code 120 and these two fields are cross-listed in the SED taxonomy under both agricultural and biological sciences. The NRC crosswalk had both listed and we therefore used both in this draft file.

In some instances a more suitable DRF code for a particular NRC Program appeared under a different NRC Field, however the instructions were to select codes within the boundaries of the original NRC crosswalk. For example, the NRC Program "hydrology" under the NRC field of "earth sciences" was matched to "geosciences, other" (559). A better selection might have been "hydrology and water resources" (585), however that code is under the NRC Field of "oceanography, atmospheric sciences and meteorology" and could not have been used under the guidelines set forth for matching.

Literature Cited

Addy, T.M & Blanchard, M.R. (2010) The problem with reform from the bottom up: Instructional practices and teacher beliefs of graduate teaching assistants following a reform-minded university teacher certificate programme. *International Journal of Science Education, 32*(8), 1045-1071.

Agresti, A. & Finlay, B. (1999) *Statistical Methods for the Social Sciences: Third edition.* Prentice Hall: New Jersey.

Allen, T.D., McManus, S.E., & Russell, J.E.A. (1999). Newcomer socialization and stress: Formal peer relationships as a source of support. *Journal of Vocational Behavior, 54*, 454-470.

Austin, A.E. (2002). Preparing the next generation of faculty: Graduate school as socialization for the academic career. *Journal of Higher Education*, *73*(1), 94-122.

Austin, A.E. (2010). Reform efforts in STEM doctoral education: Strengthening preparation for scholarly careers. In Smart, J.M. (Ed). *Higher Education: Handbook of Theory and Research*, 25, Netherlands: Springer Scientific, 91-128.

Baldi, S. (1995). Prestige determinants of first academic job for new sociology PhDs 1985-1992. *The Sociological Quarterly, 36*(4), 777-789.

Bandura, A., Barbaranellil, C., Caprara, G.V., & Partorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development*, *72* (1), 187-206

Barnes, B.J. (2010). The nature of exemplary doctoral advisors' expectations and the ways they may influence doctoral persistence. *Journal of College Student Retention, 11*(3), 323-343.

Barnes, B.J., & Austin, A.E. (2008). The role of doctoral advisors: A look at advising from the advisor's perspective. *Innovative Higher Education, 33*, 297-315.

Barnes, B.J., & Randall, J. (2011). Doctoral student satisfaction: An examination of disciplinary, enrollment, and institutional differences. *Research in Higher Education*, 1-29

Barnett, G.A., Danowski, J.A., Feeley, T.H., & Stalker, J. (2010). Measuring quality in communication doctoral education using network analysis of faculty hiring patterns. *Journal of Communication, 60*, 388-411.

Bedard, K., & Herman, D.A. (2008). Who goes to graduate/professional school? The importance of economic fluctuations, undergraduate field, and ability. *Economics of Education Review, 27*, 197-210.

Bedeian, A.G., Cavazos, D.E., Hunt, James, G., & Jaunch, L.R. (2010). Doctoral degree prestige and the academic marketplace: A study of career mobility within the management discipline. *Academy of Management Learning & Education*, *9*(1), 11-25.

Bieber, J.P. & Worley, L.K. (2006). Conceptualizing the academic life: Graduate students' perspectives. *Journal of Higher Education, 77*(6), 1009-1035.

Bragg, A.K. (1976). *The socialization process in higher education.* Washington, D.C.: The George Washington University.

Burris, V. (2004). The academic caste system: Prestige hierarchies in PhD exchange networks. *American Sociological Review*, *60*(2), 239-264.

Chatman, J.A. (1989). Improving interactional organizational research A model of person-organization fit. *Academy of Management Review, 14*, 333-349.

Cheatham, H.E., & Phelps, C.E. (1995). Promoting the development of graduate students of color. In A.S. Pruitt & P.D. Isaac (Eds.) *Student services for the changing graduate population.* New Directions for Student Services, *72,* 91-99.

Cognard-Black, A.J. (2004). Nice work if you can get it: Determinants of academic employment and other workplace rewards among new doctorate recipients. Doctoral Dissertation. The Ohio State University.

Committee to Assess Research-Doctorate Programs. (2010). A guide to the methodology of the National Research Council Assessment of Doctoral Programs. Ostriker, J.P., Holland, P.W., Kuk, C.V. & Voytuk, J.A. (Eds.). National Research Council, National Academies Press: Washington D.C. Retrieved from http://sites.nationalacademies.org/PGA/Resdoc/index.htm.

Committee on Maximizing the Potential of Women in Academic Science and Engineering, National Academy of Sciences, National Academy of Engineering, Institute of Medicine. (2006). *Beyond Bias: Fulfilling the Potential of Women in Academic Science and Engineering.* National Academies Press, Washington, D.C.

Committee to Examine the Methodology for the Assessment of Research-Doctorate Programs (2003). Assessing research-doctorate programs: A methodological study. Ostricker, J.P.

& Kuh, C.V. (Eds). National Academies Press: Washington, D.C. Retrieved from http://sites.nationalacademies.org/PGA/Resdoc/index.htm.

Correll, S. (2001). Gender and the career choice process: The role of biased self-assessments. *American Journal of Sociology, 106*(6), 1691-1730.

Creswell, J.W. (2009). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.* Thousand Oaks, California: Sage Publications.

DeAngelis, S. C. (1997). *Within-year persistence of students enrolled in graduate and professional programs: The influence of background, graduate/professional experience, academic aspirations, expected earnings, and student financial aid.* University of Arkansas at Little Rock. *ProQuest Dissertations and Theses,* Retrieved from http://search.proquest.com/docview/304409436?accountid=14214.

Deseriewicz, W. (2011). Faulty towers: The crisis in higher education. *The Nation,* May 4, 2011 Retrieved from http://www.thenation.com/article/160410/faulty-towers-crisis-higher-education.

Dodson, M.V., Fernyhough, M.E. & Holman, B.B. (2006). Advising graduate students: Mentor or tormentor. *NACTA Journal*, December, 39-43.

Ehrenberg, R.G., Jakubson, G.H., Groen, J.A., So, E., & Price, J. (2007). Inside the black box of doctoral education: What program characteristics influence students' attrition and graduation probabilities. *Educational Evaluation and Policy Analysis*, *29* (2), 134-150.

Ehrenberg, R.G. & Mavros, P.G. (1992). Do doctoral students' financial support patterns affect their times-to-degree and completion probabilities. Working paper no. 4070. National Bureau of Economic Research, Washington D.C.

Ehrenberg, R.G., Zuckerman, J.A., Groen, J.A., & Bruckner, S.M. (2009). Changing the education of scholars: An introduction to the Andrew W. Mellon foundation's graduate education initiative. In R.G. Ehrenberg & C.V. Kuh (Eds.) *Doctoral education and the faculty of the future* (p. 15-34). Ithaca, NY: Cornell University Press.

Feldon, D.F., Peugh, J., Timmerman, B.E., Maher, M.A., Hurst, M., Strickland, D., Gilmore, J.A., & Stiegelmeyer, C. (2011). Graduate students' teaching experiences improve their methodological research skills. *Science, 333*(6045), 1037-1039.

Fisk, P. (2011). What is a PhD really worth? *Nature, 272*, 381.

Fox, M.F., & Colatrella, C. (2006). Participation, performance, and advancement of women in academic science and engineering: What is at issue and why. *Journal of Technology Transfer*, *31*, 377-386.

Fox, M.F., & Stephan, P.E. (2001). Careers of young scientists: Preferences, prospects, and realities by gender and field of study. *Social Studies of Science, 31*(1), 109-122.

Gardner, S. K. (2007). "I heard it through the grapevine": doctoral student socialization in chemistry and history. *Higher Education, 54*, 723-740.

Gardner, S. K. (2008). Fitting the mold of graduate school: A qualitative study of socialization in doctoral education. *Innovative Higher Education*, *33*, 125-138

Gardner, S. (2010). Keeping up with the Joneses: Socialization and culture in doctoral education at one striving institution. *The Journal of Higher Education, 81*(6), 728-749.

Gemme, B. (2005). The changing career preferences of doctoral students. Retrieved from http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=ED489889&ERICExtSearch_SearchType_0=no&accno=ED489889.

Goldberger, M.L., Maher, B.A., Flattau, P.E. (1995). *Research-doctorate programs in the United States: Continuity and change*. Washington, D.C.: National Academy Press.

Golde, C.M. (2000) Should I stay or should I go? Student descriptions of the doctoral attrition process. *The Review of Higher Education*, *23*(2), 199-227.

Golde, C.M. (2005). The role of the department and the discipline in doctoral attrition: Lessons from four departments. *Journal of Higher Education*, *76*(6), 669-700.

Golde, C.M. & Dore, T.M. (2001). *At cross purposes: What the experiences of today's doctoral students reveal about doctoral education.* Philadelphia: Pew Charitable Trust.

Goldsmith, S.S., Presley, J.B. & Cooley, E.A. (2002). National science foundation graduate research fellowship program: Final evaluation report. WestEd Evaluation Research Program. Retrieved from http://www.nsf.gov/pubs/2002/nsf02080/start.htm.

Grusec, J.E., & Hastings, P.D. (2007). Introduction. In Grusec, J.E. & Hastings, P.D. (eds.). *Handbook of Socialization: Theory and Research.* New York, The Guilford Press, 1-41.

Hacker, A & Dreifus, C. (2010). *Higher Education? How colleges are wasting our money and failing our kids and what we can do about it.* New York: Henry Holt and Company

Hagstrom, W.O., & Hargens, L.L. (1967). Sponsored and contest mobility of American academic scientists. *Sociology of Education, 40*, 24-38.

Haley, K.J. (2006). Graduate education experience and career paths of women faculty in higher education administration. Doctoral dissertation, North Carolina State University.

Healy, C.C., & Welchert, A.J. (1990). Mentoring relations: A definition to advance research and practice. *Educational Researcher*, *19*(9), 17-21.

Heinrich, K.T. (1995). Doctoral advisement relationships between women: On friendship and betrayal. *The Journal of Higher Education, 66*(4), 447-469.

Helland, P.A. (2010). Espousal of undergraduate teaching normative patterns in first-year teaching assistants. *The Journal of Higher Education, 81*(3), 394- 415.

Hill, C., Corbett, C. & St. Rose, A. (2010) *Why so few: Women in science, technology, engineering and mathematics*. AAUW: Washington, D.C.

Hill, R.C., Castillo, L.G., Ngu, L. Q., Pepiom, K. (1999). Mentoring ethnic minority students for careers in academia: The WICHE doctoral scholars program. *The Counseling Psychologist, 27*, 827- 845.

Hoffer, T.B., Hess, M., Welch, V. Jr., & Williams, K. (2007). *Doctorate recipients from United States universities: Summary report 2006*. NORC at the University of Chicago, Illinois.

Holland, J.W. (1998). Mentoring and the faculty development of African-American doctoral students. In H.T. Frierson, Jr. (ed) *Diversity in Higher Education, Volume 2*, Stanford, CT: JAI Press, p. 17-40.

Holley, K.A. (2011). A cultural repertoire of practices in doctoral education. *International Journal of Doctoral Studies, 6,* 79-94.

June, A.W. (2008). Graduate students' pay and benefits vary widely, survey shows. *The Chronicle of Higher Education*. Retrieved from http://chronicle.com/article/Graduate-Students-Pay-and/36366.

June, A.W. (2012). Job market looks brighter for some Ph.D's: Many disciplines aren't celebrating yet, however. *The Chronicle of Higher Education.* Retrieved from http://chronicle.com/article/Job-Market-Looks-Brighter-for/130240/.

Keith, B. (1999). The institutional context of departmental prestige in American higher education. *American Educational Research Journal, 36*(3), 409-445.

Kuck, V.J., Marzabadi, C.H., Nolan, S.A., Buckner, J.P. (2004). Analysis by gender of the doctoral and postdoctoral institutions of faculty members at the top-fifty ranked chemistry departments. *Journal of Chemical Education, 81*(3), 356- 363.

Lindholm, J.A. (2004). Pathways to the professoriate: The role of self, others, and environment in shaping academic career aspirations. *Journal of Higher Education, 75*(6), 603-635.

Long, J.S. (1978). Productivity and academic position in the scientific career. *American Sociological Review*, *43*, 889-908.

Long, J.S., Allison, P.D., & McGinnis, R. (1979) Entrance into the academic career. *American Sociological Review, 44*, 816-830.

Long, J.S., & Fox, M.F. (1995). Scientific careers: Universalism and particularism. *Annual Review of Sociology*, *21*, 45-71.

Lott, J.T, Gardner, S., Pwers, D.A. (2009). Doctoral student attrition in the STEM fields: An explanatory event history analysis. *Journals of College Student Retention, 11*(2), 247-266.

Louis, K.S., Holdsworth, J.M., Anderson, M.S., & Campbell, E.G. (2007). Becoming a scientist: The effects of work-group size and organizational climate. *The Journal of Higher Education*, *78*(3), 311-336.

Lovits, B.E. (2001). *Leaving the Ivory Tower: The causes and consequences of departure from doctoral study.* Lanham, MD: Rowan & Littlefield.

Lundsford, L.G. (2007). Mentoring and talent development: Doctoral advisors and their protégés. Doctoral dissertation, University of North Carolina, Chappell Hill.

Maher, M., Ford, M.E., & Mamrick, M.A. (2005). The association of gender to factors significantly related to doctoral degree process. Paper presented at the 86th Annual meeting of the American Educational Research Association, Montreal April 11-15, 2005.

Mason, M. A., & Goulden, M. (2002). Do babies matter?: The effect of family formation on the lifelong careers of academic men and women. *Academe, 88,* 21–27.

Mason, M. A., & Goulden, M. (2004). Marriage and baby blues: Redefining gender equity in the academy. *Annals of the American Academy of Political and Social Science, 596,* 86–103.

Mason, M.A., Goulden, M., Frasch, K. (2009). Why graduate students reject the fast track: A study of thousands of doctoral students shows that they want balanced lives. *Academe, 95*(1), 1-8.

Mclintock-Comeaux, M.S. (2006). Female Doctoral Students' Family and Academic Experiences and their Relationships to Career Choices. Doctoral Dissertation. The University of Maryland at College Park.

McCormick, A.C., & Zhao, C.M. (2005). Rethinking and reframing the Carnegie classification. *Change,* 51-57.

McGinnis, R., Allison, P.D., & Long, J.S. (1982). Postdoctoral training in bioscience: Allocation and outcomes. *Social Forces, 60*(3), 701-722.

Mendoza, P. (2007). Capitalism and doctoral student socialization: A case study. *The Journal of Higher Education*, *78*(1), 71-96.

Mertz, N.T. (2004). What's a mentor, anyway? *Educational Administration Quarterly*, *40*(4), 541-560.

Morrison, E., Rudd, E. and Nerod, M. (2011). Onto, Up, Off the Academic Faculty Ladder : The Genered Effects of Transitions for a Cohort of Social Sciences Ph.D.s. *The Review of Higher Education*, *34*(4), 525-553.

Morse, R. & Flannigan, S. (2011). How U.S. News calculated the 2012 rankings. *U.S. News and World Report*, Retrieved from http://www.usnews.com/education/best-graduate-schools/articles/2011/03/14/how-us-news-calculated-the-2012-graduate-school-ranking.

National Research Council, Committee to Assess Research-Doctorate Programs. (2010). A guide to the methodology of the National Research Council Assessment of Doctoral Programs. Ostriker, J.P., Holland, P.W., Kuk, C.V. & Voytuk, J.A. (Eds.). National Research

Council, National Academies Press: Washington D.C. Retrieved from http://sites.nationalacademies.org/PGA/Resdoc/index.htm.

National Research Council (2012). *Research Universities and the Future of America: Ten Breakthrough Actions Vital to Our Nation's Prosperity and Security.* Washington, D.C.: National Academies Press.

National Science Foundation, Division of Science Resources Statistics. (2009). *Characteristics of Scientists and Engineers in the United States: 2006*. Detailed Statistical Tables NSF 09-313. Arlington, VA. http://nsf.gov.statistics/nsf09317/.

National Science Foundation (2011). *Science and Engineering indicators, 2010 Digest*. Arlington, Virginia: National Science Board (NSB 10-01).

National Science Foundation (2012). *Science and Engineering Indicators, 2012 Digest.* Arlington Virginia, National Science Board (NSB 12-01).

Nerad, M. (2004). The PhD in the US: Criticisms, facts, and remedies. *Higher Education Policy, 17*, 183-199.

Nettles, M. (1990). Success in doctoral programs: Experiences of minority and white students. *American Journal of Education, 98*, 494-522.

Nettles, M.T. (2004). Success in doctoral programs: Experiences of minority and white students. *American Journal of Education,* 98(4): 494-522.

Nettles, M.T., & Millet, C.M. (2006). *Three Magic Letters: Getting to PhD*. Baltimore: Johns Hopkins University Press.

Nyquist, J. (2002). The PhD: A tapestry of change for the 21st century. *Change, November-December*, 13-20

Olssen, M. & Peters, M.A. (2005). Neoliberalism, higher education and the knowledge economy: from the free market to knowledge capitalism. *Journal of Education Policy*

Pampel, F.C. (2000). *Logistic regression: A primer*. Sage University Paper: Thousand Oaks.

Perna, L. W. (2004). Understanding the decision to enroll in graduate school: Sex and racial/ethnic group differences. *Journal of Higher Education, 75*, 487-527.

Pleegar, S.L. & Mertz, N.T.(1994). *Final report of the ACM/NSF executive mentoring project.* New York Association for Computing Machinery.

Pole, C.J., Sprokkereef, A., Burgess, R.G, & Lakin, E. (1997). Supervision of doctoral students in the natural sciences: Expectations and experiences. *Assessment & Evaluation in Higher Education, 22*(1), 49-63.

Quinn, K. & Litzler, E. (2009). Turning away from academia: What does work-life balance have to do with it? *NASPA Journal About Women in Higher Education, 2*(1), 66-90.

Rudd, E., Picciano, J., Nerad, M. & Cerny, J. (2010). The influence of postdoctoral training on prestige and time in academic careers: Findings from PhD's-Ten Years Later, a national survey of PhD careers. Center for Innovation and Research in Graduate Education, University of Washington, Seattle. Retrieved from www.cirge.washington.edu.

Sallee, M.W. (2011). Performing masculinity: Considering gender in doctoral student socialization. *The Journal of Higher Education, 82*(2), 188-217.

Sauermann, H., & Roach,M. (2012) Science PhD career preferences: Levels, changes, and advisor encouragement. *Plos ONE, 7*(5)e3607.doic10.1371/journal.pone.0036307.

Schlosser, L.Z.; Knox, S., Moskovitz, A.R., & Hill, C.E. (2003). A qualitative examination of graduate advising relationships: The advisee perspective. *Journal of Counseling Psychology, 50*(2), 1-28.

Sweitzer, V.B. (2009). Towards a theory of doctoral student professional identity development: A developmental networks approach. *Journal of Higher Education, 80*(1), 1-33.

Taylor, M. (2012). Reform the PhD system or close it down. *Nature, 472*, 261.

Tenner, E. (2004). The pitfalls of academic mentorships. *The Chronicle of Higher Education, 50*,49, B-7.

Tinto, V. (1993). *Leaving College: Rethinking the Causes and Cures of Student Attrition.* Second Edition. University of Chicago Press: Chicago.

Toutkoushian, R.K. (2003). What can labor economics tell us about the earnings and employment prospects for faculty? In J.C. Smart (ed). *Higher Education: Handbook of Theory and Research, Vo. XVIII,* Great Britain: Kluwer Academic Publishers, 263-322.

Trautman, N. (2008). Learning to teach: Alternatives to trial by fire. *Change,* 40-46.

Trower, C.A., & Chait, R.P. (2002). Faculty diversity: Too little for too long. *Harvard Magazine, 104*(4), 33-37.

Weidman, J.C., Twale, D.J., Stein, E.L. (2001). Socialization of graduate and professional students in higher education: A perilous passage? *ASHE higher Education Report, 28* (3), 1-139.

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Biology, Department of Biological Sciences

B.A., State University of New York at Binghamton, NY 2001
Environmental Studies, Department of Geological Sciences and Environmental Studies

PROFESSIONAL EXPERIENCE

Research Assistant, Investigating Meaningfulness of Preservice Programs Across the Continuum of Teaching, 2010-2012
Syracuse University, Syracuse, NY.
Project funded by National Science Foundation (John Tillotson, Robert Yeager, and John Pennick (PIs), Monica Young, (Project Director). Project explored the relationship between science teacher education programs, teacher beliefs and practices, and student achievement. My work included designing and executing data analysis, preparing presentations and papers for conferences and journals, and assisting with reporting requirements.

TEACHING EXPERIENCE

Instructor of Record
Marshall University, Huntington, WV 2005-2009
Department of Biological Sciences.
Courses Taught: Introduction to Biology for Non-Majors, Human Anatomy.

Graduate Teaching Assistant
Syracuse University, Syracuse, NY 2011-2012
Departments of Biology and Science Teaching

Instructor, Mountwest Community and Technical College 2007-2010
Division of Allied Health and Life Sciences, Huntington, WV.

Courses Taught: Applied Human Anatomy, Applied Human Physiology, Introduction to Anatomy and Physiology.

Science Teacher, Cabell Midland High School, Ona, WV. 2006-2007

SCHOLARLY PUBLICATIONS AND ACTIVITIES

Refereed Publications

Dotger, S. & **Barry, D.S**. (in press). Lesson study as a model of professional development for graduate teaching assistants. *Research in Science Education Volume 6: Research Based Undergraduate Science Teaching.* Sunal, D, Zolman, D., Mason, C., & Sunal, C. eds.

Dotger, S., **Barry, D.S.,** Wiles, J., Benevento, E., Brzozowski, F., Hurtado, J.L., Jacobs, N., Royse, E., Ruppel, R., Sen, D., Snyder, J., Stokes, R., & Wisner, E. (2012). Developing graduate students' knowledge of Hardy-Weinberg Equilibrium through lesson study. *Journal of College Science Teaching*. 42 (1): 40- 44.

Ryan, M. & **Barry, D.S**. (2011) Competitive interactions in phytotelmata- breeding pools of two dart-poison frogs (Anura: Dendrobatidae) in Costa Rica. *Journal of Herpetology.* 45(4): 438-443.

Barry, D.S., Pauley, T.K, & Maerz, J.C. (2008) Amphibian use of man-made pools on clear-cuts in the Allegheny Mountains of West Virginia, USA. *Applied Herpetology,* 5: 121-128

Rafell, TR., Bommarity, T., **Barry, D.S.** Witiak, S.M., & Shakelton, L.A. (2008). Widespread infection of the Eastern Spotted Newt (Notophthalmus v. viridescens) by a new species of Amphibiocystidum, a genus of fungus-like mesomycetozoan parasite not previously reported in North America. *Parasitology*, 135:203-214

Presented Papers

Barry, D.S., Tillotson, J.W., & Wilmoth, J. (2012). Student scientific self-efficacy: What factors matter in predicting positive attitudes towards science? Paper presented to the Association of Science Teacher Educators National Meeting, Clearwater, FL, USA.

Jetty, L.E., **Barry, D.S.,** Tillotson, J.W. (2012). Science teacher practice in the classroom: Predicting reformed pedagogy. Paper accepted at the Association of Science Teacher Educators National Meeting, Clearwater, FL, USA.

Barry, D.S. & Dotger, S. (2011). Enhancing content knowledge in graduate teaching assistants through lesson study. Paper presented at the National Conference on Research Based Undergraduate Science Teaching, Tuscaloosa, AL, USA.

Barry, D.S., Tillotson, J.W., Young, M.O., Jetty, J.E., & Dolphin, G.R. (2011) Science teachers' beliefs about reformed teaching and learning: A quantitative analysis using the BARSTL questionnaire. Paper presented at the Association of Science Teacher Educators Annual Meeting, January 2011. Minneapolis, MN, USA.

AWARDS & RECOGNITION

Phi Kappa Phi National Honor Society 2011

National Science Foundation Graduate Research Fellowship Honorable Mention in STEM Education 2011

Women in Science and Engineering Fellow. Received stipend to support career development activities. 2011-2012