THE INSTITUTIONAL DEGREE PRODUCTION OF MASTER'S AND DOCTORATES FOR WOMEN AND UNDERREPRESENTED MINORITIES IN ENGINEERING



By

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**ABSTRACT**

This study aimed to identify which engineering school characteristics relate to higher advanced degree production rates for women and underrepresented minorities (URMs). Data from the American Society for Engineering Education (ASEE), *U.S. News and World Report* (*USNWR)* rankings of engineering graduate programs, Integrated Postsecondary Education Data System (IPEDS), and the listing of Association of American Universities (AAU) were used to first determine which schools produced the highest advanced degree rates for underrepresented groups. A second analysis identified which engineering school characteristics related to higher advanced degree production rates for underrepresented groups.

Findings revealed that a majority of engineering schools with high advanced degree production rates were located in the South and Southeast, in or adjacent to states with Historically Black Colleges and Universities (HBCUs), and in states that maintained a high percentage of URMs in the population. An engineering school's peer and faculty demographics, master's program enrollment, average annual research expenditures, admission yield rate, and AAU status also related to higher advanced degree rates for underrepresented groups. This study's findings suggest that institutional characteristics influence advanced degree rates for underrepresented groups in engineering. The characteristics identified in this study serve as a starting point from which administrators and policy makers can further examine ways to address the shortage of underrepresented individuals with advanced engineering degrees.

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# CHAPTER I: INTRODUCTION

## Purpose of Study

A recent report on the future of graduate education claims that nearly 2.5 million jobs will require an advanced degree by 2018, and that the largest growth will occur in scientific, technical, and professional fields (Wendler, Bridgeman, Cline, Millett, Rock, Bell, & McAllister, 2010). Women and underrepresented minorities[1] (URMs) are considerably underrepresented in many of the science, technology, engineering, and mathematics (STEM) fields; and, the engineering field, specifically, awards the lowest percentages of advanced degrees to URMs and women than any other STEM-related field (National Science Foundation (NSF), Division of Science Resource Statistics, 2010). This study aims to determine which engineering school characteristics relate to higher rates of master's and doctorate degrees for underrepresented groups.

In 2010, URMs earned 2,721, or roughly 5% of engineering master's degrees, and 402, or around 4% of engineering doctoral degrees reported to the American Association of Engineering Education (ASEE). ASEE reported that women, as a group, earned 9,738, or close to 16% of engineering master's degrees, and 2,066, or roughly 23% of engineering doctoral degrees. Totals for women decline by nearly 60% when examined by citizenship. Women with U.S. citizenship or permanent residency status only earned 4,161, or around 7% of engineering master's and 885, or closer to 10% of engineering doctorate degrees awarded in 2010 (ASEE, *Engineering College Profiles and Statistics*, 2011).

The glaring underrepresentation of women and URMs in advanced engineering programs provide researchers with distinct opportunities to examine the relationship between advanced

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[1] The National Science Foundation (NSF) defines "URMs" as blacks, Hispanics, and Native Americans.

education, race, and gender in this field (Freehill, Di Fabio, & Hill, 2008; National Academies, 2007; National Science Board, 2010; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010). One method to address these inequalities is to examine institutional productivity (Hubbard & Stage, 2010; Ong, Wright, Espinosa, & Orfield, 2011). This approach allows less productive colleges and universities to learn from ones that perform better, with the expectation that institutional resources could be devoted to areas that positively affect graduate degree rates for women and URMs. Institutional resources examined as part of an institution's productivity often include those related to enrollment, degrees, faculty productivity, and institutional expenditures. An institutional productivity framework follows the general consensus on the utility of the education production function, which refers to how inputs convert into outputs (Breneman, 1970; Hanushek, 1979; Hartwig, 1978; Hopkins, 1990; Shelton & Prabhakar, 1971; Wolf-Wendel, Baker, & Morphew, 2000). This type of efficiency assessment is needed because most institutions suffered budget reductions over the last few years and are continually asked to produce more with less (Wendler et al., 2010). Further, recent research that used 40 years of U.S. Department of Education data to examine bachelor's degree production in the field of engineering suggested "that *institutional* factors have not been adequately explored at a national level and that future work on gender diversity in engineering must incorporate this varied landscape" (Leetaru, 2010, p.192).

Colleges and universities must understand how their institutional features attract students to their "varied landscapes," if they are going to develop strategies to increase enrollment and graduation-rates among underrepresented students in advanced degree programs in science and engineering. Benjamin Schneider, a well known theorist in the area of organizational attractiveness, argued that "the people make the place" (1987, p. 446), or that an organization is first influenced by the individuals within them. The demographics of individuals within an organization also serve as a signal of that organization's commitment to diversity ("A Bridge for All…," 2004; Chubin, May, & Babco, 2005; Donnelly & Jacobi, 2010; Freehill, 2005; Zajicek, Morimoto, Terdalkar, Hunt, Rencis, & Lisnic, 2011). Thus, prospective women and URM graduate students could consider the demographics of students and faculty within an engineering school as the degree of an institution's commitment to diversity.

Shirley Malcom, as head of the Directorate for Education and Human Resources at the American Association for the Advancement of Science in 2008, addressed the "people make the place" (Schneider, 1987, p. 446) and 'attraction' points related to underrepresented groups in engineering distinctly, when she indicated that "In the future, *engineering* needs to offer a different face to students, especially if there is an interest in attracting females and minorities" (2008, p. 237). She further went on to emphasize that "failure to consider the role of *graduate education* in the development of faculty will ensure that the value of a diversity of perspectives, ideas, and performers will not be included into the lifeblood of the profession" (2008, p. 237). As Dr. Malcom underscored, faculty members, as essential educators of future engineers, function as a "face" in the engineering field. Research indicates that women and URM faculty affect degree rates of underrepresented groups in engineering, yet too few women and URMs earn the advanced degrees necessary to attain faculty positions to teach the next generation of engineers (Freehill et al., 2008; National Academies, 2007; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010).

In addition to faculty members, research also indicates that peers play an important role in the socialization process of underrepresented students (Bhatia & Amati, 2010; Cole & Espinoza, 2008; Gardner, 2007; Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009; Mwenda, 2010; Nettles & Millet, 2006; Wilson, Holmes, deGravelles, Sylvain, Batiste, Johnson, McGuire, Pang, & Warner, 2011). Minority-serving institutions, such as a Historically Black Colleges and Universities (HBCU), serves as an illustration of the important role that institutional demographics play in the degree production of African Americans. In 2010, HBCUs comprised seven of the top 20 schools that awarded bachelor's degrees to African Americans among those schools that reported data to the ASEE. These seven schools awarded 570 of the 1,215 bachelor's degrees awarded to African Americans at the top 20 schools (Gibbons, 2010). A further analysis of these seven HBCUs showed that they averaged around 67% of African Americans enrolled at the undergraduate-level and 30% of African American tenured/tenure-track faculty in engineering programs. The representation of African Americans at these HBCUs is far above their representation at the rest of the schools that reported data to the ASEE, where African Americans only made up roughly 5% of all undergraduates and 2% of tenured/tenure-track faculty (ASEE, *Engineering College Profiles and Statistics*, 2010).

Burrelli & Rapoport (2008) also highlighted the important role of HBCUs in a report that examined degree data for African Americans in science and engineering from the mid 1980's to 2006. During this time, African Americans earned 30% of baccalaureate degrees in science and engineering from HBCUs. The high proportions of African Americans at HBCUs – both students and faculty – is noteworthy considering that HBCUs only comprise 4% of the higher educational institutions in the U.S. (Redd, 2000). These statistics suggest that faculty and peers influence the socialization process of at least one group of underrepresented students, which is why it is important to examine how the composition of faculty and peers influence advanced degree production for underrepresented groups.

Based partially on the research that institutional demographics play an important role in attracting underrepresented groups to a college or university, the purpose of this study was to examine how institutional features connect to advanced degree production for women and URMs in the field where these groups have been the most underrepresented historically – engineering. An institutional-level approach was utilized because: (1) it allows for an examination of institutions from which to draw a general understanding of where engineering schools fall in a group with varied institutional types, resource availabilities, demographics, and prestige, which provides higher education institutions and policy makers with a model from which to address inequalities within engineering graduate programs; and, (2) it permits a better understanding of the institutional context that recruits and educates women and URM graduate students in engineering. A focus on institutional-level resources allows researchers to focus limited funds strategically and modify policies and structures to encourage degree production (Breneman, 1970; Hanushek, 1979; Hartwig, 1978; Leetaru, 2010; Shelton & Prabhakar, 1971; Wolf-Wendel et al., 2000). It also responds to the call for studies to identify institutional factors that encourage recruitment and retention of URMs and women at advanced degree levels in engineering (Leetaru, 2010; National Academies, 2007; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2005; Wendler et al., 2010).

## Research Questions

This study examined master's and doctoral degree production rates for underrepresented groups of U.S. citizens and permanent residents. Only data for U.S. citizens and permanent residents were examined because of (1) the overrepresentation of international students in engineering advanced degree programs and (2) the demand for U.S. citizens with advanced degrees in the areas of aerospace engineering and national defense, where the nature of the research often requires workers to hold U.S. citizenship or permanent residency status (Augustine, 2005; NSF, Division of Science Resources Statistics, 2009).

Both underrepresented groups were also analyzed for degree rates for master's and doctorates separately. A majority of engineering doctorate recipients earn a master's degree en route to a doctorate, and engineering master's degree rates overall have increased by almost one-third in the last ten years (NSF, Division of Science Resources Statistics, 2010; Wendler et al., 2010). The role of a master's degree – as an essential component in the socialization process for graduate students – is one reason that Lange (2006) analyzed master's degree origin data for URMs with doctorates in STEM fields. Lange reported that *engineering* doctorate recipients, as well as URMs in *STEM* fields, were more likely to earn a master's on the way to a doctorate. Lange also found that URMs were more likely to earn a master's degree in *STEM* fields from different institutions than their doctorate degree, although *engineering* doctorate recipients were more likely to earn their master's and doctorate degree from the same institution. Although Lange's findings related to the general educational pathway of engineering doctorate recipients are not surprising, as the common pathway to a doctorate in engineering often includes a prior master's degree (Kane & Gonzalez-Lenahan, 2007), her finding that engineering doctorate recipients are more likely to earn both advanced degrees from the *same* institution provide a point for possible comparison of top producing engineering schools for underrepresented groups with advanced degrees in this study. Thus, factors that influence master's degree rates for women and URMs could serve as a basis for examining factors related to doctoral degree production for underrepresented groups, and is a central reason that this study also analyzes master's degree production rates. Chapter II further examines the educational pathway of engineering doctorate recipients.

This study analyzed engineering advanced degree production rates for the following groups of U.S. citizens and permanent residents: (1) URMs, defined as blacks, Hispanics, and Native Americans and (2) women, defined as all women with U.S. citizenship or permanent residency status. The URM definition only includes those groups the NSF identifies as underrepresented (NSF, Division of Science Resources Statistics, 2011). Since the NSF does not include Asians in its definition of underrepresented, they are not included in the URM definition in this study. Since all women with U.S. citizenship or permanent residency were included in the definition for 'women,' Asians with either of these statuses were included in this group.

***Engineering Degree Production Rate***

Engineering graduate degree production rate was broadly defined as the average number of engineering graduate degrees earned by an underrepresented group at an institution out of the average number of all engineering graduate degrees awarded at an institution. An engineering school's advanced degree production rate for an underrepresented group was first analyzed by which schools produced the highest degree rates with the following questions:

1. Which engineering schools produced the highest rates of *master's* degrees for *URMs*?
2. Which engineering schools produced the highest rates of *doctoral* degrees for *URMs*?
3. Which engineering schools produced the highest rates of *master's* degrees for *women*?
4. Which engineering schools produced the highest rates of *doctoral* degrees for *women*?

A second analysis was conducted to determine if an engineering school's characteristics are related to advanced degree production rates for underrepresented groups. The first set of questions above was also asked for schools that remained in the data set after schools with missing data were removed. Additional questions addressed to determine if advanced degree production rates for underrepresented students in engineering related to engineering school characteristics included:

1. What institutional characteristics are related to the *master's* degree production rate of *URMs*?
2. What institutional characteristics are related to the *doctoral* degree production rate of *URMs* in engineering?
3. What institutional characteristics are related to the *master's* degree production rate of *women* in engineering?
4. What institutional characteristics are related to the *doctoral* degree production rate of *women* in engineering?

**Conceptual Framework Overview**

Two main frameworks were employed to examine engineering master's and doctoral degree production for women and URMs in this study. These included the (1) education production function (Hopkins, 1990) and (2) theory of institutional capital (Bourdieu, 1984; Bourdieu & Wacquant, 1992; Brosnan, 2010; Fogarty, 1997; Jewel, 2008). In its most basic form, the education production function examines how inputs convert into outputs (Hopkins, 1990). In a variety of education production function studies, data associated with enrollments, faculty productivity, or institutional expenditures were analyzed as inputs, while degree data were examined as outputs (Dundar & Lewis, 1995; Hanushek, 1979; Hartwig, 1978; Hubbard & Stage, 2010; Monk, 1989; Shelton & Prabhakar, 1971; Titus, 2009; Wolf-Wendel et al., 2000). These variables, however, can be used on either side of the production function equation, depending upon the purpose of the study. For example, studies by Hartwig (1978) and Shelton & Prabhakar (1971) used the production function to determine efficiencies within engineering programs. Input variables for these studies included aspects related to an engineering school's faculty members and average time to degree, while output variables included those related to the number of degrees at the baccalaureate, master's, and doctoral-level, average enrollment, and average research expenditures.

Hanushek (1979) advised that the production function is mainly an economic concept, and that researchers who utilize it should also couple it with a guiding framework. Wolf-Wendel and others (2000) addressed this criticism in their study of baccalaureate origins of underrepresented women with doctorate degrees by coupling the education production function with the theory of baccalaureate origins. Similarly, this study addresses Hanushek's criticism by using the theory of institutional capital as a lens from which to examine variables in the education production function model.

Researchers have applied Bourdieu's (1984) theory of capital to outcomes in the fields of accounting, law, and medicine (Brosnan, 2010; Fogarty, 1997; Jewel, 2008). Bourdieu's theory of capital generally connects an individual's capital, such as someone's background or socioeconomic status to that person's role within a culture. Bourdieu's theory highlights individual challenges to compete for capital or assets associated with different forms of capital such as those tied to cultural, economic, or symbolic resources. In general, Bourdieu connected *cultural* capital to desirable resources that develop from being a part of a certain group over time, *economic* capital to specific monetary goods, and *symbolic* capital to an individual's status in a society. Bourdieu also applied his concept of capital to 'fields,' and used higher education as an example of a 'field' where programs continually compete for the best resources to position themselves among competitors. Researchers that applied Bourdieu's concept of capital to outcomes in the fields of accounting, law, and medicine did so from the notion that certain organizational factors influenced outcomes in a particular field. These studies served as the framework for how institutional capital was applied to engineering school characteristics in this study, and these studies and the theory of capital are further discussed in Chapter II.

**Significance of Study**

Previous research on advanced degree production among underrepresented groups calls to examine data by field (Nettles & Millett, 2006; NRC, 2001; Wendler et al., 2010), yet studies often explore this issue in the broader context of 'STEM' programs. Occasionally, national reports highlight differences between STEM fields; however, the frequent pattern of national agencies, such as the NSF, to group science and engineering together when examining degree data for underrepresented groups makes it difficult to grasp the actual representation of women and URMs in specific fields. 'Science *and* engineering,' for example, includes the social sciences and psychology. In 2006-07, URMs and women represented around 11% and 47% of science *and* engineering doctoral degree recipients, respectively. The fields of social science and psychology, however, contributed to over half of the doctoral degree production in 'science' for women and URMs. Women earned nearly 4,700 of their 9,300 doctoral degrees; and, URMs earned nearly 3,700 of their approximately 8,000 total doctoral degrees in these fields (NSF, Division of Science Resources Statistics, SED, 2003–07).

Degree attainment differences exist even within specific fields of engineering. In 2010, URMs and women with U.S. citizenship or permanent residency status earned their highest rates of doctorate degrees in chemical engineering. Women undergraduate engineering students also earned their highest degree rates in chemical engineering in 2010, which partly explains why their doctorate degree rates are highest in this field. URMs in engineering, on the other hand, earned their highest bachelor's degree rates in the field of mechanical engineering (ASEE, Engineering *College Profiles and Statistics*, 2010). These statistics reveal important differences within the field of engineering. Researchers credit the chemical engineering field as being more attractive to women because of its perceived flexibility for a career path. Women with interests in chemistry or biology, for example, recognize that an engineering degree could offer them a broader career path compared to a science degree, and those with an interest in chemistry or biology find a chemical engineering degree to be a good fit. Women also indicate that a chemical engineering degree provides the training necessary to enter law or medical school and give back to their community or family either through the medical field or higher salaries that are typically received in this field. Chemical engineers often earn higher salaries because it is perceived as one of the hardest engineering disciplines, and some women even indicate that earning a degree in the toughest field is what attracted them to chemical engineering (Brawner, Lord, & Ohland, 2011).

The engineering field includes a variety of majors, all of which challenge students to think about problems from a particular engineering perspective. Even though students normally enroll in a specific engineering major (i.e., chemical), the field has become increasingly interdisciplinary as engineers work together to solve complex problems (National Academies, 2004). The goal of this study was to examine ‘engineering’ as a main field within ‘STEM’ to first determine if there are certain engineering school characteristics that relate to higher advanced degree production rates overall for underrepresented groups. The findings from this study can then be examined for how they relate to specific majors within the discipline.

In addition to extracting ‘engineering’ from ‘STEM’ in an analysis of engineering school characteristics that relate to advanced degree production rates of underrepresented groups, this study only analyzes data on U.S. citizens and permanent residents for ‘women.’ Women with

U.S. citizenship and permanent residency status earned less than half of the master's or doctorate degrees granted to 'women' as a group in 2010 (ASEE, *Engineering College Profiles and Statistics*, 2011). A problematic trend when examining data on STEM degrees is that, unlike URMs, statistics for women are normally reported in one category instead of being separated out as a subcategory within U.S. citizens, which often results in misleading data when 'women' are discussed in the context of 'underrepresented.' Ferreira (2009) pointed this phenomena out in her study of women's gains in doctorate programs in STEM fields, where she analyzed degree trends from the Survey of Earned Doctorates (SED) from 1996-2006. Ferreira reported that although women have made gains in earning engineering doctorates, their percentage is even further behind their male counterparts when only statistics for U.S. citizens are analyzed. Whereas the NSF reported an increase in engineering doctorate degrees for women between 1997 and 2007, from around 12% to 21%, Ferreira reported that figures for women with U.S. citizenship were closer to 8% each year between 1996 and 2006, or close to no growth at all during this time period. Accordingly, this study will address Ferreria's concerns by only considering U.S. citizens and permanent residents in totals for 'women.'

Since women and URMs earn such low proportions of engineering doctorate degrees, engineering undergraduate students have few underrepresented role models among engineering faculty members. Research suggests that women and minority faculty positively influence students at both the baccalaureate and doctorate-degree levels (Brazziel & Brazziel, 1997; Fox, 2001; Nettles & Millett, 2006; Price, 2010; Sonnert, Fox, & Adkins, 2007). In engineering, however, less than 15% of engineering faculty were women and less than 25% were minority (including Asians) in 2008 (Burrelli, 2008). The issue of limited role models for women and minorities in engineering follows students from undergraduate studies through the doctorate degree. Reports call to address the shortage of women and URMs with doctoral degrees in engineering fields, because these groups need to be represented among faculty members who will teach the next generation of highly demanded employees in the STEM workforce (National Academies, 2007; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010). Lowell & Regets (2006) pointed out that STEM-related jobs grew by 670% between 1950 and 2000. Other jobs only grew by around 130% during this same time period. The Building Engineering and Science Talent (BEST) program, a union between public and private organizations that seeks to increase the number of underrepresented groups participating in the STEM labor force, further emphasizes the importance of role models, and employs the reoccurring 'face' symbol to emphasize the value of such role models:

> As minority scholars complete their degrees and enter the professoriate, their presence will magnify the diverse intellectual talents they bring with them, and the unique contributions they make as members of groups long underrepresented in the science faculty ranks. Such diversity can only enhance the quality of our nation's postsecondary enterprise, while changing the face of the role models for succeeding generations of scholars and citizens (*A Bridge for All: Higher Education Design Principles to Broaden Participation in Science, Technology, Engineering and Mathematics*, 2004, p. 29).

The Woodrow Wilson Foundation's report on Ph.D. production for underrepresented groups, the National Academy of Science's "Rising above the Gathering Storm" (2007) and "Expanding Underrepresented Minority Participation" (2011) reports, "Freehill et al.'s (2008) "Confronting the "New" American Dilemma. Underrepresented Minorities in Engineering: A data-based look at diversity," and Varma & Freehill's (2010) "Special Issue on Science and Technology Workforce" all call for the need to diversify the educators who train future STEM workers. This diversity is needed to provide underrepresented groups with an opportunity for equal advancement, for science and engineering fields to benefit from diverse points of view needed to solve complex problems, and for the U.S. to compete globally in science and engineering (Freehill et al., 2008; National Academies, 2007; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010).

Underrepresented groups add to the highly in-demand engineering workforce, offer diverse perspectives to solve problems for a heterogeneous population, and enhance a profession's ability to consider methods to attract URMs and women into the field (Fleming, 2008; Freehill et al., 2008; National Academies, 2007; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010). This study examines the influence of institutional demographics, or the 'face' of engineering schools, on advanced degree production for underrepresented groups, and serves as a basis from which administrators and higher education policy makers can modify institutional features and policies within engineering schools to better promote advanced degree programs to underrepresented groups. While engineering schools may not be able to change individuals, administrators and higher education policy makers are able to modify structures and resources that influence degree rates for underrepresented groups (National Academies, 2007; National Academies, 2011; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010). This study contributes to the higher education literature by offering university administrators and policy makers a better understanding of which institutional features encourage advanced degree production for underrepresented individuals in a specific discipline.

## Summary of Introduction

Higher education administrators and policy makers must understand how institutional factors influence advanced degree rates for underrepresented groups in engineering, in order to attract higher proportions of URMs and women into engineering graduate degree programs in the future. This chapter highlighted the important role of examining graduate degree production rates specifically for non-foreign women and URMs in the field where they are the most underrepresented – engineering. Bourdieu’s (1984) framework on capital as an institutional resource, and the education production function (Hopkins, 1990) suggest that a study that includes an analysis of successful engineering graduate degree producing institutions should do so by examining institutional resources, characteristics, and demographics. This chapter provided an overview of the importance of the development of such a model to assess successful engineering graduate degree producing institutions, and outlined the conceptual model and research questions that are used to examine institutions’ graduate production rates for women and URMs in engineering.

The first part of chapter II provides an historical perspective on engineering doctoral programs, and focuses on the importance of examining master’s degree rates from an educational pathway perspective. The second part of the chapter discusses literature that used the education production function to examine degree production rates. The last part of chapter II discusses engineering graduate degree production in the context of Bourdieu’s (1984) theory of capital. Chapter III outlines the methods and data sources used in this study. Chapter IV summarizes the study’s descriptive and inferential findings. Chapter V highlights the study’s findings, discusses policy implications for higher education, and examines areas for future research.

# CHAPTER II: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

## Introduction

This chapter focuses on current literature related to engineering graduate degree production for women and URMs. Since the purpose of this study is to examine institutional factors related to engineering graduate degree production, the literature centers on identifying institutional-level influences. In order to provide a context for the study's purpose, including why it is important to examine institutional data related to master's degree production, an historical and educational pathway perspective on engineering doctoral degree production is discussed first, followed by a discussion of the conceptual framework, which includes the education production function and theory of institutional capital.

## Historical Perspective on Engineering Doctoral Degree Production

National agencies bring attention to the need for research and plans on how to address shortages in engineering doctorate degrees among underrepresented groups, particularly women or URMs earning doctoral degrees in the field (National Academies, 2007; Stine & Matthews, 2009; The Woodrow Wilson Foundation, 2005; Varma & Frehill, 2010). According to NSF data on advanced degrees earned from the mid-1960s to today, men dominated advanced engineering programs, and 'men' – as a group – continue to be overrepresented at the doctoral-level. In 1967, men (mostly U.S. citizens at the time) earned 2,595 of the 2,604 doctoral degrees awarded in engineering (NSF, Division of Science Resources Statistics, 2010). Although these early data are only publicly available by gender as a group, it is unlikely that URMs were well represented in these totals considering that no URM group earned more than 2% of engineering doctoral degrees in 2009-10 (NSF, Division of Science Resource Statistics, 2010). These data are even more disturbing when parsed by gender *and* race. In 2009-10, Hispanic men earned the most doctoral degrees out of all URM groups in engineering, with 149 degrees, while Native American women earned the fewest at only 5 (ASEE *College Profiles and Statistics*, 2011). Since these data represent such small totals, this study will not specifically examine race by gender. This study will, however, analyze the group that is most underrepresented within the 'women' group category, which includes those with U.S. citizenship or permanent residency status. In 2010, engineering schools reporting data to the ASEE awarded 885 doctorate degrees to women with U.S. citizenship or permanent residency status (ASEE *College Profiles and Statistics*, 2011).

**Educational Pathway Perspective**

This study focuses on advanced engineering degree production in an effort to determine factors that relate to degree production among the group of individuals who are most likely to advance engineering research and serve as educators in the highly in-demand engineering field (Freehill et al., 2008; National Academies, 2007; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010). It is important to recognize the postsecondary educational pathway for URMs and women who later earn doctorate degrees in engineering. The Commission on the Future of Graduate Education in the U.S. broadly defines 'pathway' related to a graduate degree as a structure where someone enters the pathway with a bachelor's degree and eventually ends with a doctoral degree. An emphasis is placed on the idea that individuals may enter the pathway at multiple points and at multiple times (Wendler et al., 2010).

A bachelor's degree is the first step in the postsecondary educational pathway to a doctorate degree (NSF, Division of Science Resources Statistics, 2010; Wendler et al., 2010). URMs and women with U.S. citizenship or permanent residency status earn higher rates of engineering degrees at the bachelor's-level than at the doctorate-level, although they only earned close to 12% and 16% of bachelor's, respectively, in 2009-10 (ASEE *College Profiles and Statistics*, 2011). A host of 'baccalaureate origin' studies and reports analyze institutional characteristics related to women and URM degree production among those with bachelor's degrees who eventually earned doctoral degrees (Brazziel & Brazziel 1997; Cooper, 2004; NSF, Division of Science Resources Statistics, 2011; Salters, 1997; Solorzano, 1995; Wolf-Wendel, 1998). These studies serve as a way for institutions to know where to recruit students, and they help institutional policy makers and recruiters better understand how these undergraduate institutions encouraged degree success and the pursuit of a doctoral program. As is often the case in research on advanced education, literature tends to relate research to a bachelor's degree first, since more students attend college at the undergraduate-level, and it is the first step in the pathway to an advanced degree (Kallio, 1995; McAnulty, 2009; Poock & Love, 2001). Specifically in the field of engineering, Freehill et al. (2008) emphasized that studies should focus on institutions that successfully recruit and retain URMs at the undergraduate-level, because less successful institutions should look to more successful ones as a model.

While these baccalaureate origin studies are somewhat useful for engineering doctoral degree programs to determine where to recruit underrepresented students, over two-thirds of individuals with engineering doctorates earn a master's degree en route (NSF, Division of Science Resources Statistics, 2010). Roughly 70% of engineering doctorate recipients in 2009 earned a master's degree in engineering. This was the highest rate among all fields that granted doctoral degrees in the U.S. When examined by race, blacks and those that identified themselves as two or more races earned the highest engineering master's degrees among all engineering doctorate recipients in 2009, with each attaining approximately 72% and 75%, respectively. Men and women with doctorate degrees held master's degrees at about the same rate; and, doctorate degree holders in civil engineering held the highest percentage of prior master's degrees among those who earned engineering doctorates in 2009, at close to 90% (NSF, Division of Science Resources Statistics, 2010). The high rate at which civil engineering doctorate degree holders earn master's degrees could be the result of changes to licensure in 1995 that required engineers to obtain at least 30 credit hours beyond the bachelor's degree (Russell, Rogers, Lenox, & Coward, 2011).

Updates in civil engineering licensing requirements cannot solely account for the nearly 100% increase in master's degree attainment in engineering in the U.S. between 1977 and 2008, as only 10% of this increase occurred in the last 10 years (NSF, National Center for Science and Engineering Statistics, 2011; Wendler et al., 2010). The increase in the rate of master's degrees over the last forty years might explain why some researchers have started to examine the role of institutional environments at the master's degree level, similar to how research explores the role of the environment of a student's baccalaureate institution. Studies that examine the impact of environments on a student's master's degree education argue that individuals within colleges and universities influence students at this level, similar to how faculty, administrators, and peers shape experiences for students at the undergraduate-level (Lange, 2006; Leslie, McClure, & Oaxaca, 1998; Nettles & Millett, 2006; Stassun, Burger, & Lange, 2010).

One groundbreaking study by Lange (2006) examined data from nearly 3,200 STEM doctoral degree recipients from the NSF's Survey of Earned Doctorates (SED) between 1998 and 2002. Lange reported that URMs were more likely to obtain a master's degree on the path toward the doctorate. She connected this finding to the importance that a master's degree plays in linking students to an institution at the graduate-level, and that those students who gain a master's degree along the way to a doctorate may be better socialized to subsequently complete a doctoral program. Based on this research, Vanderbilt and Fisk Universities created an M.S.-to-Ph.D. bridge program in physics, where students earn their M.S. degree at Fisk and Ph.D. from Vanderbilt. Since 2004, 40 URMs have participated in the program, and nearly 90% of these students were retained. In 2006, Fisk granted more master's degrees to African Americans in physics than any other U.S. school; and, in 2011, its partner, Vanderbilt, was projected to grant more URMs' Ph.D. degrees in materials science, astronomy, and physics than any other institution in the U.S. (Stassun, Holley-Bockelmann, Burger, Ernst, & Webb, 2011).

M.S.-to-Ph.D. 'bridge' programs can also be examined for their role in a student's time to degree. Stassun and others (2010), in their article on the benefits of the Fisk-to-Vanderbilt M.S.-to-Ph.D. program, noted that program participants tended to add only a year to their studies when they first completed a master's degree at Fisk. Since this program has had such success in recruiting URMs into certain science Ph.D. programs, a short increase in a student's overall time to a doctorate is minimal compared to the general benefit of an URM earning a doctoral degree. The initial success of this program serves as one indication of the importance of examining a master's degree as part of the pathway toward a doctorate, even for those in non-engineering fields.

In engineering, studies have shown that doctoral students with a master's degree are more likely to earn a Ph.D., and that they earn it at a faster rate than those who begin a doctoral program without one (Nettles & Millett, 2006; Most, 2008). Most (2008) found that students were more likely to obtain a Ph.D. in certain fields if they held a master's degree. Most examined 1989-1997 doctoral completion data from the AAU and Association of Graduate Schools' longitudinal database titled the "Project for Research on Doctoral Education." This analysis included data from nearly 5,000 doctoral students in 10 fields at 16 different colleges and universities. In the field of mechanical engineering, Most found that only around 20% of students without a master's degree had completed a doctoral degree within nine years, whereas nearly 50% with a master's degree had completed a doctoral degree in this time frame. Nettles & Millett (2006), in their study of approximately 9,000 doctoral students who completed surveys about their experiences as a student in 1996, also found that engineering doctoral students decreased their time to degree when they held a master's degree.

The high rate at which engineering doctorate recipients earn a master's en route to a doctorate indicates that the master's degree is the next step in the educational pathway for engineering students, yet a master's degree is often skipped over in the STEM doctoral 'pathway' conversation. The high rate at which engineering doctorate recipients earn master's degrees en route to a doctorate means that engineering schools potentially have a pool beyond the bachelor's degree from which to recruit qualified students into doctoral programs. Lange's (2006) research indicates that *engineering* doctorate recipients are more likely to stay at the same school for their master's and doctorate degree; however, *URMs* in STEM are more likely to attend different institutions for their master's and doctorate degree. This study compares an engineering school's production of master's and doctorate degrees for underrepresented groups in an effort to better understand if the same schools produce high degree rates for both advanced degree levels. Further, this study's examination of specific engineering school characteristics that relate to higher advanced degree rates for underrepresented groups provides an additional layer for administrators and policy makers to utilize when determining how to best recruit underrepresented students into engineering doctoral degree programs.

The education production function and theory of institutional capital were used as this study's framework to examine (1) which engineering schools produced the highest advanced degree rates for underrepresented groups and (2) which engineering school characteristics relate to higher advanced degree rates for URMs and women. The next section details this framework and applies it to institutional graduate degree production rates in engineering for URMs and women.

## Conceptual Framework

This study's framework is based on: (1) the education production function and (2) the theory of institutional capital. The education production function provided the overarching statistical model for this study, and the theory of institutional capital served as the conceptual foundation from which the variables in this study were identified. Aspects of the education production function were partially drawn from doctoral degree production studies by Hartwig (1978) and Shelton & Prabhakar (1971), who examined degree production in engineering, and Wolf-Wendel et al. (2000), who analyzed outcomes in the education field. The theory of institutional capital was modeled off of studies that connected institutional capital to educational outcomes in the field of accounting, medicine, and law (Brosnan, 2010; Fogarty, 1997; Jewel, 2008).

### *Education Production Function*

Researchers have used the production function to examine efficiencies at all levels of education, including those specifically related to Ph.D. production for women or Ph.D. production in engineering (Dundar & Lewis, 1995; Hanushek, 1979; Hartwig, 1978; Hubbard & Stage, 2010; Monk, 1989; Shelton & Prabhakar, 1971; Titus, 2009; Wolf-Wendel et al., 2000). According to Hanushek (1979), the production function refers to an efficiency model that examined the: "…correct choice of input mix given the prices of inputs" and "…[the maximization of] an output for a given set of inputs" (p. 369-370). He argued that the best way to examine the production function is by analyzing data in a specific area, because decision-makers may use the results to make funding decisions that may not accurately reflect efficiency across all areas in an organization. Hopkins (1990) also argued that the most useful production function examinations occur on smaller scales (versus across an entire university), because of the complex variables associated with higher education outcomes. Although a variety of variables can be used to describe inputs and outputs in higher education, Hopkins described overarching inputs as capital (i.e., resources) and faculty. While there are also a host of educational outputs to possibly examine in education, Hopkins identified degree production as one of the main outcomes. Thus, it is appropriate to use the production function to examine M.S. and Ph.D. degree production rates connected to a specific field, such as engineering.

In engineering, Hartwig (1978) and Shelton & Prabhakar (1971) used data from the *Directories of Engineering Research and Graduate Study* to analyze engineering school productions and efficiencies in the 1960s and ‘70s. Shelton & Prabhakar’s analysis included data between 1966 and 1969, and used faculty size as the input and baccalaureate, master’s, professional, and doctoral degrees as output variables. Hartwig’s analysis included an historical examination of data between 1956 and 1976, and used faculty size and average time to degree as input measures, and research expenditures plus enrollment and degree statistics at the baccalaureate, master’s, and doctoral-levels as output variables. Both studies highlighted the importance of the variable that is used for the denominator in efficiency ratios, where an efficiency ratio is the result of dividing an output or resource by a certain input or resource. Although larger programs produced more degrees and sponsored research, smaller programs produced baccalaureate degrees at higher rates per faculty member than larger ones in Shelton & Prabhakar’s analysis. Shelton & Prabhakar suggested that this rate may indicate that smaller schools focus more on teaching than research and graduate programs. Hartwig found that larger institutions spent about half as much to produce a Ph.D. degree per faculty research expenditure than smaller ones. While both of these studies provide a framework for variables to examine when analyzing Ph.D. production in engineering programs, neither considered production rates for underrepresented groups.

A study by Wolf-Wendel et al. (2000) demonstrates how the education production function can be used to examine Ph.D. production for women by race. This study combined the education production function with the theory of baccalaureate origins to analyze individual and institutional-level data from the Doctorate Records File for African American, white, and Latina women who earned baccalaureate degrees in 1965 and subsequently gained doctorates by 1975. The purpose of the study was to determine which institutional-level resources (amount spent on instruction per student and endowment dollars per student) contributed to the production of doctoral degrees for different groups of women. After controlling for institutional expenditures per student, the researchers found that women with doctorates earned more baccalaureate degrees at women's colleges, Hispanic Serving Institution (HSIs), or HBCUs. Further, these researchers found that women's colleges, HSIs, and HBCUs produced more baccalaureate degrees for women doctorate degree holders for each dollar spent on institutional resources. Thus, these colleges were more productive and efficient at producing baccalaureate degrees for women who later earned doctorates by 1975, and they did so with fewer resources.

Wolf-Wendel et al.'s (2000) study demonstrates how the education production function can be coupled with a guiding framework to examine Ph.D. production for underrepresented groups by institutions. Hanushek (1979) cautioned that researchers should not rely solely on the production function as a conceptual framework, because the theory involves a variety of complex inputs, and studies should use a guiding framework to derive measures for inputs and outputs. This study addresses this criticism by using the theory of institutional capital as a lens from which to examine variables in the education production function model.

### *Institutional Capital Theory*

Researchers have applied Bourdieu's (1984) theory of capital to outcomes in the fields of law, medicine, and accounting (Brosnan, 2010; Fogarty, 1997; Jewel, 2008). Bourdieu is well known for his research on the concept of capital, which he generally applies to how individual capital, such as background, class, and socioeconomic status affect practices within different cultures. Bourdieu has also applied capital to explain differences between 'fields,' such as higher education. Bourdieu used higher education as an example of a field which contains different forms of capital, including those related to cultural, economic, and symbolic forms. He argued that a variety of 'actors' compete for cultural, economic, and symbolic resources within these fields. These 'actors' feel a continued need to evaluate their placement in the competitive field and strive to gain resources that allow them to reposition their value. Bourdieu contended that a focus on a particular field allows researchers to understand the context from which individuals in these institutions develop their goals and strategies (Bourdieu & Wacquant, 1992).

Brosnan (2010), Fogarty (1997), and Jewel (2008) focused on Bourdieu's concept of 'field' in their analysis of how various actors compete for resources and outcomes in the fields of medicine, law, and accounting. Brosnan's examination of medical institutions and Jewel's analysis of law schools are particularly useful as examples from which to view the theory of institutional capital because both fields have made gains in the representation of women, as pointed out by Wendler et al. (2010): "Substantial shifts have been seen in the traditionally male fields of law and medicine, with women now comprising about half the enrollment in these professional programs, but it is unclear whether these shifts will be replicated in currently male-dominated fields such as engineering" (p. 8). Duderstadt (2010) suggests that law and medical fields have been able to achieve these parities because of curricular modifications that require undergraduates to earn degrees in liberal arts based fields. While this argument might apply to the general field of engineering, students with degrees in the chemical engineering field, for example, often pursue medical or law school after earning a bachelor's degree (Brawner et al., 2011). Thus, a broad baccalaureate education cannot be the only factor that attracts underrepresented students into the law and medical fields.

Researchers in the law and medical fields have shown that certain resources or institutional capital affect outcomes in their fields. Since these fields have made significant ground in attracting underrepresented groups into their programs, they can be used as a model for a similar study of engineering school resources. One place to start this analysis for engineering graduate programs is to examine how researchers in the law and medical fields applied institutional capital to degree outcomes in these programs.

Researchers in the law, medical, and accounting fields identified cultural, economic, and symbolic capital as resources that determined overall capital in each field, which they connected to overarching 'institutional' capital in their studies.  The specific definition for each form of institutional capital varied by researcher, although they generally agreed that *cultural* capital represented historical advantages and often connected their field's purpose to this form, *economic* capital as those financial resources that contribute to a specific outcome in a field, and *symbolic* capital to features that influence the perception of a field. While these three forms of capital represent different resources that institutions attain, it is important to recognize that each resource could affect the perception of the other and that the forms of capital can overlap. As

Smart (1993) points out, “It should be clear…that Bourdieu discusses the forms of capital in ways that overlap...” (p.393). This overlap is evident in the different ways in which researchers applied Bourdieu’s theory of capital to outcomes in accounting, law, and medicine (Brosnan, 2010; Jewel, 2008; Fogarty, 1997). In an effort to determine how to possibly categorize engineering school characteristics as a specific form of institutional capital, the following sections discuss institutional capital definitions as characterized by Brosnan, Jewel, and Fogarty. These definitions are applied to the forms of institutional capital used to examine engineering graduate degree rates in this study, which included variables associated with institutional type, program size, research expenditures, institutional prestige, and program demographics. Each section concludes with a general definition for how institutional capital fits into the various forms of capital applied to an engineering school.

*Cultural capital.*

An institution’s cultural capital can be viewed for how its purpose relates to educational outcomes (Brosnan, 2010; Fogarty, 1997; Jewel, 2008). Researchers interpret cultural capital differently, depending on the field and outcome addressed. For example, Fogarty (1997), who analyzed accounting doctoral degree and job placement data from 70 institutions, connected an institution’s role to produce knowledge with research expenditures. On the other hand, Jewel (2008), who reviewed extensive amounts of literature to show how individual and institutional capital applied to law school and the legal profession, linked cultural capital to curriculum, which she identified as a construct to rank students. Further yet, Brosnan (2010), who examined how medical schools in the United Kingdom position themselves from other institutions, related a school’s cultural capital to its position in *Good University Guide* in *The Times*, because it represented “…the ‘right’ sort of knowledge… to be a ‘good’ school” (p. 649). This guide ranks schools on research quality, admission standards, satisfaction of students, and prospects of graduates. Although all three studies examined cultural capital slightly differently, they each related a program's purpose to educate students or produce knowledge, which are key aspects in an institution's mission (Scott, 2006).

Institutional missions differ by the category in which an institution falls. The mission of a private college differs from that of a public institution, just as the mission of an historically underrepresented or women's college differs from other institutions (Scott, 2006). Several studies explore institutional type at the baccalaureate-level for how students' undergraduate institution affects their future decision to pursue a doctorate degree in science and engineering. These studies often examine data by a college's underrepresented classification, such as an institution's classification as an HBCU, HSI, or tribal college (Brazziel & Brazziel 1997; Cooper, 2004; Freehill et al., 2008; Solorzano, 1995). While these studies are useful to understand institutional influences at the baccalaureate-level in the educational pathway to a doctorate, fewer institutions that grant doctorate degrees fall into such underrepresented institutional groups. For example, only three of the doctoral-granting institutions in the ASEE's 2009 *Engineering College Profiles and Statistics* held an HBCU status (ASEE, *Engineering College Profiles and Statistics*, 2010).

Another way to categorize institutions by type is to examine their role in the Association of American Universities (AAU). The AAU is an organization of invited institutions that: (1) are leaders in the advancement of knowledge that play a significant role in fueling the country's defenses, financial markets, and overall interests; (2) works with member universities and the government to tackle governmental and institutional concerns confronting member and non-member institutions; and, (3) collaborates with the federal government and research institutions to produce studies related to important policy matters and maintain communications between the two entities (AAU, About AAU, 2010).

As far back as 1975, researchers recognized the efforts of AAU institutions to graduate higher rates of women and URMs with doctoral degrees (McCarthy & Wolfle, 1975). While these efforts initially stemmed from an institution's need to recruit diverse faculty to comply with Affirmative Action laws, the practice of AAU institutions to produce the majority of doctorates each year has persisted over time. Institutions in the AAU produce the majority of doctorate degrees in the U.S. today (AAU, Facts and Figures, 2010; Nettles & Millet, 2006). Engineering programs grant even more degrees from AAU schools than most fields. In 2008, AAU institutions granted roughly 60% of all engineering doctorate degrees (AAU Facts and Figures, 2010). In 2009-10, all but ten of the top 26, and three of the top 27 institutions that granted doctoral degrees in engineering to URMs and non-foreign women, respectively, held AAU status (ASEE, *Engineering College Profiles and Statistics*, 2011).

Doctoral degree production is closely related to an institution's ability to compete for external research funding, and AAU institutions typically vie for a significant amount of federal funding to produce research to solve important problems facing the country and world. Some of this funding is used to support doctoral students being trained as future leaders in science and engineering fields (AAU, FY12 Appropriations, 2011). While this study is not able to examine the financial support offered to individual graduate students in engineering, it is important to recognize that financial support is a significant factor in a student's decision to attend and complete a doctoral degree in engineering. An institution's ability – characterized as its status in the AAU – to provide this support should be considered when examining doctoral degree production for women and URMs (Barnes & Wells, 2009; Freehill et al., 2008; Nettles & Millett, 2006). It is an institution's ability to produce an engineering doctorate degree that this study most closely connects to cultural capital, even though it is recognized that institutional demographics could also represent the perceived advantage an institution maintains over time. This study discusses institutional demographics in the context of a perception or symbolic resource for how they relate to an underrepresented student's perception of an engineering school, which is why it is discussed in the symbolic capital section.

*Cultural capital in this study.*

An institution's ability to provide resources for doctoral education is in line with Brosnan (2010), Fogarty (1997), and Jewel's (2008) assertions that cultural capital develops over time and connects to a university's purpose to produce knowledge. Thus, this study examined an institution's AAU status as a cultural capital variable, in order to connect an institution's research mission to produce an advanced degree for an underrepresented group with its primary purpose and financial ability to do so.

*Economic capital.*

Even among AAU institutions, colleges and universities differ greatly by size and resources, which researchers have identified as variables that affect an institution's doctoral degree productivity (Breneman, 1970; Hanushek, 1979; Hartwig, 1978; Shelton & Prabhakar, 1971; Wolf-Wendel et al., 2000). Economic capital can be used to examine how financial resources and program size – as key factors in a program's ability to fund academic programs – influence degree productivity (Brosnan, 2010; Fogarty, 1997; Hartwig, 1978; Jewel, 2008). While researchers generally agree that economic capital represents specific financial resources required to accomplish certain outcomes in a field, previous researchers examined economic capital in different ways. While Brosnan (2010) and Jewel (2008) related the role of funding to a program's rank in a national publication, Fogarty (1997) and Hartwig (1978) connected a program's funding source to program size.

Both Brosnan (2010) and Jewel (2008) indirectly linked economic capital to program outcomes. Brosnan analyzed a medical school's research ranking as a form of economic capital. She argued that this ranking affected a school's ability to obtain governmental funding, because a school's outcome on the Research Assessment Exercise affected its ranking and governmental funding. This funding, in turn, affected the school's ability to recruit and produce a graduate from a medical school. Similarly, Jewel (2008) also related economic capital in law to a program's rank in guides such as *U.S. News & World Report*. Jewel argued that graduates from higher ranked programs increased the likelihood of gaining employment because of the resources they were able to spend to earn a degree from a highly ranked law school.

On the other hand, Fogarty (1997) contended that a program's economic capital relates to its size, and that larger programs tend to be more visible and require higher financial support levels. He used the number of doctoral graduates, full-time staff members, baccalaureate degrees, and annual Certified Public Accounting (CPA) candidates as size variables in his analysis of doctoral accounting graduate placements. Hartwig's (1978) analysis of the production of engineering programs also connected size, defined as the number of full-time faculty, students enrolled at the bachelor's, master's, and doctoral-level, and total research expenditures, to degree production. Hartwig's findings revealed that larger institutions spent less on research expenditures per faculty member to produce a Ph.D. graduate. While smaller institutions spent about $140,000 per faculty member on research expenditures per Ph.D. graduate, larger institutions spent about half of this per faculty member, or closer to $70,000 per Ph.D. graduate.

An engineering school's research expenditures can also be examined in light of how these funds relate to Ph.D. degree production. In 2008-09, eight out of the top 10 engineering schools in total research expenditures produced the highest levels of Ph.D. graduates; however, only two of the same institutions appeared in the top 10 when expenditures per doctoral student were examined (Gibbons, 2009). Further, the NSF and ASEE utilize a school's research expenditures as a primary variable in rankings of engineering programs (ASEE, *College Profiles and Statistics*, 2009; NSF, Division of Science Resources Statistics, *Survey of Research and Development*…," 2011).

Both cohort size and research expenditures may relate to an institution's doctoral degree production in engineering (Bowen & Rudenstine, 1992; Ph.D. Completion Project, Analysis of Baseline Data, 2007). A recent analysis of the Council of Graduate Schools' (CGS) Ph.D. completion project data indicates that smaller engineering cohorts, which contained 1 to 7 students, completed Ph.D. degrees at higher rates than those from medium or large groups. Medium groups consisted of 8 to 14 students, while large were 15 or more (Ph.D. Completion Project, Analysis of Baseline Data, 2007). These findings are in line with Bowen & Rudenstine's (1992) groundbreaking book, *In Pursuit of the Ph.D.*, where they found that programs with smaller student cohorts in economics, history, political science, English, physics, and math all completed Ph.D. programs at higher rates compared to those with larger entering student cohorts.

*Economic capital in this study.*

Although researchers disagree about which variables to analyze as economic concepts, and which side of the production function equation these variables fall, Shelton & Prabhakar (1971) argue that different variables may be considered as either inputs or outputs in an analysis of production. Therefore, economic capital in this study was generally based off of: (1) a combination of Brosnan (2010), Fogarty (1997), and Jewel's (2008) concepts of economic capital applied to outcomes in their studies, (2) Hartwig's use of student cohort size and research expenditures as input measures in his examination of engineering degree productions, and (3) the importance that national agencies attach to research expenditures. The economic capital aspects that this study explored included average annual engineering research expenditures and average annual engineering graduate program enrollment.

*Symbolic capital.*

An examination of the production of engineering graduate degrees should also consider how an institution's symbolic features affect degree rates. Unlike cultural and economic capital, researchers generally agree that prestige variables – as key factors in the perception of an 'actor' in a certain 'field' – comprise an institution's symbolic capital (Brosnan, 2010; Fogarty, 1997; Jewel, 2008). Nevertheless, researchers used slightly different variables to define 'prestige' in their various studies.

Fogarty (1997) linked symbolic capital to an accounting doctoral student's ability to work with highly productive faculty because of the prestige a program gains from its selectivity. In the case of Fogarty's study, this meant that graduates from higher ranked programs were expected to obtain academic positions at higher rates, which is exactly what he found. Jewel (2008) connected symbolic capital to institutional rank, such as that in *U.S. News & World Report*, because higher ranked institutions were able to recruit better applicants. Brosnan (2010) also placed great emphasis on the symbolic capital that rankings bring to the competitiveness of a program. Symbolic capital in her study was measured as a school's rank in *The Times' 'Good University Guide,'* where a higher rank was associated with higher prestige. Brosnan also supported her analysis with interviews with 37 students and 15 faculty members about their viewpoints regarding the curriculum at two medical schools. Results from Brosnan's analyses indicated that more clinician-scientists (compared to just clinicians) graduated from higher ranked institutions, which connected to that institution's focus on science, in addition to medical education.

Ranking guides, such as *U.S. News & World Report* (*USNWR*), often serve as resources to assess an institution's prestige (Brewer, Gates, & Goldman, 2002; Jin & Walley, 2007; Meredith, 2004; Sauder & Espeland, 2006; Sweitzer & Volkwein, 2009; Volkwein & Sweitzer, 2005). An engineering graduate program's rank in *USNWR* is based on an assessment of quality, student selectivity, faculty resources, and research activity. The quality score is comprised of scores on a scale of 1 to 5 from both peers and recruiters. The number of doctoral degrees awarded, faculty to student ratios, and the percentage of faculty in the National Academy of Engineering make up the faculty resources score. Total research expenditures and research expenditures per faculty member frame the research activity score. Student selectivity scores are based on acceptance rates and mean quantitative Graduate Record Examination (GRE) scores (Morse & Flanigan, 2009).

Entrance exam scores often serve as a key proxy that connects student quality to a program's rank in *USNWR*, which is one of the most recognized 'prestige' ranking publications in the U.S. (Brewer et al., 2002; Jin & Walley, 2007; Meredith, 2004; Sauder & Espeland, 2006; Sweitzer & Volkwein, 2009; Volkwein & Sweitzer, 2005). The most common entrance exam for graduate school is the GRE ("About the GRE," 2011). Most engineering doctorate programs use the GRE as their primary admission exam tool, despite findings that indicate it may not be the best predictor of success for women and URMs in a graduate program (Lightfoot & Doerner, 2008; Rogers & Molina, 2006). 'Traditional' admission criteria, such as the GRE, have been found to negatively correlate to URM enrollment and retention in graduate programs in fields such as psychology (Rogers & Molina, 2006). Although graduate programs often use the GRE as an admission measurement, a recent study that validated its predictability only parsed data by overarching life sciences, humanities, math-physical sciences, and social sciences groups (Kuncel, Wee, Serafin, & Hezlett 2010). Findings from Nettles & Millett's (2006) study on doctoral completion highlight the importance of aggregating these data by specific field. These authors found that engineering doctoral students were more likely to have higher rates of faculty interaction if they scored higher on the quantitative portion of the GRE. On the other hand, engineering students were less likely to have high interaction rates with faculty if they scored high on the verbal portion of the GRE. No other field had the same opposite effect.

Faculty members also maintain demographic characteristics which can be viewed as one component of an institution's level of diversity ("A Bridge for All…," 2004; Chubin et al., 2005; Donnelly & Jacobi, 2010; Freehill, 2005; Zajicek et al., 2011). It is the demographic characteristics that tenured/tenure-track faculty members convey within an engineering school that this study examines, even though it is recognized that faculty members contribute *economic* capital through academic, research, and service-related responsibilities (Schuster & Finkelstein, 2006). Further, faculty demographics could serve as a proxy of an institution's *cultural* capital, if their diversity (or lack of) is viewed as an institution's historical advantage to attract certain groups of students to their institution. It is within the institutional prestige context in which faculty variables are generally discussed in this study. HBCUs have been shown to produce nearly one-third of the bachelor's degrees for blacks who later earn doctorates in science and engineering (Burrelli & Rapoport, 2008). A unique feature that HBCUs offer is that they employ a higher percentage of black science and engineering faculty members than traditionally white institutions (TWIs) (Clewell, de Cohen, & Tsui, 2010). Research shows, however, that more diverse institutions are often perceived as less prestigious institutions (Brewer et al., 2002).

Underrepresented faculty members perform an important role in the degree production of women and URMs in STEM programs at the baccalaureate and graduate-level (Nettles & Millett, 2006; Ong et al., 2011; Price, 2010; Sonnert et al., 2007). For example, Price (2010), in a recent analysis of faculty effects on persistence in STEM fields, found that minority faculty positively influenced persistence of minority undergraduates pursuing STEM degrees. Although this same study found no significant effect for women faculty on women's persistence, Sonnert et al., in their examination of women students enrolled in science and engineering programs at Research I universities, and the percentage of women faculty at these institutions between 1984 and 2000, found that institutions with higher percentages of women undergraduates – the first step in the pathway to a doctorate degree – also had higher percentages of women science and engineering faculty members.

Further, although Nettles & Millett (2006) found that few women or URMs had same sex or race *advisors* in engineering doctoral programs, when possible, these students had same gender or race *mentors*. The authors attributed this finding to the idea that students have a greater chance of being able to select *mentors* outside of their major. The main problem in engineering is that there are too few women or URM faculty from which to assign doctoral students the same sex or race *advisors* or *mentors*. This study also found that women were less satisfied with their interactions with faculty, which the authors attributed to the continuance of an "old boys club" (p. 218) mentality in engineering programs. Similarly, Ong et al. (2011), in their examination of over 100 articles on minority women in STEM undergraduate and graduate programs, found that very few minority women received the mentorship or encouragement needed from faculty during the admission or graduate career process.

One aspect of Nettles & Millet's (2006) comprehensive study on doctoral degree completion also focused on how peer interactions by gender and race related to the doctoral socialization process. They found no differences between minorities and whites in any field; however, men in engineering had fewer interactions with peers than women. This socialization process is not limited to fellow doctoral students. Important peer interactions also take place between undergraduate and graduate students (Wilson et al., 2011). While Wilson and others highlighted the importance of a diverse graduate student body on undergraduate retention in STEM fields, in a recent analysis of IPEDS data of graduate students enrolled in STEM programs across institutions in the U.S. during 2006, results revealed that STEM graduate programs, on average, enrolled higher percentages of URMs when they also enrolled higher percentages of URMs at the undergraduate-level (Ostreko, 2010).

*Symbolic capital in this study.*

Peer and faculty demographics, GRE scores, graduate admission yield, and a program's rank in *USNWR* could all serve as signals of an institution's prestige; and, Brosnan (2010), Fogarty (1997), and Jewel (2008) suggest that 'prestige' is the main form of an institution's symbolic capital. Since underrepresented groups may use any or all of these 'prestige' signals in their decision to attend and earn an engineering graduate degree from an institution, this study discussed prestige as the gender or ethnicity of underrepresented undergraduates and master's-level students, gender or ethnicity of underrepresented tenured/tenure-track faculty members, average GRE score, graduate admission yield, and *USNWR* rank.

This section discussed how symbolic, economic, and cultural capital might be applied to resources in an engineering school. Based on studies that applied these forms of capital to academic programs in accounting, law, and medicine, this section explored possible ways to apply capital to an engineering school, with the recognition that capital could overlap depending on how the resource is examined. Figure 1 summarizes how each form of institutional capital was generally applied to this study's examination of engineering graduate degree production rates for women and URMs.

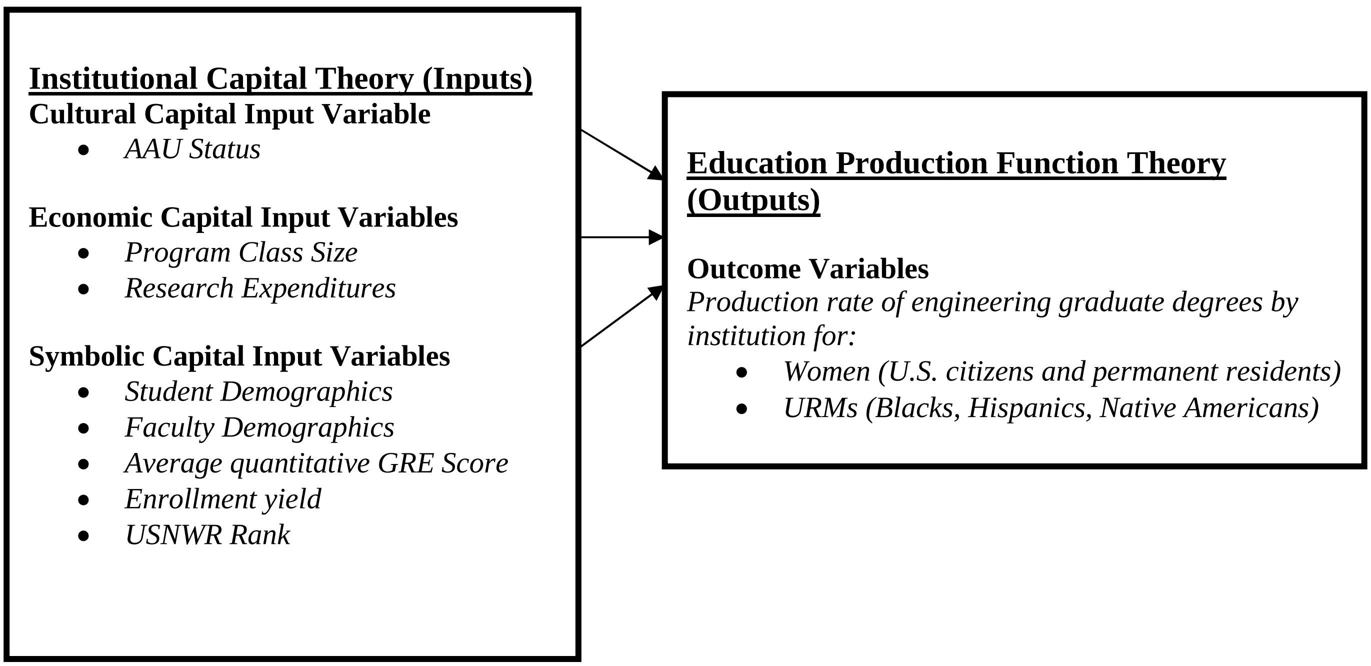


*Figure 1.* Institutional Capital Generally Applied to Input Variables in the Production of Engineering Graduate Degrees for Women and URMs

**Summary of Chapter II**

The use of Bourdieu's (1984) theory of institutional capital – as applied to the fields of medicine, accounting, and law – provides a lens from which to examine factors that influence advanced graduate degree rates for women and URMs in engineering. This chapter highlighted the general cultural, economic, and symbolic capital variables that previous research linked to advanced degree rates in engineering.  These factors must be examined in light of the educational pathway toward a doctorate; and, this study compares an engineering school's master's and doctorate degree production rates, in order to determine which schools serve as high master's degree producers from which to possibly recruit underrepresented students for doctorate programs. The next chapter details the methods used to examine engineering production rates for both M.S. and Ph.D. degrees earned by women and URMs.

# CHAPTER III: METHODOLOGY

## Introduction

This study aimed to determine which engineering school characteristics relate to higher levels of master's and doctorate degrees for underrepresented groups. This chapter re-introduces the questions employed to examine these characteristics. A discussion of the data sources, variables, final data sets, and method of analysis used to address these research questions follows. The last part of the chapter outlines the study's limitations.

## Research Questions

This study examined master's and doctoral degree production rates for the following groups of U.S. citizens and permanent residents: (1) URMs, defined as blacks, Hispanics, and Native Americans and (2) women, defined as all women with U.S. citizenship or permanent residency status. The URM definition only includes those groups the NSF identifies as underrepresented (NSF, Division of Science Resources Statistics, 2011). Since the NSF does not include Asians in its definition of underrepresented, they are not included in the URM definition in this study. Since all women with U.S. citizenship or permanent residency were included in the definition for 'women,' Asians with either of these statuses were included in this group.

Both underrepresented groups were also analyzed for degree rates for master's and doctorates separately. A majority of engineering doctorate recipients earn a master's degree en route to a doctorate (NSF, Division of Science Resources Statistics, 2010). In order to determine if the same institutional characteristics relate to engineering master's and doctorate degree production rates for underrepresented groups, this study examined these degree levels separately.

***Engineering Degree Production Rate***

Engineering graduate degree production rate was broadly defined as the average number of engineering graduate degrees earned by an underrepresented group at an institution out of the average number of all engineering graduate degrees awarded at an institution. An engineering school's advanced degree production rate for an underrepresented group was first analyzed by which schools produced the highest degree rates with the following questions:

1. Which engineering schools produced the highest rates of *master's* degrees for *URMs*?
2. Which engineering schools produced the highest rates of *doctoral* degrees for *URMs*?
3. Which engineering schools produced the highest rates of *master's* degrees for *women*?
4. Which engineering schools produced the highest rates of *doctoral* degrees for *women*?

A second analysis was conducted to determine if institutional capital characteristics are related to an engineering school's advanced degree production rate for underrepresented groups. The first set of questions above was also asked for schools that remained in the data set after schools with missing data were removed. Additional questions addressed to determine if advanced degree production rates for underrepresented students in engineering related to engineering school characteristics included:

1. What institutional characteristics are related to the *master's* degree production rate of *URMs* in engineering?
2. What institutional characteristics are related to the *doctoral* degree production rate of *URMs* in engineering?

3. What institutional characteristics are related to the *master's* degree production rate of *women* in engineering?
4. What institutional characteristics are related to the *doctoral* degree production rate of *women* in engineering?

**Data Sources and Variables**

This study examined five years of data for doctoral-granting institutions from four primary data sources. Institutional and admission data analyzed in this study included information available from the 2005 to 2009 versions of ASEE's *Engineering College Profiles and Statistics* and *U.S. News & World Report's (USNWR)* 2010 ranking of graduate programs. *USNWR* uses the current year to publish rankings for the next year, whereas ASEE publishes a profile of statistics from that year, which is why *USNWR*'s data contain a later year than ASEE's. Thus, both the 2010 *USNWR* rankings and ASEE's 2009 version of *Engineering College Profiles and Statistics* use 2009 data. In addition, certain broad institutional data, such as highest degree offered and institutional ID were obtained from the 2009 Integrated Postsecondary Education Data System (IPEDS). Finally, these data were combined with AAU's listing of member institutions available from its website in December 2010, www.aau.edu/about. Table 1 summarizes the variables and sources used to examine institutional capital characteristics of engineering doctoral degree production.

Table 1. Types of institutional capital, variables and data sources.

| Type of Institutional Capital Source | Variable | Data Source |
|---|---|---|
| *Cultural Capital (input)* | AAU Status (IV)<br>Reference = *AAU*<br>0 = *Not AAU*; 1 = *AAU* | AAU Listing |

| | | |
|---|---|---|
| *Economic Capital (input)* | 5-year average of annual research expenditures (IV) | ASEE |
| | 5-year average for master's or doctoral program enrollment (IV) | ASEE |
| *Symbolic Capital (input)* | 5-year average of graduate admission yield (IV) | ASEE |
| | *USNWR* rank (IV) | *USNWR* |
| | Average quantitative GRE score for entrants into engineering graduate programs (IV) | *USNWR* |
| | Percentage of tenured/tenure-track professors who are women or URMs (IV) | ASEE |
| | Percentage of women or URMs enrolled at the undergraduate and/or master's level (IV) | ASEE |
| *Education Production (output)* | <u>Production Rate</u>: Percentage of URMs or women with master's or doctoral degrees out of all master's or doctoral degrees awarded (DV) | ASEE |

DV = Dependent variable
IV = Independent variable

***ASEE Data***

The ASEE was founded in 1893 and serves as a non-profit organization that promotes engineering education. Members include students, faculty, staff, administrators, deans, and corporate partners (ASEE, *Our History*, 2010). Each year, the ASEE collects and publishes data on Canadian and U.S. schools of engineering and technology in its book and online database of *Engineering College Profiles and Statistics*. Deans of engineering and technology schools that report data receive a book that summarizes annual engineering statistics and institutional features for each program reporting data that year. Specifically, the profiles include information on an engineering school's demographics and graduate school admission criteria. All data are reported in summary form, and much of it is parsed by major (ASEE, *College Profiles and Statistics*, 2009). This source was the primary source used for the variables in this study.

***USNWR Data***

*USNWR* has published rankings of higher educational institutions in the U.S. since 1983. The magazine began publishing graduate school rankings in 1994 (*U.S. News and World Report*, History, 2001). This study uses engineering graduate program ranking information published in the 2010 guide. *USNWR* data were used to gather information on an institution's overall rank in *USNWR*'s ranking of engineering graduate programs. These rankings also included an institution's average quantitative GRE score, which was used as an input variable for symbolic capital in this study.

***AAU Data***

The Association of American Universities (AAU) grants membership to a select number of institutions in the U.S. This membership is based on an institution's ability to conduct significant amounts of research that lead the nation's knowledge production in defense, financial markets, and overall interests. These institutions also collaborate with member and non-member schools and the government to address institution and government concerns related to higher education (AAU, About AAU, 2010). The groups' member institutions, which consisted of 62 schools in December 2010, produce half of all doctoral degrees awarded in the U.S., and over half of the engineering doctoral degrees awarded annually (AAU Facts and Figures, 2010; Nettles & Millett, 2006). A listing of the member institutions from the AAU's website, www.aau.edu/about, was combined with ASEE, *USNWR*, and IPEDS data for analysis in this study.

### *IPEDS Data*

The U.S. Department's National Center for Education Statistics (NCES) conducts a variety of educational surveys and includes the results in the Integrated Postsecondary Education Data System (IPEDS). The Higher Education Act of 1965 mandates that colleges and universities report certain information if the institution or individuals attending their institutions receive federal student financial aid. Over 6,700 institutions report data on four main student and three institutional areas. Student data include information on: (1) financial aid, (2) persistence and success, (3) enrollment, and (4) degrees and certificates earned; and, institutional information includes: (1) characteristics, (2) fiscal and human resources, and (3) prices (NCES, IPEDS, 2010).

IPEDS variables were used to match institutions with their unit ID, which made it more efficient to combine data from multiple sources. IPEDS data were also used to verify that the institutions included in the final model granted doctoral degrees as their highest degree conferred.

### *Dependent Variables*

An engineering school's master's and doctoral degree production rate ratios for each of the research questions were the dependent variables, or outcome measures in this study. The degree production ratios were partially modeled off of previous studies that used the education production function. These studies include those by Hartwig (1978), Shelton & Prabhakar (1971), and Wolf-Wendel et al. (2000). The degree production rate formula was generally defined as the percentage of engineering graduate degrees earned by an underrepresented group out of all engineering graduate degrees granted at an institution. Eight total dependent variables were analyzed. These examinations included an analysis of (1) master's and doctorate degree rates for URMs and women by top producing engineering schools and (2) an examination of the relationship between engineering school characteristics and advanced degree production rates for underrepresented groups.

Data for degree productions were obtained from an engineering school's figures listed in the "Graduate" section of "Degrees Awarded by Program" in the ASEE's *Engineering College Profiles and Statistics* database for the years 2005, 2006, 2007, 2008, and 2009. Schools report degree totals parsed by department, gender, and ethnicity. To gain an understanding of overall degree totals over the last five years, table 2 summarizes the minimum and maximum values of the degree variables of all U.S. institutions that reported data on engineering programs to the ASEE between 2005 and 2009.

Table 2. Range of engineering degree statistics, 2005-2009.

| Degree Category | Year | Minimum Awarded | Maximum Awarded | % of Degrees for Underrepresented Group |
|---|---|---|---|---|
| Master's Degree | 2005 | 3 | 40,586 | |
| | 2006 | 2 | 38,969 | |
| | 2007 | 2 | 36,983 | |
| | 2008 | 1 | 38,986 | |
| | 2009 | 1 | 41,632 | |
| Master's Degrees for URMs | 2005 | 1 | 2,407 | 6% |
| | 2006 | 1 | 2,338 | 6% |
| | 2007 | 1 | 2,400 | 6% |
| | 2008 | 1 | 2,523 | 6% |
| | 2009 | 1 | 4,185 | 10% |
| Master's Degrees for Women with U.S. Citizenship | 2005 | 1 | 5,462 | 13% |
| | 2006 | 1 | 5,249 | 13% |

| | | | | |
|---|---|---|---|---|
| or Permanent Residency | 2007 | 1 | 4,959 | 13% |
| | 2008 | 1 | 4,996 | 13% |
| | 2009 | 1 | 5,125 | 12% |
| Doctorate Degrees | 2005 | 1 | 7,333 | |
| | 2006 | 1 | 8,332 | |
| | 2007 | 1 | 9,055 | |
| | 2008 | 1 | 9,086 | |
| | 2009 | 1 | 9,083 | |
| Doctorate Degrees for URMs | 2005 | 1 | 229 | 3% |
| | 2006 | 1 | 238 | 3% |
| | 2007 | 1 | 274 | 3% |
| | 2008 | 1 | 289 | 3% |
| | 2009 | 1 | 344 | 4% |
| Doctorate Degrees for Women with U.S. Citizenship or Permanent Residency Status | 2005 | 1 | 636 | 9% |
| | 2006 | 1 | 704 | 8% |
| | 2007 | 1 | 786 | 9% |
| | 2008 | 1 | 908 | 10% |
| | 2009 | 1 | 1,001 | 11% |

Data obtained from ASEE, *College Profiles and Statistics*, 2005, 2006, 2007, 2008, & 2009.

Table 2 shows that the underrepresented groups examined maintained a relatively consistent percentage of degrees earned between 2005 and 2009; however, degree totals and percentage change between years often varied between 2005 and 2009. In some cases, the overall number of degrees varied quite considerably, and in even more cases the percent change between some of the years was quite large. For instance, the difference between the fewest master's degrees earned in this time frame for URMs differed by a total of 1,847 when the years 2006 and

2009 are compared, which amounted to close to a 44% increase in master's degrees for URMs in 2009 compared to 2006. Similarly, overall totals and percentage differences between years at the doctoral-level for all groups were quite large during this five-year span. The overall difference between the number of doctorate degrees in the year 2005 and 2009 was 1,753 degrees, which was close to a 20% difference during this time. Overall doctorate totals for URMs only differed by a total of 115, yet this change resulted in a 33% difference when 2005 and 2009 are compared. Further, overall doctorate totals for women differed by 365 degrees, which resulted in an approximately 36% change between 2005 and 2009. Given that degree totals change from year-to-year over a period of five years, and that individual engineering schools might report very different degree totals each year, this study used five-year averages for degree totals.

***Independent Variables***

*Cultural capital definition*

Based on Brosnan (2010), Fogarty (1997), and Jewel's (2008) suggestion that cultural capital develops over time and connects to a university's purpose to produce knowledge, the general cultural capital variable in this study included an institution's AAU status. This variable most closely connects an engineering school's ability to produce an advanced degree for an underrepresented group with its primary purpose and financial ability to do so.

*Cultural capital: AAU status.*

The AAU's listing of member institutions on its website in December 2010 was used to classify an institution as "AAU." This variable was dummy coded, and those with AAU status were assigned a 1, while those without it were assigned a 0. Note that, although the University of Nebraska lost its AAU membership in May 2011, it is listed as an AAU school in this study, because it held AAU status during the years examined.

*Economic capital definition*

This study's economic capital variables were developed from: (1) a combination of Brosnan (2010), Fogarty (1997), and Jewel's (2008) concepts of economic capital applied to outcomes in their studies, (2) Hartwig's use of student cohort size and research expenditures as input measures in his examination of engineering degree productions, and (3) the importance that national agencies attach to research expenditures. The economic capital aspects that this study generally explored included average annual engineering research expenditures and average annual engineering graduate program enrollment.

*Economic capital: research expenditures.*

Research expenditures included an engineering's school's *totals* listed as "Expenditures by Research Department" in the ASEE's *Engineering College Profiles and Statistics* between the years of 2005 and 2009. Schools report dollar amounts by department for federal/national, state, foreign, industry, private/non-profit, individual, and local grants. The final model included average five-year totals.

*Economic capital: graduate program enrollment.*

Program enrollment figures included an engineering school's *totals* listed for master's or doctoral programs in "Enrollments by Class" in the ASEE's *Engineering College Profiles and Statistics* between the years of 2005 and 2009. Schools report enrollment totals parsed by department, gender, full-time/part-time status, and ethnicity. Average five-year totals were used for M.S. and Ph.D. enrollment variables.

*Symbolic capital definition*

Brosnan (2010), Fogarty (1997), and Jewel (2008) connected a program's symbolic capital to the perceived prestige of an institution. The literature review in Chapter II outlined prestige variables that generally related to advanced degree production for underrepresented groups in engineering. These prestige variables comprised this study's symbolic forms of capital and included: peer and faculty demographics, GRE scores, enrollment yield, and an engineering school's rank in *USNWR*.

*Symbolic capital: peer and faculty demographics.*

*Percentage of women or URM undergraduates.*

Data for undergraduate enrollment percentages were obtained from an engineering school's figures listed in the "Undergraduate" section of "Enrollments by Class" in the ASEE's *Engineering College Profiles and Statistics* between the years of 2005 and 2009. Schools report enrollment totals parsed by department, gender, full-time/part-time status, and ethnicity. Figures for undergraduate student enrollment by gender or URM each year were totaled and averaged for five years. Percentages for women and URM undergraduates students were calculated as the percentage of URM (or women) undergraduate students enrolled in an engineering school out of all undergraduate students enrolled in an engineering school.

*Percentage of women or URM master's students.*

Data for master's enrollment percentages were obtained from an engineering school's figures listed in the "Graduate" section of "Enrollments by Class" in the ASEE's *Engineering College Profiles and Statistics* between the years of 2005 and 2009. Schools report enrollment totals parsed by department, gender, full-time/part-time status, and ethnicity. Figures for master's student enrollment by gender or URM each year were totaled and averaged for five years. Percentages for women and URM master's students were calculated as the percentage of URM (or women) master's students enrolled in an engineering school out of the total number of all master's students enrolled in an engineering school.

*Percentage of women or URM tenured/tenure-track faculty.*

Data for faculty percentages were obtained from an engineering school's figures listed in "Engineering Faculty and Research" in the ASEE's *Engineering College Profiles and Statistics* between the years of 2005 and 2009. Schools report faculty totals for U.S. citizens and permanent residents parsed by department, gender, status (tenured/tenure-track and non-tenure-track), and ethnicity. Figures for tenured/tenure-track faculty each year were totaled and averaged for five years. Percentages for women and URM faculty were calculated as the percentage of URM (or women) tenured/tenure-track faculty in an engineering school out of all tenured/tenure-track faculty members in an engineering school.

*Symbolic capital: average quantitative GRE score.*

Average quantitative GRE scores were obtained from an engineering school's listing in *USNWR's* 2010 Guide of *Best Graduate Schools*. These averages were for entrants into engineering graduate programs. Only one year of data was included because of the consistency in which engineering schools retain their ranks in *USNWR* each year (Sweitzer & Volkwein, 2009). These ranks remain steady partly because of similar scores reported for average quantitative GRE scores of entrants into engineering school programs.

*Symbolic capital: graduate admission yield.*

Data for graduate admission yields were obtained from an engineering school's figures listed in "New Applicants" in the ASEE's *Engineering College Profiles and Statistics* between the years of 2005 and 2009. Admission yield was calculated as the percentage of graduate students who enrolled in engineering over five years out of all graduate students offered admission over the five-year period.

*Symbolic capital: USNWR rank.*

*USNWR* ranks were drawn from an engineering school's rank listed in the 2010 Guide of *Best Graduate Schools*. Rankings were kept in their original format, which means that schools with smaller figures in the results maintained higher ranks (e.g., "1" is the highest rank). Only one year of data was included because of the steady rate at which engineering schools retain their ranks in *USNWR* each year (Sweitzer & Volkwein, 2009).

## Final Data Sets

The final data sets included data on all engineering programs from the 2005 to 2009 versions of the ASEE's *Engineering College Profiles and Statistics*. Table 3 lists the programs included in this study.

Table 3. Engineering programs listed in ASEE's *Engineering College Profiles and Statistics*

| Programs | |
|---|---|
| Aerospace | Engineering (General) |
| Architectural | Engineering Management |
| Biological and Agricultural | Engineering Science and Engineering Physics |
| Biomedical | Environmental |
| Chemical | Industrial/Manufacturing |
| Civil | Mechanical |
| Civil/Environmental | Metallurgical and Materials |
| Computer | Mining |
| Computer Science (Inside Engineering Schools) | Nuclear |
| Electrical | Other |
| Electrical/Computer | Petroleum |

The use of five years of data helped to address problems with potentially skewed data reported in a specific year, because averages were used for totals that were not already being examined as percentages. This included the economic capital variables: program enrollment and research expenditures.  This practice is in line with the use of averages for multiple data points (Johnson & Christensen, 2000). The use of multiple years of data also helped to address potential problems with graduate student absences from year-to-year. It is common for graduate students to leave programs temporarily for a short period of time (CGS' Website, 2010). These absences, often referred to as leaves of absences (LOA), are not reported in enrollment statistics. The use of a five-year average, rather than an enrollment snap shot, provided a better indication of an institution's typical graduate student enrollment.

After adding IPEDS IDs to the ASEE data, institutions were first kept in the analysis if they offered a doctorate degree as their highest offering. IPEDS IDs were also added to the *USNWR's* ranks, quantitative GRE scores, and AAU listing of schools. Final data sets in the initial analysis also included only U.S. institutions that graduated, on average, at least one engineering student at the master's or doctoral-level over the five-year period. Final data sets for engineering schools in the institutional capital examination only included schools with data reported for all institutional capital variables. SPSS software was utilized to examine all data.

## Method of Analysis

### *Descriptive Statistics*

Descriptive statistics were analyzed on all variables. These included an analysis of mean, standard deviation, range, and data set size. The results section in the next chapter also discusses the top producing engineering graduate-degree producing institutions for women and URMs, and includes a comparison of these institutions by the independent variables for both the top schools and main groups for each outcome variable. A listing of each dependent variable group by their independent variable means and standard deviations is also included in the appendix.

***Multiple Regression Models***

Multiple linear regressions were used to analyze the power of institutional variables to predict an engineering school's graduate degree production rate for women and URMs. The formula used to examine these predictabilities for each group is below.

*M.S. URM degree production rate.*

$y = b_1AAU_1 + b_2Expnd_2 + b_3ProgEnrl_3 + b_4GdmtEnrl_4 + b_5USNRnk_5 + b_6GRE_6 + b_7URMFac_7 + b_8UGURM_8 + c$

- $y$ = M.S. URM degree production rate
- $b_1AAU_1$ = AAU status
- $b_2Expnd_2$ = Average annual research expenditures
- $b_3ProgEnrl_3$ = Average program enrollment at M.S-level
- $b_4GdmtEnrl_4$ = Graduate admission yield
- $b_5USNRnk_5$ = *USNWR* rank
- $b_6GRE_6$ = Average quantitative GRE score for entrants into engineering graduate program
- $b_7URMFac_7$ = Percentage of tenured/tenure-track professors who are URMs
- $b_8UGURM_8$ = Percentage of undergraduate students who are URMs
- $c$ = constant

*Ph.D. URM degree production rate.*

$y = b_1AAU_1 + b_2Expnd_2 + b_3ProgEnrl_3 + b_4GdmtEnrl_4 + b_5USNRnk_5 + b_6GRE_6 + b_7URMFac_7 + b_8UGUR_8 + b_9MSURM_9 + c$

- $y$ = Ph.D. degree production rate
- $b_1AAU_1$ = AAU status
- $b_2Expnd_2$ = Average annual research expenditures
- $b_3ProgEnrl_3$ = Average program enrollment at Ph.D.-level
- $b_4GdmtEnrl_4$ = Graduate admission yield
- $b_5USNRnk_5$ = *USNWR* rank
- $b_6GRE_6$ = Average quantitative GRE score for entrants into engineering graduate program
- $b_7URMFac_7$ = Percentage of tenured/tenure-track professors who are URMs
- $b_8UGURM_8$ = Percentage of undergraduate students who are URMs
- $b_9MSURM_9$ = Percentage of master's students who are URMs
- $c$ = constant

*M.S. women degree production rate.*

$$y = b_1 AAU_1 + b_2 Expnd_2 + b_3 ProgEnrl_3 + b_4 GdmtEnrl_4 + b_5 USNRnk_5 + b_6 GRE_6 + b_7 WomFac_7 + b_8 UGWom_8 + c$$

- $y$ = M.S. women degree production rate
- $b_1 AAU_1$ = AAU status
- $b_2 Expnd_2$ = Average annual research expenditures
- $b_3 ProgEnrl_3$ = Average program enrollment at M.S-level
- $b_4 GdmtEnrl_4$ = Graduate admission yield
- $b_5 USNRnk_5$ = *USNWR* rank
- $b_6 GRE_6$ = Average quantitative GRE score for entrants into engineering graduate program
- $b_7 WomFac_7$ = Percentage of tenured/tenure-track professors who are women
- $b_8 UGWom_8$ = Percentage of undergraduate students who are women
- $c$ = constant

*Ph.D. women degree production rate.*

$$y = b_1 AAU_1 + b_2 Expnd_2 + b_3 ProgEnrl_3 + b_4 GdmtEnrl_4 + b_5 USNRnk_5 + b_6 GRE_6 + b_7 WomFac_7 + b_8 UGWom_8 + b_9 MSWom_9 + c$$

- $y$ = Ph.D. women degree production rate
- $b_1 AAU_1$ = AAU status
- $b_2 Expnd_2$ = Average annual research expenditures
- $b_3 ProgEnrl_3$ = Average program enrollment at Ph.D.-level
- $b_4 GdmtEnrl_4$ = Graduate admission yield
- $b_5 USNRnk_5$ = *USNWR* rank
- $b_6 GRE_6$ = Average quantitative GRE score for entrants into engineering graduate program
- $b_7 WomFac_7$ = Percentage of tenured/tenure-track professors who are women
- $b_8 UGWom_8$ = Percentage of undergraduate students who are women
- $b_9 MSWom_9$ = Percentage of master's students who are women
- $c$ = constant

Berry (1993) indicates that independent variables hold an assumption of normality within a regression equation. Since few of the independent variables held a normal distribution, all independent numeric variables were converted to logs, as recommended by Miles & Shevlin (2006). These logs were used in the final regression model analyses. Tables of the distributions of the independent variables before and after log conversions are included in the appendix.

Additionally, institutions that graduated less than one student per year, on average, over the five-year period were removed from the final sample, as were any institutions that graduated so many students that their extreme totals affected the final model. Miles and Shevlin indicated that dependent variables with a z-score of +/-3 or more standard deviations from the mean are considered outliers and should possibly be removed from a final analysis. Z-scores were saved for each of the dependent variables, which resulted in 2 engineering schools above the 3 standard deviations in the M.S. URM, Ph.D. URM, and Ph.D. women groups, and 1 engineering school above 3 standard deviations in the M.S. women group. Descriptive statistics and multiple regressions were examined for all outcome variables with and without outliers, and the Ph.D. URM model was the only one where significant differences resulted when outliers were removed from the regression model. Thus, outliers were only removed from the Ph.D. URM model. Tables of the distributions of the dependent and independent variables before and after removing outliers are included in the appendix.

## Limitations

Individual engineering programs submit data to the ASEE for publication in the annual *Engineering College Profiles and Statistics* publication (ASEE, *College Profiles and Statistics*, 2009). There is a chance that an individual reporting data may misinterpret or misreport the information. The use of five years of data helps to account for skewed data reported in a specific year. Further, much of the information reported to the ASEE is also reported in *USNWR*. This includes information on admission, enrollment, institutional type, Carnegie classification, degrees, and research expenditures. The ability to check data in both sources helped to verify its accuracy. Institutions must also pay to participate in ASEE's annual survey collection. While most engineering schools participate in this survey collection, some schools may choose not to provide information because of the funding required to do so (ASEE, *College Profiles*, 2010).

Since ASEE, *USNWR*, and IPEDS data are collected annually, researchers and institutions are able to take advantage of relatively recent data; however, the early timeline for collecting data each year means that some programs or institutions may not have finalized data at the end of the collection period. These data sources allow institutions to submit updated data; although, the number of institutions that submitted changes is not reported. This limitation is not expected to pose a major problem, though, as all data collection periods end around November annually, at which time most institutions should have final data for that term or previous semesters, in the cases of earned degrees (ASEE, *College Profiles*, 2009; NCES-IPEDS Website, 2010).

Further, some schools only provided data by gender and reported all totals in the "unknown" category. Since these data were not able to be identified by specific ethnic group, they were not included in the URM models, even though some reported large totals for graduate degrees.

Graduate degree rates were also only examined for schools that IPEDS identified as granting a doctorate as the highest degree offered. Since this 'institutional' classification does not necessarily mean that an 'engineering' school grants at least a doctorate degree, some schools could have remained in the model even if the engineering program only granted a master's as the highest degree. In order to account for this limitation, the highest engineering degree offered is examined for schools that resulted in the 'top' list for the percentage of master's degrees awarded to underrepresented groups.

Finally, the changing nature of engineering graduate admission requirements must also be taken into consideration. Although it is unlikely that an institution would make significant changes to its admission requirements for a graduate degree program, an institution has the ability to change admission requirements, such as that of a GRE requirement, over time.

**Summary of Chapter III**

This chapter explained how data from the ASEE, *USNWR*, IPEDS, and AAU were used to examine institutional capital characteristics related to the graduate degree production for women and URMs in engineering. Potential limitations due to the data sources, data set, or nature of engineering graduate programs were also examined. The next chapter summarizes the study's descriptive and regression model results.

# CHAPTER IV: RESULTS

## Introduction

This study aimed to identify which engineering school characteristics relate to advanced degree production rates for underrepresented students. The first step in this examination was to determine which engineering schools granted the highest advanced degree rates for URMs and women. Once these data were analyzed, findings for the top schools in each analysis were compared to findings for all of the schools in each group. Finally, engineering school characteristics were examined for their ability to predict an engineering school's advanced degree production rate for women and URMs.

## Institutional Characteristics of Engineering Schools

The engineering degree production rates resulted in a total of eight dependent variables, which included the: (1) percentage of master's degrees awarded to URMs for all schools, (2) percentage of master's degrees awarded to URMs for schools included in the regression model analysis, (3) percentage of doctoral degrees awarded to URMs for all schools, (4) percentage of doctoral degrees awarded to URMs for schools in the regression model analysis, (5) percentage of master's degrees awarded to women for all schools, (6) percentage of master's degrees awarded to women for schools included in the regression model analysis, (7) percentage of doctoral degrees awarded to women for all schools, and (8) percentage of doctoral degrees awarded to women for schools included in the regression model analysis.

### *Dependent Variables*

Master's and doctoral degree production rates were calculated for URMs and women, where URMs included blacks, Hispanics, and Native Americans, and women included all women with U.S. citizenship or permanent residency status. Table 4 details the mean, standard deviation, and final data set size for each dependent variable that examined *which schools* produced the highest advanced degree rates This analysis resulted in a total of 163 institutions in the master's and 75 institutions in the doctoral group for URMs, and 185 institutions in the master's and 126 institutions in the doctoral group for women. Table 5 shows that engineering schools included in the final regression models resulted in 97 institutions in the master's and 63 institutions in the doctoral group for URMs, and 126 institutions in the master's and 109 institutions in the doctoral group for women.

Table 4 shows that the engineering schools in this study that granted at least 1 master's degree or 1 doctoral degree to URMs between 2005 and 2009, on average, awarded 7% of all master's and 5% of all doctoral degrees to URMs. The lowest producing schools awarded 0% at the M.S.-level and 1% at the Ph.D.-level, and the highest producing schools awarded nearly 52% at the master's and 47% at the doctoral-level. The standard deviations, or average difference between degree production rates for URMs in engineering schools, were about the same as the means for both the master's and doctoral degree-levels, at 8% and 6%, respectively.

Table 5 shows that engineering schools in the final regression models also reported around the same rates of master's and doctoral degrees for URMs as those in the overall URM groups. Schools included in the regression model examinations awarded 5% of all master's and 4% of all doctoral degrees to URMs, with the fewest producing close to 1% at both levels, and the most producing nearly 32% at the master's and 9% at the doctoral-level. The standard deviations, or average difference between degree production rates for URMs in engineering schools, were quite low for both the master's and doctoral degree-levels, at 4% and 2%, respectively.

Tables 4 and 5 also show that all engineering schools that granted at least 1 master's degree or 1 doctoral degree to women between 2005 and 2009 engineering schools, on average, awarded 14% of all master's and 10% of all doctoral degrees to women, with the fewest producing close to 1% at the master's and 3% at the doctoral-level, and the most producing nearly 33% at both levels. The standard deviations, or average difference between degree production rates for women in engineering schools, were also quite low for both the master's and doctoral degree-levels, at 6% and 5%, respectively. The only differences between the schools included in the initial analysis and the regression model analysis were for the standard deviation for the M.S. women group, where those in the institutional capital group reported a 1% greater standard deviation and close to 13% higher rate of master's degrees awarded to women.

Table 4. Degree production rates examined for which schools produced highest advanced degree rates for underrepresented groups.

| Variable | Mean | SD | Range | N |
|---|---|---|---|---|
| M.S. URM Degree Production Rate | .07 | .08 | .00 - .52 | 163 |
| Ph.D. URM Degree Production Rate | .05 | .06 | .01 - .47 | 75 |
| M.S. Women Degree Production Rate | .14 | .07 | .01 - .46 | 185 |
| Ph.D. Women Degree Production Rate | .10 | .05 | .03 - .33 | 126 |

Table 5. Degree production rates for schools examined in regression models.

| Variable | Mean | SD | Range | N |
|---|---|---|---|---|
| M.S. URM Degree Production Rate | .05 | .04 | .01 - .32 | 97 |
| Ph.D. URM Degree Production Rate | .04 | .02 | .01 - .09 | 63 |
| M.S. Women Degree Production Rate | .14 | .06 | .01 - .33 | 126 |
| Ph.D. Women Degree Production Rate | .10 | .05 | .03 - .33 | 109 |

An analysis of geographical pattern for the top producing engineering schools for URMs with master's and doctoral degrees revealed that the South, East, and in particular, schools in the Southeast produced the highest rates of engineering master's and doctoral degrees for URMs. Although location was not analyzed as one of the independent variables in the education production function, this finding is worth further discussion because of how it could relate to an institution's ability to attract URMs to its engineering graduate degree programs. Since HBCUs often produce higher percentages of blacks who later earn doctorate degrees in STEM fields (Burrelli & Rapaport, 2008), the location of HBCUs is one way to further examine an engineering school's advanced degree production rate for URMs. Figures 2 and 3 show that many of the top producing schools were located in or adjacent to states with HBCUs. Tables 6 and 7 also summarize URM population data for the states in which the top schools are located. Both models included schools in the highest URM populated state, California, and schools from the 36$^{th}$ most populated URM state, the District of Columbia. Although the District of Columbia ranks 36$^{th}$ in overall URM population, nearly 62% of its residents were URMs in 2009. The DC area maintained the highest URM population as a percentage of the state's population out of all of the 'top' producing schools, and schools from this district showed up in both models. Schools from the state with the lowest URM percentage out of its state population, Michigan, also showed up as top producers in both URM models.

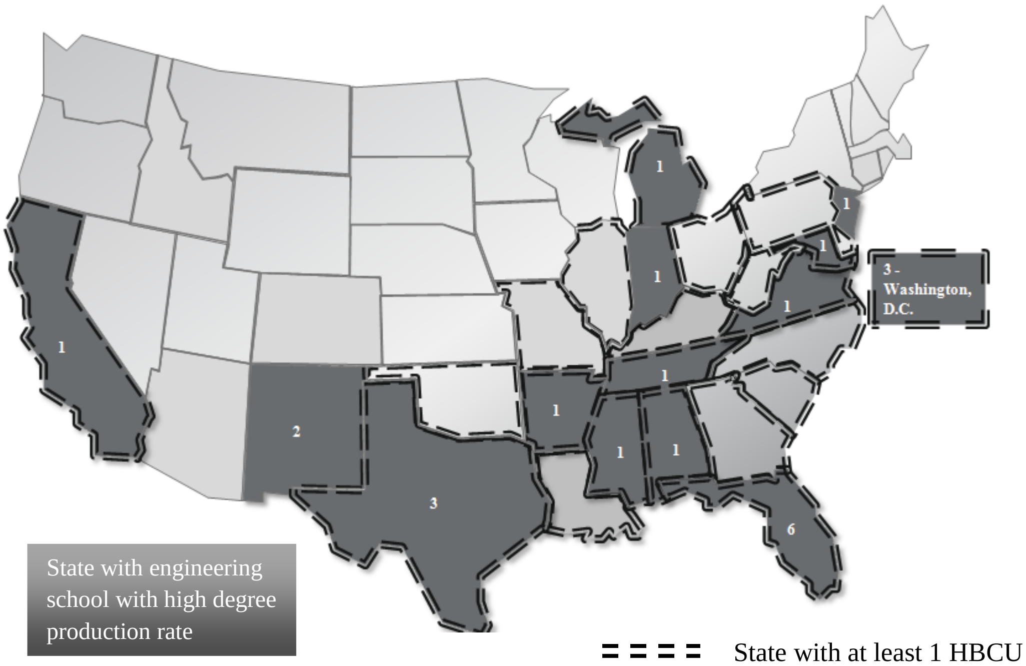


*Figure 2*. Location of Top 12 Institutions for Engineering Master's Degree Production Rate for URMs
HBCU data obtained from U.S. Department of Education's Listing of HBCUs, U.S. Department of Education, Listing of HBCUs

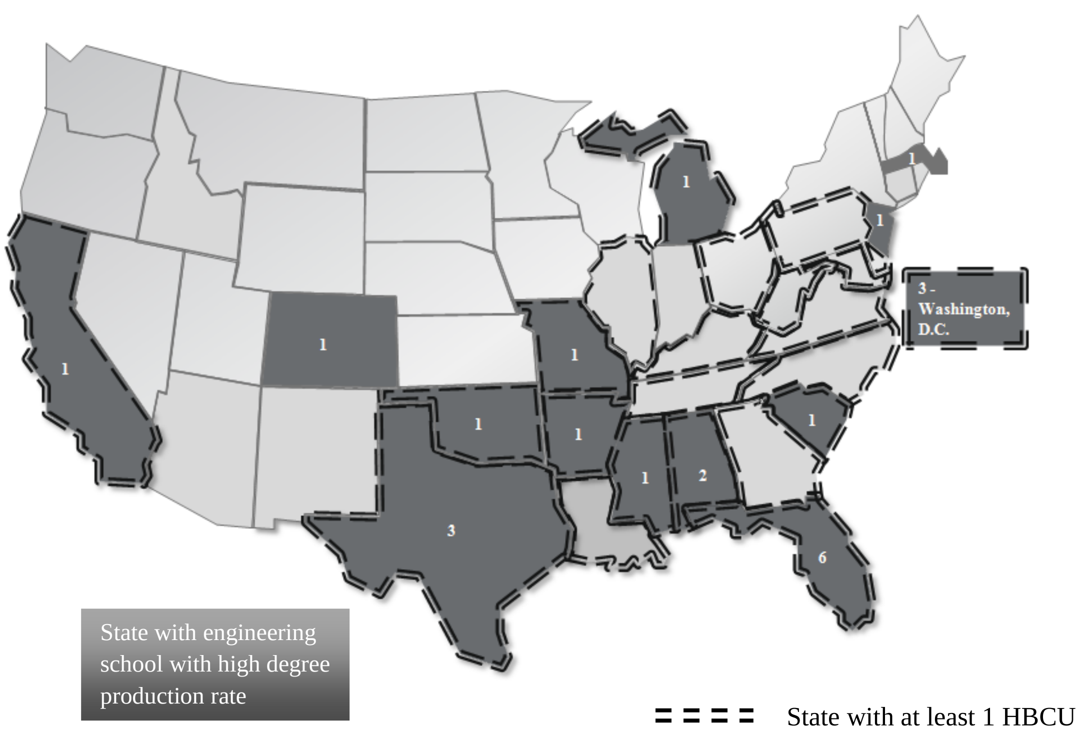


*Figure 3*. Location of Top 10 Institutions for Engineering Doctoral Degree Production Rate for URMs
HBCU data obtained from U.S. Department of Education's Listing of HBCUs, U.S. Department of Education, Listing of HBCUs

Further, many of the same schools produced the highest rates of advanced degrees at both the master's and doctoral-level for URMs. Tables 6-9 show that 11 of the 24 – or close to half – of the same schools in the 'top' groups for advanced engineering degree production rates for URMs produced the highest rates at both the master's and doctoral degree-level. Table 6 shows that nearly all of the top producing schools for master's degrees awarded a doctorate degree as the highest engineering degree offered. Tables 6 and 7 also show that top producing schools tended to enroll higher percentages of URM undergraduate students, and 11 of the top producing schools for doctorates enrolled over 10% of URMs at the master's degree-level. Tables in the appendix summarize the top schools by the remaining institutional capital variables. Although all of the top schools reported URM enrollment data, many of them contained missing data for other institutional capital variables. The institutional capital information that was reported is summarized in the tables in the appendix.

Table 6. Highest degree offered and URM state population statistics for top producing engineering schools for master's degrees for URMs.

| School | M.S. URM Degree Production Rate | Highest Engineering Degree Offered | % of URMs Enrolled at Undergrad. Level | URM State, URM Population, Overall URM Population Rank out of all U.S. States, and % URM Population in State |
|---|---|---|---|---|
| Tennessee State University | 0.52 | Doctorate | 0.84 | TN: 1,321,603 (18), 21% |
| Jackson State University | 0.46 | Master's | 0.91 | MS: 1,179,526 (20), 40% |
| Howard University | 0.46 | Doctorate | 0.74 | DC: 370,708 (36), 62% |
| University of Texas at El Paso | 0.33 | Doctorate | 0.73 | TX: 12,056,777 (2), 49% |
| Florida International University | 0.32 | Doctorate | 0.73 | FL: 6,849,789 (3), 37% |
| University of Miami | 0.32 | Doctorate | 0.35 | FL: 6,849,789 (3), 37% |
| New Mexico State University | 0.20 | Doctorate | 0.53 | NM: 1,133,951 (21), 56% |

| | | | | |
|---|---|---|---|---|
| University of California-Riverside | 0.16 | Doctorate | 0.29 | CA: 16,087,882 (1), 44% |
| Virginia Commonwealth University | 0.16 | Doctorate | 0.17 | VA: 2,129,934 (10), 27% |
| FAMU-FSU College of Engineering | 0.15 | Doctorate | 0.38 | FL: 6,849,789 (3), 37% |
| Southern Methodist University | 0.15 | Doctorate | 0.15 | TX: 12,056,777 (2), 49% |
| University of Arkansas | 0.15 | Doctorate | 0.09 | AK: 643,851 (30), 22% |
| University of South Florida | 0.15 | Doctorate | 0.24 | FL: 6,849,789 (3), 37% |
| The Catholic University of America | 0.14 | Doctorate | 0.06 | DC: 370,708 (36), 62% |
| The University of New Mexico | 0.14 | Doctorate | 0.37 | NM: 1,133,951 (21), 56% |
| Florida Atlantic University | 0.13 | Doctorate | 0.39 | FL: 6,849,789 (3), 37% |
| The George Washington University | 0.12 | Doctorate | 0.09 | DC: 370,708 (36), 62% |
| University of Central Florida | 0.12 | Doctorate | 0.22 | FL: 6,849,789 (3), 37% |
| University of Alabama at Birmingham | 0.11 | Doctorate | 0.20 | AL: 1,406,799 (17), 30% |
| Indiana University Purdue University Indianapolis | 0.11 | Doctorate | 0.11 | IN: 941,423 (24), 15% |
| Michigan State University | 0.10 | Doctorate | 0.11 | MI: 1,867,494 (13), 19% |
| New Jersey Institute of Technology | 0.10 | Doctorate | 0.28 | NJ: 2,608,709 (8), 30% |
| University of Maryland-Baltimore County | 0.10 | Doctorate | 0.16 | MD: 2,077,783 (11), 36% |
| William Marsh Rice University | 0.10 | Doctorate | 0.18 | TX: 12,056,777 (2), 49% |

Highlighted school = top producer in both URM degree production rate models
State population data obtained from 2009 U.S. Census Bureau statistics (Estimates of the Resident Population by Race…, 2010).

Table 7. URM state population statistics for top 10 producing engineering schools for doctorates for URMs.

| School | Ph.D. URM Degree Production Rate | % of URMs Enrolled at Undergrad. Level | % of URMs Enrolled at M.S. Level | URM State, URM Population, Overall URM Population Rank out of all U.S. States, and % URM Population in State |
|---|---|---|---|---|
| Howard University | 0.47 | 0.74 | 0.43 | DC: 370,708 (36), 62% |
| Florida International University | 0.19 | 0.73 | 0.42 | FL: 6,849,789 (3), 37% |

| | | | | |
|---|---|---|---|---|
| University of Texas at El Paso | 0.18 | 0.73 | 0.33 | TX: 12,056,777 (2), 49% |
| FAMU-FSU College of Engineering | 0.16 | 0.38 | 0.18 | FL: 6,849,789 (3), 37% |
| University of Alabama at Birmingham | 0.12 | 0.20 | 0.13 | AL: 1,406,799 (17), 30% |
| University of Miami | 0.09 | 0.35 | 0.25 | FL: 6,849,789 (3), 37% |
| University of South Carolina | 0.09 | 0.14 | 0.06 | SC: 1,494,316 (16), 33% |
| Wayne State University | 0.09 | 0.29 | 0.06 | MI: 1,867,494 (13), 19% |
| William Marsh Rice University | 0.08 | 0.18 | 0.06 | TX: 12,056,777 (2), 49% |
| The George Washington University | 0.07 | 0.09 | 0.13 | DC: 370,708 (36), 62% |
| The University of Alabama in Huntsville | 0.07 | 0.13 | 0.06 | AL: 1,406,799 (17), 30% |
| | | 0.24 | 0.17 | |
| University of South Florida | 0.07 | 0.14 | 0.03 | FL: 6,849,789 (3), 37% |
| Rutgers-The State University of New Jersey | 0.06 | 0.18 | 0.06 | NJ: 2,608,709 (8), 30% |
| Texas Tech University | 0.06 | 0.09 | 0.16 | TX: 12,056,777 (2), 49% |
| University of Arkansas | 0.06 | 0.06 | 0.03 | AK: 643,851 (30), 22% |
| University of Missouri | 0.06 | 0.09 | 0.07 | MO: 909,675 (26), 15% |
| Boston University | 0.05 | 0.14 | 0.08 | MA: 991,314 (23), 15% |
| George Mason University | 0.05 | 0.12 | 0.09 | VA: 2,129,934 (10), 27% |
| Mississippi State University | 0.05 | 0.13 | 0.05 | MS: 1,179,526 (20), 40% |
| Oklahoma State University | 0.05 | 0.08 | 0.05 | OK: 869,790 (27), 24% |
| University of California-Berkeley | 0.05 | 0.22 | 0.18 | CA: 16,087,882 (1), 44% |
| University of Central Florida | 0.05 | 0.08 | 0.05 | FL: 6,849,789 (3), 37% |
| University of Colorado at Boulder | 0.05 | 0.23 | 0.08 | CO: 1,253,271 (19), 25% |
| University of Florida | 0.05 | 0.74 | 0.43 | FL: 6,849,789 (3), 37% |

Highlighted school = top producer in both URM degree production rate models
State population data obtained from 2009 U.S. Census Bureau statistics (Estimates of the Resident Population by Race…, 2010).

Figures 4 and 5 show the location patterns for engineering schools that produced the highest rates of advanced degrees for women. Although the location patterns were not as pronounced for women as they were for the URM groups, many of the most productive schools were either located in the Southeast or along the coast.

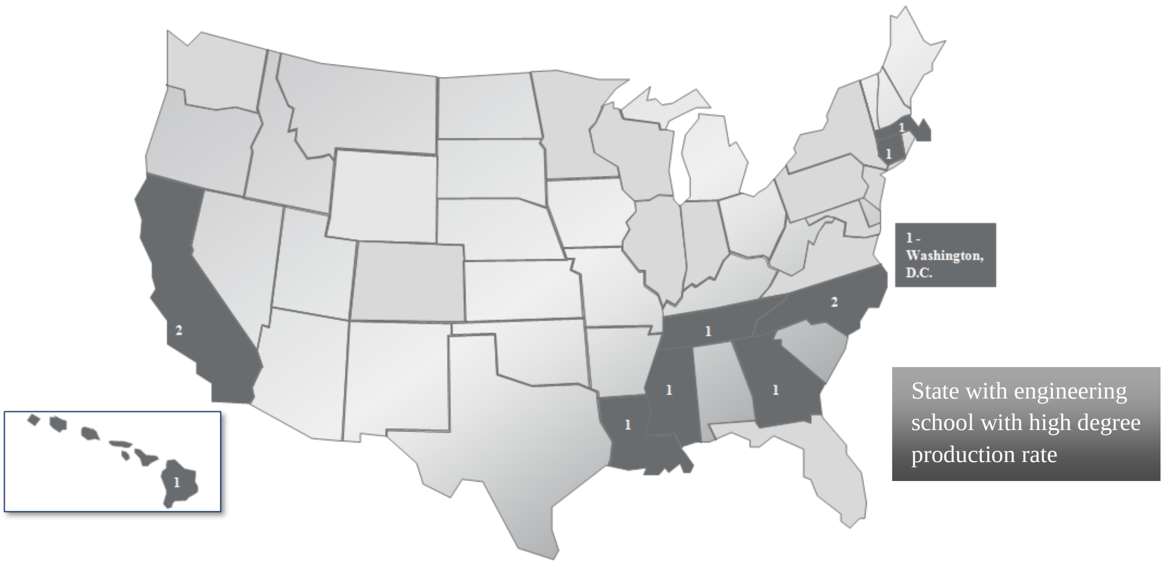


*Figure 4*. Location of Top 10 Institutions for Engineering Master's Degree Production Rate for Women

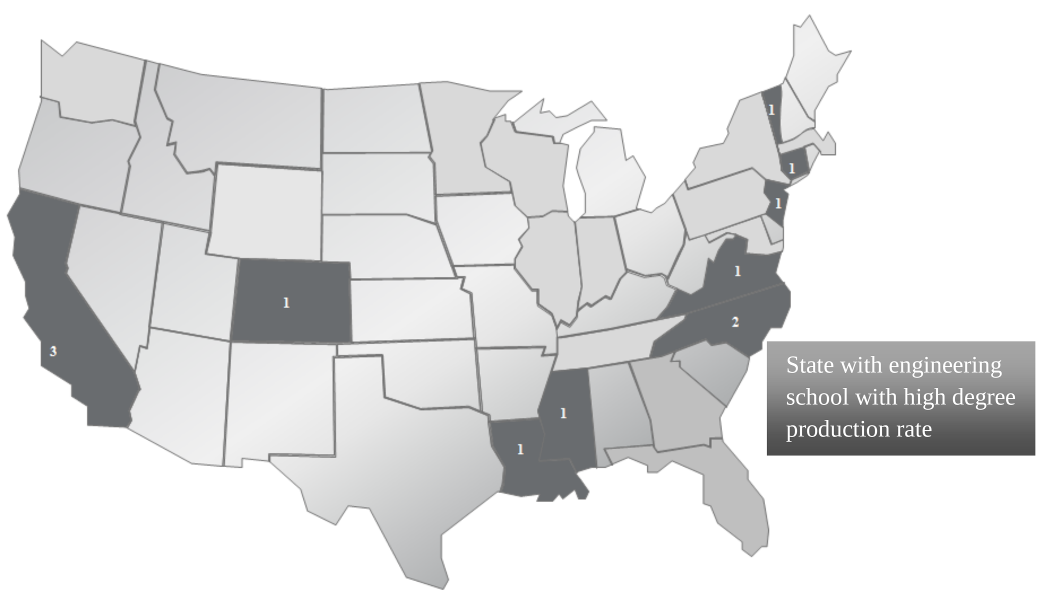


*Figure 5*. Location of Top 10 Institutions for Engineering Doctoral Degree Production Rate for Women

Similar to the URM group, many of the same schools produced the highest rates of advanced degrees at both the master's and doctoral-level for women. Tables 8 and 9 show that 5 of the 12 in the master's group and 5 of the 13 in the doctoral group – or close to 40% – of the same schools in the 'top' groups for advanced engineering degree production rates for women produced the highest rates at both the master's and doctoral degree-level. Table 8 shows that nearly all of the top schools that produced high rates of master's degrees for women awarded a doctorate degree as the highest engineering degree offered. Tables 8 and 9 also show that top producing schools tended to enroll higher percentages of women undergraduate students, and 9 of the top schools for doctorate degree rates enrolled at least 20% of women at the master's degree-level. Tables in the appendix summarize the top schools by the remaining institutional capital variables. Although most of the top schools reported enrollment data on women, many of them contained missing data for other institutional capital variables. The institutional capital information that was reported is summarized in the tables in the appendix.

Table 8. Top 10 engineering schools that produced high rates of master's degrees for women.

| School | M.S. Women Degree Production Rate | Highest Engineering Degree Offered | % of Women Enrolled at Undergrad. Level |
|---|---|---|---|
| University of North Carolina at Chapel Hill | 0.46 | Doctorate | Undergrad. degree not offered |
| Jackson State University | 0.40 | Master's | 0.25 |
| Tennessee State University | 0.35 | Doctorate | 0.24 |
| Tulane University | 0.33 | Doctorate | 0.29 |
| University of Georgia | 0.31 | Doctorate | 0.22 |
| Duke University | 0.30 | Doctorate | 0.27 |
| Yale University | 0.29 | Doctorate | 0.29 |
| The Catholic University of America | 0.28 | Doctorate | 0.17 |
| University of | 0.27 | Doctorate | 0.15 |

| | | | |
|---|---|---|---|
| California-Santa Cruz | | | |
| Tufts University | 0.25 | Doctorate | 0.27 |
| University of California-Irvine | 0.25 | Doctorate | 0.20 |
| University of Hawaii at Manoa | 0.25 | Doctorate | 0.18 |

Highlighted school = top producer in both women degree production rate models

Table 9. Top 10 engineering schools that produced high rates of doctorate degrees for women.

| School | Ph.D. Women Degree Production Rate | % of Women Enrolled at Undergrad. Level | % of Women Enrolled at M.S. Level |
|---|---|---|---|
| Duke University | 0.33 | 0.27 | 0.31 |
| University of Vermont | 0.32 | 0.15 | 0.49 |
| University of North Carolina at Chapel Hill | 0.29 | Undergrad. degree not offered | 0.45 |
| Yale University | 0.28 | 0.29 | 0.35 |
| Virginia Commonwealth University | 0.24 | 0.16 | 0.35 |
| University of California-Irvine | 0.23 | 0.20 | 0.23 |
| University of California-Riverside | 0.20 | 0.16 | 0.19 |
| Tulane University | 0.19 | 0.29 | 0.26 |
| California Institute of Technology | 0.18 | 0.25 | 0.18 |
| Colorado School of Mines | 0.18 | 0.23 | 0.31 |
| Rutgers-The State University of New Jersey | 0.17 | 0.16 | 0.20 |

Highlighted school = top producer in both women degree production rate models

***Independent Variables in the Regression Models***

The M.S. URM and Ph.D. URM degree production rate analysis in the regression models resulted in 97 and 63 engineering schools, respectively; and, the M.S. women and Ph.D. women degree production models resulted in 126 and 109 engineering schools, respectively. Tables 10 and 11 summarize the institutional capital variables for the engineering schools' master's and doctoral degree production rates for URMs and women.

Table 10 shows that a majority of the schools did not hold AAU status. Just over half of the schools in the Ph.D. URM group held AAU status, while 37%, 41%, and 45% of the schools in the M.S. URM, M.S. women, and Ph.D. women groups, respectively, held AAU status. Table 11 summarizes the economic and symbolic institutional capital variables by engineering schools' master's and doctoral degree production rates for URMs and women. Results for the economic capital variables included those for average annual research expenditures and average master's and doctoral program enrollments. Average annual research expenditures ranged quite widely, with the Ph.D. URM group reporting the highest annual averages at close to $72M, with each group reporting standard deviations of at least $44M. Schools reported average master's and doctoral program enrollments in the 400s, with the exception of the Ph.D. URM group which reported an average enrollment of close to 600 doctoral students. Standard deviations were similar for most of the groups, with each reporting average differences in the 400s. The M.S. URM group differences were slightly less at closer to 300.

Results for the symbolic capital variables included those for graduate admission yield, *USNWR* rank, average quantitative GRE score, percentage of undergraduates and master's students enrolled by respective underrepresented group, and percentage of tenured/tenure-track faculty members by underrepresented group. Table 11 shows that, on average, between 43% and 45% of students granted admission into a graduate program enrolled at that institution, with the standard deviation for each group being close to 10%. While most schools reported *USNWR* rank in the 60s, the Ph.D. URM group reported slightly higher ranks at closer to 50. Each group reported similar differences between *USNWR* ranks at close to 40 positions between ranks each. Average quantitative GRE scores were quite high, with all reporting averages in the 740s, with averages differing by around 20 points each. All schools held a rather low average for the percentage of either URMs or women among tenured/tenure-track faculty, and none of the averages exceeded 12%. None of the standard deviations for the percentages of underrepresented tenured/tenure-track faculty exceeded 5%, which means that fewer schools reported extreme differences than the averages listed in the table. Averages for the percentage of underrepresented undergraduate students were slightly higher, with the URM group reporting 11% and the women group 19%. Neither group reported more than an 8% for the standard deviation, which indicates that very few schools held extreme values for these variables. The Ph.D. women group reported even higher averages for the percentage of women enrolled at the master's-level at close to 25%. On the other hand, the URM Ph.D. group reported a lower percentage of master's URM students enrolled than undergraduates at close to 7%. Standard deviations for the percentage of underrepresented master's students enrolled for both the URM and women group were relatively low at 3% and 11%, respectively.

Table 10. Percentage distribution of engineering schools by AAU status.

| Dependent Variable Group | Independent Variable | N | Frequency | Percentage |
|---|---|---|---|---|
| M.S. URM Degree Production | *1 = AAU* | 97 | 36 | 37% |
| | *0 = Not AAU* | | | |
| Ph.D. URM Degree Production | *1 = AAU* | 75 | 34 | 54% |
| | *0 = Not AAU* | | | |
| M.S. Women Degree Production | *1 = AAU* | 126 | 51 | 41% |
| | *0 = Not AAU* | | | |
| Ph.D. Women Degree Production | *1 = AAU* | 109 | 49 | 45% |
| | *0 = Not AAU* | | | |

Table 11. Mean and standard deviations of independent variables used in regression models.

| Independent Variable Mean and (Standard Deviation) | M.S. URM Degree Production | Ph.D. URM Degree Production | M.S. Women Degree Production | Ph.D. Women Degree Production |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Average Annual Research Expenditures | $43,159,880 ($44,544,972) | $71,749,100 ($61,722,047) | $48,699,627 ($52,464,688) | $54,700,023 ($53,971,741) |
| Average M.S. Program Enrollment | 410 (289) | | 493 (452) | |
| Average PhD. Program Enrollment | | 655 (457) | | 495 (410) |
| Graduate Admission Yield | .43 (.09) | .45 (.09) | .44 (.09) | .43 (.09) |
| *USNWR* Rank | 69 (37) | 49 (35) | 68 (40) | 61 (37) |
| Average Quantitative GRE Score | 744 (20) | 749 (21) | 744 (24) | 746 (23) |
| % of URM Tenured/Tenure-Track Faculty | .05 (.03) | .05 (.02) | | |
| % of Women Tenured/Tenure-Track Faculty | | | .12 (.03) | .12 (.03) |
| % of URMs Enrolled at Undergraduate-Level | .11 (.08) | .12 (.07) | | |
| % of Women Enrolled at Undergraduate-Level | | | .19 (.05) | .19 (.05) |
| % of URMs Enrolled at the Master's-Level | | .07 (.04) | | |
| % of Women Enrolled at the Master's-Level | | | | .25 (.11) |

Together, these descriptive findings suggest that there are more similarities between each group than there are differences. That is, the engineering schools in each group in the final data set maintained similar engineering school characteristics. While tables 10 and 11 include statistics for all of the engineering schools included in the analysis of advanced degree production rates in the regression models, an examination of top schools for each group also provides a further indication of possible engineering school characteristics that could hold significance in the final regression models. The next section details the remaining four dependent variable groups and highlights the engineering schools that produced the highest rates of master's or doctoral degrees for URMs and women among those that were included in the regression model analyses.

***Descriptive Statistics for Top Engineering Schools in Regression Models that Produced Highest Rates of Advanced Degrees***

The first set of questions about which engineering schools produced the highest rates of advanced degrees for underrepresented students also guided the initial analysis of top producing schools that remained in the examination of degree rates by institutional capital characteristics. An analysis of top schools in this group was conducted to provide a general context from which to examine engineering school characteristics that could have the most potential to predict an advanced degree production rate for an underrepresented group. The following sections summarize these characteristics for the top producing engineering schools for each of the four remaining outcome variables.

*M.S. URM degree production rate.*

Table 12 summarizes an engineering school's master's degree production rate for URMs by engineering school characteristics. The table includes the top 10 engineering schools that produced master's degrees for URMs. Since many of the schools maintained the same master's degree production rate for URMs, the 'top 10' list includes a total of 18 schools. The bottom of the table compares averages for the top group with those for all schools in the M.S. URM degree production rate group. Overall, an engineering school in the top group awarded around 11% of its master’s degrees to URMs, which is close to 6% higher than the average for all schools in the M.S. URM group.

Table 12 shows that only 6 of the 18 schools, or about one-third of the schools in the top 10 list, held AAU status. This finding indicates that the highest producing institutions are less likely to emphasize doctoral education and research activity at the high level expected from an AAU school. This finding is similar to the results for all engineering schools; only 36 of the 97 schools in the main group held AAU status.

Table 12 shows that average annual research expenditures ranged from approximately $2.1M to over $131M, with the average for this group at close to $26.1M. Average master’s student class sizes ranged from a low of 22 to a high of 672, with the average for this group at close to 409. Both of these averages are considerably less than the averages for the entire M.S. URM group, with the average annual research expenditures for top producing schools reporting close to $20M less than the main group, and average M.S. program enrollment close to 100 fewer students.

Table 12 also shows that many of the prestige-related variables for top producing engineering schools for URMs with master’s degrees also ranged quite widely. The percentage of admitted students who enrolled in a graduate program ranged from a low of 31% to a high of 75%. Schools ranked in *USNWR* ranked as low as 137 and as high as 3. While this group’s highest ranked school in *USNWR*, the University of California – Berkeley, ranked among the top 10 engineering schools for the production of master’s degrees awarded to URMs, their rank on this ‘top’ list was at the bottom. In general, the top producing schools ranked lower in *USNWR*, with ranks being close to 86 compared to a rank of 69 for the overall M.S. URM group.

One component of an engineering school’s rank in *USNWR*, average quantitative GRE score, held one of the smaller differences in range for these top schools with a low of 689 and high of 776. Average quantitative GRE scores also remained about the same between the main M.S. URM group and the top group.

Although student and faculty demographic variables also varied widely from a low of 7% and high of 53% of URMs at the undergraduate-level and low of 3% and high of 20% of URM tenured/tenure-track faculty, the highest underrepresented percentages tended to generally align with the higher producing institutions. For instance, the engineering school listed second in the ‘top’ list, New Mexico State University, had the highest rate of URM undergraduate students at 53%, and one of the higher rates of URM tenured/tenure-track faculty at 14%. Overall, more schools held higher URM rates for undergraduate students than faculty, which is to be expected, given that only around 4% of all engineering doctorate degrees were awarded to URMs in 2010 (ASEE, *Engineering College Profiles and Statistics*, 2011). While the top producing schools reported around 5% lower averages for the percentage of URM tenured/tenure-track faculty than the main M.S. URM group, the top group reported close to 10% higher averages for the percentage of URM undergraduates enrolled in their engineering schools.

Table 12. Top 10 engineering schools that produced master’s degrees for URMs in regression model analysis.

| School | M.S. URM Degree Production Rate | AAU Status | Avg. Annual Research Expend. | Avg. M.S. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of URM Tenured/Tenure-Track Faculty | % of URMs Enrolled at Undergrad. Level |
|---|---|---|---|---|---|---|---|---|---|
| University of | 0.32 | Not | $3,326,809 | 106 | 0.53 | 116 | 744 | 0.08 | 0.35 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Miami | | AAU | | | | | | | |
| New Mexico State University | 0.20 | Not AAU | $37,237,692 | 318 | 0.36 | 86 | 727 | 0.14 | 0.53 |
| University of California-Riverside | 0.16 | AAU | $20,375,850 | 67 | 0.41 | 66 | 747 | 0.04 | 0.29 |
| FAMU-FSU College of Engineering | 0.15 | Not AAU | $22,232,998 | 210 | 0.31 | 102 | 736 | 0.20 | 0.38 |
| The University of New Mexico | 0.14 | Not AAU | $27,818,400 | 339 | 0.55 | 81 | 708 | 0.08 | 0.37 |
| University of Alabama at Birmingham | 0.11 | Not AAU | $8,486,095 | 184 | 0.55 | 137 | 689 | 0.05 | 0.20 |
| Indiana University Purdue University Indianapolis | 0.11 | Not AAU | $2,140,440 | 146 | 0.47 | 107 | 771 | 0.04 | 0.11 |
| University of Maryland-Baltimore County | 0.10 | Not AAU | $10,852,064 | 207 | 0.46 | 107 | 738 | 0.07 | 0.16 |
| Michigan State University | 0.10 | AAU | $31,465,000 | 201 | 0.75 | 51 | 740 | 0.04 | 0.11 |
| Tulane University | 0.09 | AAU | $4,837,371 | 22 | 0.53 | 107 | 757 | 0.03 | 0.09 |
| Old Dominion University | 0.08 | Not AAU | $19,804,676 | 524 | 0.61 | 121 | 715 | 0.11 | 0.19 |
| University of Louisville | 0.07 | Not AAU | $11,990,800 | 340 | 0.41 | 129 | 714 | 0.07 | 0.07 |
| Northwestern University | 0.07 | AAU | $41,868,428 | 510 | 0.52 | 21 | 776 | 0.06 | 0.07 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Texas Tech University | 0.07 | Not AAU | $13,357,185 | 399 | 0.35 | 99 | 730 | 0.05 | 0.18 |
| University of California-Berkeley | 0.07 | AAU | $131,379,400 | 270 | 0.49 | 3 | 776 | 0.05 | 0.08 |
| University of Illinois at Chicago | 0.07 | Not AAU | $20,833,814 | 497 | 0.38 | 66 | 738 | 0.03 | 0.21 |
| Missouri University of Science and Technology | 0.07 | Not AAU | $26,730,676 | 672 | 0.36 | 94 | 719 | 0.05 | 0.07 |
| University of Arizona | 0.07 | AAU | $35,439,816 | 411 | 0.45 | 51 | 737 | 0.05 | 0.20 |
| Top Group Averages | 0.11 | AAU: 33% | $26,120,973 | 301 | 0.47 | 86 | 737 | 0.07 | 0.20 |
| All Averages | 0.05 | AAU: 37% | $43,159,880 | 410 | 0.43 | 69 | 744 | 0.12 | 0.11 |

*Ph.D. URM degree production rate.*

Institutional characteristics for the top engineering schools that produced the highest rates of doctorates for URMs are shown in Table 13. The table includes the top 5 engineering schools that produced doctoral degrees for URMs. Since many of the schools maintained the same doctoral degree production rate for URMs, the ‘top 5’ list includes a total of 25 schools. Overall, an engineering school in the ‘top’ group awarded around 5% of its doctorate degrees to URMs, which is about 1% higher than the average rate at which all schools produced doctorates for URMs.

Table 13 shows that 12 of the top producing schools for URM doctoral degrees held AAU status, which indicates that just less than half of the highest producing institutions are likely to maintain the research funding associated with high doctoral degree productivity. Fewer of the top producing institutions held AAU status, on average, than those in the Ph.D. URM model. 34 out of 63 engineering schools in the main Ph.D. URM group held AAU status, which was close to 54% of the schools.

Average annual research expenditures ranged from around $3M to over $221M. Average doctoral student class sizes ranged from a low of 117 to a high of 2,231. Similar to the M.S. URM group, averages for the economic variables in the top Ph.D. URM group were considerably lower than that of the main Ph.D. URM group. Average annual research expenditures for top engineering schools were close to $15M less than the average for the main Ph.D. URM group. Doctoral program enrollment for engineering schools in the top group averaged close to 65 fewer students than those in the main Ph.D. URM group.

Similar to the M.S. URM group, many of the prestige-related variables for top producing engineering schools for URMs with doctoral degrees also ranged quite widely. The percentage of admitted students who enrolled in a graduate program resulted in a similar range as the M.S. URM group, with ranges from a low of 30% to a high of 75%. Averages between the top group and main Ph.D. URM group remained close to the same at around 45%.

Schools in the 'top' group held close ranks in *USNWR*, as well, although the low was slightly higher at 121 and the high remained the same as the top ranked school in the M.S. group, which was 3. The University of California – Berkeley, which held the highest *USNWR* rank in this group at 3, again showed up in the list of top schools for their doctorate degree rates awarded to URMs. In general, engineering schools with lower doctorate degree production rates in this 'top' group held higher *USNWR* ranks, although the degree production rate difference between the highest and lowest school in the list was only 4%. Overall average *USNWR* ranks for the top group reflected lower rankings, with an average close to 64 compared to 49 for all engineering schools in the main Ph.D. URM group.

The GRE ranges for this group were nearly identical to the M.S. group, with the low being 686 and the high at 780. GRE averages between the top and main Ph.D. URM group also remained about the same, with both reporting averages in the 740s.

Student and faculty demographic variables also varied widely from a low of 5% for each to a high of 35% of URMs at the undergraduate-level, 3% to 25% at the master's-level, and 2% to 14% of URM tenured/tenure-track faculty; however, the highest underrepresented percentages in this group aligned even better with their degree production rate. For instance, the top producing institution, the University of Miami, had the highest percentages of URM undergraduates and master's level students at 35% and 25%, respectively, and maintained one of the higher rates of URM tenured/tenure-track faculty at 8%. The top producing schools reported the same or very similar averages for demographic variables compared to those in the main Ph.D. URM group, with less than a 2% difference between any of the groups.

In addition to the general analysis conducted for each URM group, table 13 highlights those schools that resulted in the 'top producing' model for both the M.S. and Ph.D. groups. This analysis was conducted because the students attending an institution for a master's degree might be the same students who remain at an institution for a doctorate degree, although Lange's (2006) findings indicate that *URMs* in *STEM* tend to attend different institutions for master's and doctorate degrees. Further, in 2009, the NSF reported that nearly 70% of engineering doctorate recipients earned an engineering master's degree on the way to a doctorate (NSF, Division of Science Resources Statistics, 2010). While this study did not examine individual-level data, possible M.S.-to-Ph.D. connections could be made by comparing top producing institutions between the URM M.S. and Ph.D. groups. Only 4 of the same schools showed up as top producers in each model, or close to 16% of the same engineering schools produced high rates of master's and 22% produced high rates of doctorate degrees for URMs. The way in which this finding might relate to the conceptual framework and extant literature is further discussed in the next chapter.

Table 13. Top 5 engineering schools that produced doctoral degrees for URMs in regression model analysis.

| School | Ph.D. URM Degree Production Rate | AAU Status | Avg. Annual Research Expend. | Avg. Ph.D. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of URM Tenured/Tenure-Track Faculty | % of URMs Enrolled at Undergrad. Level | % of URMs Enrolled at M.S. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| University of Miami | 0.09 | Not AAU | $3,326,809 | 117 | 0.53 | 116 | 744 | 0.08 | 0.35 | 0.25 |
| University of South Florida | 0.07 | Not AAU | $18,818,090 | 295 | 0.42 | 119 | 698 | 0.14 | 0.24 | 0.17 |
| The George Washington University | 0.07 | Not AAU | $7,008,384 | 360 | 0.53 | 107 | 717 | 0.03 | 0.09 | 0.13 |
| The University of Alabama in Huntsville | 0.07 | Not AAU | $21,080,590 | 201 | 0.50 | 107 | 686 | 0.03 | 0.13 | 0.06 |
| University of Missouri | 0.06 | AAU | $20,160,896 | 223 | 0.44 | 86 | 737 | 0.03 | 0.06 | 0.03 |
| Rutgers-The State University of New Jersey | 0.06 | AAU | $9,564,012 | 381 | 0.49 | 51 | 752 | 0.04 | 0.14 | 0.03 |
| Texas Tech University | 0.06 | Not AAU | $13,357,185 | 235 | 0.35 | 99 | 730 | 0.05 | 0.18 | 0.06 |
| University | 0.06 | Not | $16,889,111 | 149 | 0.56 | 115 | 737 | 0.02 | 0.09 | 0.16 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| of Arkansas | | AAU | | | | | | | | |
| George Mason University | 0.05 | Not AAU | $12,872,127 | 359 | 0.46 | 121 | 698 | 0.03 | 0.14 | 0.08 |
| Boston University | 0.05 | Not AAU | $62,243,527 | 386 | 0.37 | 42 | 763 | 0.02 | 0.09 | 0.07 |
| University of Central Florida | 0.05 | Not AAU | $56,187,404 | 493 | 0.47 | 73 | 711 | 0.09 | 0.22 | 0.18 |
| Mississippi State University | 0.05 | Not AAU | $48,958,052 | 255 | 0.47 | 81 | 732 | 0.06 | 0.12 | 0.09 |
| University of California-Berkeley | 0.05 | AAU | $131,379,400 | 1461 | 0.49 | 3 | 776 | 0.05 | 0.08 | 0.05 |
| University of Colorado at Boulder | 0.05 | AAU | $57,115,893 | 530 | 0.30 | 39 | 749 | 0.05 | 0.08 | 0.05 |
| University of Florida | 0.05 | AAU | $103,640,800 | 1228 | 0.39 | 30 | 763 | 0.05 | 0.23 | 0.08 |
| Oklahoma State University | 0.05 | Not AAU | $19,703,322 | 155 | 0.39 | 102 | 738 | 0.05 | 0.13 | 0.05 |
| Georgia Institute of Technology | 0.04 | AAU | $221,578,800 | 2231 | 0.51 | 4 | 772 | 0.06 | 0.11 | 0.06 |
| Michigan State University | 0.04 | AAU | $31,465,000 | 419 | 0.75 | 51 | 740 | 0.04 | 0.11 | 0.10 |
| University of Oklahoma | 0.04 | Not AAU | $21,340,480 | 229 | 0.46 | 102 | 733 | 0.04 | 0.18 | 0.08 |
| University of Wisconsin-Madison | 0.04 | AAU | $122,929,360 | 859 | 0.55 | 15 | 780 | 0.03 | 0.05 | 0.03 |

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|---|---|---|---|---|---|---|---|---|---|---|
| University of Maryland-College Park | 0.04 | AAU | $146,301,008 | 1093 | 0.56 | 22 | 757 | 0.05 | 0.13 | 0.10 |
| University of California-Davis | 0.04 | AAU | $70,399,000 | 802 | 0.34 | 32 | 749 | 0.04 | 0.14 | 0.07 |
| The Johns Hopkins University | 0.04 | AAU | $57,793,160 | 583 | 0.37 | 25 | 766 | 0.03 | 0.09 | 0.10 |
| University of Notre Dame | 0.04 | Not AAU | $20,896,727 | 362 | 0.46 | 51 | 760 | 0.05 | 0.08 | 0.03 |
| University of Michigan | 0.04 | AAU | $154,095,887 | 1352 | 0.38 | 8 | 773 | 0.05 | 0.09 | 0.04 |
| Top Group Averages | 0.05 | AAU: 48% | $57,964,201 | 590 | 0.46 | 64 | 742 | 0.05 | 0.13 | 0.09 |
| All Group Averages | 0.04 | AAU: 54% | $71,749,100 | 655 | 0.45 | 49 | 749 | 0.05 | 0.12 | 0.07 |

Highlighted school = top producer in both URM degree production rate models

*M.S. women degree production rate.*

Table 14 summarizes an engineering school's master's degree production rate for women by engineering school characteristics. The table includes the top 10 engineering schools that produced master's degrees for women. Since many of the schools maintained the same master's degree production rate for women, the 'top 10' list includes a total of 22 schools. Overall, an engineering school in the top group awarded around 24% of its master's degrees to women, which is about 10% higher than the average rate at which all schools produced master's degrees for women.

10 of the top producing schools for master's degrees for women held AAU status. This finding suggests that just less than half of the highest producing institutions are likely to obtain the research funding levels associated with high doctoral degree production. This finding was close to the results for all engineering schools in the M.S. women group, where 51 out of the 126 schools, or close to 40%, held AAU status.

Average annual research expenditures ranged from around $1.9M to over $13M. Average master's student class sizes ranged from a low of 17 to a high of 2,108. Similar to the URM groups, averages for the economic variables in the top M.S. women group were considerably lower than that for the main M.S. women group. Average annual research expenditures for top engineering schools were close to $15M less than the average for the main M.S. women. Master's program enrollment for engineering schools in the top group averaged close to 175 fewer students than those in the main M.S. women group.

Table 14 also shows that many of the prestige-related variables for top producing engineering schools for women with master's degrees also ranged quite widely. The percentage of admitted students who enrolled in a graduate program still ranged widely, although it was much smaller than the URM groups, with a low of 35% and a high of 57%. The average for both groups, though, was nearly identical at close to 45%.

Schools also ranged similar to the top URM groups in their rank in *USNWR*, with a low of 137 and high of 3. Somewhat similar to the URM group comparisons, the average *USNWR* rank for the top engineering schools producing master's degrees for women held slightly lower ranks with an average of 70 compared to an average of 68 for the main M.S. women group. Average quantitative GRE scores between the top M.S. producing engineering schools for women and the overall group were also about the same with scores in the 740s.

Student and faculty demographic variables for this group also varied widely from a low of 13% to a high of 29% of women at the undergraduate-level to a low of 6% and a high of 21% of women tenured/tenure-track faculty, and the highest underrepresented percentages did not necessarily align with the higher producing institutions. For instance, the top producing institution, Tulane University, maintained the highest rate of women undergraduates at 29%, but they had one of the lower rates of women faculty at 8%. Likewise, the Johns Hopkins University, which ranked 9th on the list of top producing schools for engineering master's degrees for women, reported the percentage of undergraduate women at 28% and women tenured/tenure-track faculty at 12%. These patterns might reflect the overall and 'top' group averages, which held no difference in the case of the percentage of women tenured/tenure-track faculty, where both reported an average of 12%. There was also only a small difference of around 4% between the main M.S. women group and the top producing group for the percentage of undergraduate women enrolled, where the main group reported averages close to 19% and the top reported closer to 23%.

Table 14. Top 10 engineering schools that produced master's degrees for women in regression model analysis.

| School | M.S. Women Degree Production Rate | AAU Status | Avg. Annual Research Expend. | Avg. M.S. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of Women Tenured/TT Faculty | % of Women Enrolled at Undergrad. Level |
|---|---|---|---|---|---|---|---|---|---|
| Tulane University | 0.33 | AAU | $4,837,371 | 22 | 0.53 | 107 | 757 | 0.07 | 0.29 |
| University of Georgia | 0.31 | Not AAU | $4,508,174 | 24 | 0.57 | 126 | 633 | 0.06 | 0.22 |
| Duke University | 0.30 | AAU | $60,727,452 | 212 | 0.42 | 33 | 769 | 0.15 | 0.27 |
| Yale | 0.29 | AAU | $17,513,326 | 17 | 0.46 | 39 | 780 | 0.11 | 0.29 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| University | | | | | | | | | |
| University of California-Santa Cruz | 0.27 | Not AAU | $18,689,644 | 81 | 0.36 | 86 | 752 | 0.15 | 0.15 |
| University of Hawaii at Manoa | 0.25 | Not AAU | $6,598,226 | 142 | 0.46 | 137 | 746 | 0.08 | 0.18 |
| University of California-Irvine | 0.25 | AAU | $63,915,900 | 267 | 0.38 | 36 | 762 | 0.12 | 0.20 |
| Tufts University | 0.25 | Not AAU | $10,482,088 | 340 | 0.49 | 76 | 742 | 0.21 | 0.27 |
| University of Miami | 0.24 | Not AAU | $3,326,809 | 106 | 0.53 | 116 | 744 | 0.08 | 0.27 |
| Colorado School of Mines | 0.24 | Not AAU | $25,948,940 | 519 | 0.45 | 63 | 722 | 0.13 | 0.23 |
| Indiana University Purdue University Indianapolis | 0.24 | Not AAU | $2,140,440 | 146 | 0.47 | 107 | 771 | 0.19 | 0.22 |
| Marquette University | 0.23 | Not AAU | $2,500,295 | 187 | 0.35 | 126 | 737 | 0.08 | 0.19 |
| University of California-Berkeley | 0.23 | AAU | $131,379,400 | 270 | 0.49 | 3 | 776 | 0.13 | 0.21 |
| Colorado State University | 0.23 | Not AAU | $53,174,000 | 286 | 0.37 | 63 | 718 | 0.08 | 0.16 |
| The George Washington University | 0.21 | Not AAU | $7,008,383 | 897 | 0.53 | 107 | 717 | 0.17 | 0.28 |
| California Institute of | 0.21 | AAU | $70,549,248 | 65 | 0.44 | 7 | 800 | 0.13 | 0.25 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Technology | | | | | | | | | |
| Princeton University | 0.21 | AAU | $56,827,224 | 27 | 0.41 | 17 | 783 | 0.14 | 0.29 |
| Temple University | 0.21 | Not AAU | $1,879,307 | 106 | 0.44 | 137 | 725 | 0.11 | 0.13 |
| Vanderbilt University | 0.20 | AAU | $45,880,688 | 74 | 0.56 | 37 | 756 | 0.11 | 0.25 |
| University of Washington | 0.20 | AAU | $95,364,800 | 618 | 0.41 | 28 | 743 | 0.18 | 0.19 |
| The Johns Hopkins University | 0.20 | AAU | $57,793,160 | 2109 | 0.37 | 25 | 766 | 0.12 | 0.28 |
| University of Illinois at Chicago | 0.20 | Not AAU | $20,833,814 | 497 | 0.38 | 66 | 738 | 0.13 | 0.18 |
| Top Producing Averages | 0.24 | AAU: 45% | $34,630,849 | 319 | 0.45 | 70 | 747 | 0.12 | 0.23 |
| All Averages | 0.14 | AAU: 40% | $48,699,627 | 493 | 0.44 | 68 | 744 | 0.12 | 0.19 |

*Ph.D. women degree production rate.*

Engineering school characteristics for schools that produced the highest rates of doctorates for women are summarized in table 15. The table includes the top 10 engineering schools that produced doctoral degrees for women. Since many of the schools maintained the same doctoral degree production rate for women, the ‘top 10’ list includes a total of 20 schools. Overall, an engineering school in the top group awarded around 18% of its doctorate degrees to women, which is about 8% higher than the average rate at which all schools produced doctorates for women.

15 of the top producing schools for doctoral degrees for women held AAU status, which means that 75% of the highest producing institutions maintained a level of research funding likely to support doctoral education. Unlike any other group, this is the only one where this figure exceeded the average for the number of AAU schools in them main group. Only 49 out of 109, or close to 45%, of the engineering schools in the main Ph.D. women group held AAU status.

Average annual research expenditures ranged from around $2.5 million to over $240 million. Average doctoral student class sizes ranged from a low of 69 to a high of 1,597. While the averages for the main Ph.D. women group were slightly higher, the differences between the main group and top producing group were considerably less than these differences for each of the other outcome variables. Average annual research expenditures for top engineering schools were close to $5M less than the average for the main Ph.D. women; and, doctoral program enrollment for engineering schools in the top group averaged only 5 fewer students than those in the main Ph.D. women group.

Table 15 shows that many of the prestige-related variables for top producing engineering schools for women with doctorate degrees ranged quite widely, although the differences between the main and top producing group were somewhat minimal. The percentage of admitted students who enrolled in a graduate program was again smaller for this group than any of the URMs, with a low of 30% and a high of 63%. The averages between the top producing and main group were both around 45%.

While the average difference between *USNWR* ranks also varied quite widely, the difference between the average in the main group at around 60 and the top group at around 51 was quite small. Schools in the top group ranked in *USNWR* as low as 126 and as high as 1. This was also the only group where the highest ranked school in *USNWR*, the Massachusetts Institute of Technology (MIT), showed up in the top producing group. MIT's engineering doctorate degree production rate for women at 14% was the lowest among the 'top' doctorate degree producing group for women. This was also the only group where the top group held a higher average rank in *USNWR* than the main group.

Average quantitative GRE scores were also very similar between the two groups; and, the score ranges for the top Ph.D. women group were the same as that for the top M.S. women group with a low of 633 and a high of 800. Results for student and faculty demographic variables remained about the same for the main Ph.D. women and top group, with the top group averaging 1%, 5%, and 3% higher rates for the percentage of women undergraduates, women master's-level students, and women tenured/tenure-track faculty, respectively. Student and faculty demographic variables for the top group, however, varied widely from a low of 16% to a high of 39% of women at the undergraduate-level, a low of 15% and high of 53% of women at the master's-level, and a low of 7% and a high of 21% of women tenured/tenure-track faculty. Higher demographic percentages tended to generally align with higher doctorate degree productions. When schools reported lower demographic percentages within the range listed, they tended to have higher average percentages for these groups overall. For instance, Yale University's percentages for women undergraduates, master's students, and tenured/tenure-track faculty at 29%, 35%, and 11%, respectively, were among the averages reported for the top schools for these variables.

In addition to the general analysis of descriptive data, table 15 highlights those schools that resulted in the 'top producing' model for both the M.S. and Ph.D. women groups. Similar to the URM groups, this analysis was conducted because the students attending an institution for a master's degree might be the same students who remain at an institution for a doctorate degree. 11 of the same schools showed up as top producers in each model, or close to 50% of the same engineering schools produced high rates of master's and 55% produced high rates of doctorate degrees for women. The way in which this finding might relate to the conceptual framework and extant literature is further discussed in the next chapter.

Table 15. Top 10 engineering schools that produced doctoral degrees for women in institutional capital model.

| School | Ph.D. Women Degree Production Rate | AAU Status | Avg. Annual Research Expend. | Avg. Ph.D. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of Women Tenured/Tenure-Track Faculty | % of Women Enrolled at Undergrad. Level | % of Women Enrolled at M.S. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Duke University | 0.33 | AAU | $60,727,452 | 360 | 0.42 | 33 | 769 | 0.15 | 0.27 | 0.31 |
| Yale University | 0.28 | AAU | $17,513,326 | 203 | 0.46 | 39 | 780 | 0.11 | 0.29 | 0.35 |
| University of California-Irvine | 0.23 | AAU | $63,915,900 | 631 | 0.38 | 36 | 762 | 0.12 | 0.20 | 0.23 |
| University of California-Riverside | 0.20 | AAU | $20,375,850 | 303 | 0.41 | 66 | 747 | 0.08 | 0.16 | 0.19 |
| Tulane University | 0.19 | AAU | $4,837,371 | 70 | 0.53 | 107 | 757 | 0.07 | 0.29 | 0.26 |
| Colorado School of Mines | 0.18 | Not AAU | $25,948,940 | 336 | 0.45 | 63 | 722 | 0.13 | 0.23 | 0.31 |
| California Institute of Technology | 0.18 | AAU | $70,549,248 | 499 | 0.44 | 7 | 800 | 0.13 | 0.25 | 0.18 |
| Rutgers-The State University of New Jersey | 0.17 | AAU | $9,564,012 | 381 | 0.49 | 51 | 752 | 0.13 | 0.16 | 0.20 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Marquette University | 0.16 | Not AAU | $2,500,295 | 69 | 0.35 | 126 | 737 | 0.08 | 0.19 | 0.40 |
| Northwestern University | 0.16 | AAU | $41,868,428 | 711 | 0.52 | 21 | 776 | 0.10 | 0.25 | 0.34 |
| Tufts University | 0.16 | Not AAU | $10,482,088 | 164 | 0.49 | 76 | 742 | 0.21 | 0.27 | 0.32 |
| The University of Alabama in Huntsville | 0.15 | Not AAU | $21,080,590 | 201 | 0.50 | 107 | 686 | 0.16 | 0.18 | 0.53 |
| William Marsh Rice University | 0.15 | AAU | $35,619,563 | 493 | 0.51 | 33 | 768 | 0.17 | 0.31 | 0.16 |
| University of California-Berkeley | 0.15 | AAU | $131,379,400 | 1461 | 0.49 | 3 | 776 | 0.13 | 0.21 | 0.26 |
| University of Colorado at Boulder | 0.15 | AAU | $57,115,893 | 530 | 0.30 | 39 | 749 | 0.15 | 0.20 | 0.24 |
| Harvard University | 0.15 | AAU | $38,030,200 | 310 | 0.53 | 19 | 770 | 0.09 | 0.26 | 0.22 |
| The George Washington University | 0.15 | Not AAU | $7,008,384 | 360 | 0.53 | 107 | 717 | 0.17 | 0.28 | 0.38 |
| The University of Iowa | 0.14 | AAU | $34,690,917 | 283 | 0.44 | 59 | 732 | 0.10 | 0.18 | 0.17 |
| Massachusetts Institute of Technology | 0.14 | AAU | $241,469,800 | 1597 | 0.63 | 1 | 780 | 0.14 | 0.39 | 0.15 |
| University of Washington | 0.14 | AAU | $95,364,800 | 847 | 0.41 | 28 | 743 | 0.18 | 0.19 | 0.39 |
| Top Producing Averages | 0.18 | AAU: 75% | $49,502,123 | 490 | 0.46 | 51 | 753 | 0.13 | 0.24 | 0.28 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| All Averages | 0.10 | AAU:$54,700,023 45% | 495 | 0.43 | 61 | 746 | 0.12 | | 0.19 | 0.25 |

Highlighted school = top producer in both women degree production rate models

*Summary of descriptive statistics of engineering schools in the regression models that produced highest advanced degree production rates.*

The descriptive analyses provided an overview of engineering school characteristics that comprised the study's dependent degree production rate variables. The initial analysis of which schools produced the highest advanced degree rates for underrepresented groups showed that engineering schools in the South and Southeast produced higher rates of advanced degrees for URMs and women, although patterns for URMs were much more pronounced than for women. Additional analyses showed that many of the same schools that produced high rates of advanced degrees for URMs were located in or adjacent to states with HBCUs, as well as in states that maintained high percentages of URMs in the general population. Further, nearly all of the schools in the URM and women groups granted a doctorate as the highest engineering degree awarded and enrolled higher rates of underrepresented students and enrolled higher percentages of students from their respective underrepresented groups at the undergraduate and master's degree-level.

The descriptive analysis of engineering schools that remained in the regression models revealed similar engineering school characteristics across groups. A further examination of engineering schools that produced the highest rates of advanced degrees, however, showed some differences between engineering school characteristics for the top schools compared to those in the overall group.  Tables 16-19 summarize these differences.

Close to 75% of the engineering schools in the top producing group for doctorates for women held AAU status, which was around 30% more than the schools in the main group.

Around 5% more schools in the top group for master's degree production for women also held AAU status than the main group. Both URM groups reported fewer AAU schools in the top producing group than in their main groups.

The top producing group in each of the models consistently reported lower averages for annual research expenditures and graduate program enrollment. Table 19 shows that the Ph.D. women group resulted in the smallest average differences among all of the top and main group examinations.

The top producing groups also consistently reported lower average *USNWR* ranks compared to the overall group being analyzed, except for the Ph.D. women group, where top schools reported an average of 9 ranks higher than the main group. Comparisons of graduate admission yield and average quantitative GRE scores also showed several similarities between the top schools and overall groups, with most reporting similar figures for both.  A majority of the engineering schools also reported comparable percentages for demographic variables, although the top producing schools tended to report slightly higher rates. Table 16 shows that the M.S. URM group held the only exception, where the top schools reported lower rates of URM tenured/tenure-track faculty members. The top M.S. URM group, however, was the only top group to report close to a 10% higher rate of URM undergraduates enrolled at their engineering schools compared to the main M.S. URM group.

Table 16. Differences between M.S. URM outcome variables overall and by engineering schools with highest degree production rates.

| Group | M.S. URM Degree Production Rate | AAU Status | Avg. Annual Research Expend. | Avg. M.S. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of URM Tenured/Tenure-Track Faculty | % of URMs Enrolled at Undergrad. Level |
|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Top Group Averages | 0.11 | AAU: 33% | $26,120,973 | 301 | 0.47 | 86 | 737 | 0.07 | 0.20 |
| All Averages | 0.05 | AAU: 37% | $43,159,880 | 410 | 0.43 | 69 | 744 | 0.12 | 0.11 |
| Difference | 0.06 | -4% | -$17,038,907 | -109 | 0.04 | -17 | -8 | -0.05 | 0.09 |

Table 17. Differences between Ph.D. URM outcome variables overall and by engineering schools with highest degree production rates.

| Group | Ph.D. URM Degree Production Rate | AAU Status | Avg. Annual Research Expend. | Avg. Ph.D. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of URM Tenured/TT Faculty | % of URMs Enrolled at Undergrad. Level | % of URMs Enrolled at M.S. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Top Group Averages | 0.05 | AAU: 48% | $57,964,201 | 590 | 0.46 | 64 | 742 | 0.05 | 0.13 | 0.09 |
| Top Group Averages | 0.05 | AAU: 48% | $57,964,201 | 590 | 0.46 | 64 | 742 | 0.05 | 0.13 | 0.09 |
| All Group Averages | 0.04 | AAU: 54% | $71,749,100 | 655 | 0.45 | 49 | 749 | 0.05 | 0.12 | 0.07 |

Table 18. Differences between M.S. women outcome variables overall and by engineering schools with highest degree production rates.

| Group | M.S. Women Degree Production Rate | AAU Status | Avg. Annual Research Expend. | Avg. M.S. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of Women Tenured/Tenure-Track Faculty | % of Women Enrolled at Undergrad. Level |
|---|---|---|---|---|---|---|---|---|---|
| Top Producing Averages | 0.24 | AAU: 45% | $34,630,849 | 319 | 0.45 | 70 | 747 | 0.12 | 0.23 |
| All Averages | 0.14 | AAU: 40% | $48,699,627 | 493 | 0.44 | 68 | 744 | 0.12 | 0.19 |
| Difference | 0.10 | 5% | -$14,068,777 | -174 | 0.01 | -2 | 3 | 0.00 | 0.04 |

Table 19. Differences between Ph.D. women outcome variables overall and by engineering schools with highest degree production rates.

| School | Ph.D. Women | AAU Status | Avg. Annual Research | Avg. Ph.D. | Graduate Admit | *USNWR* Rank | Avg. Quant. | % of Women Tenured/Tenure- | % of Women | % of Women |
|---|---|---|---|---|---|---|---|---|---|---|

| | Degree Production Rate | | Expend. | Student Class Size | Yield | | GRE Score | Track Faculty | Enrolled at Undergrad. Level | Enrolled at M.S. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Top Producing Averages | 0.18 | AAU: 75% | $49,502,123 | 490 | 0.46 | 51 | 753 | 0.13 | 0.24 | 0.28 |
| All Averages | 0.10 | AAU: 45% | $54,700,023 | 495 | 0.43 | 61 | 746 | 0.12 | 0.19 | 0.25 |
| Difference | 0.08 | 30% | -$5,197,900 | -4 | 0.03 | 10 | 7 | 0.01 | 0.05 | 0.03 |

A summary of the descriptive variables provides a general overview of the engineering school characteristics that might hold predictive power in a regression model. The next section summarizes engineering school characteristics for their power to predict graduate degree production rates for women and URMs.

## Engineering School Characteristics that Predict Advanced Degree Production Rates for Underrepresented Groups

Four separate multiple regression analyses were conducted to determine if the cultural, economic, or symbolic capital variables of the engineering schools related to the degree production rates at the master's or doctoral-level for URMs and women in engineering. In order to address potential problems with multicollinearity, or linear relationships between independent variables, correlation matrices, tolerance correlations, and a variance inflation factor (VIF) were used to examine relationships between independent variables. Salkind (2003) indicates that strongly correlated variables – those with close to a .80 correlation or higher – have high collinearity and should be excluded from a regression analysis. Just the opposite, this figure should not reach close to 0 for tolerance correlations (Belsley, Kuh, & Welch, 1980; Miles & Shevlin, 2006). Finally, VIF values were also analyzed for collinearity. VIF values, in general, should not be greater than 10. The VIF and tolerance levels are reported in the regression tables, below.

***Engineering School Characteristics that Predict Master's Degree Production Rate for URMs***

A multiple regression was conducted to determine if certain institutional capital characteristics predicted the production rate of URM M.S. graduates in engineering. After removing institutions with missing variables, the final data set size for the regression model included 97 institutions. Table 20 summarizes the correlations between each variable. Salkind (2003) indicates that .80 or greater correlations are considered very strong correlations. The *USNWR* variable held a correlation of -.808 with average annual research expenditures and -.637 with AAU status. Since these correlations indicate that the variable might cause multicollinearity, and because the *USNWR* variable was comprised of many of the variables it held correlations with, it was removed from the final regression model.

Table 20. Zero order correlation matrix: regression model variables for M.S. URM degree production rate.

| Variable | M.S. URM Degree Production Rate | *USNWR* Rank | Average Quant. GRE | Admitted Graduate Yield % | AAU Status | Undergrad. URM Enroll % | M.S. Enroll Average | Tenured/ Tenure-Track URM Faculty % |
|---|---|---|---|---|---|---|---|---|
| *USNWR* Rank | .139 | | | | | | | |
| Average Quant. | -.113 | -.691** | | | | | | |
| Admitted Graduate Yield % | .153 | -.176 | .091 | | | | | |
| AAU Status | -.075 | -.637** | .492** | .151 | | | | |
| Undergrad URM Enroll % | .598** | .176 | -.217* | -.091 | -.190 | | | |
| M.S. Enroll Average | -.218* | -.169 | -.094 | -.257* | -.018 | -.027 | | |
| Tenured/TT URM Faculty % | .341** | -.040 | -.122 | .038 | .001 | .379** | .011 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Avg. Annual Research Expend. | -.223* | -.808** | .443** | .043 | .507** | -.185 | .379** | .051 |

*p < .05. **p <. 01

Table 21 shows that the regression model was significant, with an $R^2$ of .45, which indicates that the variables significantly predicted 45% of the variance in the model. All of the tolerance statistics were above 0, while the VIF statistics did not approach 10. Two variables – graduate admission yield and undergraduate URM enrollment – resulted in significant values. Engineering schools were more likely to grant higher percentages of master's degrees to URMs when higher percentages of URMs were enrolled at the undergraduate-level in engineering. That is, a 1% increase in the percentage of URMs enrolled at the undergraduate-level in an engineering school increases the percentage of master's degrees that school awards to URMs by the Beta coefficient, .55%. Engineering schools were also more likely to graduate higher percentages of URMs with master's degrees when they maintained higher graduate admission yields, where 'yield' referred to the percentage of students who enrolled in a graduate program after being admitted. That is, a 1% increase in the percentage of graduate students who enrolled in a program upon being admitted increases the percentage of master's degrees that school awards to URMs by the Beta coefficient, .17%. The percentage of URM undergraduates enrolled in an engineering school was the best predictor of an engineering school's master's degree production rate for URMs, as this symbolic capital variable resulted in a .000 significance-level.

Table 21. Regression model for M.S. URM degree production rate.

| Variable | Beta | Sig. | Tolerance | VIF |
|---|---|---|---|---|
| (Constant) | | .983 | | |
| Average Quantitative GRE | .031 | .756 | .641 | 1.560 |
| Admitted Graduate Yield % | .165 | .051* | .896 | 1.116 |
| AAU Status | .057 | .572 | .626 | 1.597 |
| Undergrad URM Enroll % | .549 | .000** | .795 | 1.258 |

| | | | | |
|---|---|---|---|---|
| M.S. Enroll Average | -.106 | .266 | .692 | 1.445 |
| Tenured/TT URM Faculty % | .138 | .115 | .822 | 1.217 |
| Average Total Expenditures | -.138 | .217 | .507 | 1.971 |

Note: $R^2$ = .45
*p < .05. **p <. 01

***Engineering School Characteristics that Predict Doctorate Degree Production Rate for URMs***

A multiple regression was conducted to determine if certain engineering school characteristics predicted the production rate of URM doctoral graduates in engineering. After removing institutions with missing variables plus 2 engineering schools identified as outliers because of z-scores over 3 and doctoral degree production rates for URMs over 11%, the final data set size for the regression model included 63 institutions. The *USNWR* variable held an even stronger correlation with several variables in this model, which included a -.864, -.839, -.725, and -.648 correlation with  average doctoral enrollment, average annual research expenditures, average quantitative GRE score, and AAU status, respectively. Since these correlations indicate that the variable might cause collinearity issues as discussed earlier, it was removed from the final regression model.  While the average number of doctoral students enrolled and an engineering school and average total expenditures also held a strong correlation of .876, these variables were kept in the model because they are essential in examining an engineering school's economic capital. It is recognized that this high correlation is a limitation of the model and that any significant results for these variables should be interpreted in light of this limitation.

Table 22. Zero order correlation matrix: regression model variables for Ph.D. URM degree production rate.

| Variable | Ph.D. URM Degree Production | *USNWR* Rank | Average Quant. GRE | Admitted Graduate Yield % | AAU Status | Undergrad. URM Enroll % | M.S. URM Enroll % | Doctoral Enroll Average | Tenured/ Tenure-Track URM Faculty % |
|---|---|---|---|---|---|---|---|---|---|
| *USNWR* Rank | .378** | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Average Quant. GRE | -.460$^{**}$ | -.725$^{**}$ | | | | | | | |
| Admitted Graduate Yield % | .129 | -.232 | .031 | | | | | | |
| AAU Status | -.275$^{*}$ | -.648$^{**}$ | .593$^{**}$ | .094 | | | | | |
| Undergrad. URM Enroll % | .331$^{**}$ | .036 | -.251$^{*}$ | .151 | -.197 | | | | |
| M.S. URM Enroll % | .495$^{**}$ | .201 | -.365$^{**}$ | .252$^{*}$ | -.185 | .625$^{**}$ | | | |
| Doctoral Enroll | -.461$^{**}$ | -.864$^{**}$ | .643$^{**}$ | .131 | .609$^{**}$ | -.088 | -.211 | | |
| Average Tenured/TT URM Faculty % | .203 | -.191 | -.015 | .139 | .011 | .371$^{**}$ | .265$^{*}$ | .227 | |
| Avg. Annual Research Expend. | -.534$^{**}$ | -.839$^{**}$ | .607$^{**}$ | .074 | .598$^{**}$ | -.160 | -.231 | .876$^{**}$ | .163 |

*p < .05. **p <. 01

Table 23 shows that the model was significant, with an $R^2$ of .49, which indicates that the variables in the model predicted 49% of the variance. Although all of the tolerance values were above 0 and VIF values were less than 10, the tolerance and VIF values for doctoral enrollment average and average annual research expenditures were closer to the limits with .191 and .219 tolerance and 5.25 and 4.56 VIF values, respectively. Two variables – URM M.S. enrollment and average annual research expenditures – resulted in significant values. Engineering schools were more likely to grant higher rates of doctoral degrees in engineering to URMs when they enrolled a higher percentage of URMs at the master's-level. A 1% increase in the percentage of URMs enrolled at the master's-level in an engineering school increases the percentage of doctoral degrees that school awards to URMs by the Beta coefficient, .30%. Engineering schools were also more likely to grant higher rates of doctorate degrees to URMs when they reported lower annual average research expenditures. A 1% increase in average annual research expenditures in an engineering school decreases the percentage of doctoral degrees that school awards to URMs by the Beta coefficient, .49%. An engineering school's annual average research expenditures was the best predictor of an engineering school's doctoral degree production rate for URMs, as this economic capital variable resulted in a .024 significance-level, which was just slightly higher than the .029 level that resulted from the percentage of URM engineering master's students enrolled.

Table 23. Regression model for doctoral URM degree production rate.

| Variable | Beta | Sig. | Tolerance | VIF |
|---|---|---|---|---|
| (Constant) | | .179 | | |
| Average Quantitative GRE | -.126 | .381 | .470 | 2.125 |
| Admitted Graduate Yield % | .058 | .575 | .894 | 1.118 |
| AAU Status | .161 | .233 | .533 | 1.876 |
| Undergraduate URM Enroll % | -.027 | .837 | .544 | 1.837 |
| M.S. URM Enroll % | .303 | .029* | .519 | 1.926 |
| Doctoral Enroll Average | -.048 | .830 | .191 | 5.248 |
| Tenured/TT URM Faculty % | .211 | .063 | .770 | 1.299 |
| Average Total Expenditures | -.485 | .024* | .219 | 4.558 |

Note: $R^2$ = .49
*p < .05. **p <. 01

As discussed in the descriptive findings, a higher percentage of URM Ph.D. students might earn degrees from institutions with higher percentages of URM M.S. students, because the master's students could be the same group of students continuing on to the doctorate degree program. Another way to examine this relationship is to determine if there is a correlation between the outcome variables for the M.S. and Ph.D. URM group. Table 24 shows that the M.S. and Ph.D. URM degree production variables were significantly correlated, although they did not approach the .80 level at which variables are considered to be strongly correlated. Thus, while it is likely that higher master's URM degree rates in an engineering school are related to higher doctoral URM degree rates in that engineering school, the level of correlation for these groups in this study showed that this might only partially explain this relationship.

Table 24. Zero order correlation matrix: M.S. URM degree production rate and Ph.D. URM degree production rate variables.

| Variable | Ph.D. URM Degree Production |
|---|---|
| M.S. URM Degree Production | .544** |

*p < .05. **p <. 01

*Summary of findings for engineering school characteristics that predict advanced degree production rates for URMs.*

Table 25 summarizes the $R^2$ values and significant predictors for the URM degree models. Neither of the models resulted in the same significant predictor variables. While engineering schools produced higher rates of master's degrees for URMs when they enrolled higher percentage of URM undergraduates and maintained higher graduate admission yields, schools awarded the highest rates of doctorates for URMs when they enrolled higher percentages of URMs at the master's degree-level and reported lower average annual research expenditures. The $R^2$ values for the URM models were close, with the Ph.D. URM degree production rate model predicting a slightly higher rate of variance at around 49%.

Table 25. Model summary of $R^2$ values and significant variables for URM graduate degree production rate models.

| Model | $R^2$ |
|---|---|
| M.S. URM Degree Production Rate (no location variables) | .447 |
| * *Admitted Graduate Yield % (Beta .165, Sig .051*)* | |
| **Undergraduate URM Enroll % (Beta .549, Sig .000**)* | |
| | |
| Ph.D. URM Degree Production Rate (no location variables) | .486 |
| * *M.S. URM Enroll % (Beta .303, Sig .029**)* | |
| * Average Total Expenditures *(Beta -.485, Sig .024**)* | |

***Engineering School Characteristics that Predict Master's Degree Production Rate for Women***

A multiple regression was conducted to determine if certain engineering school characteristics predicted the production rate of women M.S. graduates in engineering. After removing institutions with missing variables, the final data set size for the regression model included 126 institutions. Table 26 shows that the *USNWR* variable held a strong correlation with several variables in this model, which included correlations of -.813, -.678, and -.657 with average annual research expenditures, AAU status, and average quantitative GRE score, respectively. Since these correlations indicate that the variable might cause collinearity issues as discussed earlier, it was removed from the final regression model.

Table 26. Zero order correlation matrix: regression model variables for M.S. women degree production rate.

| Variable | M.S. Women Degree Production | *USNWR* Rank | Avg. Quant. GRE | Admitted Graduate Yield % | AAU Status | Undergrad. Women Enroll % | M.S. Enroll Average | Tenured/ Tenure-Track Women Faculty % |
|---|---|---|---|---|---|---|---|---|
| *USNWR* Rank | -.092 | | | | | | | |
| Avg. Quant. GRE | .073 | -.657** | | | | | | |
| Admitted Graduate Yield % | .213* | -.190* | -.010 | | | | | |
| AAU Status | .203* | -.678** | .564** | .134 | | | | |
| Undergrad Women Enroll % | .507** | -.470** | .347** | .181* | .429** | | | |
| M.S. Enroll Average | -.414** | -.315** | .060 | -.147 | .083 | -.090 | | |
| Tenured/TT Women Faculty % | .137 | -.157 | .114 | -.184* | .120 | .175* | .075 | |
| Avg. Annual Research Expend. | -.120 | -.813** | .507** | .039 | .585** | .212* | .428** | .133 |

*p < .05. **p <. 01

Table 27 shows that the model was significant, with an $R^2$ of .43, which means that the variables predicted 43% of the variance in the model. All of the variables were within the recommended range for tolerance and VIF values. Three variables – undergraduate women enrollment, master's program class size, and the percentage of women tenured/tenure-track faculty members – resulted in significant values. Engineering schools were more likely to award higher rates of master's degrees to women when they enrolled higher percentages of women at the undergraduate-level, enrolled smaller M.S. cohorts, and employed higher rates of women tenured/tenure-track faculty. A 1% increase in the percentage of women enrolled at the undergraduate-level in an engineering school increases the percentage of master's degrees that school awards to women by the Beta coefficient, .43%. An average of 1 more master's student in an enrollment class decreases the percentage of master's degrees that school awards to women by the Beta coefficient, -.30%. The percentage of undergraduate women enrolled in an engineering school and the average master's student class size were the best predictors, and each resulted in a .000 significance level. The significance level for the percentage of women tenured/tenure-track faculty was slightly higher at .025, where a 1% increase in the percentage of women tenured/tenure-track faculty members an engineering school increases the percentage of master's degrees that school awards to women by the Beta coefficient, .17%.

Table 27. Regression model for M.S. women degree production rate.

| Variable | Beta | Sig. | Tolerance | VIF |
|---|---|---|---|---|
| (Constant) | | .127 | | |
| Average Quantitative GRE | -.088 | .325 | .599 | 1.671 |
| Admitted Graduate Yield % | .089 | .221 | .910 | 1.098 |
| AAU Status | .115 | .246 | .486 | 2.056 |
| Undergrad Women Enroll % | .428 | .000** | .743 | 1.346 |
| M.S. Enroll Average | -.297 | .000** | .726 | 1.377 |
| Tenured/TT Women Faculty % | .165 | .025* | .894 | 1.119 |

| | | | | |
|---|---|---|---|---|
| Average Total Expenditures | -.106 | .299 | .462 | 2.163 |

Note: $R^2$ = .44
*p < .05. **p <. 01

***Engineering School Characteristics that Predict Doctorate Degree Production Rate for Women***

A multiple regression was conducted to determine if certain engineering school characteristics predicted the production rate of women doctoral graduates in engineering. After removing institutions with missing variables, the final data set size for the regression model included 109 institutions. Table 28 shows that the *USNWR* variable held a strong correlation with several variables in this model, which included correlations of -.823, -.806, -.706, and -.665 with average doctoral enrollment, average annual research expenditures, average quantitative GRE score, and AAU status, respectively. Since these correlations indicate that the variable might cause collinearity issues as discussed earlier, it was removed from the final regression model. While the average number of doctoral students enrolled and an engineering school and average total expenditures also held a strong correlation of .864, these variables were kept in the model because they are essential in examining an engineering school's economic capital. It is recognized that this high correlation is a limitation of the model and that any significant results for these variables should be interpreted in light of this limitation.

Table 28. Zero order correlation matrix: regression model variables for Ph.D. women degree production rate.

| Variable | Ph.D. Women Degree Production | *USNWR* Rank | Avg. Quant. GRE | Admitted Graduate Yield % | AAU Status | Undergrad. Women Enroll % | M.S. Women Enroll % | Doctoral Enroll Average | Tenured/ Tenure-Track Women Faculty % |
|---|---|---|---|---|---|---|---|---|---|
| *USNWR* Rank | -.149 | | | | | | | | |
| Avg. Quant. GRE | .185 | -.706** | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Admitted Graduate Yield % | .131 | -.243* | .077 | | | | | | |
| AAU Status | .333** | -.665** | .607** | .195* | | | | | |
| Undergrad. Women Enroll % | .505** | -.434** | .403** | .243* | .383** | | | | |
| M.S. Women Enroll % | .283** | .187 | -.203* | .166 | -.172 | .170 | | | |
| Doctoral Enroll Average | -.021 | -.823** | .540** | .157 | .583** | .171 | -.150 | | |
| Tenured/TT Women Faculty % | .243* | -.185 | .086 | -.003 | .094 | .111 | .163 | .188 | |
| Avg. Annual Research Expend. | -.019 | -.806** | .524** | .100 | .572** | .135 | -.206* | .864** | .156 |

*p < .05. **p <. 01

Table 29 shows that the model was significant, with an $R^2$ of .40, which indicates that the variables predicted 40% of the variance in the model. While all of the tolerance values were above 0 and VIF values were less than 10, the tolerance and VIF values for doctoral enrollment average and average annual research expenditures were closer to the limits with .225 and .238 tolerance and 4.45 and 4.20 VIF values, respectively. Four variables – AAU status, undergraduate women enrolled, master’s women enrolled, and tenured/tenure-track women faculty – resulted in significant values. Engineering schools were more likely to award doctoral degrees to women when they held AAU status, maintained higher percentages of women enrolled at the undergraduate and master’s degree-levels, and employed higher percentages of tenured/tenure-track women in engineering schools.

The indication of AAU status in an engineering school increased the percentage of doctorate degrees that engineering school awarded to women by the Beta coefficient, .42%. A

1% increase in the percentage of women enrolled at the undergraduate-level in an engineering school increases the percentage of doctoral degrees that school awards to women by the Beta coefficient, .37%. AAU status and the percentage of undergraduate women enrolled in an engineering school were the best predictors of an engineering school's doctorate degree production rate for women, with both resulting in a .000 significance-level. The percentage of women enrolled at the master's level and percentage of women tenured/tenure-track faculty members also held significance, although slightly lower at .026 and .018, respectively. A 1% increase in the percentage of women enrolled at the master's degree-level in an engineering school increases the percentage of doctoral degrees that school awards to women by the Beta coefficient, .20%. A 1% increase in the percentage of tenured/tenure-track women faculty members in an engineering school increases the percentage of doctoral degrees that school awards to women by the Beta coefficient, .20%.

Table 29. Regression model for doctoral women degree production rate.

| Variable | Beta | Sig. | Tolerance | VIF |
|---|---|---|---|---|
| (Constant) | | .204 | | |
| Average Quantitative GRE | -.093 | .394 | .513 | 1.949 |
| Admitted Graduate Yield % | -.009 | .918 | .880 | 1.136 |
| AAU Status | .416 | .000** | .491 | 2.036 |
| Undergraduate Women Enroll % | .373 | .000** | .720 | 1.388 |
| M.S. Women Enroll % | .196 | .026* | .811 | 1.233 |
| Doctoral Enroll Average | -.167 | .313 | .225 | 4.446 |
| Tenured/TT Women Faculty % | .197 | .018* | .921 | 1.085 |
| Average Total Expenditures | -.113 | .481 | .238 | 4.199 |

Note: $R^2$ = .40
*p < .05. **p <. 01

As discussed throughout this study, a higher percentage of women Ph.D. students might earn degrees from institutions with higher percentages of women M.S. students, because the master's students could be the same group of students continuing on to the doctorate degree program. Thus, correlations between the outcome variables for the women group were also examined to determine if the variables significantly related to one another. Table 30 shows that the M.S. and Ph.D. women degree production variables were significantly correlated, although they did not approach the .80 level at which variables are considered to be highly correlated. This correlation was also less than the correlation for the URM group, which held a .544 correlation. Therefore, while it is likely that an engineering school's master's degree rates for women are related to higher doctoral degree rates for women in that engineering school, the level of correlation for these groups in this study showed that this might only moderately explain this relationship.

Table 30. Zero order correlation matrix: M.S. women degree production rate and Ph.D. women degree production rate variables.

| Variable | Ph.D. Women Degree Production |
|---|---|
| M.S. Women Degree Production | .315** |

*p < .05. **p <. 01

*Summary of findings for engineering school characteristics that predict advanced degree rate for women.*

Table 31 summarizes the $R^2$ values and significant predictors for the women degree models. Unlike the URM group regression model comparisons, the women group resulted in two common significant predictor variables, which included the percentage of undergraduate women enrolled in an engineering school and percentage of women tenured/tenure-track faculty members. Engineering schools also produced higher rates of master's degrees for women when they enrolled smaller average master's program cohorts and higher rates of doctorates for women when they held AAU status and enrolled higher percentages of women at the master's-level.

The $R^2$ values for the women regression models were close, with the M.S. women degree production rate model predicting around 4% more variance than the M.S. model.

Table 31. Model summary of $R^2$ values and significant variables for women graduate degree production rate models.

| Model | $R^2$ |
|---|---|
| M.S. Women Degree Production Rate | .441 |
| ** Undergraduate Women Enroll % (Beta .428, Sig .000**)* | |
| **M.S. Enroll Average (Beta .-.297, Sig .000**)* | |
| **Tenured/TT Women Faculty % (Beta .164, Sig .025*)* | |
| | |
| Ph.D. Women Degree Production Rate | .400 |
| ** AAU Status (Beta .416, Sig .000**)* | |
| **Undergraduate Women Enroll % (Beta .373, Sig .000**)* | |
| ** M.S. Women Enroll % (Beta .196, Sig .026*)* | |
| **Tenured/TT Women Faculty % (Beta .197, Sig .018**)* | |

*Summary of regression model findings.*

The regression models revealed that a combination of engineering school characteristics predicted advanced engineering degree rates for URMs and women in this study. While Tables 32 and 33 show that none of the models resulted in the exact same significant predictors of institutional capital, all of the models resulted in significant demographic-related predictors. Both models for advanced degree production rates for women held significant predictors for the percentage of women undergraduates enrolled and percentages of women tenured/tenure-track faculty members. The M.S. URM and women models also both held significance for the percentage of undergraduates from their respective underrepresented group enrolled in an engineering school. That is, engineering schools granted higher rates of master's degrees to underrepresented students when they enrolled higher rates of underrepresented students from their respective underrepresented group. Further, both Ph.D. models revealed that engineering schools were more likely to grant higher rates of doctorates to URMs and women when schools enrolled higher percentages of master's students from their respective underrepresented group.

Engineering schools also produced higher rates of doctorate degrees for women when they held AAU status, higher rates of master's degrees for women when they enrolled smaller master's class sizes, and produced higher rates of doctorates for URMs when they reported lower annual average research expenditures.

Table 32. Engineering school characteristics that predicted advanced degree rates for URMs.

| Dependent Variable Group | Avg. Annual Research Expenditures | Grad Yield % | Undergrad. URM Enroll % | M.S. URM Enroll % |
|---|---|---|---|---|
| M.S. URM Degree Production Rate | | + | + | |
| Ph.D. URM Degree Production Rate | - | | | + |

+ Significant positive predictor variable, - Significant negative predictor variable

Table 33. Engineering school characteristics that predicted advanced degree rates for women.

| Dependent Variable Group | AAU (1=*Yes*, 0 = *No*) | M.S. Enroll Avg. | % Women Tenured/TT Profs | Undergrad. Women Enroll % | M.S. Women Enroll % |
|---|---|---|---|---|---|
| M.S. Women Degree Production Rate | | - | + | + | |
| Ph.D. Women Degree Production Rate | + | | + | + | + |

+ Significant positive predictor variable, - Significant negative predictor variable

Overall, these findings suggest that institutional demographics do indeed influence an engineering school's ability to award advanced degrees to underrepresented groups. This finding is in line with research that indicates program demographics influence degree production for underrepresented groups (Nettles & Millett, 2006; Ong et al., 2011; Ostreko, 2010; Price, 2010; Sonnert et al., 2007). The undergraduate enrollment, master's enrollment, and faculty predictor demographic variables from underrepresented groups are especially noteworthy in light of their low representation in this study.

## Summary of Chapter IV

This chapter discussed the descriptive statistics and regression analyses that were examined to determine if engineering school characteristics related to M.S. and Ph.D. degree production rates for women and URMs in engineering. Descriptive findings were summarized by which schools produced the highest advanced degree rates overall and by which schools produced highest advanced degree rates for those that remained in the regression models. Descriptive data also summarized engineering school characteristics as a group and by schools that awarded the highest rates of advanced degrees to URMs and women. Finally, multiple regressions revealed the power of certain engineering school characteristics to predict graduate degree production rates for women and URMs. The next chapter highlights this study's main findings, further connects the findings to the conceptual model and extant literature, relates the findings to implications for higher education, and provides recommendations for future research.

# CHAPTER V: DISCUSSION AND CONCLUSIONS

## Introduction

This study aimed to determine which engineering schools produce the highest rates of advanced degrees for underrepresented students and which engineering school characteristics relate to higher levels of master's and doctorate degrees for underrepresented groups. Findings revealed trends and relationships between an engineering school's characteristics and its advanced degree production rate for underrepresented groups. This chapter highlights these major findings, discusses specific institutional capital findings, connects the findings to implications for higher education, and offers recommendations for future research.

## Highlight of Major Findings

In general, this study sought to uncover: (1) which engineering schools produced the highest rates of advanced degrees for underrepresented groups, and (2) which engineering school characteristics related to higher rates of advanced degrees for underrepresented students. Major findings for each of these main questions are outlined below.

1. ***Which engineering schools produced the highest rates of advanced degrees for underrepresented groups?***

An initial analysis of an engineering school's advanced degree rates revealed that close to half of the same engineering schools produced high rates of both master's and doctorate degrees for URMs, which suggests that URMs might earn both degrees at the same school. A majority of these top producing schools were located in the South and Southeast and in or adjacent to states with HBCUs. Further, 22 of the schools that produced the highest rates of master's degrees and 21 of the schools that produced the highest rates of doctorates for URMs – or around 90% - were located in states where URMs comprised at least 20% of the population. The percentage of

URMs in the population was as high as 62% for those schools located in Washington, D.C., and schools in California, the state with the highest overall URM population, also showed up in both models. These geographical patterns indicate that URMs might choose to attend schools closer to home and that location could be an important factor to consider when recruiting an URM to an advanced degree program in engineering. Similarly, engineering schools that produced the highest rates of advanced degrees for URMs tended to enroll higher percentages of URM students, which indicate that URMs might find the climate at these institutions more appealing for graduate study.

Similar to the URM models, engineering schools that produced the highest rates of advanced degrees for women also tended to enroll higher percentages of women students. Nearly 40% of the same schools also produced high degree rates at the master's and doctorate levels. Women might also tend to stay at the same school for both degrees and find schools with higher percentage of women students more attractive for graduate study.

***2. Which engineering school characteristics relate to advanced degree production rates for underrepresented groups?***

Results from the examinations conducted for the schools that remained in the regression models repeatedly demonstrated the importance of an institution's demographics. Engineering schools produced higher rates of advanced degrees for underrepresented groups when a higher percentage of underrepresented undergraduates and master's students enrolled. Engineering schools also produced higher rates of advanced degrees for women when they reported higher rates of women tenured/tenure-track faculty members. These repeated demographic-related findings suggest that underrepresented students tend to pursue engineering graduate degrees at institutions that appear to maintain a more welcoming climate for underrepresented groups.

This study's findings also highlighted the importance of a master's or doctoral program's cohort size. This study found that engineering schools produced higher rates of master's degrees for women when they enrolled smaller master's program cohorts. While this finding was only significant at the master's-level for women, the top producing engineering schools for master's for URMs and doctorates for both underrepresented groups consistently reported lower average program sizes than the lower producing schools. These findings indicate that underrepresented students might also find smaller programs more appealing for graduate study.

This study also highlighted the importance of an engineering school's ability to produce a doctorate degree. While engineering school's produced higher rates of doctorates for women when they held AAU status, they produced higher rates of doctorates for URMs when they reported lower annual average research expenditures. This finding suggests that URM doctoral students are more likely to attend less research intensive engineering schools, while women doctoral students are more likely to attend the most research intensive engineering schools.

These major findings connect to several aspects in the conceptual model. The next section further relates this study's findings to the education production function and institutional capital theory.

**Findings Related to the Conceptual Model**

This study's findings offered several results that connect an engineering school's characteristics to advanced degree rates for underrepresented groups. This section discusses how these characteristics connect to an engineering school's advanced degree production rate for URMs and women.

This study generally connected an engineering school's cultural capital to its status in the AAU. This definition connected Brosnan (2010), Fogarty (1997), and Jewel's (2008) argument that cultural capital develops over time and connects to a university's purpose to produce knowledge. AAU schools tend to compete most successfully for research funding, which is often used to support doctoral education (About AAU, 2010). Since AAU schools should have a greater ability to award higher rates of doctorate degrees because of their research base, engineering schools with AAU status should, in theory, produce the highest rates of doctorate degrees for underrepresented groups. Engineering schools only maintained higher levels of participation in the AAU in the regression model that was analyzed for doctorate degree rates for women. In this model, an engineering school's AAU status significantly predicted higher rates of doctorates for women. This finding was only significant for the model that analyzed doctorate degree rates for women, even though engineering schools overall produced close to 60% of doctoral degrees in 2008 from AAU institutions (AAU Facts and Figures, 2010). In 1975, McCarthy & Wolfle (1975) reported on the efforts of AAU schools to produce doctorate degrees for underrepresented groups. These researchers reported that around 1% of AAU schools produced doctorates for women in engineering. The significant finding that AAU schools in this study were more likely to produce higher rates of doctorates for women in engineering shows that considerable ground has been made by women at AAU schools. This finding supports the notion that engineering schools with AAU status are more likely to have the opportunity to use their research funds to support higher rates for women earning doctorate degrees.

The descriptive findings also suggest that engineering schools with AAU status are less likely to produce high rates of doctorates for URMs compared to those without membership. This finding indicates that the engineering schools with *less* ability to financially support doctoral students through research grants are the ones *most* likely to award higher rates of doctorates to URMs. While the regression model findings related to an institution's demographics and average research expenditures might help to explain this finding, it is also important to interpret this finding in light of the low doctorate degree rates for URMs in this study. The engineering school with the highest doctorate degree production rate for URMs examined in the regression model only awarded 9% of all doctorates to URMs. Further yet, this finding could relate back to an engineering school's ability and plan to utilize research funds to recruit and retain URMs in doctorate programs. Engineering schools in the AAU should have a greater ability to offer financial support to graduate students. While this study did not examine financial support offers from AAU schools, it is one area engineering schools should consider as a way to increase the representation of URMs in advanced programs.

Since the majority of individuals with engineering doctorates earn a master's degree beforehand, this study also examined an engineering school's ability to provide financial resources for graduate study – signified as its membership in the AAU – for master's level students. The descriptive finding that few engineering schools held AAU status when master's degree rates were examined might not seem significant since an AAU institution's role is to support *doctoral* education. This finding, however, is noteworthy because of the doctoral-level granting status that each institution in this study maintained. That is, this study only examined schools that awarded a doctorate as the highest degree. Thus, the schools in this study had a greater chance of being a member in the AAU than would have been the case if institutions that only granted a master's degree were kept in the analysis. This finding further suggests that, with the exception of women pursuing doctorate degrees, non-AAU schools attract higher rates of underrepresented students into their advanced programs.

Certain financial aspects that determine an engineering school's ability to produce an advanced degree also connected back to a school's general economic capital, which included an engineering school's average annual research expenditures and graduate program enrollment. This general definition (1) connected Brosnan (2010), Fogarty (1997), and Jewel's (2008) rationale that suggested economic capital included those resources necessary for a program to function, (2) specifically linked degree production rates to student cohort size and research expenditures, both of which Hartwig (1978) examined in his analysis of the production of engineering programs, and (3) allowed for a focus on the importance that national agencies connect to research expenditures. Descriptive findings showed that averages for all of the engineering schools in each underrepresented group plus those for the top producing groups consistently reported lower averages for annual average research expenditures and average graduate program enrollment. The regression models for the women's group also showed a significant finding for average master's student class size, while average annual research expenditures resulted in a significant value in the regression model examined for doctorate degree rates for URMs.

Engineering schools tended to grant higher rates of doctorates to URMs when they reported lower average annual research expenditures. This finding was consistent for the descriptive and regression model findings. Descriptive findings also showed that engineering schools were more likely to produce higher rates of doctorates for URMs when they enrolled smaller average doctoral class sizes. Together, these findings suggest that less research intensive and smaller engineering schools grant higher rates of doctorates for URMs. Even though AAU schools – or those with higher rates of annual average research expenditures – produce the majority of engineering doctorates, the finding for URMs is similar to the engineering school productivity study by Shelton & Prabhakar's (1971), where they found that smaller engineering schools produced higher rates of baccalaureate degrees than larger ones.

An engineering graduate program's cohort size could also further explain why engineering schools with lower annual average research expenditures produced higher rates of doctorates for URMs. While average class size only resulted in a significant value in the regression model that examined master's degree rates for women, the top producing institutions for all groups consistently reported lower averages for program enrollment. These findings are in line with Bowen & Rudenstine's (1992) well established book, *In Pursuit of the Ph.D.*, where they found that programs with smaller student cohorts in economics, history, political science, English, physics, and math all completed Ph.D. programs at higher rates compared to those with larger entering student cohorts. This finding also connects to more current research from the CGS' Ph.D. Completion Project, where they found that engineering doctoral cohorts, that contained 1 to 7 students, completed doctoral degrees at greater rates than those from groups with 8 or more students (Ph.D. Completion Project, Analysis of Baseline Data, 2007). Additionally, since engineering doctoral students often complete a master's degree prior to enrolling in a doctorate program, this finding suggests that the smaller cohort connection for underrepresented groups could actually begin at the master's degree-level.

The importance of student demographics at the master's degree-level was evident for both groups. Student and faculty demographic data were examined as part of the general symbolic capital variables. Other variables examined for their relationship to an engineering school's symbolic features and its advanced degree production rate for underrepresented groups included GRE scores, graduate admission yield, and a program's rank in *USNWR*. This general definition of symbolic capital connected an institution's prestige to Brosnan (2010), Fogarty (1997), and Jewel's (2008) argument that 'prestige' closely relates to perceptions, such as those derived from demographics, selectivity, and ranking guides. Descriptive findings showed that engineering schools in each group reported a wide range of faculty and student demographic percentages, graduate admission yields, and *USNWR* ranks, while average quantitative GRE scores tended to remain high and around the same rate. It is likely that average GRE scores resulted in high and the most consistent scores because schools only reported averages for students entering their programs, which would only include applicants with relatively high score on the quantitative portion of the GRE.

On the other hand, engineering schools that produced the highest rates of master's degrees for women and both master's and doctorates for URMs repeatedly maintained lower average *USNWR* ranks compared to all of the schools in these groups. This finding could connect back to the lower percentages of AAU schools in these top producing groups, since average research expenditures factor into an engineering school's *USNWR* rank (Morse & Flanigan, 2009). Since none of the regression models for these groups resulted in a significant value for an engineering school's AAU status, the lower *USNWR* ranks further suggests that the top producing schools for master's degrees for women and advanced degrees for URMs were less research intense.

The demographic variables, nearly all of which resulted in higher average percentages for the top groups, could provide additional explanations for the lower average *USNWR* ranks for schools that produced the highest rates of master's degrees for women and advanced degrees for URMs. All of the demographic variables resulted in significant values in at least one of the regression models, with the exception of the percentage of URM tenured/tenure-track faculty, Engineering schools with higher advanced degree production rates for underrepresented groups could have received a lower peer ranking, if they were viewed as less selective because of their diversity (Brewer et al., 2002).

While an engineering school's peer score in its *USNWR* rank might decrease because of its diversity, engineering schools that maintained higher rates of women tenured/tenure-track faculty granted higher rates of advanced degrees for women. The very low percentage in which URMs are represented among engineering faculty – an average of 5% in this study – might explain why this variable was not significant in the regression models. The percentage of women tenured/tenure-track faculty resulted in significant values in both degree production models for women, even though women faculty only comprised an average of 12% of tenured/tenure-track faculty members in the regression models.  Since faculty are one reason that students select engineering doctoral degree programs, this finding supports previous research and reports that emphasize the important role of women faculty role models in the doctoral degree production of women in STEM fields (Freehill et al., 2008; National Academies, 2007; Nettles & Millett, 2006; Ong et al., 2011; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010). This finding is particularly noteworthy considering that women comprised such a small percentage of engineering faculty members in this study.

Engineering schools also produced higher rates of master's degrees for both women and URMs when schools maintained higher rates of undergraduate students in their respective underrepresented group. Similarly, engineering schools produced higher rates of doctorates for women and URMs when higher percentages of women or URMs were enrolled in master's programs. These variables resulted in significant values, even though the average enrollment in undergraduate programs was between 11% and 12% for URMs and 19% for women, and 7% and 25% in master's programs for URMs and women, respectively. The demographic findings could relate back to the perceived prestige an institution maintains, and schools with higher rates of URMs which could be perceived as less selective maintain this negative perception, even though

HBCUs grant high rates of bachelor's degrees for blacks who later earned a doctorate degree in science or engineering (Brewer et al., 2002; Burrelli & Rapoport, 2008).

While it has been shown that HBCUs play a significant role in the future educational achievement for blacks in science *and* engineering programs, the purpose of this study was to isolate *engineering* degree data to determine if similar characteristics identified in the science *and* engineering or STEM-related literature also apply to the field of engineering. The next section compares this study's findings to the STEM-related literature.

**Comparison of STEM Literature and Engineering Specific Findings**

Studies that examine factors that relate to the doctoral degree production of underrepresented students in engineering programs often do so from a STEM-related approach. These studies rarely consider the master's degree in the analyses of the role of a student's educational pathway. Since researchers and reports call to examine these data by field, and because the common pathway to an engineering doctorate degree includes a master's degree, this study aimed to identify institutional characteristics that related specifically to engineering advanced degree production for underrepresented groups.

Figure 6 compares some of this study's major findings with STEM-related literature. Similar to STEM-related reports that indicate the importance of HBCUs, this study's findings for the location of engineering schools with high rates of advanced degrees for URMs suggest that HBCUs might continue to play an important role in the advanced degree production rate for URMs in engineering programs. While very few HBCU schools were in this study, the general South and Southeast location of HBCUs and higher URM population in this part of the country (U.S. Census, 2009) indicates that URMs might attend an HBCU as an undergraduate before continuing on to a graduate degree at a school in the same region. Strayhorn's (2009) finding about the importance that URMs place on location when selecting a science or engineering graduate program supports the idea that URMs might not travel far from home, or possibly, their undergraduate institution, when selecting an engineering graduate school.

The literature on the role of HBCUs in the development of a black student's plans for a doctorate degree often credits the role of peers and faculty (Brazziel & Brazziel 1997; Cooper, 2004; Freehill et al., 2008; Perna, Lundy-Wagner, Drezner, Gasman, Yoon, Bose, & Gary, 2009; Solorzano, 1995). The importance of peers and faculty consistently resulted in significant relationships for how their demographics related to an engineering school's advanced degree production rate for underrepresented students in this study. Previous STEM-related literature reported mixed results on the role of women faculty and degree outcomes for women in STEM programs, while most studies agreed that URM faculty influenced degree outcomes for URMs (Nettles & Millet, 2006; Ong et al., 2011; Price, 2010; Sonnert et al., 2007). Findings from this study for engineering advanced degree programs, however, revealed just the opposite. That is, higher rates of women tenured/tenure-track faculty members increased an engineering school's rates of advanced degrees for women, while the faculty finding was not significant for URMs.

| **Underrepresented Student Theme** | **STEM-Related Literature** | **This Study's Findings** |
|---|---|---|
| Educational Pathway | HBCUs produce majority of baccalaureate degrees for blacks who earn doctorates in STEM fields (Burrelli & Rapoport, 2008).<br>Location is an important factor when URMs consider graduate school in science and engineering (Strayhorn, 2009). | Location patterns for engineering schools that produced the highest rates of advanced degrees for URMs showed a frequent pattern of schools to be located in South and Southeast and in or adjacent to states with HBCUs. These schools were also located in states with a high percentage of URMs in the population. |
| Institutional Demographics | Peers influence degree rates for underrepresented students in STEM programs (Bhatia & | Engineering schools consistently reported higher rates of advanced degrees for underrepresented |

| | | |
|---|---|---|
| | Amati, 2010; Cole & Espinoza, 2008; Gardner, 2007; Hurtado et al., 2009; Mwenda, 2010; Nettles & Millett, 2006; Ostreko, 2010; Wilson et al., 2011).<br>URM faculty members positively influence degree rates of URMs in STEM fields. Findings for the role of women faculty and degrees for women in STEM are mixed programs (Nettles & Millet, 2006; Ong et al., 2011; Price, 2010; Sonnert et al., 2007). | groups when they reported higher rates of undergraduate and master's-level students enrolled. Significant findings revealed that engineering schools that reported higher rates of women tenured/tenure-track faculty members reported higher rates of advanced degrees for women. This finding was not significant for URMs. |

*Figure 6.* Comparison of STEM-Related and Engineering Findings for Factors that Relate to Advanced Degree Production for Underrepresented Groups

The finding for women engineering faculty members provides additional clarification to the important role of women faculty in the production of advanced degrees for women in the engineering-related literature. This finding, plus those highlighted earlier, possibly relate to policy implications at the national and institutional-level. The next section outlines these potential policy implications.

## Policy Implications

Findings from this study, as well as current data on the number of women and URMs earning advanced engineering degrees, highlight the country's slow progress to address the representation of underrepresented groups in engineering graduate programs. Reports that highlight these issues call for the need to examine both national and institutional-related policies that focus on advanced degrees for underrepresented groups (National Academies, 2007; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010). This section examines this study's findings in light of national and institutional policies associated with advanced degree production for underrepresented groups in engineering.  Specific attention is focused on policies that government agencies or institutions could modify to attract underrepresented individuals into advanced engineering degree programs.

***National Policy Implications***

Policies and programs that address the shortages of underrepresented groups in advanced engineering programs began with the development of the National Consortium for Graduate Degrees for Minorities in Science & Engineering (GEM) Fellowship in the mid-1970s (About GEM Fellowship, 2011). The GEM Fellowship, sponsored by industries, science and engineering organizations, and higher educational institutions, led initial efforts to recruit URMs into science and engineering graduate programs. This program began nearly twenty years before the federal government invested significant resources to address how to recruit underrepresented students into engineering graduate programs. The Louis Stokes Alliance for Minority Participation Program signified the first federal effort to provide fellowship funding to URMs in STEM graduate programs (Clewell, De Cohen, Deterding, & Tsui, 2006). The Alliance for Graduate Education for the Professoriate (AGEP) and Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE) program developed more recently, in 1998 and 2001, respectively (AGEP History, 2011; ADVANCE at a Glance, 2011).

Only in the last twenty years have serious national efforts been made to address shortages of engineering advanced degrees among underrepresented groups (Clewell et al., 2006; AGEP History, 2011; ADVANCE at a Glance, 2011). This study's findings – that so few institutions produce advanced engineering degrees for underrepresented groups – could serve as a justification for a need to invest additional resources in federal programs that address this issue. Shirley Malcom, as head of the AAAS in her testimony to Congress in 2010, referenced a study that showed initial success of AGEP programs; however, the 2011 NSF budget discussed the possibility of combining AGEP with other diversity initiatives, such as ADVANCE and LSAMP (Malcom, 2010). While this move might result in cost savings for the NSF, this study's findings suggests that most institutions need additional guidance and support on how to diversify the graduate student body in engineering programs. Further, reports that draw attention to this issue indicate a need to continue and enhance federally sponsored programs ("A Bridge for all…," 2004; Chubin et al., 2005, Malcom, 2010; Wendler et al., 2010).

Additional funding is not the only way to examine policies related to advanced degree production rates for women and URMs in engineering. This study found that nearly 40% of the same schools for women and 50% of the same schools of URMs produced high degree rates at both the master's and doctoral degree levels. Further, engineering schools were likely to award higher rates of doctorates for women and URMs when they enrolled higher percentages of women or URMs at the master's degree-level; and, top producing engineering schools were located in seven of the 10 most populated URM states as a percentage of the overall population and 11 of the top 20 most populated URM states overall (U.S. Census, 2009). Strayhorn (2009) highlighted closeness to home as one of the reasons African American males chose an institution for graduate study in science or engineering. Certain geographic enrollment patterns could also emerge because of limited financial resources that inhibit an URMs ability to travel far from home, commitments to family members, and a general concentration of residency in these areas (Stassun, 2003; Stassun et al., 2010). The states that tend to produce higher rates of advanced degrees for URMs could be specifically targeted for funds to support graduate students in these engineering schools. Engineering schools outside of these states, especially those in the AAU, could also possibly attract higher rates of URMs into their graduate programs if they can offer enough financial support to offset costs associated with travelling farther from an URMs permanent residence.

While this study was not able to address whether or not the same students remained at the same school for both degrees, the location pattern and finding that an engineering school's doctorate degree production rate for an underrepresented group increased when higher rates of underrepresented master's students were enrolled suggest that national reports should focus additional attention on master's-degree origins of engineering doctorate recipients. The NSF publishes a list of master's degree origins based on SED data; however, the list does not parse data by broad field, institution, and individual demographics. Individual-level demographic data for SED recipients are only available to researchers approved to examine restricted data. While researchers may apply for these data, this type of information sharing makes it more difficult for engineering schools to readily use master's degree origin data in their decision to recruit from a particular institution or to partner with a college or university on a master's-to-doctorate 'bridge' program.

***Institutional Policy Implications***

On the other hand, most engineering schools are able to use institutional-level data available from the ASEE to make programmatic and policy decisions to enhance diversity within graduate programs. Recent reports indicate that individual institutions need to research how their policies and practices affect the recruitment and retention of underrepresented students in STEM programs (National Academies, 2007; The Woodrow Wilson Foundation, 2005; Varma & Freehill, 2010). This study provided a list of top producing institutions from which other engineering schools can examine institutional-related features and polices that influence women and URMs to pursue and complete advanced degrees. Additionally, this study found that engineering schools reported higher rates of advanced degrees for *URMs* when they enrolled a higher percentage of graduate students admitted into an engineering program, maintained higher percentages of URM undergraduates, reported lower levels of annual research expenditures, and enrolled smaller master's program cohorts. Engineering schools reported higher rates of advanced degrees for *women* when they held AAU status, enrolled a higher percentage of women undergraduate and master's degree students, employed higher percentages of women tenured/tenure-track faculty, and maintained smaller master's program cohorts.

This study showed that certain institutional characteristics should be further examined for how they relate to diversity within engineering graduate programs. This study confirmed that institutions granted more engineering graduate degrees to underrepresented students when there were more underrepresented students enrolled, as well as more advanced degrees for women when higher rates of women were employed. As demonstrated in this study, however, most doctoral-granting schools lack graduate student and faculty diversity within engineering programs. One theory that supports this finding is Schneider's (1987) idea on organizational attractiveness, where he argued that the people are the most important appeal factor in an organization. Consequently, engineering schools should examine their efforts and policies to recruit underrepresented individuals into all aspects of their programs.

Bensimon (2005) offers another theory that supports how individuals within an organization can examine educational inequalities. Bensimon suggests that organizations have the responsibility to learn about inequality issues related to individuals within their organization, which she appropriately titled "organizational learning" (p. 100). Bensimon argues that individuals within an organization are responsible for addressing equality issues, and that it is the effect of their ideas, attitudes, and viewpoints that determine whether an organization can make significant changes to address equality issues. Engineering schools could use both the organizational attractiveness and organizational learning theories to examine how their policies and practices as a unit within a larger organization relate to the participation of underrepresented students in graduate programs. For instance, compared to top graduate degree producing institutions for URMs and women in this study, do lower producing engineering schools have an office specifically devoted to diversity and equity? If so, does the office serve all individuals within the university, is it specific to engineering, and how is it promoted to graduate students? In addition to the important role that faculty play in degree outcomes for underrepresented groups, studies that specifically address issues with diversity within engineering graduate programs highlight the role of university staff, and in particular, those within diversity offices (DeLoatch, Kerns, Morell, Purdy, Smith, & Truesdale, 2008; Simon, 2010).

Specifically related to recruitment of URMs, which undergraduate institutions and which parts of the country do engineering schools recruit underrepresented students? The location patterns in this study indicate that engineering schools should focus attention on recruiting URMs from states with higher percentages of URMs in the population.

From a broad institutional perspective, what policies and programs managed by the institution encourage participation of underrepresented groups? Funding for programs such as AGEP and ADVANCE tend to be at the institution rather than school or college-level (AGEP History, 2011; ADVANCE at a Glance, 2011). Thus, an engineering school also relies on programs and policies that the institution maintains to attract and address equality issues across the university.

An engineering school also relies on other university programs to become a member of or maintain its membership in the AAU (AAU Membership Policy, 2010). Other broad aspects that resulted in significant values in the regression models included an institution's AAU status, master's program cohort size, and percentage of students admitted into a graduate program that later enrolled. AAU status was generally connected to an engineering school's cultural capital because it served as a signal of an engineering school's ability to produce research and provide funds to support doctoral education. AAU schools tend to receive more national grants that support doctoral education; however, certain programs likely benefit more from this support, given that the research funding evaluated for membership focuses on particular areas and specifically excludes agricultural-related research funds (AAU Membership Policy). Consequently, not all engineering schools necessarily receive equal benefits from their membership in the AAU. The resources an engineering school receives from national grants should be examined for how they relate to the recruitment and retention of underrepresented groups. Research Experiences for Undergraduates (REUs), for example, are often funded through national agencies (National Institutes of Health (NIH), Office of Intramural Training & Education, 2012; NSF, REU, 2012). Engineering schools should examine their offering and support of programs that offer research for undergraduates, such as REUs, since these programs tend to encourage individuals to pursue advanced degrees (Eagan Jr., Garcia, Herrera, Garibay, Hurtado, & Chang, 2010; Hurtado et al., 2009; Hurtado, Sáenz, Espinosa, Cabrera, & Cerna, 2007; Jones, Barlow, & Villarejo, 2010).

Nearly all graduate students – even those who are not part of an underrepresented group – consider financial support in their decision to attend an institution for graduate study (Barnes & Wells, 2009; Freehill et al., 2008; Hurtado et al., 2007; Malcom, 2008; Mwenda, 2010; Millett & Nettles, 2006; Nettles & Millett, 2006; Stolle-McAllister, Sto. Domingo, & Carrillo, 2011; Strayhorn, 2009). While this study was not able to analyze financial support and program selection from an individual-level basis, the finding that institutions produced higher rates of URMs with master's degrees when they maintained a higher graduate admittance yield suggests that URM and non-URM master's-level students might value similar aspects when selecting an engineering graduate program. Thus, engineering schools should also determine which policies encourage the recruitment and retention of master's students in general, as it could be that underrepresented students examine many of the same factors that students from the majority analyze when selecting an institution for graduate study.

A general model for engineering graduate program recruitment and retention would provide a starting point for how to address diversity issues within engineering graduate programs; and, this study's findings provide additional aspects that engineering schools and national agencies should consider when developing policies related to advanced degree production for URMs and women. The next section provides recommendations for future research in this area.

## Recommendations for Future Research

Before discussing recommendations for future research, it is helpful to reflect on how the data in this study could have been examined differently, as this will help to lay ground for future research with similar data sets. Some of these considerations could be undertaken in a similar study, while others would address additional issues related to diversity within engineering programs.

### *Possible Modifications or Additions for Future Research with this Study's data*

First, the descriptive findings revealed very few differences in average quantitative GRE scores for entrants into an engineering school's graduate programs. This is to be expected given that these averages are for students who gained admission into a program. Average GRE scores of all applicants to an engineering graduate program would have been a better way to examine this variable. While data on all applicants are not available through the *USNWR* rankings, this is something that could potentially be requested from the Educational Testing Service (ETS) (ETS website, About ETS Research, 2012). Correlation comparisons for the *USNWR* variable also showed that the items that comprise the overall rank, such as average quantitative GRE score, maintained too strong of a correlation to remain in the regression model. A future study that examines rank as a symbol of prestige might consider using only one of the variables that comprises an engineering school's rank in *USNWR*, such as the percentage of faculty in the National Academy of Engineering.

Since the ASEE maintains institutional-level data on programs at all degree levels and specific engineering programs, a future study could examine data for bachelor's, master's, and doctorate degrees by program for all students and degree-granting institutions. This would allow for an analysis of master's and doctorate-degree granting institutions by their engineering degree production at all levels and by specific groups (i.e., international students, white men, Asians). The comparison of these data would reveal possible differences between degree levels, institutional type, majors, and groups that are equally or overrepresented in engineering graduate programs. These data could be examined over several time periods, which would allow for an analysis of which engineering schools report higher degree rates from an historical perspective. Further, these data could be combined with additional institutional-level IPEDS data to provide a general context of the institution in which the engineering school resides. This context could provide an additional layer from which to examine institutional demographics, size, and productivity.

The finding related to an engineering school's research expenditures and doctorate degree rate for URMs could also be further explained if additional productivity data were included in an analysis. One way to interpret the finding that an engineering school produced higher rates of doctorates for URMs when they reported lower annual average research expenditures is that, perhaps, these schools are more efficient with the use of their research funding to support URMs in doctorate programs. An institutional productivity study by Wolf-Wendel and others (2000), for example, found that women's colleges, HSIs, and HBCUs produced more baccalaureate degrees for women doctorate degree holders for each dollar spent on institutional resource. A future study related to engineering doctorate degrees could examine additional efficiency resources, such as number of Graduate Research Assistantships (GRAs), to determine if engineering schools produce higher rates of doctorates for URMs based on the percentage of graduate students with GRA appointments. ASEE collects and publishes the number of GRA appointments in an engineering school each year.

An engineering school's ASEE and IPEDS data could also be compared to GEM, ADVANCE, and AGEP data to see if the existence of these programs relates to higher advanced degree rates for underrepresented students in engineering. The next section begins with a discussion of how these programs relate to an institution's commitment to diversity. Future research on the educational pathway of an engineering doctorate degree recipient and the importance of further parsing data by gender, race, and major are also examined for future research areas.

***Institutional Commitment to Diversity***

This study's reoccurring finding that institutional demographic features predicted advanced engineering degree rates suggests that future research in this area should focus on institutional commitment to diversity. A comprehensive national study could provide a better understanding of the current resources that address diversity in advanced engineering education programs. Such a study should include an analysis of programs such as GEM, AGEP, and ADVANCE ("A Bridge for All…,"2004; Chubin et al., 2005; Donnelly & Jacobi, 2010; Freehill, 2005; Zajicek et al., 2011). A recent evaluation of current ADVANCE programs showed mixed results for the ultimate end goal, which was to gain more women faculty in engineering. The evaluation examined two cohorts of ADVANCE awards, and the second group, which started with fewer engineering women faculty, showed the most progress (Zajicek, Rencis, Morimoto, & Hunt, 2010). A study that analyzed the effect of the AGEP program on enrollment and degrees in STEM Ph.D. programs also reported a nearly 26% increase in the percentage of URMs enrolled in these programs; however, the authors found no change in the number of doctoral degrees granted overall to URMs in engineering between 1997-98 and 2004-05 (George, Campbell, Kibler, Carson, & Malcom, 2007).

While the ADVANCE and AGEP programs show some progress for women and URMs participating in engineering doctoral programs, additional qualitative studies might also help engineering schools better understand reasons that underrepresented students pursue a doctoral program. Most of the extant literature that uses qualitative methods to explore questions related to underrepresented students who pursue science and engineering doctoral programs does so from a narrow institutional or program specific approach (Mwenda, 2010; Perna et al., 2009; Stolle-McAllister, Sto. Doming, & Carrillo, 2011). These qualitative studies could possibly be used as a starting point for a much more comprehensive study, which is needed to better generalize findings across institutions, and to make mixed findings more clear. A qualitative study of the top engineering advanced degree institutions for underrepresented groups in this study could provide researchers with more in-depth information on why underrepresented groups select their programs for graduate study. A more in-depth qualitative study might also help to provide additional explanations for why only top producing engineering schools for women with doctorates held AAU status. Since AAU schools award higher rates of doctorates than non-AAU schools, a more detailed examination of these schools would provide higher education policy makers with a better framework from which to encourage AAU institutions to also produce higher rates of advanced engineering degrees for underrepresented groups.

### *Educational Pathway Exploration*

Some of the same schools resulted in higher degree production rates for underrepresented students at both the M.S. and Ph.D.-level. This finding coupled with the fact that the majority of individuals with doctorates in engineering earn a master's degree en route suggests that masters-to-doctorate 'bridge' programs are another area that merits further exploration. M.S.-to-Ph.D. engineering 'bridge' programs are another area where researchers could use both qualitative and quantitative analyses to further examine relationships between M.S. and Ph.D. programs, as well as, possible collaborations between schools. 'Bridge' programs encourage underrepresented participation from high school-to-baccalaureate degree programs, baccalaureate-to-master's degree programs, and baccalaureate/master's degree programs-to-doctorate degree programs (Freehill, Jacquez, Ketcham, Lain, Williams, & Pena, 2006). While data on baccalaureate origins of underrepresented individuals with doctorate degrees in engineering is published regularly by the NSF, trends for master's degree origins are less widely distributed. Institutions have created M.S.-to-Ph.D. 'bridge' programs based on Lange's (2006) finding that URMs are more likely to earn an M.S. degree on the way to a doctorate (Stassun et al., 2011). This study's findings, however, do not necessarily mean that URMs attend the same institution for master's and doctoral programs. In fact, Lange's research on *URMs'* educational pathway in *STEM* programs also indicated that URMs were more likely to earn each degree from a different institution. Future research that includes both individual and institutional-level data would better account for master's-degree locations of *underrepresented engineering* doctorate recipients. Further, since this study only included schools that granted a doctorate as the highest degree available at an institution, future studies could also compare master's degree rates for underrepresented students from institutions that grant the master's as the highest degree in engineering. The latter analysis might have the best likelihood of identifying possible 'bridge' collaborations between master's-only engineering schools and doctorate-degree granting institutions.

***Specific URM Group and Major-Level Data***

The most useful analyses, whether of a focus on an institution's commitment to diversity or an underrepresented student's educational pathway, might come about if data are examined by specific engineering major and URM group. This study was not able to parse data by major or specific ethnic group because the sample was too small for such an examination. Although engineering is an interdisciplinary field, the accrediting bodies, engineering organizations, and national agencies recognize important differences between engineering majors (ABET, Criteria for Accrediting Engineering Programs, 2012-2013; ASEE, Divisions, 2011; NSF, Directorate for Engineering, 2011). According to the ASEE, African Americans, Native Americans, and Hispanics earned 65 doctoral degrees in chemical engineering in 2010, which was the highest total for this group among all engineering majors. This same group earned less than 10 doctoral degrees in the fields of architectural, mining, petroleum, civil/environmental, biological/agricultural, and environmental engineering. Women with U.S. citizenship or permanent residency status earned 144 doctoral degrees in chemical engineering in 2010, which was also their highest among any other engineering major. Women also earned their fewest doctoral degrees in architectural, mining, and petroleum engineering (ASEE, Engineering *College Profiles and Statistics*, 2010).

Differences also exist between 'women' and 'URM' as a group. URMs make up the 'women' group, just as both genders comprise the 'URM' group. For instance, African Americans – as a group – earned 21 engineering doctoral degrees in chemical engineering in 2010, which was their highest degree total among all engineering fields. African American men, however, earned 15 doctoral degrees in electrical engineering, which was their highest degree total; and, African American women earned 10 doctoral degrees in biomedical engineering, which was their highest doctoral degree total out of all engineering majors (ASEE, Engineering *College Profiles and Statistics*, 2010).

An analysis of advanced engineering degree production rates by specific ethnic group, gender, and major could also help explain this study's findings that connected higher percentages of underrepresented undergraduate or master's-level engineering students with higher advanced degree production rates for a particular group. This study determined that a relationship exist, but it is unclear whether this connection developed because underrepresented advanced degree-seeking students were drawn toward programs with higher levels of underrepresented undergraduates, or if underrepresented undergraduates were attracted to programs with higher proportions of underrepresented graduate students. A qualitative study that focuses on the findings from this study could help to better explain the relationships found between the demographic variables in this study, and account for small sample sizes that result when data are parsed by gender, ethnic group, and engineering major.

This study's findings demonstrate a need to further examine advanced degree data in engineering among underrepresented groups, including an analysis aggregated by specific ethnic group, gender, and major. The pattern of some schools to produce high degree production rates at both the master's and doctoral-level also indicates a need to analyze master's-to-doctoral degree factors and trends. Future studies should use a combination of individual and institutional-level data, along with quantitative and qualitative methods, to examine diversity indicators in advanced engineering degree programs. Such indicators could include an institution's participation in underrepresented programs, such as AGEP, GEM, and ADVANCE.

## Conclusion

This study revealed which engineering schools produced the highest rates of advanced degrees for underrepresented students and confirmed that several engineering school characteristics relate to advanced degree production rates for these groups. The education production function provided an economic model from which to view institutional resources, while the institutional capital theory allowed for an examination of these resources by their general cultural, economic, and symbolic representation. A variety of engineering school characteristics significantly predicted advanced degree rates for URMs and women. Certain institutional characteristics clearly influence advanced degree rates for underrepresented groups in engineering; and, institutions with lower degree production rates for women and URMs should look to the top producing institutions as a starting point from which to highlight or modify institutional characteristics to attract underrepresented students into their programs.

The top producing institutions in this study must also continue to recruit underrepresented students into their engineering graduate programs, as very few of the top producing schools granted close to half of their degrees to underrepresented groups. This study showed that higher education administrators, engineering schools, and policy makers must continue to develop initiatives to support the recruitment and retention of women and URMs in engineering graduate programs. The country's competitiveness in the engineering field, diverse viewpoints needed in engineering education and research to solve complex problems, and the opportunity for women and URMs to have an equal chance for advancement in the engineering field all rely on continued and increased efforts to recruit and retain underrepresented students in advanced engineering programs.

# CHAPTER VI: APPENDIX

Table 34. All schools included in the initial M.S. URM degree production rate analysis.

| School |
|---|
| Air Force Institute of Technology |
| Arizona State University |
| Auburn University |
| Boston University |
| Brigham Young University |
| California Institute of Technology |
| Carnegie Mellon University |
| Case Western Reserve University |
| Clarkson University |
| Clemson University |
| Cleveland State University |
| Colorado School of Mines |
| Colorado State University |
| Columbia University |
| Cornell University |
| Dartmouth College |
| Drexel University |
| FAMU-FSU College of Engineering |
| Florida Atlantic University |
| Florida Institute of Technology |
| Florida International University |
| George Mason University |
| Georgia Institute of Technology |
| Harvard University |
| Howard University |
| Idaho State University |
| Illinois Institute of Technology |
| Indiana University Purdue University Indianapolis |
| Iowa State University |
| Jackson State University |
| Kansas State University |
| Lehigh University |
| Louisiana State University |
| Louisiana Tech University |
| Marquette University |
| Massachusetts Institute of Technology |
| Michigan State University |
| Michigan Technological University |

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| Mississippi State University |
| Missouri University of Science and Technology |
| Naval Postgraduate School |
| New Jersey Institute of Technology |
| New Mexico Institute of Mining & Technology |
| New Mexico State University |
| North Carolina State University |
| Northeastern University |
| Northern Illinois University |
| Northwestern University |
| Oakland University |
| Oklahoma State University |
| Old Dominion University |
| Oregon State University |
| Polytechnic Institute of New York University |
| Portland State University |
| Princeton University |
| Purdue University |
| Rensselaer Polytechnic Institute |
| Rutgers-The State University of New Jersey |
| San Diego State University |
| South Dakota School of Mines and Technology |
| Southern Illinois University Carbondale |
| Southern Methodist University |
| Stanford University |
| Stevens Institute of Technology |
| Stony Brook University |
| Syracuse University |
| Temple University |
| Tennessee State University |
| Texas A&M University |
| Texas A&M University - Kingsville |
| Texas Tech University |
| The Catholic University of America |
| The George Washington University |
| The Johns Hopkins University |
| The Ohio State University |
| The Pennsylvania State University |
| The State University of New York at Binghamton |
| The University of Akron |
| The University of Alabama |
| The University of Alabama in Huntsville |

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| The University of Iowa |
| The University of Memphis |
| The University of Mississippi |
| The University of New Mexico |
| The University of Texas at Arlington |
| The University of Texas at Austin |
| The University of Texas at Dallas |
| Tufts University |
| Tulane University |
| University of Alabama at Birmingham |
| University of Alaska Fairbanks |
| University of Arizona |
| University of Arkansas |
| University of Bridgeport |
| University of California-Berkeley |
| University of California-Davis |
| University of California-Los Angeles |
| University of California-Riverside |
| University of California-San Diego |
| University of California-Santa Barbara |
| University of California-Santa Cruz |
| University of Central Florida |
| University of Cincinnati |
| University of Colorado at Boulder |
| University of Colorado at Denver |
| University of Connecticut |
| University of Dayton |
| University of Delaware |
| University of Florida |
| University of Hartford |
| University of Hawaii at Manoa |
| University of Houston |
| University of Idaho |
| University of Illinois at Chicago |
| University of Illinois at Urbana-Champaign |
| University of Kansas |
| University of Kentucky |
| University of Louisiana at Lafayette |
| University of Louisville |
| University of Maryland-Baltimore County |
| University of Maryland-College Park |
| University of Massachusetts Amherst |

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|---|
| University of Massachusetts Lowell |
| University of Miami |
| University of Michigan |
| University of Minnesota -Twin Cities |
| University of Missouri |
| University of Nebraska-Lincoln |
| University of Nevada-Las Vegas |
| University of Nevada-Reno |
| University of New Orleans |
| University of Notre Dame |
| University of Oklahoma |
| University of Pennsylvania |
| University of Pittsburgh |
| University of Rochester |
| University of Saint Thomas |
| University of South Alabama |
| University of South Carolina |
| University of South Florida |
| University of Southern California |
| University of Tennessee-Knoxville |
| University of Texas at El Paso |
| University of Tulsa |
| University of Utah |
| University of Virginia |
| University of Washington |
| University of Wisconsin-Madison |
| University of Wisconsin-Milwaukee |
| University of Wyoming |
| Vanderbilt University |
| Virginia Commonwealth University |
| Virginia Polytechnic Institute and State University |
| Washington State University |
| Washington University |
| Wayne State University |
| West Virginia University |
| Western Michigan University |
| Wichita State University |
| Widener University |
| William Marsh Rice University |
| Worcester Polytechnic Institute |
| Wright State University |

Table 35. All schools included in the initial Ph.D. URM degree production rate analysis.

| School |
| --- |
| Arizona State University |
| Auburn University |
| Boston University |
| Carnegie Mellon University |
| Colorado School of Mines |
| Columbia University |
| Cornell University |
| Drexel University |
| FAMU-FSU College of Engineering |
| Florida International University |
| George Mason University |
| Georgia Institute of Technology |
| Howard University |
| Iowa State University |
| Massachusetts Institute of Technology |
| Michigan State University |
| Michigan Technological University |
| Mississippi State University |
| North Carolina State University |
| Northwestern University |
| Oklahoma State University |
| Princeton University |
| Purdue University |
| Rensselaer Polytechnic Institute |
| Rutgers-The State University of New Jersey |
| Stanford University |
| Stony Brook University |
| Texas A&M University |
| Texas Tech University |
| The George Washington University |
| The Johns Hopkins University |
| The Pennsylvania State University |
| The University of Alabama in Huntsville |
| The University of Iowa |
| The University of New Mexico |
| The University of Texas at Arlington |
| The University of Texas at Austin |
| University of Alabama at Birmingham |
| University of Arizona |
| University of Arkansas |

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|---|
| University of California-Berkeley |
| University of California-Davis |
| University of California-Los Angeles |
| University of California-San Diego |
| University of California-Santa Barbara |
| University of Central Florida |
| University of Cincinnati |
| University of Colorado at Boulder |
| University of Connecticut |
| University of Delaware |
| University of Florida |
| University of Houston |
| University of Illinois at Chicago |
| University of Illinois at Urbana-Champaign |
| University of Kentucky |
| University of Maryland-College Park |
| University of Massachusetts Amherst |
| University of Miami |
| University of Michigan |
| University of Minnesota -Twin Cities |
| University of Missouri |
| University of Notre Dame |
| University of Oklahoma |
| University of Pennsylvania |
| University of Pittsburgh |
| University of South Carolina |
| University of South Florida |
| University of Southern California |
| University of Texas at El Paso |
| University of Washington |
| University of Wisconsin-Madison |
| Vanderbilt University |
| Virginia Polytechnic Institute and State University |
| Wayne State University |
| William Marsh Rice University |

Table 36. All schools included in the initial M.S. women degree production rate analysis.

| School |
|---|
| Air Force Institute of Technology |
| Arizona State University |
| Auburn University |
| Baylor University |

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| Boston University |
| Brigham Young University |
| Brown University |
| California Institute of Technology |
| Carnegie Mellon University |
| Case Western Reserve University |
| Clarkson University |
| Clemson University |
| Cleveland State University |
| Colorado School of Mines |
| Colorado State University |
| Columbia University |
| Cornell University |
| Dartmouth College |
| Drexel University |
| Duke University |
| FAMU-FSU College of Engineering |
| Florida Atlantic University |
| Florida Institute of Technology |
| Florida International University |
| George Mason University |
| Georgia Institute of Technology |
| Harvard University |
| Howard University |
| Idaho State University |
| Illinois Institute of Technology |
| Indiana University Purdue University Indianapolis |
| Iowa State University |
| Jackson State University |
| Kansas State University |
| Lehigh University |
| Louisiana State University |
| Louisiana Tech University |
| Marquette University |
| Massachusetts Institute of Technology |
| Michigan State University |
| Michigan Technological University |
| Mississippi State University |
| Missouri University of Science and Technology |
| Montana State University |
| Naval Postgraduate School |
| New Jersey Institute of Technology |

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|---|
| New Mexico Institute of Mining & Technology |
| New Mexico State University |
| North Carolina State University |
| North Dakota State University |
| Northeastern University |
| Northern Illinois University |
| Northwestern University |
| Oakland University |
| Ohio University |
| Oklahoma State University |
| Old Dominion University |
| Oregon State University |
| Polytechnic Institute of New York University |
| Portland State University |
| Princeton University |
| Purdue University |
| Rensselaer Polytechnic Institute |
| Rutgers-The State University of New Jersey |
| San Diego State University |
| South Dakota School of Mines and Technology |
| South Dakota State University |
| Southern Illinois University Carbondale |
| Southern Methodist University |
| Stanford University |
| Stevens Institute of Technology |
| Stony Brook University |
| SUNY-College of Environ. Science and Forestry |
| Syracuse University |
| Temple University |
| Tennessee State University |
| Texas A&M University |
| Texas A&M University - Kingsville |
| Texas Tech University |
| The Catholic University of America |
| The George Washington University |
| The Johns Hopkins University |
| The Ohio State University |
| The Pennsylvania State University |
| The State University of New York at Binghamton |
| The University of Akron |
| The University of Alabama |
| The University of Alabama in Huntsville |

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|---|
| The University of Iowa |
| The University of Memphis |
| The University of Mississippi |
| The University of New Mexico |
| The University of Texas at Arlington |
| The University of Texas at Austin |
| The University of Texas at Dallas |
| The University of Toledo |
| Tufts University |
| Tulane University |
| University of Alabama at Birmingham |
| University of Alaska Fairbanks |
| University of Arizona |
| University of Arkansas |
| University of Bridgeport |
| University of California-Berkeley |
| University of California-Davis |
| University of California-Irvine |
| University of California-Los Angeles |
| University of California-Riverside |
| University of California-San Diego |
| University of California-Santa Barbara |
| University of California-Santa Cruz |
| University of Central Florida |
| University of Cincinnati |
| University of Colorado at Boulder |
| University of Colorado at Denver |
| University of Connecticut |
| University of Dayton |
| University of Delaware |
| University of Denver |
| University of Florida |
| University of Georgia |
| University of Hartford |
| University of Hawaii at Manoa |
| University of Houston |
| University of Idaho |
| University of Illinois at Chicago |
| University of Illinois at Urbana-Champaign |
| University of Kansas |
| University of Kentucky |
| University of Louisiana at Lafayette |

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|---|
| University of Louisville |
| University of Maine |
| University of Maryland-Baltimore County |
| University of Maryland-College Park |
| University of Massachusetts Amherst |
| University of Massachusetts Lowell |
| University of Miami |
| University of Michigan |
| University of Minnesota -Twin Cities |
| University of Missouri |
| University of Missouri - Kansas City |
| University of Nebraska-Lincoln |
| University of Nevada-Las Vegas |
| University of Nevada-Reno |
| University of New Hampshire |
| University of New Orleans |
| University of North Carolina at Chapel Hill |
| University of North Dakota |
| University of North Texas |
| University of Notre Dame |
| University of Oklahoma |
| University of Pennsylvania |
| University of Pittsburgh |
| University of Rhode Island |
| University of Rochester |
| University of Saint Thomas |
| University of South Alabama |
| University of South Carolina |
| University of South Florida |
| University of Southern California |
| University of Tennessee-Knoxville |
| University of Texas at El Paso |
| University of Tulsa |
| University of Utah |
| University of Vermont |
| University of Virginia |
| University of Washington |
| University of Wisconsin-Madison |
| University of Wisconsin-Milwaukee |
| University of Wyoming |
| Utah State University |
| Vanderbilt University |

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| Virginia Commonwealth University |
| Virginia Polytechnic Institute and State University |
| Washington State University |
| Washington University |
| Wayne State University |
| West Virginia University |
| Western Michigan University |
| Wichita State University |
| Widener University |
| William Marsh Rice University |
| Worcester Polytechnic Institute |
| Wright State University |
| Yale University |

Table 37. All schools included in the initial Ph.D. women degree production rate analysis.

| School |
|---|
| Air Force Institute of Technology |
| Arizona State University |
| Auburn University |
| Boston University |
| Brown University |
| California Institute of Technology |
| Carnegie Mellon University |
| Case Western Reserve University |
| Clarkson University |
| Clemson University |
| Colorado School of Mines |
| Colorado State University |
| Columbia University |
| Cornell University |
| Dartmouth College |
| Drexel University |
| Duke University |
| FAMU-FSU College of Engineering |
| Florida International University |
| George Mason University |
| Georgia Institute of Technology |
| Harvard University |
| Illinois Institute of Technology |
| Iowa State University |
| Kansas State University |
| Lehigh University |

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| Louisiana State University |
| Louisiana Tech University |
| Marquette University |
| Massachusetts Institute of Technology |
| Michigan State University |
| Michigan Technological University |
| Mississippi State University |
| Missouri University of Science and Technology |
| New Jersey Institute of Technology |
| New Mexico State University |
| North Carolina State University |
| Northeastern University |
| Northwestern University |
| Old Dominion University |
| Oregon State University |
| Polytechnic Institute of New York University |
| Princeton University |
| Purdue University |
| Rensselaer Polytechnic Institute |
| Rutgers-The State University of New Jersey |
| Southern Methodist University |
| Stanford University |
| Stony Brook University |
| Texas A&M University |
| Texas Tech University |
| The George Washington University |
| The Johns Hopkins University |
| The Ohio State University |
| The Pennsylvania State University |
| The University of Alabama |
| The University of Alabama in Huntsville |
| The University of Iowa |
| The University of New Mexico |
| The University of Texas at Arlington |
| The University of Texas at Austin |
| The University of Texas at Dallas |
| Tufts University |
| Tulane University |
| University of Alabama at Birmingham |
| University of Arizona |
| University of Arkansas |
| University of California-Berkeley |

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| University of California-Davis |
| University of California-Irvine |
| University of California-Los Angeles |
| University of California-Riverside |
| University of California-San Diego |
| University of California-Santa Barbara |
| University of California-Santa Cruz |
| University of Central Florida |
| University of Cincinnati |
| University of Colorado at Boulder |
| University of Connecticut |
| University of Dayton |
| University of Delaware |
| University of Florida |
| University of Houston |
| University of Idaho |
| University of Illinois at Chicago |
| University of Illinois at Urbana-Champaign |
| University of Kentucky |
| University of Louisville |
| University of Maryland-College Park |
| University of Massachusetts Amherst |
| University of Massachusetts Lowell |
| University of Miami |
| University of Michigan |
| University of Minnesota -Twin Cities |
| University of Missouri |
| University of Nebraska-Lincoln |
| University of New Orleans |
| University of North Carolina at Chapel Hill |
| University of Notre Dame |
| University of Oklahoma |
| University of Pennsylvania |
| University of Pittsburgh |
| University of Rochester |
| University of South Carolina |
| University of South Florida |
| University of Southern California |
| University of Tennessee-Knoxville |
| University of Texas at El Paso |
| University of Tulsa |
| University of Utah |

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|---|
| University of Vermont |
| University of Virginia |
| University of Washington |
| University of Wisconsin-Madison |
| Utah State University |
| Vanderbilt University |
| Virginia Commonwealth University |
| Virginia Polytechnic Institute and State University |
| Washington State University |
| Washington University |
| Wayne State University |
| West Virginia University |
| William Marsh Rice University |
| Worcester Polytechnic Institute |
| Wright State University |
| Yale University |

Table 38. Engineering school characteristics of schools that produced highest master's degree rates for URMs.

| School | M.S. URM Degree Production Rate | AAU Status | Location | Avg. Annual Research Expend. | Avg. M.S. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of URM Tenured/ Tenure-Track Faculty | % of URMs Enrolled at Undergrad. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Tennessee State University | 0.52 | Not AAU | Southeast | $2,061,840 | 60 | 0.62 | NR | N/A | 0.25 | 0.84 |
| Jackson State University | 0.46 | Not AAU | Southeast | $4,168,440 | 33 | 0.59 | NR | N/A | 0.28 | 0.91 |
| Howard University | 0.46 | Not AAU | Mid East | $4,760,426 | 54 | 0.56 | NR | N/A | 0.67 | 0.74 |
| University of Texas at El Paso | 0.33 | Not AAU | Southwest | $3,850,229 | 341 | 0.50 | NR | 591 | 0.28 | 0.73 |
| Florida International University | 0.33 | Not AAU | Southeast | $14,346,130 | 577 | 0.44 | NR | 706 | 0.16 | 0.73 |
| University of Miami | 0.32 | Not AAU | Southeast | $3,326,808 | 106 | 0.53 | 116 | 744 | 0.08 | 0.35 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| New Mexico State University | 0.20 | Not AAU | Southwest | $37,237,693 | 318 | 0.36 | 86 | 727 | 0.14 | 0.53 |
| Virginia Commonwealth University | 0.16 | Not AAU | Southeast | $4,848,523 | 121 | 0.42 | NR | 719 | 0.08 | 0.17 |
| University of California-Riverside | 0.16 | AAU | Far West | $20,375,850 | 67 | 0.41 | 66 | 747 | 0.04 | 0.29 |
| University of Arkansas | 0.15 | Not AAU | Southeast | $16,889,111 | 566 | 0.56 | 115 | 737 | 0.02 | 0.09 |
| Southern Methodist University | 0.15 | Not AAU | Southwest | $1,064,267 | 795 | 0.52 | 121 | 728 | 0.05 | 0.15 |
| FAMU-FSU College of Engineering | 0.15 | Not AAU | Southeast | $22,232,999 | 210 | 0.31 | 102 | 736 | 0.20 | 0.38 |
| University of South Florida | 0.15 | Not AAU | Southeast | $18,818,090 | 404 | 0.42 | 119 | 698 | 0.14 | 0.24 |
| The Catholic University of America | 0.15 | Not AAU | Mid East | $230,000 | 110 | 0.47 | NR | N/A | 0.04 | 0.06 |
| The University of New Mexico | 0.14 | Not AAU | Southwest | $27,818,400 | 339 | 0.55 | 81 | 708 | 0.08 | 0.37 |
| Florida Atlantic University | 0.13 | Not AAU | Southeast | $7,988,396 | 256 | 0.59 | NR | 679 | 0.11 | 0.39 |
| University of Central Florida | 0.12 | Not AAU | Southeast | $56,187,404 | 555 | 0.47 | 73 | 711 | 0.09 | 0.22 |
| The George Washington University | 0.12 | Not AAU | Mid East | $7,008,383 | 897 | 0.53 | 107 | 717 | 0.03 | 0.09 |
| University of Alabama at Birmingham | 0.11 | Not AAU | Southeast | $8,486,095 | 184 | 0.55 | 137 | 689 | 0.05 | 0.20 |
| Indiana University Purdue University | 0.11 | Not AAU | Great Lakes | $2,140,439 | 146 | 0.47 | 107 | 771 | 0.04 | 0.11 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Indianapolis | | | | | | | | | | |
| University of Maryland-Baltimore County | 0.10 | Not AAU | Mid East | $10,852,064 | 207 | 0.46 | 107 | 738 | 0.07 | 0.16 |
| William Marsh Rice University | 0.10 | AAU | Southwest | $35,619,563 | 54 | 0.51 | 33 | 768 | Not reported | 0.18 |
| Michigan State University | 0.10 | AAU | Great Lakes | $31,465,000 | 201 | 0.75 | 51 | 740 | 0.04 | 0.11 |
| New Jersey Institute of Technology | 0.10 | Not AAU | Mid East | $34,737,375 | 1466 | 0.46 | 86 | 695 | 0.07 | 0.28 |

Highlighted school = top producer in both URM degree production rate models.

Table 39. Engineering school characteristics of schools that produced highest rates of doctorate degrees for URMs.

| School | Ph.D. URM Degree Production Rate | AAU Status | Location | Avg. Annual Research Expend. | Avg. Ph.D. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of URM Tenured/Tenure-Track Faculty | % of URMs Enrolled at Undergrad. Level | % of URMs Enrolled at M.S. Level |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Howard University | 0.47 | Not AAU | Mid East | $4,760,426 | 19 | 0.56 | NR | N/A | 0.67 | 0.74 | 0.43 |
| Florida International University | 0.19 | Not AAU | Southeast | $14,346,130 | 253 | 0.44 | NR | 706 | 0.16 | 0.73 | 0.42 |
| University of Texas at El Paso | 0.18 | Not AAU | Southwest | $3,850,229 | 104 | 0.5 | NR | 591 | 0.28 | 0.73 | 0.33 |
| FAMU-FSU College of Engineering | 0.16 | Not AAU | Southeast | $22,232,999 | 193 | 0.31 | 102 | 736 | 0.20 | 0.38 | 0.18 |
| University of Alabama at Birmingham | 0.12 | Not AAU | Southeast | $8,486,095 | 81 | 0.55 | 137 | 689 | 0.05 | 0.20 | 0.13 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Wayne State University | 0.09 | Not AAU | Great Lakes | $15,153,852 | 227 | 0.37 | 116 | N/A | 0.07 | 0.29 | 0.06 |
| University of Miami | 0.09 | Not AAU | Southeast | $3,326,808 | 117 | 0.53 | 116 | 744 | 0.08 | 0.35 | 0.25 |
| University of South Carolina | 0.09 | Not AAU | Southeast | $18,026,329 | 243 | 0.5 | 102 | 735 | 0.00 | 0.14 | 0.06 |
| William Marsh Rice University | 0.08 | AAU | Southwest | $35,619,563 | 493 | 0.51 | 33 | 768 | 0.00 | 0.18 | 0.06 |
| University of South Florida | 0.07 | Not AAU | Southeast | $18,818,090 | 295 | 0.42 | 119 | 698 | 0.14 | 0.24 | 0.17 |
| The George Washington University | 0.07 | Not AAU | Mid East | $7,008,383 | 360 | 0.53 | 107 | 717 | 0.03 | 0.09 | 0.13 |
| The University of Alabama in Huntsville | 0.07 | Not AAU | Southeast | $21,080,590 | 201 | 0.5 | 107 | 686 | 0.03 | 0.13 | 0.06 |
| University of Missouri | 0.06 | AAU | Plains | $20,160,895 | 223 | 0.44 | 86 | 737 | 0.03 | 0.06 | 0.03 |
| Rutgers-The State University of New Jersey | 0.06 | AAU | Mid East | $9,564,012 | 381 | 0.49 | 51 | 752 | 0.04 | 0.14 | 0.03 |
| Texas Tech University | 0.06 | Not AAU | Southwest | $13,357,185 | 235 | 0.35 | 99 | 730 | 0.05 | 0.18 | 0.06 |
| University of Arkansas | 0.06 | Not AAU | Southeast | $16,889,111 | 149 | 0.56 | 115 | 737 | 0.02 | 0.09 | 0.16 |
| George Mason University | 0.05 | Not AAU | Southeast | $12,872,127 | 359 | 0.46 | 121 | 698 | 0.03 | 0.14 | 0.08 |
| Boston University | 0.05 | Not AAU | New England | $62,243,527 | 386 | 0.37 | 42 | 763 | 0.02 | 0.09 | 0.07 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| University of Central Florida | 0.05 | Not AAU | Southeast | $56,187,404 | 493 | 0.47 | 73 | 711 | 0.09 | 0.22 | 0.18 |
| Mississippi State University | 0.05 | Not AAU | Southeast | $48,958,053 | 255 | 0.47 | 81 | 732 | 0.06 | 0.12 | 0.09 |
| University of California-Berkeley | 0.05 | AAU | Far West | $131,379,400 | 1461 | 0.49 | 3 | 776 | 0.05 | 0.08 | 0.05 |
| University of Colorado at Boulder | 0.05 | AAU | Rocky Mount. | $57,115,893 | 530 | 0.3 | 39 | 749 | 0.05 | 0.08 | 0.05 |
| University of Florida | 0.05 | AAU | Southeast | $103,640,800 | 1228 | 0.39 | 30 | 763 | 0.05 | 0.23 | 0.08 |
| Oklahoma State University | 0.05 | Not AAU | Southwest | $19,703,321 | 155 | 0.39 | 102 | 738 | 0.05 | 0.13 | 0.05 |
| Georgia Institute of Technology | 0.04 | AAU | Southeast | $221,578,800 | 2231 | 0.51 | 4 | 772 | 0.06 | 0.11 | 0.06 |
| Michigan State University | 0.04 | AAU | Great Lakes | $31,465,000 | 419 | 0.75 | 51 | 740 | 0.04 | 0.11 | 0.10 |
| University of Oklahoma | 0.04 | Not AAU | Southwest | $21,340,480 | 229 | 0.46 | 102 | 733 | 0.04 | 0.18 | 0.08 |
| University of Wisconsin-Madison | 0.04 | AAU | Plains | $122,929,359 | 859 | 0.55 | 15 | 780 | 0.03 | 0.05 | 0.03 |
| University of Maryland-College Park | 0.04 | AAU | Mid East | $146,301,002 | 1093 | 0.56 | 22 | 757 | 0.05 | 0.13 | 0.10 |
| University of California- | 0.04 | AAU | Far West | $70,399,000 | 802 | 0.34 | 32 | 749 | 0.04 | 0.14 | 0.07 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Davis | | | | | | | | | | | |
| The Johns Hopkins University | 0.04 | AAU | Mid East | $57,793,160 | 583 | 0.37 | 25 | 766 | 0.03 | 0.09 | 0.10 |
| University of Notre Dame | 0.04 | Not AAU | Great Lakes | $20,896,727 | 362 | 0.46 | 51 | 760 | 0.05 | 0.08 | 0.03 |
| University of Michigan | 0.04 | AAU | Great Lakes | $154,095,887 | 1352 | 0.38 | 8 | 773 | 0.05 | 0.09 | 0.04 |

Highlighted school = top producer in both URM degree production rate models

Table 40. Engineering school characteristics of schools that produced highest rates of master's degrees for women.

| School | M.S. Women Degree Production Rate | AAU Status | Location | Avg. Annual Research Expend. | Avg. M.S. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of Women Tenured/Tenure-Track Faculty | % of Women Enrolled at Undergrad. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| University of North Carolina at Chapel Hill | 0.46 | AAU | Southeast | $3,271,135 | 13 | 0.44 | 66 | 718 | 0.12 | No undergrad. degree offered |
| Jackson State University | 0.40 | Not AAU | Southeast | $4,168,440 | 33 | 0.59 | N/A | N/A | 0.14 | 0.25 |
| Tennessee State University | 0.35 | Not AAU | Southeast | $2,061,840 | 60 | 0.62 | NR | N/A | 0.23 | 0.24 |
| Tulane University | 0.33 | AAU | Southeast | $4,837,371 | 22 | 0.53 | 107 | 757 | 0.07 | 0.29 |
| University of Georgia | 0.31 | Not AAU | Southeast | $4,508,174 | 24 | 0.57 | 126 | 633 | 0.06 | 0.22 |
| Duke University | 0.30 | AAU | Southeast | $60,727,452 | 212 | 0.42 | 33 | 769 | 0.15 | 0.27 |
| Yale University | 0.29 | AAU | New England | $17,513,325 | 17 | 0.46 | 39 | 780 | 0.11 | 0.29 |

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|---|---|---|---|---|---|---|---|---|---|---|
| The Catholic University of America | 0.28 | Not AAU | Mid East | $230,000 | 110 | 0.47 | N/A | N/A | 0.08 | 0.17 |
| University of California-Santa Cruz | 0.27 | Not AAU | Far West | $18,689,644 | 81 | 0.36 | 86 | 752 | 0.15 | 0.15 |
| Tufts University | 0.25 | Not AAU | New England | $10,482,088 | 340 | 0.49 | 76 | 742 | 0.21 | 0.27 |
| University of California-Irvine | 0.25 | AAU | Far West | $63,915,901 | 267 | 0.38 | 36 | 762 | 0.12 | 0.20 |
| University of Hawaii at Manoa | 0.25 | Not AAU | Far West | $6,598,225 | 142 | 0.46 | 137 | 746 | 0.08 | 0.18 |

Highlighted school = top producer in both women degree production rate models

Table 41. Engineering school characteristics of schools that produced highest rates of doctorate degrees for women.

| School | Ph.D. Women Degree Production Rate | AAU Status | Location | Avg. Annual Research Expend. | Avg. Ph.D. Student Class Size | Graduate Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of Women Tenured/TT Faculty | % of Women Enrolled at Undergrad. Level | % of Women Enrolled at M.S. Level |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Duke University | 0.33 | AAU | Southeast | $60,727,452 | 360 | 0.42 | 33 | 769 | 0.15 | 0.27 | 0.31 |
| University of Vermont | 0.32 | Not AAU | New England | $2,696,763 | 66 | 0.39 | NR | 716 | 0.13 | 0.15 | 0.49 |
| University of North Carolina at Chapel Hill | 0.29 | AAU | Southeast | $3,271,135 | 20 | 0.44 | 66 | 718 | 0.12 | 0.00 | 0.45 |
| Yale University | 0.28 | AAU | New England | $17,513,325 | 203 | 0.46 | 39 | 780 | 0.11 | 0.29 | 0.35 |
| Virginia Commonwealth | 0.24 | Not AAU | Southeast | $4,848,523 | 91 | 0.42 | NR | 719 | 0.16 | 0.16 | 0.35 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| University | | | | | | | | | | | | |
| University of California-Irvine | 0.23 | AAU | Far West | $63,915,901 | 631 | 0.38 | 36 | 762 | 0.12 | 0.20 | 0.23 |
| University of California-Riverside | 0.2 | AAU | Far West | $20,375,850 | 303 | 0.41 | 66 | 747 | 0.08 | 0.16 | 0.19 |
| Tulane University | 0.19 | AAU | Southeast | $4,837,371 | 70 | 0.53 | 107 | 757 | 0.07 | 0.29 | 0.26 |
| California Institute of Technology | 0.18 | AAU | Far West | $70,549,247 | 499 | 0.44 | 7 | 800 | 0.13 | 0.25 | 0.18 |
| Colorado School of Mines | 0.18 | Not AAU | Rocky Mount. | $25,948,940 | 336 | 0.45 | 63 | 722 | 0.13 | 0.23 | 0.31 |
| Rutgers-The State University of New Jersey | 0.17 | AAU | Mid East | $9,564,012 | 381 | 0.49 | 51 | 752 | 0.13 | 0.16 | 0.20 |

Highlighted school = top producer in both women degree production rate models

Table 42. Distribution of independent variables before log transformation and after transformation for M.S. URM group.

| | Independent Variable | Mean | SD |
|---|---|---|---|
| No Log Transform | Average Annual Research Expenditures | $43,159,880.76 | $44,544,972 |
| Log Transform | | $17.13 | $.99 |
| No Log Transform | Average M.S. Program Enrollment | 410 | 289 |
| Log Transform | | 6 | .83 |
| No Log Transform | Graduate Admission Yield | .43 | .09 |
| Log Transform | | -.87 | .21 |
| No Log Transform | *USNWR* Rank | 69 | 37 |
| Log Transform | | 4.01 | .80 |
| No Log Transform | Average Quantitative GRE Score | 744 | 20 |

| | | | |
|---|---|---|---|
| Log Transform | | 7 | .03 |
| No Log Transform | % of URM Tenured/Tenure-Track Faculty | .05 | .03 |
| Log Transform | | -3 | .66 |
| No Log Transform | % of URMs Enrolled at Undergraduate-Level | .11 | .08 |
| Log Transform | | -2 | .62 |

Table 43. Distribution of independent variables before log transformation and after transformation for Ph.D. URM group in regression model analysis.

| Dependent Variable Group | Independent Variable | Mean | SD |
|---|---|---|---|
| No Log Transform | Average Annual Research Expenditures | $71,749,100 | $61,722,047 |
| Log Transformation | | $18 | $.94 |
| No Log Transform | Average PhD. Program Enrollment | 655 | 457 |
| Log Transformation | | 6.26 | .55 |
| No Log Transform | Graduate Admission Yield | .45 | .09 |
| Log Transformation | | -.82 | .20 |
| No Log Transform | *USNWR* Rank | 49 | 35 |
| Log Transformation | | 4 | 1 |
| No Log Transform | Average Quantitative GRE Score | 749 | 21 |
| Log Transformation | | 7 | .03 |
| No Log Transform | % of URM Tenured/Tenure-Track Faculty | .05 | .02 |
| Log Transformation | | -3 | .52 |
| No Log Transform | % of URMs Enrolled at Undergraduate-Level | .12 | .07 |
| Log Transformation | | -2 | .55 |
| No Log Transform | % of URMs Enrolled at | .07 | .04 |

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|---|---|---|---|
| Log Transformation | the Master's-Level | -3 | .55 |

Table 44. Distribution of independent variables before log transformation and after transformation for M.S. women group in regression model analysis.

| Dependent Variable Group | Independent Variable | Mean | SD |
|---|---|---|---|
| No Log Transform | Average Annual Research Expenditures | $48,699,627 | $52,464,688 |
| Log Transformation | | $17 | $1 |
| No Log Transform | Average M.S. Program Enrollment | 493 | 452 |
| Log Transformation | | 6 | .97 |
| No Log Transform | Graduate Admission Yield | .44 | .09 |
| Log Transformation | | -.85 | .21 |
| No Log Transform | *USNWR* Rank | 68 | 40 |
| Log Transformation | | 4 | .97 |
| No Log Transform | Average Quantitative GRE Score | 744 | 24 |
| Log Transformation | | 7 | .03 |
| No Log Transform | % of Women Tenured/Tenure-Track Faculty | .12 | .03 |
| Log Transformation | | -2 | .61 |
| No Log Transform | % of Women Enrolled at Undergraduate-Level | .19 | .05 |
| Log Transformation | | -2 | .29 |

Table 45. Distribution of independent variables before log transformation and after transformation for Ph.D. women group in regression model analysis.

| Dependent Variable Group | Independent Variable | Mean | SD |
|---|---|---|---|

| | | | |
|---|---|---|---|
| No Log Transform | Average Annual Research Expenditures | $54,700,023 | $53,971,741 |
| Log Transformation | | $17 | $1 |
| No Log Transform | Average Ph.D. Program Enrollment | 495 | 410 |
| Log Transformation | | 6 | .77 |
| No Log Transform | Graduate Admission Yield | .43 | .09 |
| Log Transformation | | -.86 | .21 |
| No Log Transform | *USNWR* Rank | 61 | 37 |
| Log Transformation | | 4 | .97 |
| No Log Transform | Average Quantitative GRE Score | 746 | 23 |
| Log Transformation | | 6.61 | .03 |
| No Log Transform | % of Women Tenured/Tenure-Track Faculty | .12 | .03 |
| Log Transformation | | -2 | .28 |
| No Log Transform | % of Women Enrolled at Undergraduate-Level | .19 | .05 |
| Log Transformation | | -2 | .27 |
| No Log Transform | % of Women Enrolled at the Master's-Level | .25 | .11 |
| Log Transformation | | -2 | .46 |

Table 46. Distribution of variables for Ph.D. URM group before and after removed two outliers in regression model analysis.

| Dependent Variable Group | Independent Variable | Mean or % Distribution | SD |
|---|---|---|---|
| Before outliers removed | AAU Status | 52% | |
| After outliers removed | | 54% | |

| | | | |
|---|---|---|---|
| Before outliers removed | Average Annual Research Expenditures | $70,014,037 | $61,549,555 |
| After outliers removed | | $71,749,100 | $61,722,047 |
| Before outliers removed | Average PhD. Program Enrollment | 639 | 459 |
| After outliers removed | | 655 | 457 |
| Before outliers removed | Graduate Admission Yield | .45 | .09 |
| After outliers removed | | .45 | .09 |
| Before outliers removed | *USNWR* Rank | 51 | 37 |
| After outliers removed | | 49 | 35 |
| Before outliers removed | Average Quantitative GRE Score | 748 | 22 |
| After outliers removed | | 749 | 21 |
| Before outliers removed | % of URM Tenured/Tenure-Track Faculty | .05 | .03 |
| After outliers removed | | .05 | .02 |
| Before outliers removed | % of URMs Enrolled at the Undergraduate-Level | .13 | .08 |
| After outliers removed | | .12 | .07 |
| Before outliers removed | % of URMs Enrolled at the Master's-Level | .07 | .05 |
| After outliers removed | | .07 | .04 |

Table 47. Schools included in the regression model to examine M.S. URM degree production rates.

| School | M.S. URM Degree Prod. Rate | AAU Status | Location | Avg. Annual Research Expend. | Avg. M.S. Student Class Size | Grad. Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of URM Tenured/ TT Faculty | % of URMs Enrolled at Undergrad. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| University of Miami | 0.32 | Not AAU | Southeast | $3,326,809 | 106 | 0.53 | 116 | 744 | 0.08 | 0.35 |
| New Mexico State University | 0.20 | Not AAU | Southwest | $37,237,692 | 318 | 0.36 | 86 | 727 | 0.14 | 0.53 |
| University of California-Riverside | 0.16 | AAU | Far West | $20,375,850 | 67 | 0.41 | 66 | 747 | 0.04 | 0.29 |
| FAMU-FSU College of Engineering | 0.15 | Not AAU | Southeast | $22,232,998 | 210 | 0.31 | 102 | 736 | 0.2 | 0.38 |
| The University of New Mexico | 0.14 | Not AAU | Southwest | $27,818,400 | 339 | 0.55 | 81 | 708 | 0.08 | 0.37 |
| University of Alabama at Birmingham | 0.11 | Not AAU | Southeast | $8,486,095 | 184 | 0.55 | 137 | 689 | 0.05 | 0.20 |
| Indiana University Purdue University Indianapolis | 0.11 | Not AAU | Great Lakes | $2,140,440 | 146 | 0.47 | 107 | 771 | 0.04 | 0.11 |
| University of Maryland-Baltimore County | 0.1 | Not AAU | Mid East | $10,852,064 | 207 | 0.46 | 107 | 738 | 0.07 | 0.16 |
| Michigan State University | 0.1 | AAU | Great Lakes | $31,465,000 | 201 | 0.75 | 51 | 740 | 0.04 | 0.11 |
| Tulane University | 0.09 | AAU | Southeast | $4,837,371 | 22 | 0.53 | 107 | 757 | 0.03 | 0.09 |
| Old Dominion University | 0.08 | Not AAU | Southeast | $19,804,676 | 524 | 0.61 | 121 | 715 | 0.11 | 0.19 |
| University of Louisville | 0.07 | Not AAU | Southeast | $11,990,800 | 340 | 0.41 | 129 | 714 | 0.07 | 0.07 |
| Northwestern University | 0.07 | AAU | Great Lakes | $41,868,428 | 510 | 0.52 | 21 | 776 | 0.06 | 0.07 |
| Texas Tech University | 0.07 | Not AAU | Southwest | $13,357,185 | 399 | 0.35 | 99 | 730 | 0.05 | 0.18 |
| University of California-Berkeley | 0.07 | AAU | Far West | $131,379,400 | 270 | 0.49 | 3 | 776 | 0.05 | 0.08 |
| University of Illinois at Chicago | 0.07 | Not AAU | Great Lakes | $20,833,814 | 497 | 0.38 | 66 | 738 | 0.03 | 0.21 |
| Missouri University of Science and Technology | 0.07 | Not AAU | Plains | $26,730,676 | 672 | 0.36 | 94 | 719 | 0.05 | 0.07 |
| University of Arizona | 0.07 | AAU | Southwest | $35,439,816 | 411 | 0.45 | 51 | 737 | 0.05 | 0.20 |
| University of California- | 0.06 | AAU | Far West | $89,973,040 | 603 | 0.41 | 15 | 765 | 0.01 | 0.09 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Los Angeles | | | | | | | | | | |
| The University of Alabama | 0.06 | Not AAU | Southeast | $9,403,049 | 151 | 0.39 | 113 | 733 | 0.06 | 0.16 |
| University of Houston | 0.06 | Not AAU | Southwest | $17,784,894 | 615 | 0.38 | 81 | 748 | 0.01 | 0.32 |
| Rensselaer Polytechnic Institute | 0.06 | Not AAU | Mid East | $61,337,908 | 161 | 0.44 | 35 | 752 | 0.05 | 0.10 |
| University of Pittsburgh | 0.06 | AAU | Mid East | $60,342,000 | 328 | 0.32 | 48 | 746 | 0.04 | 0.07 |
| Auburn University | 0.06 | Not AAU | Southeast | $44,207,600 | 396 | 0.28 | 70 | 725 | 0.06 | 0.13 |
| Rutgers-The State University of New Jersey | 0.06 | AAU | Mid East | $9,564,012 | 316 | 0.49 | 51 | 752 | 0.04 | 0.14 |
| Mississippi State University | 0.06 | Not AAU | Southeast | $48,958,052 | 261 | 0.47 | 81 | 732 | 0.06 | 0.12 |
| Drexel University | 0.06 | Not AAU | Mid East | $34,604,508 | 596 | 0.35 | 59 | 734 | 0.02 | 0.07 |
| University of California-Davis | 0.06 | AAU | Far West | $70,399,000 | 320 | 0.34 | 32 | 749 | 0.04 | 0.14 |
| Texas A&M University | 0.06 | AAU | Southwest | $208,601,000 | 1518 | 0.41 | 12 | 754 | 0.08 | 0.16 |
| University of Massachusetts Amherst | 0.05 | Not AAU | New England | $44,299,984 | 242 | 0.36 | 51 | 754 | 0.02 | 0.08 |
| Vanderbilt University | 0.05 | AAU | Southeast | $45,880,688 | 74 | 0.56 | 37 | 756 | 0.01 | 0.10 |
| University of California-Santa Cruz | 0.05 | Not AAU | Far West | $18,689,644 | 81 | 0.36 | 86 | 752 | 0.07 | 0.19 |
| Polytechnic Institute of New York University | 0.05 | Not AAU | Mid East | $10,937,471 | 1095 | 0.31 | 69 | 758 | 0.01 | 0.23 |
| Purdue University | 0.05 | AAU | Great Lakes | $156,315,888 | 903 | 0.38 | 13 | 763 | 0.05 | 0.05 |
| Princeton University | 0.05 | AAU | Mid East | $56,827,224 | 27 | 0.41 | 17 | 783 | 0.05 | 0.11 |
| University of Colorado at Boulder | 0.05 | AAU | Rockies | $57,115,893 | 884 | 0.3 | 39 | 749 | 0.05 | 0.08 |
| University of Oklahoma | 0.05 | Not AAU | Southwest | $21,340,480 | 338 | 0.46 | 102 | 733 | 0.04 | 0.18 |
| The University of Alabama in Huntsville | 0.05 | Not AAU | Southeast | $21,080,590 | 435 | 0.5 | 107 | 686 | 0.03 | 0.13 |
| Dartmouth College | 0.05 | Not AAU | New England | $19,594,550 | 107 | 0.51 | 48 | 770 | 0.01 | 0.14 |
| Boston University | 0.05 | Not AAU | New England | $62,243,527 | 215 | 0.37 | 42 | 763 | 0.02 | 0.09 |
| University of Virginia | 0.05 | AAU | Southeast | $54,445,669 | 278 | 0.49 | 39 | 762 | 0.07 | 0.07 |
| University of Notre Dame | 0.05 | Not AAU | Great Lakes | $20,896,727 | 47 | 0.46 | 51 | 760 | 0.05 | 0.08 |
| University of | 0.05 | Not | Far West | $6,598,226 | 142 | 0.46 | 137 | 746 | 0.03 | 0.02 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Hawaii at Manoa | | AAU | | | | | | | | |
| University of Tennessee-Knoxville | 0.05 | Not AAU | Southeast | $40,293,372 | 509 | 0.34 | 73 | 731 | 0.03 | 0.09 |
| Tufts University | 0.05 | Not AAU | New England | $10,482,088 | 340 | 0.49 | 76 | 742 | 0.04 | 0.07 |
| North Carolina State University | 0.05 | Not AAU | Southeast | $110,060,800 | 1155 | 0.64 | 30 | 756 | 0.05 | 0.1 |
| Colorado School of Mines | 0.05 | Not AAU | Rockies | $25,948,940 | 519 | 0.45 | 63 | 722 | 0.03 | 0.07 |
| Temple University | 0.04 | Not AAU | Mid East | $1,879,307 | 106 | 0.44 | 137 | 725 | 0.14 | 0.19 |
| University of Washington | 0.04 | AAU | Far West | $95,364,800 | 618 | 0.41 | 28 | 743 | 0.03 | 0.07 |
| Washington State University | 0.04 | Not AAU | Far West | $16,686,796 | 266 | 0.55 | 76 | 740 | 0.05 | 0.07 |
| Cornell University | 0.04 | AAU | Mid East | $115,680,416 | 543 | 0.53 | 10 | 774 | 0.05 | 0.07 |
| Worcester Polytechnic Institute | 0.04 | Not AAU | New England | $10,909,369 | 448 | 0.32 | 94 | 736 | 0.03 | 0.07 |
| University of Minnesota - Twin Cities | 0.04 | AAU | Plains | $80,443,112 | 833 | 0.4 | 28 | 761 | 0.03 | 0.05 |
| Lehigh University | 0.04 | Not AAU | Mid East | $30,738,006 | 203 | 0.43 | 42 | 768 | 0.04 | 0.06 |
| California Institute of Technology | 0.04 | AAU | Far West | $70,549,248 | 65 | 0.44 | 7 | 800 | 0.02 | 0.04 |
| Syracuse University | 0.04 | AAU | Mid East | $13,860,399 | 572 | 0.31 | 81 | 741 | 0.03 | 0.16 |
| Iowa State University | 0.04 | AAU | Plains | $70,196,414 | 437 | 0.6 | 45 | 756 | 0.02 | 0.05 |
| The University of Iowa | 0.04 | AAU | Plains | $34,690,917 | 176 | 0.44 | 59 | 732 | 0.03 | 0.05 |
| University of Wisconsin-Madison | 0.04 | AAU | Great Lakes | $122,929,360 | 678 | 0.55 | 15 | 780 | 0.03 | 0.05 |
| University of Illinois at Urbana-Champaign | 0.04 | AAU | Great Lakes | $198,634,096 | 842 | 0.52 | 5 | 770 | 0.04 | 0.06 |
| Virginia Polytechnic Institute and State University | 0.04 | Not AAU | Southeast | $97,132,400 | 861 | 0.55 | 25 | 744 | 0.07 | 0.07 |
| Stony Brook University | 0.04 | AAU | Mid East | $25,532,803 | 466 | 0.37 | 62 | 759 | 0.04 | 0.10 |
| Oklahoma State University | 0.04 | Not AAU | Southwest | $19,703,322 | 540 | 0.39 | 102 | 738 | 0.05 | 0.13 |
| Clemson University | 0.03 | Not AAU | Southeast | $30,113,740 | 472 | 0.31 | 76 | 736 | 0.05 | 0.10 |
| University of Nevada-Reno | 0.03 | Not AAU | Far West | $12,556,341 | 153 | 0.46 | 126 | 723 | 0.04 | 0.11 |

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|---|---|---|---|---|---|---|---|---|---|---|
| Wright State University | 0.03 | Not AAU | Great Lakes | $8,251,400 | 440 | 0.34 | 137 | 687 | 0.01 | 0.11 |
| Carnegie Mellon University | 0.03 | AAU | Mid East | $225,030,352 | 764 | 0.5 | 6 | 759 | 0.05 | 0.11 |
| Marquette University | 0.03 | Not AAU | Great Lakes | $2,500,295 | 187 | 0.35 | 126 | 737 | 0.02 | 0.08 |
| University of Pennsylvania | 0.03 | AAU | Mid East | $47,870,532 | 707 | 0.41 | 23 | 757 | 0.06 | 0.07 |
| Northeastern University | 0.03 | Not AAU | New England | $27,506,952 | 718 | 0.36 | 59 | 757 | 0.03 | 0.08 |
| University of Cincinnati | 0.03 | Not AAU | Great Lakes | $20,702,486 | 533 | 0.44 | 73 | 753 | 0.07 | 0.06 |
| University of Missouri | 0.03 | AAU | Plains | $20,160,896 | 249 | 0.44 | 86 | 737 | 0.03 | 0.06 |
| Louisiana State University | 0.03 | Not AAU | Southeast | $16,183,580 | 288 | 0.33 | 99 | 734 | 0.05 | 0.12 |
| Case Western Reserve University | 0.03 | AAU | Great Lakes | $39,438,788 | 244 | 0.32 | 47 | 737 | 0.04 | 0.04 |
| University of Wyoming | 0.03 | Not AAU | Rockies | $10,089,510 | 106 | 0.46 | 137 | 726 | 0.01 | 0.04 |
| The Pennsylvania State University | 0.03 | AAU | Mid East | $119,091,856 | 550 | 0.33 | 23 | 768 | 0.07 | 0.06 |
| University of Connecticut | 0.03 | Not AAU | New England | $25,169,000 | 225 | 0.48 | 70 | 735 | 0.04 | 0.09 |
| Michigan Technological University | 0.03 | Not AAU | Great Lakes | $19,835,658 | 308 | 0.31 | 86 | 734 | 0.01 | 0.03 |
| Colorado State University | 0.03 | Not AAU | Rockies | $53,174,000 | 286 | 0.37 | 63 | 718 | 0.07 | 0.07 |
| The State University of New York at Binghamton | 0.03 | Not AAU | Mid East | $12,940,897 | 454 | 0.39 | 116 | 721 | 0.01 | 0.06 |
| Brigham Young University | 0.03 | Not AAU | Rockies | $11,956,838 | 268 | 0.7 | 102 | 745 | 0.01 | 0.03 |
| Kansas State University | 0.03 | Not AAU | Plains | $18,990,200 | 371 | 0.38 | 99 | 758 | 0.00 | 0.06 |
| Arizona State University | 0.03 | Not AAU | Southwest | $55,326,808 | 1090 | 0.34 | 44 | 762 | 0.05 | 0.2 |
| West Virginia University | 0.03 | Not AAU | Southeast | $23,970,420 | 510 | 0.46 | 113 | 724 | 0.03 | 0.03 |
| University of Nebraska-Lincoln | 0.03 | AAU | Plains | $23,215,334 | 264 | 0.44 | 94 | 733 | 0.03 | 0.05 |
| Oregon State University | 0.03 | Not AAU | Far West | $24,061,340 | 351 | 0.42 | 85 | 716 | 0.02 | 0.05 |
| The University of Texas at Dallas | 0.03 | Not AAU | Southwest | $25,791,466 | 789 | 0.34 | 76 | 747 | 0.04 | 0.15 |
| The University of Akron | 0.03 | Not AAU | Great Lakes | $4,087,245 | 171 | 0.4 | 129 | 726 | 0.10 | 0.06 |
| University of | 0.02 | AAU | Plains | $14,864,478 | 487 | 0.45 | 86 | 746 | 0.06 | 0.07 |

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|---|---|---|---|---|---|---|---|---|---|---|
| Kansas | | | | | | | | | | |
| University of Utah | 0.02 | Not AAU | Rockies | $47,179,400 | 427 | 0.45 | 63 | 749 | 0.03 | 0.05 |
| The Ohio State University | 0.02 | AAU | Great Lakes | $114,750,000 | 504 | 0.41 | 25 | 765 | 0.03 | 0.06 |
| University of Delaware | 0.02 | Not AAU | Mid East | $31,968,864 | 176 | 0.52 | 45 | 756 | 0.07 | 0.09 |
| Harvard University | 0.02 | AAU | New England | $38,030,200 | 37 | 0.53 | 19 | 770 | 0.03 | 0.10 |
| Illinois Institute of Technology | 0.02 | Not AAU | Great Lakes | $17,865,620 | 1218 | 0.22 | 76 | 742 | 0.04 | 0.11 |
| University of Rochester | 0.02 | AAU | Mid East | $92,523,200 | 120 | 0.43 | 37 | 765 | 0.03 | 0.06 |
| Louisiana Tech University | 0.01 | Not AAU | Southeast | $11,431,038 | 247 | 0.39 | 129 | 711 | 0.06 | 0.14 |
| University of Kentucky | 0.01 | Not AAU | Southeast | $26,544,502 | 317 | 0.31 | 86 | 756 | 0.03 | 0.04 |

Table 48. Schools included in the regression model to examine Ph.D. URM degree production rates.

| School | Ph.D. URM Degree Prod. Rate | AAU Status | Location | Avg. Annual Research Expend. | Avg. Ph.D. Student Class Size | Grad. Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of URM Tenured /TT Faculty | % of URMs Enrolled at Undergrad. Level | % of URMs Enrolled at M.S. Level |
|---|---|---|---|---|---|---|---|---|---|---|---|
| University of Miami | 0.09 | Not AAU | Southeast | $3,326,809 | 117 | 0.53 | 116 | 744 | 0.08 | 0.35 | 0.25 |
| University of South Florida | 0.07 | Not AAU | Southeast | $18,818,090 | 295 | 0.42 | 119 | 698 | 0.14 | 0.24 | 0.17 |
| The George Washington University | 0.07 | Not AAU | Mid East | $7,008,384 | 360 | 0.53 | 107 | 717 | 0.03 | 0.09 | 0.13 |
| The University of Alabama in Huntsville | 0.07 | Not AAU | Southeast | $21,080,590 | 201 | 0.5 | 107 | 686 | 0.03 | 0.13 | 0.06 |
| University of Missouri | 0.06 | AAU | Plains | $20,160,896 | 223 | 0.44 | 86 | 737 | 0.03 | 0.06 | 0.03 |
| Rutgers-The State University of New Jersey | 0.06 | AAU | Mid East | $9,564,012 | 381 | 0.49 | 51 | 752 | 0.04 | 0.14 | 0.03 |
| Texas Tech University | 0.06 | Not AAU | Southwest | $13,357,185 | 235 | 0.35 | 99 | 730 | 0.05 | 0.18 | 0.06 |
| University of Arkansas | 0.06 | Not AAU | Southeast | $16,889,111 | 149 | 0.56 | 115 | 737 | 0.02 | 0.09 | 0.16 |
| George Mason University | 0.05 | Not AAU | Southeast | $12,872,127 | 359 | 0.46 | 121 | 698 | 0.03 | 0.14 | 0.08 |
| Boston University | 0.05 | Not AAU | New England | $62,243,527 | 386 | 0.37 | 42 | 763 | 0.02 | 0.09 | 0.07 |
| University of Central Florida | 0.05 | Not AAU | Southeast | $56,187,404 | 493 | 0.47 | 73 | 711 | 0.09 | 0.22 | 0.18 |
| Mississippi State University | 0.05 | Not AAU | Southeast | $48,958,052 | 255 | 0.47 | 81 | 732 | 0.06 | 0.12 | 0.09 |
| University of | 0.05 | AAU | Far West | $131,379,400 | 1461 | 0.49 | 3 | 776 | 0.05 | 0.08 | 0.05 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| California-Berkeley | | | | | | | | | | | |
| University of Colorado at Boulder | 0.05 | AAU | Rockies | $57,115,893 | 530 | 0.3 | 39 | 749 | 0.05 | 0.08 | 0.05 |
| University of Florida | 0.05 | AAU | Southeast | $103,640,800 | 1228 | 0.39 | 30 | 763 | 0.05 | 0.23 | 0.08 |
| Oklahoma State University | 0.05 | Not AAU | Southwest | $19,703,322 | 155 | 0.39 | 102 | 738 | 0.05 | 0.13 | 0.05 |
| Georgia Institute of Technology | 0.04 | AAU | Southeast | $221,578,800 | 2231 | 0.51 | 4 | 772 | 0.06 | 0.11 | 0.06 |
| Michigan State University | 0.04 | AAU | Great Lakes | $31,465,000 | 419 | 0.75 | 51 | 740 | 0.04 | 0.11 | 0.1 |
| University of Oklahoma | 0.04 | Not AAU | Southwest | $21,340,480 | 229 | 0.46 | 102 | 733 | 0.04 | 0.18 | 0.08 |
| University of Wisconsin-Madison | 0.04 | AAU | Great Lakes | $122,929,360 | 859 | 0.55 | 15 | 780 | 0.03 | 0.05 | 0.03 |
| University of Maryland-College Park | 0.04 | AAU | Mid East | $146,301,008 | 1093 | 0.56 | 22 | 757 | 0.05 | 0.13 | 0.10 |
| University of California-Davis | 0.04 | AAU | Far West | $70,399,000 | 802 | 0.34 | 32 | 749 | 0.04 | 0.14 | 0.07 |
| The Johns Hopkins University | 0.04 | AAU | Mid East | $57,793,160 | 583 | 0.37 | 25 | 766 | 0.03 | 0.09 | 0.10 |
| University of Notre Dame | 0.04 | Not AAU | Great Lakes | $20,896,727 | 362 | 0.46 | 51 | 760 | 0.05 | 0.08 | 0.03 |
| University of Michigan | 0.04 | AAU | Great Lakes | $154,095,887 | 1352 | 0.38 | 8 | 773 | 0.05 | 0.09 | 0.04 |
| Auburn University | 0.03 | Not AAU | Southeast | $44,207,600 | 317 | 0.28 | 70 | 725 | 0.06 | 0.13 | 0.06 |
| Virginia Polytechnic Institute and State University | 0.03 | Not AAU | Southeast | $97,132,400 | 1031 | 0.55 | 25 | 744 | 0.07 | 0.07 | 0.04 |
| Vanderbilt University | 0.03 | AAU | Southeast | $45,880,688 | 323 | 0.56 | 37 | 756 | 0.01 | 0.10 | 0.06 |
| Drexel University | 0.03 | Not AAU | Mid East | $34,604,508 | 377 | 0.35 | 59 | 734 | 0.02 | 0.07 | 0.09 |
| The University of Iowa | 0.03 | AAU | Plains | $34,690,917 | 283 | 0.44 | 59 | 732 | 0.03 | 0.05 | 0.03 |
| University of Arizona | 0.03 | AAU | Southwest | $35,439,816 | 479 | 0.45 | 51 | 737 | 0.05 | 0.20 | 0.10 |
| Rensselaer Polytechnic Institute | 0.03 | Not AAU | Mid East | $61,337,908 | 522 | 0.44 | 35 | 752 | 0.05 | 0.10 | 0.08 |
| Princeton University | 0.03 | AAU | Mid East | $56,827,224 | 473 | 0.41 | 17 | 783 | 0.05 | 0.11 | 0.11 |
| Michigan Technological University | 0.03 | Not AAU | Great Lakes | $19,835,658 | 245 | 0.31 | 86 | 734 | 0.01 | 0.03 | 0.02 |
| The University of New Mexico | 0.03 | Not AAU | Southwest | $27,818,400 | 275 | 0.55 | 81 | 708 | 0.08 | 0.37 | 0.20 |
| Texas A&M | 0.03 | AAU | Southwest | $208,601,000 | 979 | 0.41 | 12 | 754 | 0.08 | 0.16 | 0.06 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| University | | | | | | | | | | | |
| Massachusetts Institute of Technology | 0.03 | AAU | New England | $241,469,800 | 1597 | 0.63 | 1 | 780 | 0.06 | 0.23 | 0.06 |
| Cornell University | 0.03 | AAU | Mid East | $115,680,416 | 840 | 0.53 | 10 | 774 | 0.05 | 0.07 | 0.05 |
| University of Pittsburgh | 0.03 | AAU | Mid East | $60,342,000 | 367 | 0.32 | 48 | 746 | 0.04 | 0.07 | 0.06 |
| Northwestern University | 0.03 | AAU | Great Lakes | $41,868,428 | 711 | 0.52 | 21 | 776 | 0.06 | 0.07 | 0.07 |
| University of Delaware | 0.03 | Not AAU | Mid East | $31,968,864 | 474 | 0.52 | 45 | 756 | 0.07 | 0.09 | 0.03 |
| Stony Brook University | 0.03 | AAU | Mid East | $25,532,803 | 471 | 0.37 | 62 | 759 | 0.04 | 0.10 | 0.04 |
| North Carolina State University | 0.03 | Not AAU | Southeast | $110,060,800 | 963 | 0.64 | 30 | 756 | 0.05 | 0.10 | 0.05 |
| Stanford University | 0.03 | AAU | Far West | $157,122,768 | 1541 | 0.51 | 2 | 777 | 0.06 | 0.23 | 0.05 |
| University of Pennsylvania | 0.03 | AAU | Mid East | $47,870,532 | 426 | 0.41 | 23 | 757 | 0.06 | 0.07 | 0.03 |
| The University of Texas at Austin | 0.03 | AAU | Southwest | $136,732,304 | 1142 | 0.43 | 9 | 765 | 0.07 | 0.18 | 0.08 |
| University of Kentucky | 0.03 | Not AAU | Southeast | $26,544,502 | 253 | 0.31 | 86 | 756 | 0.03 | 0.04 | 0.02 |
| University of California-Los Angeles | 0.03 | AAU | Far West | $89,973,040 | 813 | 0.41 | 15 | 765 | 0.01 | 0.09 | 0.07 |
| University of Illinois at Chicago | 0.03 | Not AAU | Great Lakes | $20,833,814 | 429 | 0.38 | 66 | 738 | 0.03 | 0.21 | 0.07 |
| Colorado School of Mines | 0.03 | Not AAU | Rockies | $25,948,940 | 336 | 0.45 | 63 | 722 | 0.03 | 0.07 | 0.05 |
| Purdue University | 0.02 | AAU | Great Lakes | $156,315,888 | 1475 | 0.38 | 13 | 763 | 0.05 | 0.05 | 0.05 |
| University of Houston | 0.02 | Not AAU | Southwest | $17,784,894 | 299 | 0.38 | 81 | 748 | 0.01 | 0.32 | 0.07 |
| University of Washington | 0.02 | AAU | Far West | $95,364,800 | 847 | 0.41 | 28 | 743 | 0.03 | 0.07 | 0.05 |
| University of Massachusetts Amherst | 0.02 | Not AAU | New England | $44,299,984 | 414 | 0.36 | 51 | 754 | 0.02 | 0.08 | 0.02 |
| University of Connecticut | 0.02 | Not AAU | New England | $25,169,000 | 310 | 0.48 | 70 | 735 | 0.04 | 0.09 | 0.08 |
| Arizona State University | 0.02 | Not AAU | Southwest | $55,326,808 | 751 | 0.34 | 44 | 762 | 0.05 | 0.20 | 0.05 |
| Carnegie Mellon University | 0.02 | AAU | Mid East | $225,030,352 | 1035 | 0.5 | 6 | 759 | 0.05 | 0.11 | 0.02 |
| University of Cincinnati | 0.02 | Not AAU | Great Lakes | $20,702,486 | 433 | 0.44 | 73 | 753 | 0.07 | 0.06 | 0.03 |
| University of Illinois at Urbana-Champaign | 0.01 | AAU | Great Lakes | $198,634,096 | 1690 | 0.52 | 5 | 770 | 0.04 | 0.06 | 0.03 |
| University of Minnesota - Twin Cities | 0.01 | AAU | Plains | $80,443,112 | 970 | 0.4 | 28 | 761 | 0.03 | 0.05 | 0.03 |
| Iowa State | 0.01 | AAU | Plains | $70,196,414 | 504 | 0.6 | 45 | 756 | 0.02 | 0.05 | 0.05 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| University | | | | | | | | | | | |
| The Pennsylvania State University | 0.01 | AAU | Mid East | $119,091,856 | 1105 | 0.33 | 23 | 768 | 0.07 | 0.06 | 0.04 |
| University of Southern California | 0.01 | AAU | Far West | $164,403,488 | 984 | 0.44 | 10 | 758 | 0.03 | 0.14 | 0.05 |

Table 49. Schools included in the regression model to examine M.S. women degree production rates.

| School | M.S. Women Degree Prod. Rate | AAU Status | Location | Avg. Annual Research Expend. | Avg. M.S. Student Class Size | Grad. Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of Women Tenured/ TT Faculty | % of Women Enrolled at Undergrad. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| Tulane University | 0.33 | AAU | Southeast | $4,837,371 | 22 | 0.53 | 107 | 757 | 0.07 | 0.29 |
| University of Georgia | 0.31 | Not AAU | Southeast | $4,508,174 | 24 | 0.57 | 126 | 633 | 0.06 | 0.22 |
| Duke University | 0.3 | AAU | Southeast | $60,727,452 | 212 | 0.42 | 33 | 769 | 0.15 | 0.27 |
| Yale University | 0.29 | AAU | New England | $17,513,326 | 17 | 0.46 | 39 | 780 | 0.11 | 0.29 |
| University of California-Santa Cruz | 0.27 | Not AAU | Far West | $18,689,644 | 81 | 0.36 | 86 | 752 | 0.15 | 0.15 |
| University of Hawaii at Manoa | 0.25 | Not AAU | Far West | $6,598,226 | 142 | 0.46 | 137 | 746 | 0.08 | 0.18 |
| University of California-Irvine | 0.25 | AAU | Far West | $63,915,900 | 267 | 0.38 | 36 | 762 | 0.12 | 0.20 |
| Tufts University | 0.25 | Not AAU | New England | $10,482,088 | 340 | 0.49 | 76 | 742 | 0.21 | 0.27 |
| University of Miami | 0.24 | Not AAU | Southeast | $3,326,809 | 106 | 0.53 | 116 | 744 | 0.08 | 0.27 |
| Colorado School of Mines | 0.24 | Not AAU | Rockies | $25,948,940 | 519 | 0.45 | 63 | 722 | 0.13 | 0.23 |
| Indiana University Purdue University | 0.24 | Not AAU | Great Lakes | $2,140,440 | 146 | 0.47 | 107 | 771 | 0.19 | 0.22 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Indianapolis | | | | | | | | | | |
| Marquette University | 0.23 | Not AAU | Great Lakes | $2,500,295 | 187 | 0.35 | 126 | 737 | 0.08 | 0.19 |
| University of California-Berkeley | 0.23 | AAU | Far West | $131,379,400 | 270 | 0.49 | 3 | 776 | 0.13 | 0.21 |
| Colorado State University | 0.23 | Not AAU | Rockies | $53,174,000 | 286 | 0.37 | 63 | 718 | 0.08 | 0.16 |
| The George Washington University | 0.21 | Not AAU | Mid East | $7,008,383 | 897 | 0.53 | 107 | 717 | 0.17 | 0.28 |
| California Institute of Technology | 0.21 | AAU | Far West | $70,549,248 | 65 | 0.44 | 7 | 800 | 0.13 | 0.25 |
| Princeton University | 0.21 | AAU | Mid East | $56,827,224 | 27 | 0.41 | 17 | 783 | 0.14 | 0.29 |
| Temple University | 0.21 | Not AAU | Mid East | $1,879,307 | 106 | 0.44 | 137 | 725 | 0.11 | 0.13 |
| Vanderbilt University | 0.2 | AAU | Southeast | $45,880,688 | 74 | 0.56 | 37 | 756 | 0.11 | 0.25 |
| University of Washington | 0.2 | AAU | Far West | $95,364,800 | 618 | 0.41 | 28 | 743 | 0.18 | 0.19 |
| The Johns Hopkins University | 0.2 | AAU | Mid East | $57,793,160 | 2109 | 0.37 | 25 | 766 | 0.12 | 0.28 |
| University of Illinois at Chicago | 0.2 | Not AAU | Great Lakes | $20,833,814 | 497 | 0.38 | 66 | 738 | 0.13 | 0.18 |
| University of California-Davis | 0.19 | AAU | Far West | $70,399,000 | 320 | 0.34 | 32 | 749 | 0.16 | 0.22 |
| University of Arkansas | 0.19 | Not AAU | Southeast | $16,889,111 | 566 | 0.56 | 115 | 737 | 0.11 | 0.15 |
| University of California-Riverside | 0.19 | AAU | Far West | $20,375,850 | 67 | 0.41 | 66 | 747 | 0.08 | 0.16 |
| Washington University | 0.19 | AAU | Plains | $26,896,378 | 457 | 0.49 | 48 | 767 | 0.10 | 0.26 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Northwestern University | 0.18 | AAU | Great Lakes | $41,868,428 | 510 | 0.52 | 21 | 776 | 0.10 | 0.25 |
| University of Colorado at Boulder | 0.18 | AAU | Rockies | $57,115,893 | 884 | 0.3 | 39 | 749 | 0.15 | 0.20 |
| Massachusetts Institute of Technology | 0.17 | AAU | New England | $241,469,800 | 1088 | 0.63 | 1 | 780 | 0.14 | 0.39 |
| University of Virginia | 0.17 | AAU | Southeast | $54,445,669 | 278 | 0.49 | 39 | 762 | 0.12 | 0.27 |
| Washington State University | 0.17 | Not AAU | Far West | $16,686,796 | 266 | 0.55 | 76 | 740 | 0.14 | 0.13 |
| University of South Florida | 0.17 | Not AAU | Southeast | $18,818,090 | 404 | 0.42 | 119 | 698 | 0.10 | 0.17 |
| The University of Iowa | 0.17 | AAU | Plains | $34,690,917 | 176 | 0.44 | 59 | 732 | 0.10 | 0.18 |
| University of California-San Diego | 0.16 | AAU | Far West | $135,585,408 | 403 | 0.36 | 13 | 775 | 0.10 | 0.24 |
| University of Nebraska-Lincoln | 0.16 | AAU | Plains | $23,215,334 | 264 | 0.44 | 94 | 733 | 0.10 | 0.11 |
| Drexel University | 0.16 | Not AAU | Mid East | $34,604,508 | 596 | 0.35 | 59 | 734 | 0.17 | 0.14 |
| Michigan Technological University | 0.16 | Not AAU | Great Lakes | $19,835,658 | 308 | 0.31 | 86 | 734 | 0.13 | 0.14 |
| William Marsh Rice University | 0.16 | AAU | Southwest | $35,619,563 | 54 | 0.51 | 33 | 768 | 0.17 | 0.31 |
| University of Nevada-Reno | 0.16 | Not AAU | Far West | $12,556,341 | 153 | 0.46 | 126 | 723 | 0.11 | 0.17 |
| University of Pittsburgh | 0.16 | AAU | Mid East | $60,342,000 | 328 | 0.32 | 48 | 746 | 0.15 | 0.20 |
| Southern Methodist University | 0.15 | Not AAU | Southwest | $1,064,267 | 795 | 0.52 | 121 | 728 | 0.07 | 0.29 |
| University of California-Los Angeles | 0.15 | AAU | Far West | $89,973,040 | 603 | 0.41 | 15 | 765 | 0.1 | 0.19 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Harvard University | 0.15 | AAU | New England | $38,030,200 | 37 | 0.53 | 19 | 770 | 0.09 | 0.26 |
| Worcester Polytechnic Institute | 0.15 | Not AAU | New England | $10,909,369 | 448 | 0.32 | 94 | 736 | 0.16 | 0.20 |
| Boston University | 0.15 | Not AAU | New England | $62,243,527 | 215 | 0.37 | 42 | 763 | 0.12 | 0.22 |
| Old Dominion University | 0.14 | Not AAU | Southeast | $19,804,676 | 524 | 0.61 | 121 | 715 | 0.08 | 0.13 |
| Stanford University | 0.14 | AAU | Far West | $157,122,760 | 1745 | 0.51 | 2 | 777 | 0.13 | 0.30 |
| University of Louisville | 0.14 | Not AAU | Southeast | $11,990,800 | 340 | 0.41 | 129 | 714 | 0.13 | 0.14 |
| University of Michigan | 0.14 | AAU | Great Lakes | $154,095,887 | 1135 | 0.38 | 8 | 773 | 0.14 | 0.22 |
| The Pennsylvania State University | 0.14 | AAU | Mid East | $119,091,856 | 550 | 0.33 | 23 | 768 | 0.13 | 0.16 |
| University of Notre Dame | 0.14 | Not AAU | Great Lakes | $20,896,727 | 47 | 0.46 | 51 | 760 | 0.11 | 0.25 |
| Rensselaer Polytechnic Institute | 0.14 | Not AAU | Mid East | $61,337,908 | 161 | 0.44 | 35 | 752 | 0.12 | 0.20 |
| Case Western Reserve University | 0.14 | AAU | Great Lakes | $39,438,788 | 244 | 0.32 | 47 | 737 | 0.11 | 0.20 |
| George Mason University | 0.14 | Not AAU | Southeast | $12,872,127 | 1260 | 0.46 | 121 | 698 | 0.18 | 0.15 |
| Virginia Polytechnic Institute and State University | 0.14 | Not AAU | Southeast | $97,132,400 | 861 | 0.55 | 25 | 744 | 0.13 | 0.15 |
| University of Arizona | 0.13 | AAU | Southwest | $35,439,816 | 411 | 0.45 | 51 | 737 | 0.10 | 0.20 |
| Clarkson University | 0.13 | Not AAU | Mid East | $8,324,071 | 134 | 0.3 | 107 | 734 | 0.14 | 0.14 |
| University of Connecticut | 0.13 | Not AAU | New England | $25,169,000 | 225 | 0.48 | 70 | 735 | 0.12 | 0.17 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| University of Maryland-College Park | 0.13 | AAU | Mid East | $146,301,008 | 831 | 0.56 | 22 | 757 | 0.10 | 0.16 |
| Cornell University | 0.13 | AAU | Mid East | $115,680,416 | 543 | 0.53 | 10 | 774 | 0.11 | 0.26 |
| The University of Alabama in Huntsville | 0.13 | Not AAU | Southeast | $21,080,590 | 435 | 0.5 | 107 | 686 | 0.16 | 0.18 |
| Missouri University of Science and Technology | 0.13 | Not AAU | Plains | $26,730,676 | 672 | 0.36 | 94 | 719 | 0.09 | 0.18 |
| New Mexico State University | 0.13 | Not AAU | Southwest | $37,237,692 | 318 | 0.36 | 86 | 727 | 0.07 | 0.28 |
| University of Pennsylvania | 0.13 | AAU | Mid East | $47,870,532 | 707 | 0.41 | 23 | 757 | 0.12 | 0.23 |
| University of Maine | 0.13 | Not AAU | New England | $10,607,379 | 86 | 0.62 | 129 | 709 | 0.11 | 0.11 |
| University of Delaware | 0.13 | Not AAU | Mid East | $31,968,864 | 176 | 0.52 | 45 | 756 | 0.14 | 0.19 |
| The University of New Mexico | 0.13 | Not AAU | Southwest | $27,818,400 | 339 | 0.55 | 81 | 708 | 0.11 | 0.23 |
| Dartmouth College | 0.13 | Not AAU | New England | $19,594,550 | 107 | 0.51 | 48 | 770 | 0.13 | 0.23 |
| University of Tennessee-Knoxville | 0.13 | Not AAU | Southeast | $40,293,372 | 509 | 0.34 | 73 | 731 | 0.05 | 0.15 |
| FAMU-FSU College of Engineering | 0.13 | Not AAU | Southeast | $22,232,998 | 210 | 0.31 | 102 | 736 | 0.10 | 0.20 |
| Purdue University | 0.13 | AAU | Great Lakes | $156,315,888 | 903 | 0.38 | 13 | 763 | 0.14 | 0.16 |
| The University of Texas at Austin | 0.12 | AAU | Southwest | $136,732,304 | 1024 | 0.43 | 9 | 765 | 0.11 | 0.22 |
| University of Rochester | 0.12 | AAU | Mid East | $92,523,200 | 120 | 0.43 | 37 | 765 | 0.09 | 0.24 |
| Rutgers-The State University | 0.12 | AAU | Mid East | $9,564,012 | 316 | 0.49 | 51 | 752 | 0.13 | 0.16 |

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|---|---|---|---|---|---|---|---|---|---|---|
| of New Jersey | | | | | | | | | | |
| Iowa State University | 0.12 | AAU | Plains | $70,196,414 | 437 | 0.6 | 45 | 756 | 0.11 | 0.14 |
| Auburn University | 0.12 | Not AAU | Southeast | $44,207,600 | 396 | 0.28 | 70 | 725 | 0.08 | 0.15 |
| University of Massachusetts Amherst | 0.12 | Not AAU | New England | $44,299,984 | 242 | 0.36 | 51 | 754 | 0.11 | 0.13 |
| Lehigh University | 0.12 | Not AAU | Mid East | $30,738,006 | 203 | 0.43 | 42 | 768 | 0.09 | 0.21 |
| North Carolina State University | 0.12 | Not AAU | Southeast | $110,060,800 | 1155 | 0.64 | 30 | 756 | 0.10 | 0.16 |
| University of Minnesota - Twin Cities | 0.12 | AAU | Plains | $80,443,112 | 833 | 0.4 | 28 | 761 | 0.10 | 0.14 |
| University of Wisconsin-Madison | 0.12 | AAU | Great Lakes | $122,929,360 | 678 | 0.55 | 15 | 780 | 0.13 | 0.17 |
| University of Wyoming | 0.12 | Not AAU | Rockies | $10,089,510 | 106 | 0.46 | 137 | 726 | 0.08 | 0.14 |
| Michigan State University | 0.12 | AAU | Great Lakes | $31,465,000 | 201 | 0.75 | 51 | 740 | 0.11 | 0.16 |
| University of Florida | 0.12 | AAU | Southeast | $103,640,800 | 1219 | 0.39 | 30 | 763 | 0.10 | 0.24 |
| University of Central Florida | 0.12 | Not AAU | Southeast | $56,187,404 | 555 | 0.47 | 73 | 711 | 0.11 | 0.16 |
| University of Alabama at Birmingham | 0.12 | Not AAU | Southeast | $8,486,095 | 184 | 0.55 | 137 | 689 | 0.12 | 0.20 |
| The University of Alabama | 0.11 | Not AAU | Southeast | $9,403,049 | 151 | 0.39 | 113 | 733 | 0.11 | 0.18 |
| University of Kansas | 0.11 | AAU | Plains | $14,864,478 | 487 | 0.45 | 86 | 746 | 0.13 | 0.19 |
| University of Maryland-Baltimore County | 0.11 | Not AAU | Mid East | $10,852,064 | 207 | 0.46 | 107 | 738 | 0.21 | 0.13 |
| Stony Brook | 0.11 | AAU | Mid East | $25,532,803 | 466 | 0.37 | 62 | 759 | 0.16 | 0.16 |

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|---|---|---|---|---|---|---|---|---|---|---|
| University | | | | | | | | | | |
| Carnegie Mellon University | 0.11 | AAU | Mid East | $225,030,352 | 764 | 0.5 | 6 | 759 | 0.14 | 0.22 |
| Kansas State University | 0.11 | Not AAU | Plains | $18,990,200 | 371 | 0.38 | 99 | 758 | 0.12 | 0.13 |
| New Jersey Institute of Technology | 0.11 | Not AAU | Mid East | $34,737,376 | 1466 | 0.46 | 86 | 695 | 0.08 | 0.15 |
| University of Cincinnati | 0.11 | Not AAU | Great Lakes | $20,702,486 | 533 | 0.44 | 73 | 753 | 0.03 | 0.15 |
| University of Illinois at Urbana-Champaign | 0.1 | AAU | Great Lakes | $198,634,096 | 842 | 0.52 | 5 | 770 | 0.09 | 0.15 |
| Polytechnic Institute of New York University | 0.1 | Not AAU | Mid East | $10,937,471 | 1095 | 0.31 | 69 | 758 | 0.13 | 0.14 |
| Georgia Institute of Technology | 0.1 | AAU | Southeast | $221,578,800 | 1926 | 0.51 | 4 | 772 | 0.13 | 0.20 |
| The Ohio State University | 0.1 | AAU | Great Lakes | $114,750,000 | 504 | 0.41 | 25 | 765 | 0.11 | 0.14 |
| Northeastern University | 0.1 | Not AAU | New England | $27,506,952 | 718 | 0.36 | 59 | 757 | 0.15 | 0.16 |
| West Virginia University | 0.1 | Not AAU | Southeast | $23,970,420 | 510 | 0.46 | 113 | 724 | 0.06 | 0.11 |
| Oregon State University | 0.1 | Not AAU | Far West | $24,061,340 | 351 | 0.42 | 85 | 716 | 0.15 | 0.13 |
| Clemson University | 0.09 | Not AAU | Southeast | $30,113,740 | 472 | 0.31 | 76 | 736 | 0.10 | 0.17 |
| Wright State University | 0.09 | Not AAU | Great Lakes | $8,251,400 | 440 | 0.34 | 137 | 687 | 0.10 | 0.14 |
| The University of Akron | 0.09 | Not AAU | Great Lakes | $4,087,245 | 171 | 0.4 | 129 | 726 | 0.10 | 0.13 |
| University of Southern California | 0.08 | AAU | Far West | $164,403,483 | 2879 | 0.44 | 10 | 758 | 0.07 | 0.25 |

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|---|---|---|---|---|---|---|---|---|---|---|
| Mississippi State University | 0.08 | Not AAU | Southeast | $48,958,052 | 261 | 0.47 | 81 | 732 | 0.15 | 0.16 |
| Arizona State University | 0.08 | Not AAU | Southwest | $55,326,808 | 1090 | 0.34 | 44 | 762 | 0.13 | 0.19 |
| University of Utah | 0.08 | Not AAU | Rockies | $47,179,400 | 427 | 0.45 | 63 | 749 | 0.12 | 0.11 |
| Texas Tech University | 0.08 | Not AAU | Southwest | $13,357,185 | 399 | 0.35 | 99 | 730 | 0.14 | 0.12 |
| University of Kentucky | 0.08 | Not AAU | Southeast | $26,544,502 | 317 | 0.31 | 86 | 756 | 0.11 | 0.14 |
| University of Houston | 0.08 | Not AAU | Southwest | $17,784,894 | 615 | 0.38 | 81 | 748 | 0.09 | 0.2 |
| University of New Hampshire | 0.08 | Not AAU | New England | $12,316,779 | 163 | 0.34 | 121 | 735 | 0.15 | 0.13 |
| University of South Carolina | 0.08 | Not AAU | Southeast | $18,026,330 | 165 | 0.5 | 102 | 735 | 0.08 | 0.15 |
| University of Missouri | 0.07 | AAU | Plains | $20,160,896 | 249 | 0.44 | 86 | 737 | 0.08 | 0.13 |
| Texas A&M University | 0.07 | AAU | Southwest | $208,601,000 | 1518 | 0.41 | 12 | 754 | 0.13 | 0.20 |
| Oklahoma State University | 0.07 | Not AAU | Southwest | $19,703,322 | 540 | 0.39 | 102 | 738 | 0.08 | 0.16 |
| University of Oklahoma | 0.07 | Not AAU | Southwest | $21,340,480 | 338 | 0.46 | 102 | 733 | 0.10 | 0.18 |
| The University of Texas at Dallas | 0.06 | Not AAU | Southwest | $25,791,466 | 789 | 0.34 | 76 | 747 | 0.10 | 0.11 |
| The State University of New York at Binghamton | 0.06 | Not AAU | Mid East | $12,940,897 | 454 | 0.39 | 116 | 721 | 0.14 | 0.12 |
| Brigham Young University | 0.06 | Not AAU | Rockies | $11,956,838 | 268 | 0.7 | 102 | 745 | 0.00 | 0.10 |
| Ohio University | 0.06 | Not AAU | Great Lakes | $14,465,557 | 200 | 0.32 | 121 | 748 | 0.10 | 0.10 |
| Syracuse University | 0.05 | AAU | Mid East | $13,860,399 | 572 | 0.31 | 81 | 741 | 0.16 | 0.23 |
| The University | 0.05 | Not AAU | Great Lakes | $10,423,525 | 224 | 0.37 | 137 | 747 | 0.14 | 0.11 |

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|---|---|---|---|---|---|---|---|---|---|---|
| of Toledo | | | | | | | | | | |
| Illinois Institute of Technology | 0.04 | Not AAU | Great Lakes | $17,865,620 | 1218 | 0.22 | 76 | 742 | 0.08 | 0.17 |
| Louisiana State University | 0.04 | Not AAU | Southeast | $16,183,580 | 288 | 0.33 | 99 | 734 | 0.09 | 0.16 |
| Louisiana Tech University | 0.03 | Not AAU | Southeast | $11,431,038 | 247 | 0.39 | 129 | 711 | 0.12 | 0.11 |

Table 50. Schools included in regression model to examine Ph.D. women degree production rates.

| School | Ph.D. Women Degree Prod. Rate | AAU Status | Location | Avg. Annual Research Expend. | Avg. Ph.D. Student Class Size | Grad. Admit Yield | *USNWR* Rank | Avg. Quant. GRE Score | % of Women Tenured/TT Faculty | % of Women Enrolled at Undergrad. Level | % of Women Enrolled at M.S. Level |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Duke University | 0.33 | AAU | Southeast | $60,727,452 | 360 | 0.42 | 33 | 769 | 0.15 | 0.27 | 0.31 |
| Yale University | 0.28 | AAU | New England | $17,513,326 | 203 | 0.46 | 39 | 780 | 0.11 | 0.29 | 0.35 |
| University of California-Irvine | 0.23 | AAU | Far West | $63,915,900 | 631 | 0.38 | 36 | 762 | 0.12 | 0.20 | 0.23 |
| University of California-Riverside | 0.2 | AAU | Far West | $20,375,850 | 303 | 0.41 | 66 | 747 | 0.08 | 0.16 | 0.19 |
| Tulane University | 0.19 | AAU | Southeast | $4,837,371 | 70 | 0.53 | 107 | 757 | 0.07 | 0.29 | 0.26 |
| Colorado School of Mines | 0.18 | Not AAU | Rockies | $25,948,940 | 336 | 0.45 | 63 | 722 | 0.13 | 0.23 | 0.31 |
| California Institute of Technology | 0.18 | AAU | Far West | $70,549,248 | 499 | 0.44 | 7 | 800 | 0.13 | 0.25 | 0.18 |
| Rutgers-The State University of New Jersey | 0.17 | AAU | Mid East | $9,564,012 | 381 | 0.49 | 51 | 752 | 0.13 | 0.16 | 0.20 |
| Marquette University | 0.16 | Not AAU | Great Lakes | $2,500,295 | 69 | 0.35 | 126 | 737 | 0.08 | 0.19 | 0.40 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Northwestern University | 0.16 | AAU | Great Lakes | $41,868,428 | 711 | 0.52 | 21 | 776 | 0.10 | 0.25 | 0.34 |
| Tufts University | 0.16 | Not AAU | New England | $10,482,088 | 164 | 0.49 | 76 | 742 | 0.21 | 0.27 | 0.32 |
| The University of Alabama in Huntsville | 0.15 | Not AAU | Southeast | $21,080,590 | 201 | 0.5 | 107 | 686 | 0.16 | 0.18 | 0.53 |
| William Marsh Rice University | 0.15 | AAU | Southwest | $35,619,563 | 493 | 0.51 | 33 | 768 | 0.17 | 0.31 | 0.16 |
| University of California-Berkeley | 0.15 | AAU | Far West | $131,379,400 | 1461 | 0.49 | 3 | 776 | 0.13 | 0.21 | 0.26 |
| University of Colorado at Boulder | 0.15 | AAU | Rockies | $57,115,893 | 530 | 0.3 | 39 | 749 | 0.15 | 0.20 | 0.24 |
| Harvard University | 0.15 | AAU | New England | $38,030,200 | 310 | 0.53 | 19 | 770 | 0.09 | 0.26 | 0.22 |
| The George Washington University | 0.15 | Not AAU | Mid East | $7,008,384 | 360 | 0.53 | 107 | 717 | 0.17 | 0.28 | 0.38 |
| The University of Iowa | 0.14 | AAU | Plains | $34,690,917 | 283 | 0.44 | 59 | 732 | 0.10 | 0.18 | 0.17 |
| Massachusetts Institute of Technology | 0.14 | AAU | New England | $241,469,800 | 1597 | 0.63 | 1 | 780 | 0.14 | 0.39 | 0.15 |
| University of Washington | 0.14 | AAU | Far West | $95,364,800 | 847 | 0.41 | 28 | 743 | 0.18 | 0.19 | 0.39 |
| University of Pennsylvania | 0.13 | AAU | Mid East | $47,870,532 | 426 | 0.41 | 23 | 757 | 0.12 | 0.23 | 0.24 |
| Vanderbilt University | 0.13 | AAU | Southeast | $45,880,688 | 323 | 0.56 | 37 | 756 | 0.11 | 0.25 | 0.24 |
| Drexel University | 0.13 | Not AAU | Mid East | $34,604,508 | 377 | 0.35 | 59 | 734 | 0.17 | 0.14 | 0.42 |
| Colorado State University | 0.12 | Not AAU | Rockies | $53,174,000 | 245 | 0.37 | 63 | 718 | 0.08 | 0.16 | 0.29 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| George Mason University | 0.12 | Not AAU | Southeast | $12,872,127 | 359 | 0.46 | 121 | 698 | 0.18 | 0.15 | 0.37 |
| University of Alabama at Birmingham | 0.12 | Not AAU | Southeast | $8,486,095 | 81 | 0.55 | 137 | 689 | 0.12 | 0.20 | 0.40 |
| The Johns Hopkins University | 0.12 | AAU | Mid East | $57,793,160 | 583 | 0.37 | 25 | 766 | 0.12 | 0.28 | 0.52 |
| University of California-Davis | 0.12 | AAU | Far West | $70,399,000 | 802 | 0.34 | 32 | 749 | 0.16 | 0.22 | 0.22 |
| University of California-San Diego | 0.12 | AAU | Far West | $135,585,408 | 816 | 0.36 | 13 | 775 | 0.10 | 0.24 | 0.13 |
| Boston University | 0.12 | Not AAU | New England | $62,243,527 | 386 | 0.37 | 42 | 763 | 0.12 | 0.22 | 0.21 |
| New Mexico State University | 0.12 | Not AAU | Southwest | $37,237,692 | 84 | 0.36 | 86 | 727 | 0.07 | 0.28 | 0.13 |
| University of Notre Dame | 0.11 | Not AAU | Great Lakes | $20,896,727 | 362 | 0.46 | 51 | 760 | 0.11 | 0.25 | 0.28 |
| University of Pittsburgh | 0.11 | AAU | Mid East | $60,342,000 | 367 | 0.32 | 48 | 746 | 0.15 | 0.20 | 0.53 |
| Cornell University | 0.11 | AAU | Mid East | $115,680,416 | 840 | 0.53 | 10 | 774 | 0.11 | 0.26 | 0.14 |
| University of Wisconsin-Madison | 0.1 | AAU | Great Lakes | $122,929,360 | 859 | 0.55 | 15 | 780 | 0.13 | 0.17 | 0.28 |
| University of Central Florida | 0.1 | Not AAU | Southeast | $56,187,404 | 493 | 0.47 | 73 | 711 | 0.11 | 0.16 | 0.40 |
| Stanford University | 0.1 | AAU | Far West | $157,122,760 | 1541 | 0.51 | 2 | 777 | 0.13 | 0.30 | 0.17 |
| Carnegie Mellon University | 0.1 | AAU | Mid East | $225,030,352 | 1035 | 0.5 | 6 | 759 | 0.14 | 0.22 | 0.11 |
| University of Illinois at Chicago | 0.1 | Not AAU | Great Lakes | $20,833,814 | 429 | 0.38 | 66 | 738 | 0.13 | 0.18 | 0.27 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Dartmouth College | 0.09 | Not AAU | New England | $19,594,550 | 106 | 0.51 | 48 | 770 | 0.13 | 0.23 | 0.11 |
| Washington University | 0.09 | AAU | Plains | $26,896,378 | 300 | 0.49 | 48 | 767 | 0.10 | 0.26 | 0.47 |
| University of Michigan | 0.09 | AAU | Great Lakes | $154,095,887 | 1352 | 0.38 | 8 | 773 | 0.14 | 0.22 | 0.16 |
| FAMU-FSU College of Engineering | 0.09 | Not AAU | Southeast | $22,232,998 | 193 | 0.31 | 102 | 736 | 0.10 | 0.20 | 0.17 |
| Georgia Institute of Technology | 0.09 | AAU | Southeast | $221,578,800 | 2231 | 0.51 | 4 | 772 | 0.13 | 0.20 | 0.24 |
| University of Virginia | 0.09 | AAU | Southeast | $54,445,669 | 467 | 0.49 | 39 | 762 | 0.12 | 0.27 | 0.33 |
| University of Delaware | 0.09 | Not AAU | Mid East | $31,968,864 | 474 | 0.52 | 45 | 756 | 0.14 | 0.19 | 0.23 |
| Wright State University | 0.09 | Not AAU | Great Lakes | $8,251,400 | 125 | 0.34 | 137 | 687 | 0.10 | 0.14 | 0.21 |
| Case Western Reserve University | 0.09 | AAU | Great Lakes | $39,438,788 | 374 | 0.32 | 47 | 737 | 0.11 | 0.20 | 0.30 |
| Mississippi State University | 0.09 | Not AAU | Southeast | $48,958,052 | 255 | 0.47 | 81 | 732 | 0.15 | 0.16 | 0.28 |
| University of Miami | 0.09 | Not AAU | Southeast | $3,326,809 | 117 | 0.53 | 116 | 744 | 0.08 | 0.27 | 0.31 |
| University of Massachusetts Amherst | 0.09 | Not AAU | New England | $44,299,984 | 414 | 0.36 | 51 | 754 | 0.11 | 0.13 | 0.14 |
| University of Arizona | 0.09 | AAU | Southwest | $35,439,816 | 479 | 0.45 | 51 | 737 | 0.10 | 0.20 | 0.14 |
| Michigan Technological University | 0.09 | Not AAU | Great Lakes | $19,835,658 | 245 | 0.31 | 86 | 734 | 0.13 | 0.14 | 0.19 |
| Iowa State University | 0.09 | AAU | Plains | $70,196,414 | 504 | 0.6 | 45 | 756 | 0.11 | 0.14 | 0.17 |
| University of California-Los Angeles | 0.09 | AAU | Far West | $89,973,040 | 813 | 0.41 | 15 | 765 | 0.10 | 0.19 | 0.14 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Auburn University | 0.09 | Not AAU | Southeast | $44,207,600 | 317 | 0.28 | 70 | 725 | 0.08 | 0.15 | 0.29 |
| Worcester Polytechnic Institute | 0.09 | Not AAU | New England | $10,909,369 | 149 | 0.32 | 94 | 736 | 0.16 | 0.20 | 0.40 |
| Old Dominion University | 0.09 | Not AAU | Southeast | $19,804,676 | 199 | 0.61 | 121 | 715 | 0.08 | 0.13 | 0.44 |
| University of Florida | 0.08 | AAU | Southeast | $103,640,800 | 1228 | 0.39 | 30 | 763 | 0.10 | 0.24 | 0.11 |
| The University of Texas at Austin | 0.08 | AAU | Southwest | $136,732,304 | 1142 | 0.43 | 9 | 765 | 0.11 | 0.22 | 0.21 |
| University of Arkansas | 0.08 | Not AAU | Southeast | $16,889,111 | 149 | 0.56 | 115 | 737 | 0.11 | 0.15 | 0.38 |
| University of Kentucky | 0.08 | Not AAU | Southeast | $26,544,502 | 253 | 0.31 | 86 | 756 | 0.11 | 0.14 | 0.15 |
| Virginia Polytechnic Institute and State University | 0.08 | Not AAU | Southeast | $97,132,400 | 1031 | 0.55 | 25 | 744 | 0.13 | 0.15 | 0.23 |
| Clarkson University | 0.08 | Not AAU | Mid East | $8,324,071 | 87 | 0.3 | 107 | 734 | 0.14 | 0.14 | 0.10 |
| Princeton University | 0.08 | AAU | Mid East | $56,827,224 | 473 | 0.41 | 17 | 783 | 0.14 | 0.29 | 0.25 |
| University of South Florida | 0.08 | Not AAU | Southeast | $18,818,090 | 295 | 0.42 | 119 | 698 | 0.10 | 0.17 | 0.31 |
| University of Rochester | 0.08 | AAU | Mid East | $92,523,200 | 317 | 0.43 | 37 | 765 | 0.09 | 0.24 | 0.18 |
| University of Minnesota - Twin Cities | 0.08 | AAU | Plains | $80,443,112 | 970 | 0.4 | 28 | 761 | 0.10 | 0.14 | 0.17 |
| University of Maryland-College Park | 0.08 | AAU | Mid East | $146,301,008 | 1093 | 0.56 | 22 | 757 | 0.10 | 0.16 | 0.32 |
| University of California-Santa Cruz | 0.08 | Not AAU | Far West | $18,689,644 | 241 | 0.36 | 86 | 752 | 0.15 | 0.15 | 0.23 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| The University of New Mexico | 0.08 | Not AAU | Southwest | $27,818,400 | 275 | 0.55 | 81 | 708 | 0.11 | 0.23 | 0.15 |
| University of Missouri | 0.07 | AAU | Plains | $20,160,896 | 223 | 0.44 | 86 | 737 | 0.08 | 0.13 | 0.08 |
| Southern Methodist University | 0.07 | Not AAU | Southwest | $1,064,267 | 135 | 0.52 | 121 | 728 | 0.07 | 0.29 | 0.43 |
| Rensselaer Polytechnic Institute | 0.07 | Not AAU | Mid East | $61,337,908 | 522 | 0.44 | 35 | 752 | 0.12 | 0.20 | 0.33 |
| Oregon State University | 0.07 | Not AAU | Far West | $24,061,340 | 244 | 0.42 | 85 | 716 | 0.15 | 0.13 | 0.23 |
| Stony Brook University | 0.07 | AAU | Mid East | $25,532,803 | 471 | 0.37 | 62 | 759 | 0.16 | 0.16 | 0.14 |
| Arizona State University | 0.07 | Not AAU | Southwest | $55,326,808 | 751 | 0.34 | 44 | 762 | 0.13 | 0.19 | 0.22 |
| North Carolina State University | 0.07 | Not AAU | Southeast | $110,060,800 | 963 | 0.64 | 30 | 756 | 0.10 | 0.16 | 0.26 |
| University of Southern California | 0.07 | AAU | Far West | $164,403,488 | 984 | 0.44 | 10 | 758 | 0.07 | 0.25 | 0.18 |
| The Pennsylvania State University | 0.07 | AAU | Mid East | $119,091,856 | 1105 | 0.33 | 23 | 768 | 0.13 | 0.16 | 0.15 |
| University of South Carolina | 0.07 | Not AAU | Southeast | $18,026,330 | 243 | 0.5 | 102 | 735 | 0.08 | 0.15 | 0.40 |
| University of Utah | 0.07 | Not AAU | Rockies | $47,179,400 | 407 | 0.45 | 63 | 749 | 0.12 | 0.11 | 0.29 |
| The University of Alabama | 0.06 | Not AAU | Southeast | $9,403,049 | 121 | 0.39 | 113 | 733 | 0.11 | 0.18 | 0.27 |
| Missouri University of Science and Technology | 0.06 | Not AAU | Plains | $26,730,676 | 258 | 0.36 | 94 | 719 | 0.09 | 0.18 | 0.32 |
| Clemson | 0.06 | Not | Southeast | $30,113,740 | 368 | 0.31 | 76 | 736 | 0.10 | 0.17 | 0.18 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| University | | AAU | | | | | | | | | |
| Northeastern University | 0.06 | Not AAU | New England | $27,506,952 | 264 | 0.36 | 59 | 757 | 0.15 | 0.16 | 0.18 |
| Texas Tech University | 0.06 | Not AAU | Southwest | $13,357,185 | 235 | 0.35 | 99 | 730 | 0.14 | 0.12 | 0.18 |
| Purdue University | 0.06 | AAU | Great Lakes | $156,315,888 | 1475 | 0.38 | 13 | 763 | 0.14 | 0.16 | 0.26 |
| University of Tennessee-Knoxville | 0.06 | Not AAU | Southeast | $40,293,372 | 344 | 0.34 | 73 | 731 | 0.05 | 0.15 | 0.44 |
| Louisiana State University | 0.06 | Not AAU | Southeast | $16,183,580 | 321 | 0.33 | 99 | 734 | 0.09 | 0.16 | 0.10 |
| University of Connecticut | 0.06 | Not AAU | New England | $25,169,000 | 310 | 0.48 | 70 | 735 | 0.12 | 0.17 | 0.30 |
| University of Nebraska-Lincoln | 0.06 | AAU | Plains | $23,215,334 | 236 | 0.44 | 94 | 733 | 0.10 | 0.11 | 0.18 |
| West Virginia University | 0.06 | Not AAU | Southeast | $23,970,420 | 196 | 0.46 | 113 | 724 | 0.06 | 0.11 | 0.17 |
| Kansas State University | 0.05 | Not AAU | Plains | $18,990,200 | 116 | 0.38 | 99 | 758 | 0.12 | 0.13 | 0.31 |
| University of Oklahoma | 0.05 | Not AAU | Southwest | $21,340,480 | 229 | 0.46 | 102 | 733 | 0.10 | 0.18 | 0.18 |
| University of Louisville | 0.05 | Not AAU | Southeast | $11,990,800 | 170 | 0.41 | 129 | 714 | 0.13 | 0.14 | 0.36 |
| New Jersey Institute of Technology | 0.05 | Not AAU | Mid East | $34,737,376 | 257 | 0.46 | 86 | 695 | 0.08 | 0.15 | 0.22 |
| Lehigh University | 0.05 | Not AAU | Mid East | $30,738,006 | 378 | 0.43 | 42 | 768 | 0.09 | 0.21 | 0.33 |
| Michigan State University | 0.05 | AAU | Great Lakes | $31,465,000 | 419 | 0.75 | 51 | 740 | 0.11 | 0.16 | 0.13 |
| University of Houston | 0.05 | Not AAU | Southwest | $17,784,894 | 299 | 0.38 | 81 | 748 | 0.09 | 0.20 | 0.15 |
| Polytechnic Institute of New York | 0.05 | Not AAU | Mid East | $10,937,471 | 136 | 0.31 | 69 | 758 | 0.13 | 0.14 | 0.17 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| University | | | | | | | | | | | |
| University of Illinois at Urbana-Champaign | 0.05 | AAU | Great Lakes | $198,634,096 | 1690 | 0.52 | 5 | 770 | 0.09 | 0.15 | 0.14 |
| Louisiana Tech University | 0.05 | Not AAU | Southeast | $11,431,038 | 135 | 0.39 | 129 | 711 | 0.12 | 0.11 | 0.05 |
| Washington State University | 0.04 | Not AAU | Far West | $16,686,796 | 216 | 0.55 | 76 | 740 | 0.14 | 0.13 | 0.38 |
| Texas A&M University | 0.04 | AAU | Southwest | $208,601,000 | 979 | 0.41 | 12 | 754 | 0.13 | 0.20 | 0.12 |
| Illinois Institute of Technology | 0.04 | Not AAU | Great Lakes | $17,865,620 | 296 | 0.22 | 76 | 742 | 0.08 | 0.17 | 0.12 |
| The Ohio State University | 0.04 | AAU | Great Lakes | $114,750,000 | 830 | 0.41 | 25 | 765 | 0.11 | 0.14 | 0.10 |
| University of Cincinnati | 0.04 | Not AAU | Great Lakes | $20,702,486 | 433 | 0.44 | 73 | 753 | 0.03 | 0.15 | 0.10 |
| The University of Texas at Dallas | 0.03 | Not AAU | Southwest | $25,791,466 | 279 | 0.34 | 76 | 747 | 0.10 | 0.11 | 0.13 |

# CHAPTER VII: REFERENCES


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