*Broadening Participation in* **STEM Graduate Education**

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The United States is at a critical juncture in its ability to remain internationally competitive in science, technology, engineering, and mathematics (STEM). At present, too few people from diverse populations, including women, participate in the STEM academic and workforce communities. This series of issue briefs is produced by American Institutes for Research (AIR) to promote research, policy, and practice related to broadening the participation of traditionally underrepresented groups in STEM doctoral education and the workforce.

AIR supports the national effort to prepare more students for educational and career success in STEM by improving teaching and providing all students with the 21st century skills needed to thrive in the global economy; meeting the diverse needs of all students—especially those from underrepresented groups; and using technology, evidence, and innovative practice to support continuous improvement and accountability.

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# The Nonacademic Careers of STEM PhD Holders

## Overview

Most students enter into science, technology, engineering, or mathematics (STEM) PhD programs planning to work in academia, but many STEM PhD holders eventually seek nonacademic positions (Amsen, 2011; Austin, 2013; Sauermann & Roach, 2012). There are many reasons for this decision, including changing research interests or the appeal of nonacademic work settings, location, or job benefits (Sauermann & Roach, 2012). In addition, the academic job market has tightened in recent years, and many STEM academic appointments require multiple postdoctorate positions that typically pay relatively low salaries. As a result, more than half of STEM PhD holders are employed in nonacademic positions (Austin, 2013, Kulis, Shaw, & Chong, 2000; National Science Foundation & National Center for Science and Engineering Statistics, 2012).

Considerable research has examined employment in academia and the differential experiences of women of all races and ethnicities and underrepresented minorities. These studies reveal inequities in the type and prestige of the academic positions that female and underrepresented minority male STEM PhD holders obtain. Women and underrepresented minority men are less likely than White men to be employed in research universities, and they are more likely to be in contingent (part-time or nontenure-track) positions rather than in tenured or tenure-track positions (Beede et al., 2011; Berger, Kirshstein, Zhang, & Carter, 2002; National Science Foundation & National Center for Science and Engineering Statistics, 2013).

Fewer studies have examined the nonacademic employment of STEM PhD holders and how nonacademic employment patterns may differ across groups (Aanerud, 2007). This issue brief explores gender and racial differences of STEM PhD holders in nonacademic careers. Like the academic sector, the nonacademic STEM sector has a strong influence on the nation's economy, security, and capacity for innovation (Cadwalader, 2013; Sonnert, Fox, & Adkins, 2007). Recruiting and retaining women and underrepresented minorities in these critical fields is vital to meeting the national demand for more STEM professionals, particularly for STEM PhD holders (Hira, 2010; National Research Council, 2007; Stine & Matthews, 2009). Not only will retaining women and underrepresented minorities in nonacademic STEM careers help the nation meet its economic, national security, and technological goals by capitalizing on the STEM training and talent of the individuals in these groups, but it also will expand the diversity of role models for a new generation of scientists.

Certainly, a STEM degree does not guarantee a STEM career. Engineers and scientists leave STEM careers for a variety of reasons including pursuit of a career that offers a better work–life balance, a promising promotion, or a higher salary (Glass, Sassler, Levitte, & Michelmore, 2013; Williams & Ceci, 2012). If women and underrepresented men with doctoral degrees in STEM pursue work activities marginally related to STEM or pursue careers outside of STEM, growth and innovation in these critical disciplines is minimized, and opportunities for increasing and diversifying the STEM community are unfulfilled.

This issue brief addresses the nonacademic career pathways of STEM PhD holders and examines employment patterns by gender and race/ethnicity. Specifically, the brief explores the nonacademic job sectors in which STEM PhD holders were employed and the types of work activities in which they were engaged to determine how women and male underrepresented minorities compare to their colleagues in the nonacademic workforce. The primary research questions are as follows:

1. How do nonacademic career choices and work activities differ by gender and race/ethnicity?
2. How does the proportion of nonacademic STEM PhD holders working outside of STEM fields differ by gender and race/ethnicity?

Key findings include the following:

- *Approximately half of Black, Hispanic, and White female STEM PhD holders and Black and Hispanic male STEM PhD holders were in nonacademic careers, whereas two thirds of Asian female STEM PhD holders and almost three fourths of Asian male STEM PhD holders were in nonacademic careers. About three fifths of White male STEM PhD holders were in nonacademic careers.*
- *Among those in nonacademic careers, the largest proportion worked in private, for-profit organizations or government; however, Black, Hispanic, and White female STEM PhD holders were more likely to work in government and less likely to work in private, for-profit organizations compared with Asian females and males of all racial/ethnic groups.*
- *Approximately half of STEM PhD holders in nonacademic careers worked on research and development (R&D) as their primary activity, but Black, Hispanic, and White female STEM PhD holders were less likely to work on R&D compared with other groups.*
- *Approximately one fifth of STEM PhD holders in nonacademic careers did not work in a STEM field; however, Black, Hispanic, and White female STEM PhD holders were more likely to work outside of STEM compared with other groups.*

## Methodology

The data were drawn from the 2010 Survey of Doctorate Recipients (SDR) (National Science Foundation, & National Center for Science Engineering and Statistics, 2010a). The 2010 SDR collected information from STEM doctorate recipients about their careers as of October 2010. The SDR, which began in 1973, is conducted every two to three years. Each year that the SDR is administered, a sample of new PhD holders is added from the Survey of Earned Doctorates (SED), which surveys all PhD holders upon graduation (National Science Foundation & National Center for Science and Engineering Statistics, 2010b).[1] The SDR sample thus includes a panel of PhD holders ranging from the first year that the doctorate was earned to individuals up to the age of 76 who may have received their doctorate at any point.

[1] PhD field and demographic characteristics used in this brief came from the Survey of Earned Doctorates (SED).

All analyses were weighted to reflect the full population of PhD holders in the United States. The sample for this study was limited to PhD holders who earned their degree in one of the broad STEM fields of engineering, mathematics, computer and information sciences, biological/biomedical sciences, physical sciences, and agricultural sciences/natural resources. The sample also was limited to employed U.S. citizens and U.S. permanent residents living in the United States who identified as Black, Hispanic, Asian, or White. It excluded other racial/ethnic groups.[2] Relatively few employed PhD holders identified as Native American (0.2 percent), Pacific Islander (0.1 percent), or multiracial (1.1 percent), so these groups were excluded from the analyses. Analyses also excluded PhD holders who were out of the labor force and those in postdoctoral positions.[3] Most PhD holders in this study were in the middle to end of their career; 78 percent received their degree 10 or more years prior to October 2010.[4]

We conducted three main analyses for this brief. First, we examined the percentage of STEM PhD holders in academic and nonacademic careers to set the context before turning our focus to nonacademic careers. Academic careers include tenure-track and nontenure-track positions in higher education institutions. Nonacademic careers include all other employers.[5] We categorized nonacademic careers into four sectors:

- *Private, for-profit* companies or organizations
- *Private, nonprofit* organizations including tax-exempt and charitable organizations
- *Government*, including local, state, and federal government and the military
- *Self-employed or other employers* including PhD holders who are self-employed in a nonincorporated or incorporated business or professional practice and other types of employment

Next, we examined respondents' primary work activities. Respondents were asked to indicate the activity in which they spent the most hours during a typical workweek. The SDR survey item included 14 work activity responses, which we collapsed into five categories: (1) basic research, (2) applied research, (3) development, (4) management, and (5) professional and other services. (See the Technical Appendix for more details on this classification.)

Finally, we examined whether STEM PhD holders in nonacademic careers reported working in a STEM field. For the purpose of our analyses, jobs in engineering, physical sciences, computer sciences, mathematics, statistics, agricultural sciences, biological sciences, or other science and engineering occupations were coded as STEM-based careers. PhD holders who worked outside of these fields were coded as not working in STEM.

Throughout this brief, we disaggregate findings by gender and race/ethnicity. Some of the gender and racial/ethnic groups are small relative to other groups, but their sizes are sufficient to make comparisons among groups.[6]

Descriptive statistics and chi-square tests of independence were used to test differences among gender and racial/ethnic groups in career pathways. All reported differences are statistically significant using an alpha level of .05.

[2] Analyses included the following racial/ethnic groups: "Asian, non-Hispanic only," "Black, non-Hispanic only," "Hispanic, any race," and "White, non-Hispanic only." It excluded "American Indian/Alaska Native, non-Hispanic only," "Non-Hispanic Native Hawaiian/other Pacific Islander," and "multiple race."

[3] Among U.S. citizens and permanent residents with a PhD in a STEM field, PhD holders out of the labor force made up 14.6 percent of survey respondents. STEM PhD holders in postdoctoral positions made up 4.3 percent of employed survey respondents.

[4] The weighted sample size of academic and nonacademic PhD holders in analyses for this brief is 419,848. The unweighted sample size of academic and nonacademic PhD holders is 15,952.

[5] PhD holders who worked in K–12 education were included in nonacademic careers (1.1 percent of all employed PhD holders in STEM).

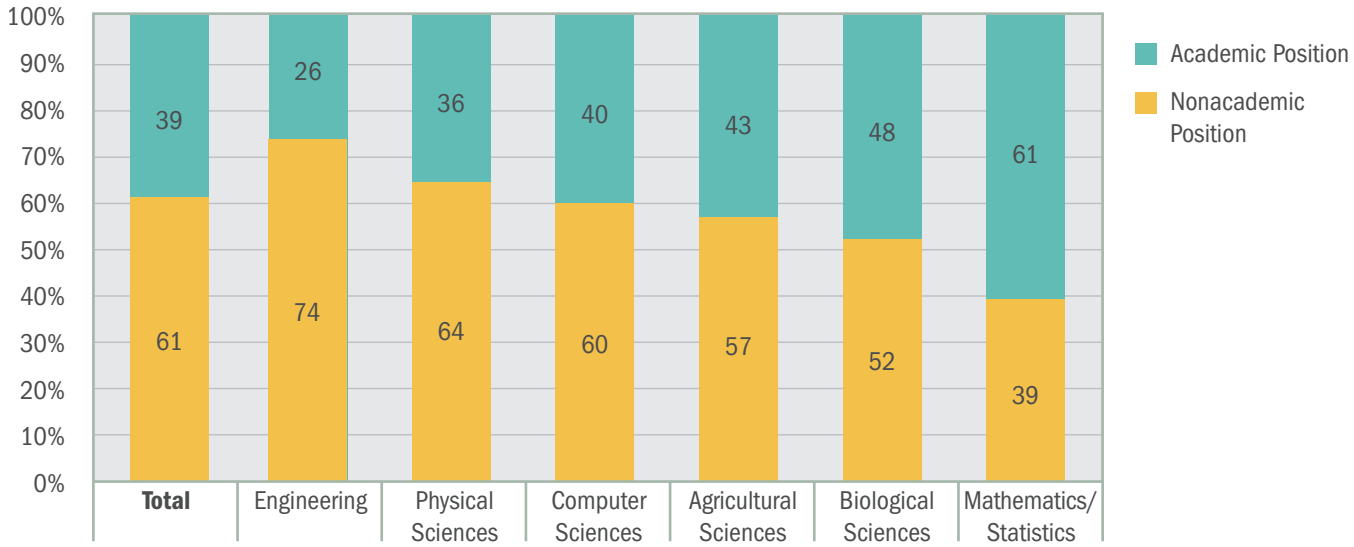
[6] Among academic and nonacademic PhD holders, Black and Hispanic females each make up 1 percent, Asian females make up 5 percent, and White females make up 16 percent. Black and Hispanic males each make up 2 percent, Asian males make up 17 percent, and White males make up 56 percent. The smallest gender and racial/ethnic group is Black females with a weighted sample size of 2,788 and unweighted sample size of 256.

# Findings

## STEM PHD HOLDERS IN NONACADEMIC AND ACADEMIC CAREERS

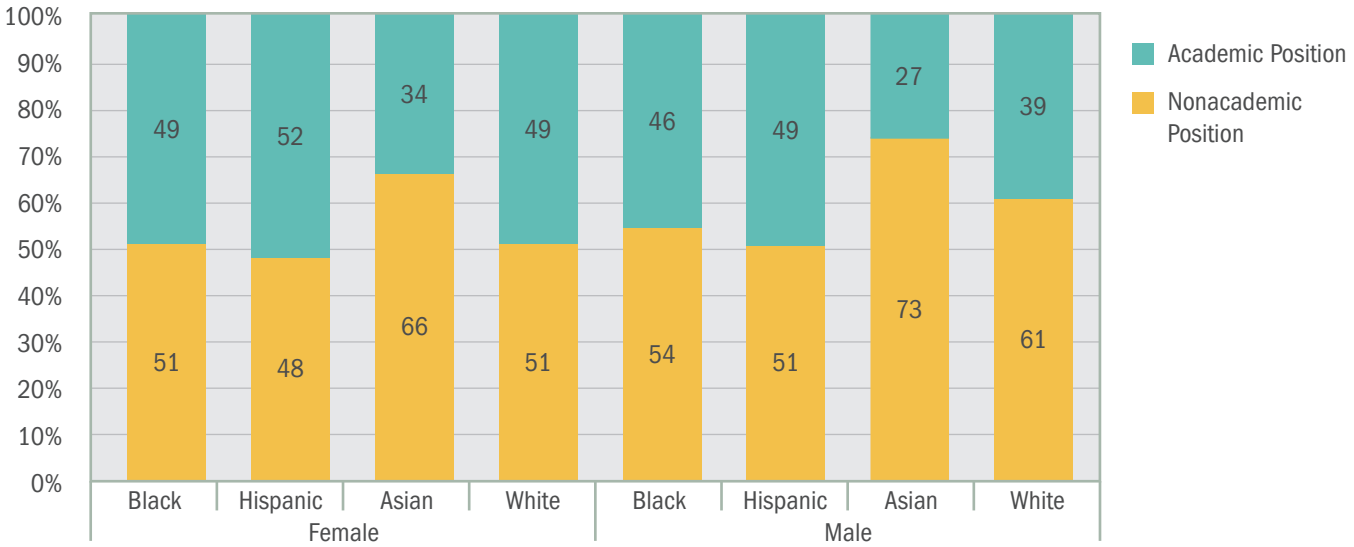
A majority of employed STEM PhD holders (61 percent) were working in nonacademic careers in 2010 (see Figure 1). Engineering PhD holders comprised the largest group working in nonacademic careers (74 percent). Mathematics/ statistics was the only field in which less than half of PhD holders were working in nonacademic careers (39 percent).

**Figure 1. Percentage Distribution of Employed STEM PhD Holders, by Career Type and by STEM Field**




Half or more of the STEM PhD holders in nearly all gender/racial groups were working in nonacademic positions; however, Asian STEM PhD holders were most likely to be in nonacademic careers (see Figure 2). Two thirds of Asian female PhD holders (66 percent) and almost three quarters of Asian male PhD holders were in nonacademic positions (73 percent). About three fifths of White male PhD holders were also in nonacademic careers (61 percent). The remaining groups, Black and Hispanic males and females and White females, were nearly evenly split between academic and nonacademic careers.

**Figure 2. Percentage Distribution of Employed STEM PhD Holders, by Career Type and by Gender and Racial/Ethnic Group**



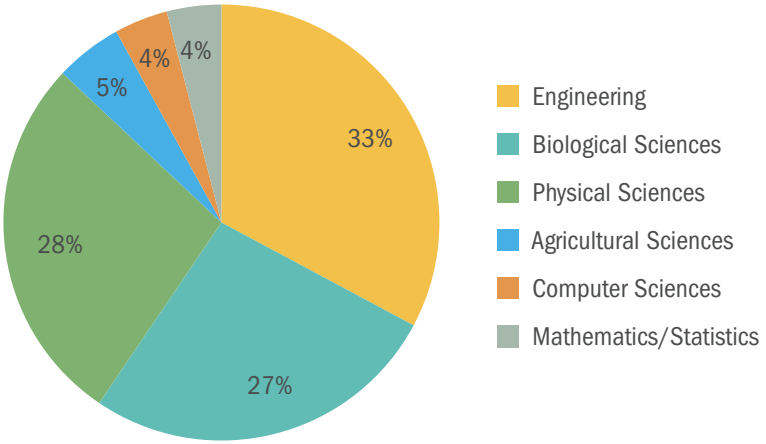
## PHD FIELDS OF NONACADEMIC STEM PHD HOLDERS

Hereafter, the brief focuses on STEM PhD holders in nonacademic careers, most of whom have had their PhD for more than 10 years. Among those in nonacademic careers, 88 percent graduated with doctoral degrees in one of three fields: engineering, biological sciences, or physical sciences; 5 percent or less of STEM degree holders in nonacademic positions held PhD degrees in either agricultural sciences, computer sciences, or mathematics/statistics (see Figure 3).

**Differences in PhD Fields**

Females in nonacademic careers most often had doctoral degrees in the biological sciences, whereas males most often had doctoral degrees in engineering. Among females, almost half (48 percent) had a PhD in the biological sciences, and 17 percent had a PhD in engineering. Among males, about one third (37 percent) had a PhD in engineering, whereas just more than one fifth (21 percent) of males had a PhD in the biological sciences. This pattern for females and males persisted across all racial/ethnic groups.

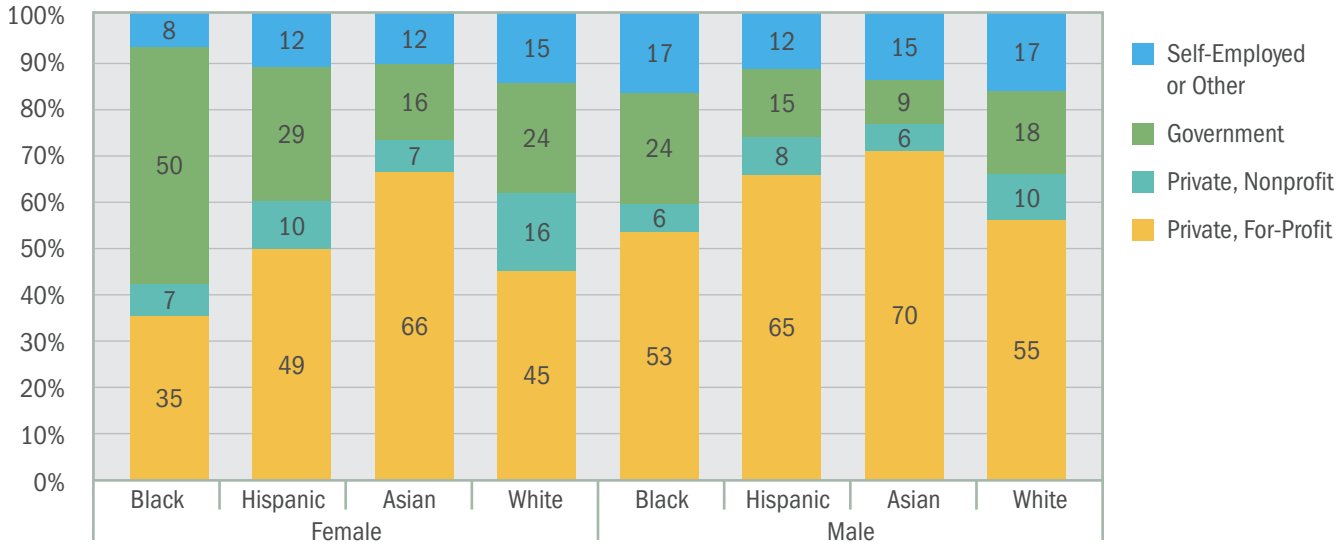
**Figure 3. Percentage Distribution of Employed STEM PhD Holders Who Worked in Nonacademic Careers, by PhD Field**




## CAREER SECTORS OF NONACADEMIC STEM PHD HOLDERS

The private, for-profit sector tended to be the largest employer of nonacademic STEM PhD holders across career sectors (see Figure 4). Black females were an exception, with 50 percent employed by government. Less than half of Black, Hispanic, and White female PhD holders worked for private, for-profit businesses, compared with more than half of all males and Asian females. Asian females, Asian males, and Hispanic males had the highest proportion of STEM PhD holders in private for-profit business (65 to 70 percent). Among the other nonacademic sectors, female PhD holders were more likely to be employed in government than their male peers, and indeed, Black female PhD holders were twice as likely. In each group, the lowest proportion of STEM PhD holders reported working in the private, nonprofit sector (6 to 16 percent) or being self-employed or in other job sectors (8 to 17 percent).

**Figure 4. Percentage Distribution of STEM PhD Holders in Nonacademic Positions, by Career Sector and by Gender and Racial/Ethnic Group**

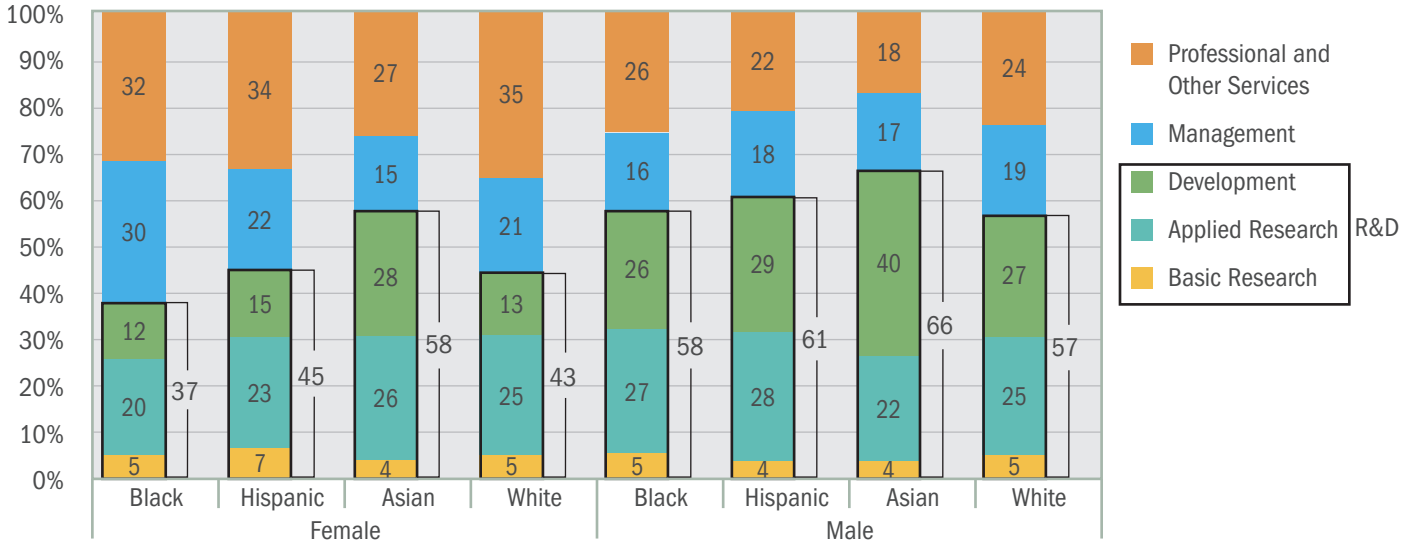


## WORK ACTIVITIES OF NONACADEMIC STEM PHD HOLDERS

STEM PhD holders in nonacademic positions reported engaging in a variety of work activities: basic research, applied research, development, management, and professional and other services. For the purpose of this brief, we categorized work activities as "research and development" (R&D), a common composition that combines basic and applied research and product development (Organisation for Economic Co-Operation and Development, 2002), and non-R&D work activities, to include management and professional and other services. In Figure 5, the bold box indicates R&D work activities.

Overall, 57 percent of STEM PhD holders were involved in R&D as their primary work activity, though the proportion who reported R&D as a primary work activity differed, particularly between female and male PhD holders. Less than half of female Black, Hispanic, and White STEM PhD holders indicated that R&D was a main work activity compared with a majority of males and Asian females (see Figure 5). Black female PhD holders were least likely to report focusing on R&D work (37 percent), whereas Asian male PhD holders were the most likely to report focusing on R&D (66 percent).

**Figure 5. Percentage Distribution of STEM PhD Holders in Nonacademic Positions, by Primary Work Activity and by Gender and Racial/Ethnic Group**




**Differences in R&D**

STEM careers change over time, and the work activities that those careers require change as well. Among those in nonacademic careers, older PhD holders were less likely involved in research and development compared with younger PhD holders. This pattern persisted across all gender and racial/ethnic groups.

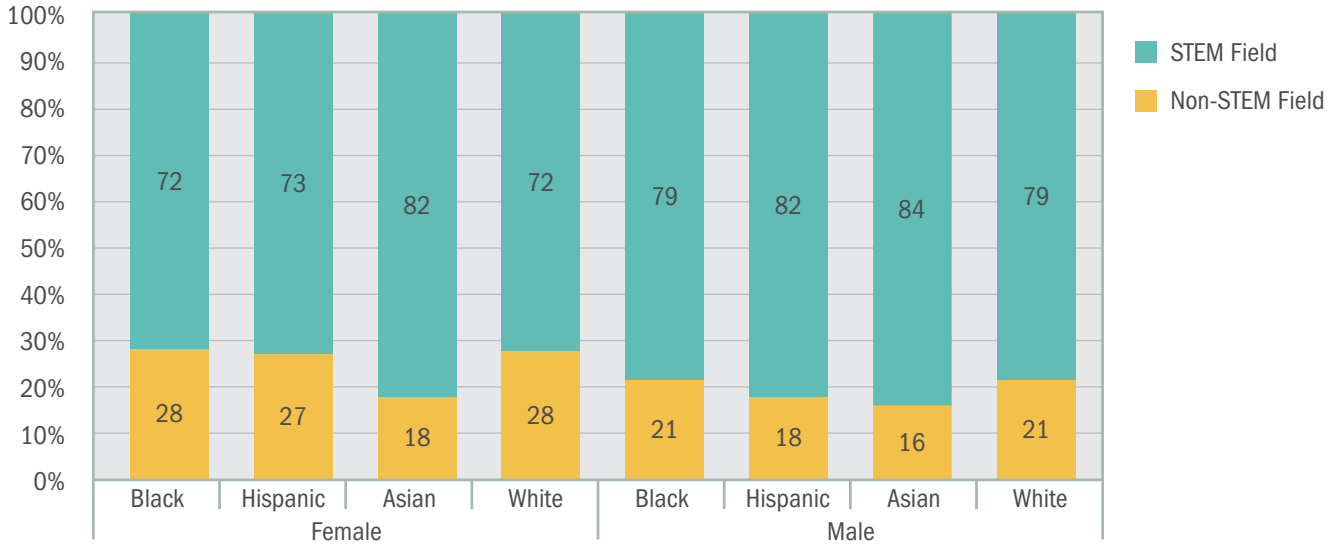
Within R&D, few STEM PhD holders, regardless of gender and race/ethnicity, reported conducting basic research. Instead, most PhD holders reported primarily engaging in applied research or development. About one fourth of all respondent groups indicated applied research as their main work activity (see Figure 5). However, females, and especially Black, Hispanic, and White females, were notably less likely to report development (e.g., producing materials, equipment, processes, or applications) as a primary work activity (12 to 15 percent) compared with other groups. In contrast, 40 percent of Asian male PhD holders reported development activities as their primary work activity.

Outside of R&D, large shares of PhD holders indicated that their primary work activity involved management as well as professional and other services (see Figure 5). Again, the proportion of female Black, Hispanic, and White PhD holders stands out as different from the other groups. They were more likely to report management as their primary work activity (21 to 30 percent) and more likely to report working in professional and other services (32 to 35 percent) compared with Asian females and all males.

### NONACADEMIC STEM PHD HOLDERS WORKING OUTSIDE OF STEM FIELDS

A minority of STEM PhD holders in nonacademic careers reported working outside of a STEM field (21 percent). Yet, the proportion of employed degree holders who left STEM careers differed for female Black, Hispanic, and White PhD holders from the other groups examined. More than one fourth of Black, Hispanic, and White females with STEM degrees reported working in a field outside of STEM (27 to 28 percent, see Figure 6). In comparison, approximately one fifth of the male and Asian female STEM PhD holders were in a non-STEM career (16 to 21 percent).

**Figure 6. Percentage Distribution of STEM PhD Holders in Nonacademic Positions, by Employment Outside of STEM and by Gender and Racial/Ethnic Group**




## Implications

To summarize, a majority of employed STEM PhD holders, who had earned their degrees between 1959 and 2010, were working in nonacademic positions as of October 2010. Among those in nonacademic careers, the largest share worked in private, for-profit companies, but a substantial proportion worked in government. Approximately half of STEM PhD holders reported R&D as their main work activity. Notably, 21 percent of STEM PhD holders were not employed in a STEM field.

Across all types of careers and work activities, female Black, Hispanic, and White PhD holders differed from male PhD holders of any race/ethnicity and Asian female PhD holders. Female Black, Hispanic, and White PhD holders were slightly less likely to enter into nonacademic careers than the other groups examined. Furthermore, among those in nonacademic careers, these women were less likely to be involved in R&D and more likely to work in government and in a non-STEM field compared with other groups.

Two findings stand out. Although most PhD programs focus on training future professors and researchers to become highly proficient in research practices (Amsen, 2011; Cadwalader, 2013; June, 2011), our analyses showed that performing work unassociated with R&D in nonacademic careers is common, particularly among female STEM PhD holders. As a result, PhD students lack training in areas that may feature strongly in their career pursuits. Connections to and retention in STEM, particularly for underrepresented groups may improve if PhD training and career guidance were more relevant to the nonacademic career sectors that most students will enter and the common work activities in which they will engage.

In addition, our analyses showed that not only were Black, Hispanic, and White female PhD holders less likely to engage in R&D work activities, they also were more likely to leave the STEM workforce altogether compared with other groups. The loss of STEM talent in the domestic workforce is troubling for several reasons. Attaining a PhD is costly in terms of time and money for individuals and institutions (Center for STEM Education & Innovation, & Delta Cost Project, 2013; Zeiser, Kirshstein, & Tanenbaum, 2013). Likewise, losing PhD holders from STEM fields strains the national STEM pipeline. Women, particularly Black and Hispanic women, are underrepresented at every stage of the STEM education pipeline, and they are most likely to leave the STEM workforce compared with other groups, diminishing STEM growth and diversification.

The data analyzed for this brief could not address why approximately half of STEM PhD holders in nonacademic careers do not primarily work in R&D, or why Black, Hispanic, and White female STEM PhD holders, in particular, pursued nonacademic careers outside of STEM more often than other STEM PhD holders. However, these findings suggest that postsecondary institutional, workplace, and national policies may be inadequate to promote growth and retention in STEM for all gender and ethnic groups. Some higher education policies already support a wider definition of STEM training to include a broader set of skills relevant to nonacademic careers (Thune, 2010). An expansion of these policies may help retain more PhD holders, particularly female PhD holders in STEM (Rodriguez et al., 2012; Thune, 2010). For example, STEM PhD programs may adopt nonacademic career guidance and training in leadership, networking, and entrepreneurship (Cadwalader, 2013; Sauermann & Roach, 2012). Change in the work environment also may increase retention in STEM, such as instituting flexible schedules and adjusting promotion procedures (Kim, 2012). Furthermore, national policy can influence research spending and expand scholarships for students (Hira, 2010). Ultimately, STEM PhD program, workplace, and national policies form an interconnected system and may be used to foster greater commitment to STEM fields for everyone (Hira, 2010).

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# Technical Appendix. Classification of Work Activities

| | |
|---|---|
| **Basic Research** | (1) Working to gain scientific knowledge for its own sake (5 percent) |
| **Applied Research** | (1) Working to gain scientific knowledge to meet a recognized need (24 percent) |
| **Development** | (1) Development of knowledge from research for the production of materials and devices (14 percent)<br>(2) Design of equipment, processes, structures, or models (5 percent)<br>(3) Computer applications, programming, or systems development (8 percent) |
| **Management** | (1) Managing or supervising people or projects (19 percent) |
| **Professional and Other Services** | (1) Accounting, finance, and contracts (2 percent)<br>(2) Employee relations including recruiting, personnel development, or training (0.4 percent)<br>(3) Production, operations, or maintenance (2 percent)<br>(4) Professional services including health care, financial services, or legal services (9 percent)<br>(5) Sales, purchasing, or marketing (3 percent)<br>(6) Quality or productivity management (2 percent)<br>(7) Teaching (3 percent)<br>(8) Other (4 percent) |

*Note:* The percentage of employed PhD holders in nonacademic jobs who indicated each item as their main work activity is shown in parentheses.

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