Compensation and Benefits for Science, Technology, Engineering, and Mathematics (STEM) Workers

A Comparison of the Federal Government and the Private Sector

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Preface

In a companion report to the 2019 National Defense Authorization Act, the U.S. Senate Committee on Armed Services directed the Department of Defense, in consultation with the Office of Personnel Management and the Department of Energy, to conduct an examination of salary and benefits for government professional engineers and scientists as compared with those of similar positions in the private sector. The Deputy Assistant Secretary of Defense for Civilian Personnel Policy asked the RAND Corporation's National Defense Research Institute (NDRI) to undertake the prescribed analysis and assist in developing the required report.

This report describes the analysis and findings of the NDRI study, which compares the compensation and employment trends of the science, technology, engineering, and mathematics workforces in the public (federal civilian) sector and the private sector. It is intended for policymakers who work in federal compensation policy. The research reported here completed quality assurance review in October 2019 and underwent security review with the sponsor and the Defense Office of Prepublication and Security Review before public release.

This research was sponsored by the Deputy Assistant Secretary of Defense (Civilian Personnel Policy) and was conducted within the Forces and Resources Policy Center of the RAND National Security Research Division (NSRD), which operates the National Defense Research Institute (NDRI), a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Navy, the Marine Corps, the defense agencies, and the defense intelligence enterprise.

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Summary

U.S. government concerns about hiring and retaining scientists and engineers to contribute to national defense and the civilian economy has a long history, dating back to at least the World War II era. In 2005[1] the National Academies published a report, *Rising Above the Gathering Storm*, to underscore these concerns. Following this report, the U.S. Congress passed laws to improve the size and caliber of the science, technology, engineering, and mathematics (STEM) workforce and investment in STEM education.

This trend of U.S. government interest in STEM workforce matters continues. In its accompanying report to the 2019 National Defense Authorization Act (NDAA), the U.S. Senate Committee on Armed Services directed the Department of Defense (DoD), in consultation with the Office of Personnel Management (OPM) and the Department of Energy, to conduct a comparison of salary and benefits for government professional engineers and scientists to similar positions in the private sector. The report lays out the motivation for its mandate: "The committee believes the Department of Defense must develop new and innovative methods to attract and manage talent with highly valuable technical skills" (U.S. Senate Committee on Armed Services, 2018, p. 283).

To address the 2019 NDAA congressional requirement, the Deputy Assistant Secretary of Defense for Civilian Personnel Policy asked the RAND Corporation's National Defense Research Institute (NDRI) to undertake the analysis outlined in the congressional report language and to assist in developing the required report. The NDRI's approach to the DoD request is to interpret "engineers and scientists" as the STEM workforce in the federal government, as compared with the STEM workforce in the U.S. private sector. The basic question our analysis addresses is whether STEM workers in the federal government are competitively compensated compared with STEM workers in the private sector.

Our Approach

Our primary approach involved a labor market analysis to examine the private-sector and federal STEM workforces. Before we could begin this analysis, we had to determine which occupations (and workers) would be included in STEM versus non-STEM workforces. This was not straightforward, as STEM has varying definitions, including one from each of our principal data sources, the OPM and the U.S. Census Bureau. We created our own workforce definition of STEM that built off the OPM definition but adhered to the National Science Foundation's scope of STEM disciplines. Our definition included social scientists and workers without a college

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[1] "Rising Above the Gathering Storm" has more than one edition. The first prepublication edition was released in 2005; a complete version of the report was first published in 2007, and an updated version was published in 2010.

degree, but it excluded the health professions. To facilitate comparisons, we created a crosswalk of five occupational categories in each data set that covers the same occupations: those in the life sciences, the physical sciences, engineering, information technology (IT) and computer science, and the social sciences.

We compared the composition of workers in the private and federal sectors, as well as comparing wages, unemployment rates, work hours, and, where possible, benefits. We also conduct extensive subgroup analyses, examining the five occupation categories, education levels, gender, race/ethnicity, and (in some cases) geographic regions.

To conduct these analyses we compiled and analyzed workforce data from U.S. government sources: the Current Population Survey (CPS) from the U.S. Census Bureau, the Defense Manpower Data Center (DMDC) from DoD, and FedScope from the OPM.[2] The CPS is a monthly survey of U.S. households that collects information about their work and earnings, among other topics. STEM workers in both the private sector and the federal government can be identified via their occupation and industry. The CPS also includes an annual supplement, the Annual Social and Economic Survey (ASEC), that collects more detailed work and earnings data, which we also used. FedScope is the publicly available census of all federal employees that includes occupation, agency, and other characteristics. The DMDC is a restricted data set (to which RAND has access) that is a census of all employees of DoD; unlike FedScope, which is stripped down for the public version and excludes certain key variables, DMDC is an expansive data set. For all data sets, we use the years of data available in FedScope (2005–2018), since it was the most restricted.

These data sources are not without limitations. We were not able to compare hiring, worker quality and job quality, and the majority of tenure and retention trends. We therefore supplemented our quantitative analyses with a review of literature and policy regarding STEM workforce hiring and retention trends. We also considered using data from third-party surveys of private-sector compensation, but unfortunately found that those data sources tend to omit crosswalks to the public-sector data that we would have needed to analyze federal STEM trends in compensation.

Other analysis was also limited by conceptual and logistical challenges. One conceptual challenge is how to measure compensation, which has numerous components (pay and various benefits) and determinants (experience, education, preferences, and wage differentials). Compensation is not "an island": the language of the NDAA specifically mentions the need to hire, but compensation—the subject of study the NDAA requested—is just one part of that. There were also logistical challenges with the data. FedScope, in its public version, is limited; it does not link workers across quarters or to accessions or separations, greatly curtailing our ability to do retention analysis. The way income is reported in the CPS makes comparisons outside the survey problematic enough that we did not pursue them.

Despite these challenges, our approach provides findings that can be used by policymakers to understand STEM workforce trends.

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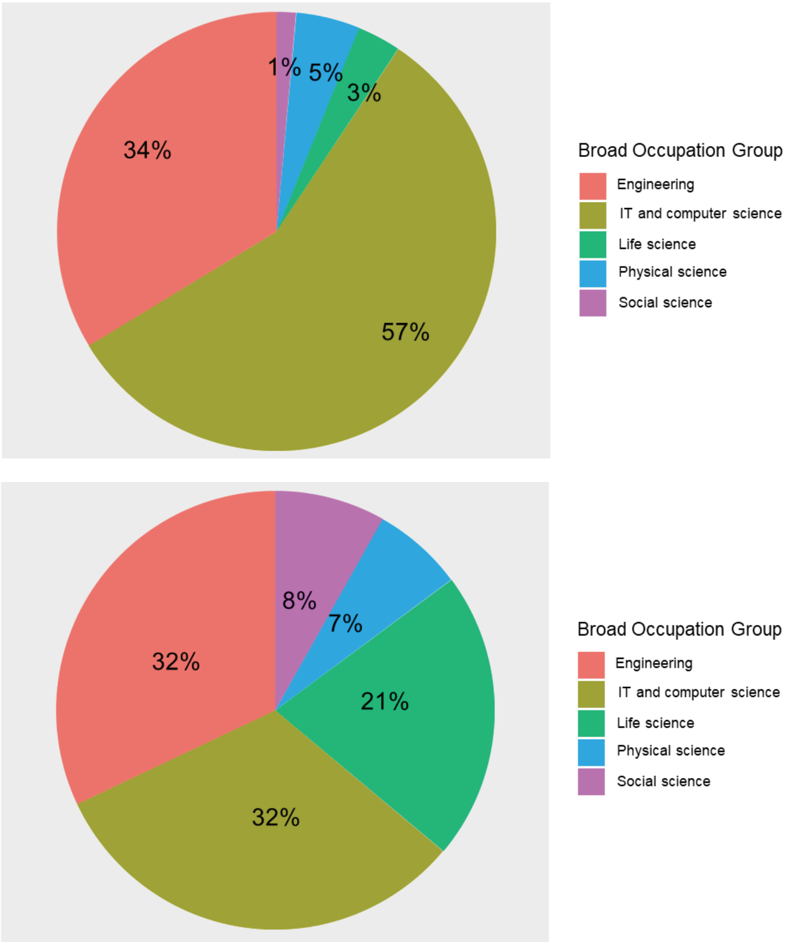
[2] In this report's figures and tables, we indicate which of these sources of workforce data we used in our analysis. With the exception of DMCD data, the data sets are available to the public via each agency's website.

The Composition of STEM Workforces

In comparing STEM workers in the private sector and the federal government, it is important to consider whether these workforces, conditional on being considered part of STEM, are similar. We want to understand if federal workers are competitively compensated, but the average wages of workers reflect not only their pay but also their composition along dimensions that determine wages, such as education, experience, or occupation. Hence, understanding who works in both sectors provides necessary context for how those sectors are compensated in the aggregate.

There were 8.8 million STEM workers in the private sector in 2018, accounting for 7.7 percent of overall full-time employment; there were 320,000 STEM workers in the federal government in 2018, representing about 17 percent of the total full-time federal workforce. As we show in Figure S.1, private-sector STEM workers are highly concentrated in engineering and in

Figure S.1. Shares of the Private-Sector STEM Workforce (Top) and Federal STEM Workforce (Bottom) by Broad Occupation Group, 2018



SOURCES: CPS (via the U.S. Census Bureau); FedScope (via OPM).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Counts include both employed and unemployed workers.

IT and computer science, with marginal shares in the life, physical, or social sciences, but federal STEM workers, with the same share of engineers, have less concentration in IT and computer science and more in the other categories—in, particular life science.

STEM workers are also more educated that non-STEM workers in both sectors (see Table S.1). Only 19.4 percent and 15.9 percent of STEM workers in the federal and private-sector workforce, respectively, do not have a postsecondary degree, compared with 41.6 percent and 56.2 percent of their non-STEM counterparts. Overall, the federal workforce has higher educational attainment than the private-sector workforce, and this holds within STEM as well. Federal STEM workers have higher shares of advanced and master's degree holders (10.4 percent and 24.3 percent, respectively) than the private sector (5.7 and 23.3 percent, respectively), while the private sector has a higher share of terminal bachelor's degree holders (46.9 percent, compared with 40.7 percent in the federal sector).

Table S.1. Distribution of Federal and Private-Sector Workers, by Education Level and STEM Status, 2018

Education Level	STEM Workers (Percentage)		Non-STEM Workers (Percentage)	
	Federal	Private	Federal	Private
Advanced degree	10.4	5.7	5.9	3.3
Master's degree	24.3	23.3	15.2	7.2
Bachelor's degree	40.7	46.9	27.0	22.5
Associate's degree	4.4	5.2	7.2	6.0
Technical college training	0.8	3.1	3.1	4.8
No degree/some college	19.4	15.9	41.6	56.2

SOURCES: CPS (via the U.S. Census Bureau); FedScope (via OPM).
NOTE: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The public sector refers to federal workers. Counts include both employed and unemployed workers.

However, STEM, as both an educational discipline and a subset of the workforce, has long had issues regarding lack of diversity. In both sectors there is considerably less gender and racial and ethnic diversity in STEM than outside it. White men make up half of STEM workers in both the federal and private-sector STEM workforces, while they account for a little more than one in three workers in non-STEM occupations in both sectors. The federal STEM workforce fares modestly better in being closer to the non-STEM gender distribution of workers: 31.3 percent of federal STEM workers are women, compared with 46.6 percent of non-STEM workers, while just 22.6 percent of private-sector STEM workers are women, compared with 42.8 percent of non-STEM workers. The nonwhite share is similar in both sectors: 29.8 percent in the federal workforce versus 33.4 in the private sector. However, the federal workforce has a larger share of black and Hispanic workers: 21.8 percent, compared with 14.4 percent in the private sector. The Asian share is notably smaller in the federal workforce: 7.9 percent, versus 19 percent in the private sector.

Table S.2. Share of Workforce, by Gender, Race/Ethnicity, Sector, and STEM Status, 2018

Demographic Group	STEM Workers (Percentage)		Non-STEM Workers (Percentage)	
	Federal	Private	Federal	Private
Male	68.7	77.4	53.4	57.2
Female	31.3	22.6	46.6	42.8
White	70.2	66.6	59.2	62.4
Hispanic	7.6	7.8	12.6	19.7
Black	14.2	6.6	22.8	12.1
Asian	7.9	19.0	5.4	5.7
White male	49.9	52.8	33.7	36.0
White female	20.3	13.9	25.5	26.4
Hispanic male	5.6	6.1	7.6	12.3
Hispanic female	2.0	1.7	5.0	7.5
Black male	7.1	4.6	9.6	6.1
Black female	7.1	2.0	13.1	6.0
Asian male	5.7	14.1	2.8	2.9
Asian female	2.2	4.9	2.6	2.8

SOURCE: CPS (via the U.S. Census Bureau).
NOTE: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The public sector refers to federal workers. Counts include both employed and unemployed workers.

Federal Versus Private-Sector Compensation for STEM

We find, as many researchers have previously documented, that workers in STEM earn more than workers not in STEM, sometimes referred to as the STEM pay premium. This was true when comparing private-sector STEM and non-STEM workers, as well as federal STEM and non-STEM workers. The latter is perhaps more surprising at first blush; pay increases in the federal sector are followed within the General Schedule (GS) pay plans. However, it may be the case that STEM workers enter GS plans at higher GS pay grades than non-STEM workers, even conditional on similar levels of educational attainment. Moreover, 23 percent of STEM workers were on a separate pay plan—some of them specific to STEM—and these workers tended to earn higher incomes.

The pay differences between federal STEM and private-sector STEM workers is much more varied. We show in Table S.3 the 2018 annual earnings of each educational, demographic, and nativity group. Comparing within groups of educational attainment, it appears that private-sector STEM workers earn more; they have higher wages for all groups except those with an associate's degree. However, if we were instead to show the average over a multiyear time frame, say, 2010–2018 (the most recent economic expansion) or 2005–2018 (the scope of our data), federal STEM workers without a degree or with a bachelor's degree earn more than private-sector STEM workers, suggesting an erosion of federal worker salary over time. This would align with the three-year federal pay freeze for 2011–2013. In general, the higher the worker's education, the better the private sector pays over the federal government, both in and outside STEM.

Table S.3. Annual Earnings, by Demographic Characteristics, Sector, and STEM Status, 2018

Demographic Group	STEM Workers		Non-STEM Workers	
	Federal	Private	Federal	Private
Advanced degree	$103,108	$126,913	$143,113	$148,723
Master's degree	$94,368	$110,445	$90,424	$101,022
Bachelor's degree	$91,324	$95,436	$76,743	$74,467
Associate's degree	$87,002	$76,463	$51,862	$50,697
Technical college	$54,650	$74,630	$62,654	$50,809
No degree/ some college	$61,153	$66,840	$53,938	$41,238
Male	$94,509	$99,557	$76,193	$64,506
Female	$78,545	$79,571	$64,628	$49,152
White	$91,188	$95,449	$77,379	$65,187
Hispanic	$85,127	$80,674	$59,015	$41,147
Black	$79,596	$77,797	$63,929	$43,003
Asian	$75,775	$106,345	$70,896	$68,900
White male	$99,080	$100,056	$82,966	$73,453
White female	$76,861	$78,667	$70,396	$54,008
Hispanic male	$85,985	$82,945	$64,941	$43,990
Hispanic female	$83,162	$71,884	$50,921	$36,564
Black male	$87,393	$82,330	$69,076	$46,960
Black female	$72,169	$66,066	$60,056	$39,226
Asian male	$78,246	$111,015	$64,648	$77,360
Asian female	$61,102	$92,134	$79,155	$59,440
Native born	$87,483	$91,020	$70,038	$59,548
Foreign born	$95,702	$105,541	$75,170	$51,376

SOURCE: CPS (via the U.S. Census Bureau).

NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The table excludes the "Other" race Census category from calculations that are too small for comparison. Income figures are expressed in real 2018 dollars.

In terms of demographic groups, the private sector has much higher compensation for Asian STEM workers (a difference of $30,000 for both men and women), close to parity for white workers of both genders, and lower pay for black and Hispanic workers. Within each race/ethnicity, men earn more than women, and the STEM premium is considerable. The differences in income by nativity were less striking.

Comparing like groups has intuitive benefits, but also severe limitations. As we noted earlier, the composition of a group is fundamental in determining the group's average wages. White men may earn more in STEM, but white male STEM workers may be more educated or experienced than white male non-STEM workers, explaining part of the difference. Even within a group like bachelor's degree holders, there is likely a large difference in pay between more and less experienced workers, or workers who are in IT and computer science versus biology. This same caveat applies comparing across groups; native-born workers earn less than foreign-born workers in STEM in both the federal and private sectors, but foreign-born workers may have higher educational attainment, on average, or be more likely to be in managerial or supervisory roles.

To control for these compositional differences, we use regression analysis to estimate the statistical relationship between STEM workers' incomes and being a federal employee. A regression estimates the relationship between a dependent variable (in this case, income) and a single characteristic, holding the other characteristics constant. Hence, we estimate the federal premium on annual earnings among STEM workers, but this should not be thought of as a causal effect. A regression coefficient controls for what we can observe in the data about a worker; there are still many things we do not observe—such as job quality, worker quality, worker productivity, or worker preferences—and this means that our controls are not exhaustive. Moreover, a regression is not synonymous with causality. We cannot say that working for the federal government results in a person's wages being lower or higher than they would be in the private sector. Yet the statistical relationship expressed through the coefficient, which we call the federal premium, is still informative in understanding how workers are compensated in the federal government versus the private sector because the difference in earnings is no longer reflecting the differences in characteristics.

In Table S.4 we estimate this federal premium in two regressions. For these regressions, we use the 2009–2018 waves of the CPS Annual Social and Economic Supplement (ASEC) and examine STEM workers only. We regress annual earned income on an indicator for being a federal worker. In the first regression we have no controls, and in the second we add controls for educational attainment, occupation within the five broad STEM categories, age,[3] gender, race/ethnicity, region, location (urban versus rural), and year. In the second regression we are controlling for the different compositions of the federal and private-sector STEM workforces. In the first row of Table S.4, the coefficient is \$3,712 and significant, meaning that it is statistically different from zero. The overall difference in income between federal and private STEM workers is that federal workers earn about \$4,000 more per year. However, when we add the full set of controls—in effect controlling for the composition of the two groups—the federal employee indicator has a coefficient of –\$2,585. Or, controlling for the composition of the federal and STEM workforces, federal workers make about \$2,600 less. The federal premium is, in fact, negative.

Table S.4. Select Regression Coefficients from Regressions of Annual Income on Worker Characteristics Among STEM Workers

Specification	Coefficient on Federal Sector	*P*-Value for Federal Sector
Federal employee indicator	\$3,712	0.000
+ Controls	\$–2,585	0.000

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: The table shows the single regression coefficient on a dummy for being a federal worker and the associated *p*-value in two regressions. The second regression includes controls for educational attainment, occupation within STEM categories, age and age squared, gender, race/ethnicity, region, whether urban or rural, and year. The sample is of all full-time STEM workers.

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[3] In the regression, we include age and age squared, the preferred practice in wage-determinant regressions. See, for example, Oaxaca, 1973.

Additional Factors That Could Affect STEM Workforce Hiring and Retention Trends

The regression analysis found that federal STEM workers earn $2,600 less than private-sector STEM workers. However, earnings are but one aspect of compensation. We performed the same regression analysis, but instead regressed hours worked, the probability of having health insurance coverage, and the probability of having retirement benefits. Again, this analysis was only on STEM workers, and controlled for the composition of the two groups. Though the regression on income found federal workers earn less, the other regressions showed that federal workers work shorter hours and are more likely to receive benefits. Yet because the data available for private-sector workers does not include any details of the benefits, we have no way of assessing if, net of monetary benefits, federal workers have similar compensation overall. Data from third-party vendors may shed some light on these compensation issues in the private sector, but, as noted previously, such data cannot be crosswalked to public-sector data.

Moreover, while a regression is a powerful statistical tool in isolating specific relationships, it is contingent on what is observed. In the data we see education, occupation, age, gender, race/ethnicity, region, and year. We cannot observe a whole other host of factors that could render much larger or smaller the $2,600 difference in earnings estimated here. In general, we have no measure of job quality, job satisfaction, worker quality, or worker preference. It could be the case that workers have a preference for policy work or public service, so much so that they would have to be paid more to work in the private sector, or vice versa. These worker preferences might not just extend to the nature of the work or job but also the compensation. It could be the case that some workers place a higher value on health or retirement benefits, both of which are more common (and arguably more generous) among federal workers, or that some workers place a higher value on stock options, which is not included in federal benefits, or paid family leave, which was not included in federal benefits during the window of our analysis, but has since been added. These preferences—which no doubt vary across individuals—are key for understanding estimated earnings differences and could also vary across groups of individuals, such as by age, gender, and race/ethnicity.

However, even if we could observe all of this—preferences for types of work and the value of nonmonetary benefits—a difference in $2,600 in expected pay is based on realized choices. We know the wages of private-sector workers and federal workers, but we do not know what an individual federal worker would make if he or she moved to the private sector, or vice versa. The estimate of $2,600 thus cannot be interpreted as the differential in pay for the same worker offered the same job in the federal and private sectors.

Finally, our study of the compensation of federal STEM workers was motivated by the need for the federal government to attract and retain highly talented workers. Yet compensation is just one component of hiring and retention, and there is much more room to study what features of federal employment may make hiring STEM workers more difficult. We note that there are known issues with delays in federal hiring, but also that federal hiring mechanisms such as USAJOBS, designed to suit all agencies and occupations in the federal system, likely lack features that have evolved in occupation-specific labor markets so that the cost of applying for a federal job may be higher than the cost of applying for a private-sector job.

There are also aspects of employment unique to federal government that may influence hiring and retention but that, to the best of our knowledge, have not been thoroughly studied for that purpose. Federal workers are subject to shutdowns, pay freezes, and hiring freezes—things that affect work and pay but are completely uncorrelated with an individual's worker performance. It is also an indelible aspect of federal work that the administration changes hands every four or eight years, and with it an estimated 4,000 political appointees. These frequent turnovers, or prolonged vacancies, can change daily work life or overall work mission, and much that lies in between.

For the most part, the relationship of these unique federal features to hiring and retaining high-quality talent, whether STEM or not, is not understood. And the effect could be twofold—first, in the direct, *tangible* effect on current and prospective employees, and second, on the *perception* of what it is like to work for the federal government. For example, a shutdown may have a tangible effect on hiring and retention: applications cannot be reviewed, and applicants cannot be interviewed during a furlough, and those applicants may move to other jobs in the meantime, and current employees who are not being paid and not working may find another job and leave. Or, it could have a perception effect on hiring and retention: federal jobs are viewed as worse, so fewer or different candidates decide to apply, or federal workers are viewed as frustrated or poorly treated, and more firms attempt to hire them. We do not know to what extent either effect is occurring, and we believe that careful, nonpartisan research could improve our understanding of these factors and their effects.

Recommendations

Our finding that federal STEM workers earn $2,600 less is not equivalent to a solution, or recommendation, to pay all federal STEM workers $2,600 more. Instead, our recommendation is for more analysis and targeted evaluations to understand what our regressions could not uncover. We have noted, for example, that we have no measure of worker preferences or perceptions of job quality in the federal versus private sectors. We were also limited in our analysis by the data available, but better data, or additional data (such as those provided by third-party vendors on private-sector compensation and benefits), would enable additional insight into compensation. Most importantly, our study was tasked with comparing compensation, but there are many policy determinants of federal compensation that, while outside the scope of our study, are relevant to STEM worker pay.

Hence, we recommend the following policy changes, primarily around data collection:

- Improve the publicly available version of FedScope along an array of measures (e.g., longitudinally linked data that includes gender and race/ethnicity) to enable more research.
- Collect salary information both before and after federal employment for arriving or departing workers.

We also recommend the following studies to further understand federal compensation competitiveness:

- Investigate further the private-public STEM compensation differences in which federal difference in pay is larger than the estimated average difference ($2,600).
- Investigate the source of gender and race/ethnicity disparities in the federal government.
- Conduct a thorough implementation analysis of current, non-GS pay plans, their effectiveness, and their usage.
- Conduct focus groups and interviews with federal STEM workers to understand the motivations and values of those workers and how they view their compensation and benefits package, and how this varies by age.

This study was tasked with comparing compensation, but as we note at the start, it is motivated by the desire to hire and retain talented STEM workers in the federal government. Although pay is critical, it is but one component of attracting workers to jobs. Especially if total compensation (pay and benefits) is roughly comparable for federal and private-sector STEM workers, as we find in our analysis, it suggests that other factors may be contributing to any existing recruitment and retention challenges.

There are three aspects unique to federal employment that we think are both relevant to hiring and retention and in need of further analysis. First, hiring for the federal government is primarily conducted through USAJOBS, but there are also STEM-specific hiring authorities and hiring programs, such as the American Association for the Advancement of Science Fellowships. An evaluation of the various hiring mechanisms with an eye toward STEM could help identify for which STEM workers or which STEM labor markets the federal government's hiring process is not competitive. Second, federal workers are subject to disruptions that are unrelated to their individual contribution or performance, including shutdowns, pay freezes, and hiring freezes. For the most part, the relationship of these disruptions to hiring and retaining high-quality talent, whether in STEM or not, is not understood. Careful, nonpartisan research could improve our understanding of these factors and their effects.

Finally, changes in leadership that occur with each new administration—or within administrations—are an indelible feature of federal service. Our concern in terms of the attraction and retention of high-quality STEM workers is that frequent changes to leadership, or prolonged vacancies in leadership, may make entering or remaining in federal service less desirable. New leadership can lead to policy uncertainty, changes in mission, or changes in basic workplace features, such as physical location of an office, that affect day-to-day work. Unfortunately, there is no existing data on turnover and the vacancies of political appointees, and therefore we cannot determine if leadership changes, or frequent leadership changes, affect hiring or retention.

In sum, further research that spans quantitative and qualitative methods could yield more insight into hiring and retention difficulties based on compensation or other causes across employers of STEM workers in the federal government.

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Abbreviations

AAAS	American Association for the Advancement of Science
ASEC	Annual Social and Economic Supplement
ATUS	American Time Use Survey
BLS	Bureau of Labor Statistics
CAGR	compound annual growth rate
CPPA	Critical Position Pay Authority
CPS	Current Population Survey
CRS	Congressional Research Service
DMDC	Defense Manpower Data Center
DoD	Department of Defense
DOE	Department of Energy
EERE	Energy Efficiency and Renewable Energy
EMPSTAT	Employee Status
FEDVIP	Federal Employee Dental and Vision Insurance Program
FEGLI	Federal Employees’ Group Life Insurance Program
FEHB	Federal Employee Health Benefits
FEPCA	Federal Employees Pay Comparability Act
FERS	Federal Employees Retirement System
FLTCIP	Federal Long-Term Care Insurance Program
FSAFEDS	Federal Flexible Spending Account Program
FY	fiscal year
GAO	Government Accountability Office
GS	General Schedule
GSA	General Services Administration

IT	information technology
NCS	National Compensation Survey
NDAA	National Defense Authorization Act
NDRI	National Defense Research Institute
NIU	not in universe
NSB	National Science Board
NSF	National Science Foundation
O*NET	Occupational Information Network
OPM	Office of Personnel Management
PMA	President’s Management Agenda
S&E	science and engineering
SES	Senior Executive Service
SOC	Standard Occupational Classification
STEM	science, technology, engineering, and mathematics
STP	Science, Technology, and Policy
TSP	Thrift Savings Plan

1. Introduction to Science, Technology, Engineering, and Mathematics in the Workforce

In its companion report to the 2019 National Defense Authorization Act (NDAA), the U.S. Senate Committee on Armed Services directed the Department of Defense (DoD), in consultation with the Department of Energy (DOE) and the Office of Personnel Management (OPM), to conduct a comparison of salary and benefits for government professional engineers and scientists to similar positions in the private sector (U.S. Senate Committee on Armed Services, 2018, p. 283). The Deputy Assistant Secretary for Civilian Personnel Policy asked the RAND Corporation's National Defense Research Institute (NDRI) to undertake the prescribed analysis and to assist in developing the required report.

RAND's approach to the DoD request is to interpret "engineers and scientists" as the science, technology, engineering, and mathematics (STEM) workforce in the federal government. We examine all of STEM in order to include workers that are formally considered scientists, such as computer scientists, and those who are in growing areas but not technically scientists, such as workers in information technology (IT), which encompasses burgeoning fields such as cybersecurity, machine learning, and artificial intelligence. Hence, this report can serve as a primary or foundational comparison of STEM workers in the private sector and federal government and key reference for future studies that have a much narrower focus than "engineers and scientists." In addition, RAND's approach is to interpret "comparison of salary and benefits" as a comprehensive analysis of the STEM labor market that includes issues in compensation and determinants of compensation, beyond a dollar-for-dollar comparison of pay. We do this so that this report not only answers the DoD request but provides understanding of what drives the answer we provide.

The Importance of, and Interest in, the STEM Workforce

Policymaker interest in cultivating a class of capable scientists and engineers to contribute to national defense and the civilian economy, and in ensuring that the public sector can compete with the private sector for these workers, dates at least to the World War II era. In July 1945 the Director of the Office of Scientific Research and Development wrote in a report to the President,

> The most important single factor in scientific and technical work is the quality of the personnel employed. The procedures currently followed within the Government for recruiting, classifying and compensating such personnel place the Government under a severe handicap in competing with industry and the universities for first-class scientific talent (Bush, 1945).

More than a half century later, the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine's 2005 report *Rising Above the Gathering Storm* (hereafter the NAS report) underscored the importance of investing in the science and engineering (S&E) workforce as part of a strategy to compete in the global economy and warned that the United States risked falling behind if policymakers failed to act. The report motivated the 2007 passage of the America COMPETES Act (Public Law 110-69), which authorized higher funding levels for federal research and included several provisions designed to improve the size and caliber of the STEM workforce (Congressional Research Service [CRS], 2015). This legislation was reauthorized in 2011 (Public Law 111-358). Subsequently, the American Innovation and Competitiveness Act (Public Law 114-329), enacted in 2017, demonstrated continued congressional interest in the STEM workforce and STEM education.

As these reports and congressional actions demonstrate, it has long been the espoused view of policymakers that STEM workers are critical for enhancing U.S. economic competitiveness and quality of life. There is widespread support for the view that a capable STEM workforce is important for innovation and economic growth, even among those who disagree on other questions related to this workforce (Carnevale, Smith, and Melton, 2011; Kelly et al., 2004; Rothwell, 2013; Teitelbaum, 2014). There is also broad agreement that STEM knowledge and skills are becoming increasingly important across the economy, and that current and future jobs are more likely to draw on these abilities than the jobs of the past (Baird, Bozick, and Harris, 2017; Carnevale, Smith, and Melton, 2011). STEM occupations have grown faster than non-STEM occupations in recent years and are projected to continue to do so (CRS, 2017; Noonan, 2017).

One contention from the literature is that the STEM workforce merits particular attention because demand for STEM workers outstrips supply, resulting in worker shortages that undermine the nation’s competitiveness (NAS, 2007; President’s Council of Advisors on Science and Technology, 2012). Studies that describe existing or potential shortages of STEM workers often ascribe blame to the educational system. A pipeline is a common metaphor for the path from early education to a STEM job, with researchers identifying leaks and policymakers seeking to plug them (Metcalf, 2010; U.S. Department of Education, 2018).

In addition to improving STEM education programs for native-born Americans, there are calls for expanding pathways for foreign students or guest workers to stay in the United States to help meet the demand for STEM workers (NAS, 2007). However, it is disputed that there is a shortage of STEM workers, especially in discussions of whether such a perceived shortage necessitates more foreign workers. Prior research has claimed a shortage is manufactured by those seeking to increase worker supply to depress labor costs (Capelli, 2015; Salzman, Kuehn, and Lowell, 2013; Teitelbaum, 2014). Part of this dispute is likely a reflection of the fact that the STEM workforce and labor market is not uniform, with some segments of the STEM workforce experiencing tighter labor market conditions than others (Hira 2010; National Science Board [NSB], 2015; Noonan, 2017; Xu and Larson, 2015).

The debate surrounding whether there is a shortage or surplus of STEM workers relates to another reason why policymakers have voiced that the STEM workforce is important: a belief that STEM jobs are “good” jobs—offering higher pay, better benefits, and a degree of job stability that eludes workers in other occupations in today's economy (Langdon et al., 2011; Noonan, 2017). The size and the strength of the STEM workforce, and the benefits of STEM jobs, depends on another unresolved debate: exactly how to define a STEM job, or a STEM worker, in today's economy.

Definitions of STEM in the Literature

Existing research is not consistent with respect to how the STEM workforce is defined, and definitional differences can contribute to differences in findings from one study to the next. Later in this chapter, and in greater detail in Appendix B, we describe how we define STEM workers and the sources we draw on for the analysis in this report. In Table 1.1 we summarize common

Table 1.1. Definitions of the STEM Workforce

Source	Term	Included in Definition
U.S. Census Bureau (Landivar, 2013)	STEM	Includes social scientists; includes managers and sales workers in these fields
	STEM-related	Health care practitioners and technicians, and architects
National Science Board (NSB, 2018b)	STEM	S&E occupations, S&E managers, and S&E technicians and technologists
	S&E	Includes social scientists; requires bachelor's degree or higher in S&E field
	S&E-related	Health-related occupations, S&E managers, S&E technicians and technologists, architects, actuaries, S&E teachers; requires S&E knowledge or training
Bureau of Labor Statistics (Fayer, Lacey, and Watson, 2017)	STEM	Includes architects; includes managers, salespersons, and teachers in these fields; excludes social scientists
Economics and Statistics Administration (Noonan, 2017)	STEM	Includes architects and actuaries; includes managers, salespersons, and teachers in these fields
Graf, Fry, and Funk, 2018	STEM	Includes health-related occupations; excludes social scientists
Carnevale, Smith, and Melton, 2011	STEM	Includes architects; includes technicians in these fields; excludes social scientists
Rothwell, 2013	High-STEM	Defined as an occupation at least 1.5 standard deviations above the mean in the need for knowledge of science, engineering, mathematics, *or* technology, per the U.S. Department of Labor's Occupational Information Network (O*NET) system
	Super-STEM	Defined as an occupation at least 1.5 standard deviations above the mean on the average *across* the four subject area scores, per O*NET
Anderson, Baird, and Bozick, 2018	Core STEM	Worker self-reports as employed in a STEM job and occupation is considered STEM according to the definition of STEM used by either the U.S. Census Bureau (Landivar, 2013) or in Rothwell (2013)
	Periphery STEM	Worker self-reports as employed in a STEM job but occupation is not defined as STEM per the U.S. Census Bureau (Landivar, 2013) or in Rothwell (2013)

NOTES: The table shows the source, term, and definitions of the STEM workforce from various sources. All definitions of STEM include computer and mathematical scientists, engineers, life scientists, and physical scientists; we do not enumerate them in each definition, but indicate whether that definition includes other fields or professions.

definitions of STEM that are used by researchers and government agencies. All definitions of the STEM workforce listed in Table 1.1 include computer and mathematical scientists, engineers, life scientists, and physical scientists, in addition to those enumerated in the "Included in Definition" column.

Government statistical agencies typically categorize STEM workers by their occupation, which is defined by the Bureau of Labor Statistics (BLS) as "a set of activities or tasks that employees are paid to perform" regardless of industry (2018a). Some occupations are consistently included in the STEM workforce. These include engineers, computer and mathematical scientists, physical scientists, and life scientists. However, there is less consistency with respect to social sciences and certain STEM-related fields, such as medical professions and architects. The NSB (2018b), the National Science Foundation (NSF), and the U.S. Census Bureau (Landivar, 2013) include social sciences, while the BLS (Fayer, Lacey, and Watson, 2017) and the Department of Commerce's Economics and Statistics Administration (ESA; see Noonan, 2017) do not. The NSB and NSF parse STEM occupations into S&E occupations and technology occupations, and identify a set of "S&E-related occupations"—principally health-related occupations (NSB, 2018b). Graf, Fry, and Funk (2018) include health-related workers in their definition of the STEM workforce.

Other researchers have developed alternative conceptions of the STEM workforce that recognize gradations in the extent to which jobs within occupations involve STEM knowledge and skills. For example, Rothwell (2013) draws on the Department of Labor's O*NET system to create ratings, for each occupation, of how much knowledge that occupation requires in each of the four STEM subjects. Occupations at least 1.5 standard deviations above the mean on one measure are designated as "high STEM occupations" and those at least 1.5 standard deviations above the mean when averaging across all four fields are deemed "super STEM occupations." Anderson, Baird, and Bozick (2018) write that this approach uncovers more "blue-collar STEM jobs" as opposed to more traditional definitions. Carnevale, Smith, and Melton (2011) also employ a more expansive approach that includes more technical workers without bachelor's degrees. For their part, Anderson, Baird, and Bozick (2018) surveyed workers about whether their jobs were STEM jobs, labeling those that overlapped with more traditional U.S. Census–based STEM definitions the "core" STEM workforce and those that did not the "periphery" STEM workforce.

In this chapter we reference sources that utilize these various definitions of STEM. Most commonly, we cite government reports and data that utilize traditional, occupation-based definitions, some of which include social sciences and some of which do not. We also include a discussion of how findings vary if a more expansive definition is used. Readers should be mindful, as Anderson, Baird, and Bozick (2018) write, that "defining STEM is not simply an esoteric academic exercise, but one that has real consequences for how policymakers, educators, and employers structure and support the school-to-work pipeline in the United States."

Existing Research on STEM Compensation and Benefits

Numerous government reports and academic studies have considered the topic of STEM compensation and benefits, though the scope of existing analyses varies, and few such studies have devoted significant attention to differences between private-sector and federal government STEM jobs. Rather, most have focused on the extent to which STEM workers receive a wage premium—higher pay than similar workers in non-STEM positions—or are less likely to be unemployed than are non-STEM workers.[1] In the aggregate, the headline findings are consistent: workers in STEM occupations earn more and face lower unemployment rates than their counterparts in non-STEM occupations (Baird, Bozick, and Harris, 2017; Carnevale, Smith, and Melton, 2011; NSB, 2018b; Noonan, 2017). However, the experiences of workers across STEM occupations vary significantly.

Controlling for other factors that influence labor market outcomes tends to reduce but not eliminate the observed returns from working in STEM (NSB, 2018b; Noonan, 2017). In particular, because STEM workers are often highly educated and highly trained, it can be difficult to separate how much of the observed salary premium is due to working in a STEM field from the expected benefits of being highly educated, regardless of field. Other professional occupations that require a high level of educational attainment, such as lawyers and financial professionals, also tend to earn high pay.

Tables 1.2 and 1.3 provide a framework for considering STEM compensation and benefits, broadly defined, recognizing that this workforce is not homogeneous. Table 1.2 lists dimensions of the STEM workforce, from the NSB (2015), showing the different segments into which this workforce can be divided. There is a perception that STEM is dominated by young, highly educated technology workers at start-up firms in Silicon Valley; the reality is that there is a wide range of STEM occupations, ages and levels of educational attainment of workers, and types of employers. Levels and trends in STEM compensation and benefits will vary according to these workforce dimensions.

Table 1.2. STEM Workforce Dimensions

Dimension	Examples
Degree/education level	Ph.D. or sub-baccalaureate STEM workforce
Degree field	Life sciences, engineering, IT
Occupation	Postsecondary teacher in STEM, chemical engineer, biomedical technician
Geography	Metropolitan versus rural, Silicon Valley versus Research Triangle
Employer type/sector	Academia, industry, government
Career stage	New graduates, midcareer, late-stage career

SOURCE: NSB, 2015.

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[1] Research has also been conducted on the overall differences between federal and private-sector pay and benefits, extending beyond the STEM fields. Examples of this work include Bewerunge and Rosen, 2013; Biggs and Richwine, 2011; Bradley, 2012; Congressional Budget Office (CBO), 2017; Government Accountability Office (GAO), 2012; and Reilly, 2013.

Table 1.3, drawn from Hira (2010), lists "elements" of the STEM workforce system along with corresponding metrics. These metrics either directly or indirectly reflect STEM compensation and benefits or, in plain terms, whether STEM jobs are good, high-paying jobs. These elements can contribute to who works in STEM and whether they are likely to persist. In addition to those identified by Hira (2010) and listed in the table, other factors can affect these decisions. Notably, cultural norms and workplace culture can play a major role (for examples, see Cech and Pham, 2017; and Reed and Acosta-Rubio, 2018).

Table 1.3. STEM Workforce Elements and Metrics

Elements	Metrics
Rewards	Wages, benefits, wage changes, wages relative to peer occupations, social meaning, work-life balance
Risk and uncertainty	Probability of job loss, technological obsolescence, job tenure, unemployment rates, career tenure, job insecurity
Employment trends and forecasts	Employment levels, employment changes, employment volatility, stay rates
Talent pool	Incumbent STEM workers, gender representation, minority representation, recent immigrants, foreign students, foreign guest workers, former STEM workers, K–12 students

SOURCE: Hira, 2010.

STEM jobs, in general or according to one of the dimensions of the workforce outlined in Table 1.2, may fare better in some metrics described in Table 1.3 than in others. For example, a STEM job in the highly urban, highly concentrated tech sector in the San Francisco Bay Area may pay extremely high wages but may not have retirement benefits or job security and may have a high risk of technical obsolescence. In contrast, a STEM job in the semirural tech sector in Omaha, Nebraska, one of the several so-called Silicon Prairies, pays lower wages but has higher security and more opportunity for on-the-job training. STEM jobs may be highly desirable by some metrics but less desirable by others, and a person's occupation, place of residence, gender, age, and race/ethnicity, as well as personal preferences, may affect how these factors balance out for an individual STEM worker. In other words, as we have previously discussed, STEM jobs are often regarded as important in the economy and important to economic growth. But that importance does not necessarily translate to a STEM job being a good job; what makes a good job good can vary considerably based on the characteristics of the job (Table 1.2), how it performs across a wide array of metrics (Table 1.3), and a person's preferences toward each.

Neither the existing literature nor this report can fully account for how every segment of the STEM workforce, across every definition of that workforce, breaks down on each of these metrics. Part of this is driven by which data are available and which metrics are preferred by researchers. We make the distinction here—that jobs that are considered valuable to the economy are not necessarily valued by workers, or all workers, for a variety of reasons beyond pay—to provide context for the quantitative analysis that follows in the remaining chapters and its ultimate limitations.

With this caveat in mind, we now turn to a discussion of key findings in existing literature on STEM wages, unemployment rates, employment trends, and nonmonetary compensation and benefits.

Wages

There is a clear, consistent finding that STEM jobs pay more on average than non-STEM jobs, regardless of precisely how STEM is defined. This finding of higher earnings is often referred to as the "STEM premium." Raw, unadjusted comparisons—those that do not control for a worker's individual characteristics but make broad population comparisons— suggest the starkest differences between STEM and non-STEM work. The NSB (2018b) reports that workers in STEM occupations earn annual salaries two times greater, on average, than non-STEM workers (about $89,500 versus $44,500 in 2016). A BLS analysis (Fayer, Lacey, and Watson, 2017) found similar results.

The overall average masks variation across STEM occupations. In general, engineers and computer and mathematical scientists command higher pay than physical and life scientists, though there is also variation within these broad occupation groups (Carnevale, Smith, and Melton, 2011; Fayer, Lacey, and Watson, 2017; NSB, 2018b). A few individual STEM occupations pay less than the national average across all occupations—typically, technician occupations that do not require a bachelor's degree (Fayer, Lacey, and Watson, 2017).

Comparing workers *within* education categories reduces but does not eliminate the STEM earnings premium. In addition, comparing *across* education categories facilitates an analysis of how this premium varies for workers with different levels of educational attainment. Table 1.4 summarizes key findings in the literature. Noonan (2017) finds that average hourly earnings for STEM workers are higher than earnings for non-STEM workers with similar levels of educational attainment, though the percentage premium decreases with education level. Workers with less than a bachelor's degree earn 60–70 percent more in STEM jobs, workers with only a bachelor's degree earn about 40 percent more, and workers with a graduate degree earn about 30 percent more than workers in non-STEM jobs. Other studies confirm that STEM workers without bachelor's degrees enjoy the largest percentage premiums over similarly educated non-STEM workers, even if they are a minority of all STEM workers (Carnevale, Smith, and Melton, 2011; Graf, Fry, and Funk, 2018; NSB, 2015). Some have found that earnings in STEM jobs for the most highly educated workers fall short of what these workers are able to earn in certain other professional occupations, such as the medical and legal professions (Carnevale, Smith, and Melton, 2011; NSB, 2015; Salzman, 2013).

Other factors can also be associated with differences in earnings, including age, gender, race/ethnicity, and geography. Noonan (2017) performs a regression analysis to control for these and finds that this reduces the hourly earnings premium for STEM workers compared with non-STEM workers with the same level of education—to 38 percent for those with less than a bachelor's degree, 28 percent for those with a bachelor's degree only, and 15 percent for those

Table 1.4. Wage Premium for STEM Workers Within and Across Education Levels

			STEM Wage Premium by Education Level (Percentage)					
Source	Years of Data Collection	Metric	High School or Lower	Some College	Bachelor's Degree	Master's Degree	Professional/ Doctoral Degree	Overall Premium (Percentage)
Graf, Fry, and Funk, 2018	2016	Median annual earnings, full-time year-round workers (ages 25+)	38.1	35.2	36.4	34.3	31.5	-
Baird, Bozick, and Harris, 2017	2015	Average hourly earnings, full- and part-time workers (ages 25–64)	—	—	—	—	—	***35.4***
Noonan, 2017	2015	Average hourly earnings, full-time workers only (ages 25+)	69.8	61.3	38.6	29.0[a]		—
	2015			***38.0***[b]	***27.6***	***14.9***[a]		***29.3***
	2010			—	—	—		***26***
	1994			—	—	—		***18***

NOTES: Regressed values are in boldface and italics.

[a] Value reported for workers with a graduate degree.

[b] Value reported for workers with less than a bachelor's degree.

with a graduate degree. Controlling for educational attainment and other factors, Noonan finds a regression-adjusted STEM premium of 29 percent (in 2015) across all STEM workers, up 3 percentage points from 2010 and 11 percentage points from 1994. By educational attainment, the sharpest increase over time in the regression-adjusted STEM premium is, again, among those with less than a bachelor's degree, rising from about 25 percent in 1994 to 38 percent in 2015. Baird, Bozick, and Harris (2017) calculate a somewhat higher regression-adjusted STEM hourly wage premium of 35 percent in 2015 but do not consider whether it has risen or fallen over time.

A rising STEM earnings premium indicates that wage growth is faster in STEM occupations than in non-STEM occupations. It is also suggestive of tight labor markets and possible talent shortages. The evidence that STEM wages are indeed being bid up faster than wages for non-STEM occupations is mixed and can vary by occupation and the time frame being analyzed. In addition to Noonan (2017), Carnevale, Smith, and Melton (2011) also calculate that STEM wages have grown faster than non-STEM wages, overall and when controlling for education, when looking over an extended time frame—in their case, from the early 1980s to the late 2000s. By contrast, Teitelbaum writes with respect to science and technology jobs that "strong upward pressure on real wages . . . relative to other education-intensive professions" is "conspicuously absent from the contemporary marketplace" (2004, p. 13). More recently, two analyses looking at three- or four-year periods ending in 2016 found little difference in average annual wage growth between STEM and non-STEM occupations, though computer and mathematical occupations experienced notably faster-than-average wage growth (CRS, 2017; NSB, 2018b).

STEM wages, the STEM wage premium, and changes in this premium over time vary by other characteristics, including gender, race/ethnicity, and geography. We summarize some of these differences in the section “Topics of Interest in the STEM Workforce” later in this chapter.

The Unemployment Rate

The unemployment rate for a given occupation is a useful metric for gauging the desirability of that occupation—both because it indicates the likelihood that workers may find themselves out of a job and because it relates to current and expected compensation and benefits. A lower unemployment rate is associated with greater bargaining power on the side of the worker, and potentially a stronger compensation package, while a higher unemployment rate shifts the balance of power to employers. Consistent with this expectation, findings on STEM versus non-STEM unemployment rates generally track closely with those on wages.

As above, the overall picture is that STEM workers fare better than non-STEM workers; there is a consistently lower unemployment rate for STEM occupations in the aggregate, but with variation by occupation and educational attainment (CRS, 2017; NSB, 2018b; Noonan, 2017). With respect to occupation, there is not as direct a mapping between wages and unemployment rates as theory suggests. Life scientists, for example, post a lower-than-average unemployment rate but receive lower-than-average wages compared with other STEM workers (CRS, 2017). As regards education, controlling for occupation tends to have a more pronounced effect in washing out differences between STEM and non-STEM occupations for unemployment than for wages (CRS, 2017; Noonan, 2017; Teitelbaum, 2014). While less educated STEM workers continue to fare better than similarly educated non-STEM workers, there is little difference in unemployment rates between STEM and non-STEM workers with at least a bachelor’s degree, and the STEM rate has matched or exceeded the non-STEM rate on a few occasions in the twenty-first century (Carnevale, Smith, and Melton, 2011; Noonan, 2017).

Unemployment rates, however, can be misleading, masking both underemployment and those who divert from STEM to work in non-STEM fields (Carnevale, Smith, and Melton, 2011; Hira, 2010; NSB, 2015). More STEM workers in part-time jobs would prefer full-time jobs than would non-STEM part-time workers (NSF, 2019). Also, as Hira (2010) notes, “The IT worker who described himself as unemployable does not show up on the IT unemployment rolls. Instead, he shows up as employed but as a retail worker or a writer.” Relatedly, retention in STEM is another important signal of whether STEM fields offer good job opportunities. Diversion to non-STEM occupations can be either voluntary or involuntary, though both would be suggestive of STEM jobs being less desirable (i.e., an individual either leaves because the non-STEM job is more desirable or because the STEM labor market is not robust enough for him or her to land a job). Retention versus diversion rates can vary by STEM occupation, as well as by gender, race/ethnicity, and other characteristics of workers. We consider this topic later in this discussion but note here that the “involuntary out-of-field” rate varies by STEM occupation, with higher rates for life scientists and physical scientists than for engineers and computer and mathematical scientists (NSB, 2018b).

Employment Trends

The growth rate of STEM jobs can also indicate the desirability of working in STEM. “Faster than average employment growth can mean greater opportunities,” notes Hira (2010), and it can also make it more likely that demand for STEM workers will outstrip the supply of these workers, redounding to the benefit of those with STEM knowledge and skills. Mirroring the findings for wages and unemployment rates, STEM occupations on the whole have grown faster in recent years than non-STEM occupations, and are expected to continue to do so, but there is variation across occupations (CRS, 2017; Noonan, 2017). Computer and mathematics occupations have tended to fair best by this metric, with the notable exception of computer occupations in the early 2000s after the tech bubble burst (Gascon and Karson, 2017).

There are major differences depending on what time period is considered. For example, Noonan (2017) found that STEM employment grew six times faster than non-STEM employment from 2005 to 2015, but the differential impact of the Great Recession (in which job losses came disproportionately to non-STEM occupations) is an important driver of this result. Counting from May 2009 (when nonfarm payroll employment was near but not yet at its recession-era trough) to May 2015, STEM employment growth was about twice as fast as growth in non-STEM occupations (Fayer, Lacey, and Watson, 2017). As the recovery took hold, from 2012 to 2016, STEM employment grew about 1.6 times faster than non-STEM employment (CRS, 2017). This approximates the long-term trend, from 1960 to 2015, of 3-percent average annual growth for STEM jobs versus 2 percent for non-STEM jobs—that is, a STEM growth rate about 1.5 times the non-STEM growth rate (NSB, 2018b).

BLS employment projections covering 2016–2026 show that STEM employment was expected to continue to grow 1.5 times faster than non-STEM employment, with employment projected to increase by 10.8 percent for STEM occupations versus a 7.2-percent increase for non-STEM occupations (BLS, 2019a). Computer and mathematical occupations were projected to grow fastest (13.7 percent), followed by life, physical, and social science occupations (9.6 percent), and then architecture and engineering occupations (7.5 percent). These projections should be taken with a grain of salt, and past BLS research clarifies the distinction between a “forecast” and a “projection,” with the latter less likely to track to actual outcomes and involving more assumptions (Byun, Henderson, and Toossi, 2015).

Together with past patterns in STEM employment, unemployment, and wages, the employment projections can be used to bolster a case that by many traditional measures STEM jobs are desirable and likely will continue to be. However, these rosy aggregate-level trends and projections may mask challenges and instability in segments of the workforce. Moreover, fast percentage growth in employment may nonetheless result in relatively few jobs in comparison with the workforce as a whole, considering the relatively small size of many STEM fields.

Nonmonetary Compensation and Benefits

While take-home pay and the demand for workers as indicated by unemployment rates and future employment projections are critical determinants of whether an occupation offers good job opportunities, these are not the only factors that influence whether a job is desirable. From health and retirement benefits to the availability of paid family leave, the flexibility to control when and where work is performed, and more, nonmonetary compensation and benefits can sway decisions to take or remain in a job, in particular during a strong economy and for workers whose skills are in demand by employers. A growing body of literature explores how nonmonetary compensation influences job selection, job satisfaction, and worker productivity (Cassar and Meier, 2018; Rosso, Dekas, and Wrzesniewski, 2010). The millennial generation, in particular, is perceived as prizing workplace flexibility and jobs that provide a sense of purpose or meaning (Brack and Kelly, 2012; Moritz, 2014; Nolan, 2015).

However, there is a paucity of existing data and literature that delves into variation in nonmonetary benefits and compensation by occupation at a level of granularity that would permit a comparison of STEM and non-STEM occupations. A handful of private companies survey select workplaces for trends in benefits, though these are not publicly available and typically do not include STEM identification. The BLS, Census Bureau, NSB, and other core sources frequently referenced above in the context of wage, unemployment, and employment trends make little reference to these factors when comparing STEM and non-STEM work. Insight into whether STEM jobs offer stronger or weaker nonmonetary compensation and benefits packages than non-STEM jobs, therefore, may be gained through two approaches, each of which has significant limitations: (1) assuming STEM jobs are comparable to professional occupations generally (i.e., zooming out); and (2) drawing on anecdotal evidence from a subset of STEM fields or individual employers (i.e., zooming in). The "Topics of Interest in the STEM Workforce" section that follows expands on the discussion of work-life balance in STEM jobs. The analyses in the remaining chapters of this report consider approaches to characterizing and comparing nonmonetary compensation and benefits for STEM jobs in the private versus public sectors.

A data-grounded approach to considering nonmonetary compensation and benefits in STEM jobs uses the BLS's National Compensation Survey, which does not have detailed occupation categories, but broad groupings of classes of workers, so looking at STEM workers only is not possible. But if we assume that STEM jobs are comparable to jobs in "professional and related occupations" generally, given that many STEM occupations fall within this broader category, we can compare these "professional" jobs with jobs in service, sales, construction, or production occupations on measures of access to retirement and other benefits. The results using this method are clear: jobs in professional and related occupations are more likely than other private sector occupations to offer virtually every type of benefit tabulated in the National Compensation Survey (BLS, 2018c). Categories include defined benefit and/or defined contribution retirement plans (85 percent in professional and related occupations, versus 71 percent across all civilian occupations as of 2018); health care (86 percent, versus 72 percent);

life insurance (77 percent, versus 60 percent); paid sick leave (89 percent, versus 74 percent), paid family leave (27 percent, versus 17 percent), childcare (17 percent, versus 11 percent), a flexible workplace (11 percent, versus 7 percent), subsidized commuting (13 percent, versus 8 percent), and a wellness program (60 percent, versus 43 percent).

While it is not unreasonable to expect that STEM jobs in professional occupations might offer similar benefits as jobs in professional occupations generally, the limitations of this approach are clear: not all jobs in professional and related occupations are STEM jobs, and not all STEM jobs are in professional and related occupations. In particular, many STEM jobs that require less than a bachelor's degree may fall within other occupational groups (e.g., production, extraction, or construction), and may have benefit offerings that align more closely with jobs in those fields.

Attempting to characterize nonmonetary compensation and benefit offerings across STEM jobs generally from anecdotal information about a subset of STEM occupations or employers is necessarily a flawed endeavor. No such analysis could capture all types of STEM jobs at all levels of educational attainment in all geographic locations. However, it is noteworthy that certain STEM jobs—namely, tech jobs at high-profile firms and start-ups—are perhaps more associated with novel, desirable workplace perks than any other occupation. These range from generously paid parental leave programs (Lotze, 2019; Molla, 2018), to catered meals and massages (Jones, 2017), to Ping-Pong tables (Elinson, 2016), to nap pods (Cassidy, 2017). These perks may come with strings—real or perceived. In some instances, they may be designed to encourage working longer hours (Stolzoff, 2018), or in the case of unlimited time off, may actually result in using less vacation than when receiving a fixed allotment of days (Clark, 2017). In any case, such perks are limited to a subset of STEM workers, and there's likely to be significant variation across the broader STEM workforce in terms of nonmonetary compensation and benefits. For example, some STEM jobs may be more conducive to workplace flexibility than others (e.g., computer and engineering workers may be able to work remotely more easily than life and physical scientists).

Topics of Interest in the STEM Workforce

The STEM workforce and education and training programs that prepare people to enter it are of considerable interest to policymakers and researchers, as described above, because of a belief that STEM jobs are good jobs, are important for economic competitiveness, and may lack a sufficient supply of talent. Existing research spans beyond the basic comparisons of characteristics of STEM and non-STEM jobs described above. In this section we discuss several topics of interest in the literature on the STEM workforce economy-wide. They are

- gender diversity and the gender pay gap
- racial and ethnic diversity and associated pay disparities
- geographic concentration
- middle-skills STEM jobs

- diversion from STEM
- work-life balance
- job stability.

Some of these topics relate more directly to STEM compensation and benefits than others. We selected topics of interest based on what were the most prominent in the literature on the STEM workforce. Again, as in the rest of this chapter, we are discussing STEM broadly and not distinguishing between the private sector and the federal government as STEM employers. In some cases, there may be differences in the issues we discuss along those lines. We do not attempt to parse between those sectors in this chapter, saving that discussion for later chapters in this report.

Gender Diversity and the Gender Pay Gap

The underrepresentation of women in STEM occupations relative to their overall share of the labor force has long been a matter of concern. While the share of women working in most STEM occupations has increased over a period of decades, consistent with the economy-wide trend of greater women's participation in the paid labor force, the progress has been uneven, has partially been reversed in the case of computer occupations, and remains far short of parity between women and men (Landivar, 2013). Common definitions of the STEM workforce show women accounting for only about one in four STEM workers, despite being nearly half of the employed population in the overall economy (Landivar, 2013; Noonan, 2017). Narrower definitions that identify a "super-STEM" workforce find an even lower share of women (Rothwell, 2013). Underrepresentation is particularly pronounced in engineering (NSF, 2019).

The persistence of gender disparities in STEM occupations has occurred even as women have come to earn about half of STEM bachelor's degrees, though the share of STEM advanced degrees earned by women remains slightly lower, at 40–45 percent (NSF, 2019). The disparity between degree earning and working in STEM may be explained in part by the higher rate at which women work in "STEM-related" or "periphery" STEM jobs (Anderson, Baird, and Bozick, 2018; NSB, 2018b), most notably in health professions. These jobs often require a solid grounding in the STEM fields, and may require a STEM degree, but are excluded from the most common definitions of the STEM workforce. If health professions are included, women with a STEM degree may, by some measures, be more likely than men to work in a STEM occupation (Graf, Fry, and Funk, 2018).

The underrepresentation of women in STEM in most research is less a matter of definitional nuance and more the result of the complex interaction of educational practices, cultural norms, and policies that limit women's participation in STEM or make it more likely that they choose to leave the field (Blickenstaff, 2005; Cannady, Greenwald, and Harris, 2014; Cech and Blair-Loy, 2019; Metcalf, 2010). Contributing causes range from gendered stereotypes girls encounter at early ages (Shapiro and Williams, 2012), to a lack of mentors and role models (Dasgupta and Stout, 2014), to inadequate family-friendly workplace policies that especially harm working mothers (Cech and Blair-Loy, 2019). Policymakers continue to seek ways to promote the entry or reentry of women into the STEM pipeline and ultimately STEM jobs; the NSF, for example, funds a broad array of research proposals under the Organizational Change for Gender Equity in STEM Academic Professionals, or ADVANCE, umbrella, and a report of the NAS (2011) calls expanding underrepresented minorities, including women, a "national priority."

A related question is whether there is a gender pay gap in STEM occupations, with women working full-time, year-round, earning less than their male counterparts, as has repeatedly been shown to be the case across all occupations in the economy (Blau and Khan, 2017). The evidence on this front could be considered a mixed verdict: yes, there is a gender pay gap in STEM, but it is somewhat smaller than in non-STEM occupations. After controlling for other factors that influence wages such as age, race/ethnicity, educational attainment, and region, Noonan (2017) calculates a gender pay gap of 16 percent in STEM versus 19 percent in non-STEM occupations. Another way to state this is to say that the STEM premium is larger for women than for men; women in STEM earn more, on average, than their non-STEM female counterparts, and that difference is larger than the earnings difference between STEM and non-STEM men. Baird, Bozick, and Harris (2018) also identify a higher STEM hourly wage premium for women than for men.

The distribution of women across STEM occupations—for example, the smaller share of women in the more lucrative engineering and computer occupations—may drive some of these results. The pay gap shrinks somewhat when looking within occupations and restricting to college graduates (Noonan, 2017). Anderson, Baird, and Bozick (2018) also show that occupational choice within a broader set of STEM jobs matters; they find a STEM premium for women working in a "core" STEM job but not for those working in "periphery" STEM jobs. Hence, disparity in wages between men and women within STEM may moderate or drive women's lower participation in the STEM workforce; despite STEM women making more than their non-STEM female counterparts, they make less than their STEM male counterparts.

Racial and Ethnic Diversity and Associated Pay Disparities

Black and Hispanic workers are also underrepresented in STEM relative to their shares of the overall workforce. The nonwhite population is growing faster than the white population and is critical to the long-term success of the U.S. economy (NAS, 2011). Again, the definition of STEM can matter significantly, but according to common definitions, the black and Hispanic shares of the STEM workforce are half or less their shares of the broader working-age population: roughly 10–15 percent of STEM workers, versus 25–30 percent of the population (CRS, 2018; Landivar, 2013; NSB, 2018b).

Unlike the case with gender diversity, the underrepresentation of black and Hispanic workers in STEM differs little across the major categories of STEM occupations: mathematics, computer occupations, engineering, life sciences, and physical sciences (Landivar, 2013; Graf, Fry, and Funk, 2018). Similar to women, broader definitions of STEM that include health-related workers, or "technical" STEM workers, show somewhat greater representation of these underrepresented groups (Graf, Fry, and Funk, 2018; NSB, 2015), while narrower definitions of a “super-STEM” workforce show somewhat less (Rothwell, 2013). In contrast to blacks and Hispanics, Asians are overrepresented in STEM fields, with their overrepresentation increasing as definitions of STEM become more restrictive, and with especially high rates of employment in computing, engineering, and life sciences occupations (Graf, Fry, and Funk, 2018; Landivar, 2013; Rothwell, 2013). However, this masks significant differences within the Asian population, with some segments of this population underrepresented relative to the general population in STEM (Asian Americans Advancing Justice, 2014).

The literature seeking to understand why blacks and Hispanics, in particular, are underrepresented in STEM employment tends to home in on similar explanations as those offered to account for the low share of women in these jobs. The pipeline metaphor is common, if perhaps insufficient given the multitude of possible paths to landing in a STEM profession, and researchers have sought to understand how disparities in the educational system, early life opportunities, and access to mentors and role models contribute to limiting the participation of black and Hispanic workers in STEM (Beasley and Fischer, 2012; Cannady, Greenwald, and Harris, 2015; NAS, 2011; Syed and Chemers, 2011; Wang, 2013). Even among those who graduate with STEM degrees, blacks and Hispanics are less likely to be working in a STEM job than are white or Asian STEM degree holders (NSF, 2019), suggesting that obstacles extend beyond obtaining a STEM degree.

Underrepresentation of minorities could be explained by differing preferences for jobs; indeed, even the term *underrepresentation* assumes a distribution of preferences within and across minorities. However, that minorities are underrepresented in STEM—to the detriment of U.S. competitiveness—is the conclusion of the NAS (2011). There is considerable evidence that minorities experience barriers to participation and success in STEM, beginning as students and continuing through the workforce (Espinosa, 2011; Carlone and Johnson, 2007; Murphy, Steele, and Gross, 2007; Ramsey, Betz, and Sekaquaptewa, 2013). These barriers range from feeling that their race/ethnicity prevents them from belonging in STEM as students (Johnson, 2012; Rainey et al., 2018)—a key component of academic success (Strayhorn, 2012)—to feeling discriminated against in the workplace (Funk and Parker, 2018).

Blacks and Hispanics are not only underrepresented in STEM occupations but also earn less on average than their white, non-Hispanic counterparts within those STEM occupations (Baird, Bozick, and Harris, 2017; Carnevale, Smith, and Melton, 2011; NSB, 2018b). Again, this finding is consistent with trends in the broader economy. The evidence is mixed with respect to whether the pay disparity by race/ethnicity is larger or smaller for STEM workers than for non-STEM workers, and can depend on how STEM is defined. Carnevale, Smith, and Melton (2011) find that “the gap is not nearly as wide as it is among non-STEM workers,” while Baird, Bozick, and Harris (2017) find a larger STEM premium (as a percentage of non-STEM hourly wages) for black STEM workers but a smaller premium for Hispanics. As for unemployment, black and Hispanic STEM workers face higher unemployment rates than white, non-Hispanic STEM workers, but lower rates than black and Hispanic workers in non-STEM occupations (Landivar, 2013; NSF, 2019).

Geographic Concentration

STEM jobs are not equally distributed across the country, resulting in disparities both in access to these jobs and in receipt of benefits that accrue to the local economy from having a high share of STEM jobs. According to one analysis, the 20 metropolitan areas with the highest share of S&E jobs as a proportion of the workforce account for 19 percent of S&E employment nationally but just 9 percent of all employment (NSB, 2018b). Metropolitan areas with an S&E workforce share above 10 percent and total employment across all occupations of more than 1 million (as of 2016) are San Jose, California; San Francisco; Seattle; and Washington, D.C. Considering a broader set of metropolitan areas lessens the disparity; the share of STEM jobs in the top 100 metropolitan areas is just slightly above these areas' share of the population (Rothwell, 2013). Some STEM occupations are more concentrated than others (e.g., computer and engineering occupations), while others are more dispersed—notably, those that do not require a bachelor's degree (Rothwell, 2013).

The concentration of STEM workers is consistent with related activity, such as research and development (Shackelford and Wolfe, 2016), technology and entrepreneurship clusters (Chatterji, Glaeser, and Kerr, 2013), and where venture capital is focused (Florida, 2017). All of these findings track with a broader trend toward a concentration of economic activity and gains, with urban areas faring better than rural areas and a subset of large metropolitan areas racing ahead of the rest (Economic Innovation Group, 2018). Past research has shown that areas with higher shares of highly educated workers fare better economically—with faster job, wage, and productivity growth—owing in part to the innovative, creative capacity of these workers and associated knowledge spillovers (Peri, Shih, and Sparber, 2015; Winters, 2014; Wright, Ellis, and Townley, 2017). Several studies have directly considered the connection between STEM workers and economic outcomes, and have found benefits to higher concentrations of these workers (Peri, Shih, and Sparber, 2015; Rothwell, 2013; Winters, 2014).

The direction of causation may not always be apparent. Do areas with high shares of STEM workers fare better because they have STEM workers, or are STEM workers drawn to areas that already have healthy, dynamic economies? Xu and Larson (2015) note that some companies may struggle to recruit STEM workers to regions perceived as less desirable. Moreover, given that areas with high shares of STEM workers tend to have a higher cost of living, are their earnings high enough to account for this? Relatedly, this underscores the importance of adjusting for geography when calculating nationwide STEM premiums, as the skew of STEM workers toward higher-cost-of-living areas could drive up the apparent premium without actually signifying higher purchasing power. Finally, to the extent that benefits accrue to a region because it has a high share of STEM workers, are these benefits limited to those working in STEM, or do others in the economy also benefit? Existing research suggests that STEM workers do earn enough to offset the higher cost of living, but that non-STEM workers in those areas may not share in these gains. As Rothwell (2013) writes, “STEM knowledge boosts the earnings of highly skilled workers but not low-skilled workers, whose wages increase only in proportion to living costs.”

Middle-Skills STEM Jobs

The preponderance of research on the STEM workforce has focused on workers with at least a bachelor’s degree and, in particular, a degree in a STEM field. As Baird, Bozick, and Harris (2017) write, “The role of associate’s degrees, occupational certifications, and occupational licenses in the STEM economy has been largely ignored.” This is partially a result of data availability. However, three key findings described above could motivate further exploration of the characteristics and dynamics of the portion of STEM workforce that does not have bachelor’s degrees: (1) the STEM premium relative to similarly educated workers is higher for those without bachelor’s degrees (Carnevale, Smith, and Melton, 2011; Graf, Fry, and Funk, 2018; NSB, 2015; Noonan, 2017); (2) the segment of STEM workers without bachelor’s degrees tends to have greater racial, ethnic, and gender diversity; and (3) STEM jobs that do not require bachelor’s degrees are more widely dispersed across the country (Rothwell, 2013). Collectively, these findings suggest that expanding pathways into so-called middle-skills, or technical, STEM employment may enhance access to good-quality jobs for a broad swath of Americans.

Moreover, researchers have identified labor shortages for some middle-skills STEM jobs and connected these labor supply issues to the inadequacy of the sub-baccalaureate education and workforce development system (Gonzalez et al., 2015; Gonzalez et al., 2019; Holzer, 2015). Despite the returns from working in STEM, the vast majority of associate’s degrees are awarded in non-STEM fields, and non-STEM degrees have driven most of the growth in associate’s degree attainment over the past decade (Baird, Bozick, and Harris, 2017). Even for those who do pursue and obtain degrees, sub-baccalaureate programs in STEM may lack a sufficient connection to local job markets and may not equip students with the skills required by employers in the area with middle-skills jobs to offer (Gonzalez et al., 2019). While not inconsistent with specialized, localized shortages, such as those that are the focus of Gonzalez et al. (2019), others place more of the burden on employers to offer on-the-job training or more competitive compensation to attract workers (Van Rens, 2015; Weaver and Osterman, 2017).

Diversion from STEM

A common extension of the STEM pipeline metaphor is to consider places where the pipeline leaks—that is, where students or workers divert from studying or working in STEM, voluntarily or involuntarily. Policymakers seeking to expand the supply of STEM workers, or of workers who enjoy the benefits associated with STEM employment, may consider approaches to reduce diversion, while researchers may explore why diversion happens, the extent to which it is by choice, and the implications for the STEM workforce and broader economy.

Carnevale, Smith, and Melton (2011) identify four choke points at which people tend to divert:

- in college, when more than three out of four high school students who test in the top mathematics quartile don't start with a STEM major in college
- in college, where only half of all students who start in a STEM major graduate with one
- in the workplace, where just ten of the 19 graduates with a bachelor's degree in a STEM major will work in a corresponding occupation early in their careers
- after ten years in the labor market, when only eight of these original ten graduates will still be working in a STEM occupation.

Their core finding is that "the general demand for their competencies outside of traditional STEM occupations is what enables these students and workers to divert" (Carnevale, Smith, and Melton, 2011). They point out, for example, that while the STEM premium exists, pay tends to be even higher in other occupations dominated by highly educated workers, such as managerial and professional occupations and health care, especially as workers gain more experience. The highest-performing students may be able to earn more by entering these fields instead (Salzman, 2013). Moreover, workers with STEM degrees tend to earn more than workers without these degrees—even if they are not working in a STEM occupation (Carnevale, Smith, and Melton, 2011; NSB, 2018b; Noonan, 2017). In part, this may be attributable to people working in STEM-related fields that might be considered STEM in broader definitions; but it also raises the issue of "selection bias" into STEM employment, with the possibility that STEM workers earn more because they are highly motivated and highly skilled, and not because they work in STEM (Salzman, 2013).

Diversion from STEM can also be involuntary—the rate for S&E graduates involuntarily working out of the field was about 8 percent according to one recent survey (NSB, 2018b). Deming and Noray (2018) find that constantly changing technology can contribute to STEM workers leaving the field later in their careers as the skills they learned when they were in school become obsolete. This underscores the importance of guarding against skill erosion and obsolescence by continually upskilling and evolving over one's career. In some instances, employers may develop training programs for their employees that foster skill evolution (Donovan and Benko, 2016), while in others, the burden falls to individuals to stay at the cutting edge in order to remain competitive for STEM jobs—notably, those in computer programming (Rajgopal and Westly, 2018; Turner-Trauring, 2017).

More subtly, diversion may be the result of a complex set of factors that drive some to continue to pursue STEM and others to exit the field—in particular, women and minorities, as discussed above. To a lesser extent there may also be some diversion into STEM fields, with adults previously unemployed or working in other fields transitioning to STEM careers (Gonzalez and Bozick, 2016). Some educational programs (most notably, coding boot camps) exist for this demographic, either offered by current employers encouraging upskilling or by independent institutions (Lohr, 2017).

Work-Life Balance

While nonmonetary compensation and benefits are an important part of what makes a job desirable (as discussed above), there is limited research on this topic that focuses on the STEM workforce. However, some existing literature explores work-life balance in STEM jobs, often but not exclusively in the context of obstacles to women persisting in STEM careers. Again, an important caveat is that findings based on a subset of STEM jobs, typically those that require advanced educational attainment or involve working in research institutions, may not apply to the STEM workforce more broadly. The ability to balance work and home life inevitably varies—by occupation, industry, location, and other factors.

Caveats aside, STEM jobs often are perceived as faring poorer on measures of work-life balance, particularly in relation to other factors that draw people to jobs. A Pew Research Center survey found that about seven in ten American adults surveyed believed that STEM jobs pay more than jobs in other industries, but only about one in five thought that STEM jobs afforded more ability to balance work and family needs; about one in three thought there was less flexibility, while half said it was about the same (Funk and Parker, 2018). The same survey found that one-third believed that it being "more difficult to balance work/family in STEM jobs" is a "major reason" why women are underrepresented in STEM. Other studies have found similar results. Tan-Wilson and Stamp (2015) discuss "students' concerns that they would not be able to raise a family while also developing a career based on graduate training in STEM fields." Cech and Blair-Loy (2014) explore "flexibility stigma" among STEM academics and cite other work that shows that women are more likely to consider leaving and to cite family reasons for doing so. And Weisgram and Diekman (2017) describe perceptions of an incongruity between careers in STEM and having a family; such perceptions harden as people progress through school and into the workforce.

All of these papers emphasize the role of perception and the value of dispelling perceptions that may not equate with reality in order to recruit and retain workers seeking to balance work and family. However, in the case of academic scientists in particular, the long track through graduate school and postdoctoral work that can extend well into when women and men might seek to start a family, coupled with a tendency for work to require physical presence in a laboratory or in the field, may pose a real barrier (Weisgram and Diekman, 2017). Cech and Blair-Loy (2019) find that among STEM workers with doctoral degrees, having children is associated with significantly higher rates of new mothers and new fathers alike leaving full-time STEM work; this is attributed in part to "cultural expectations." Women are particularly likely to exit STEM fields when they become parents, or to switch to less-lucrative part-time STEM work (Cech and Blair-Loy, 2019). Aiming to improve work-life balance in STEM, the NSF established in 2011 the Career-Life Balance Initiative, a ten-year plan "to provide greater work-related flexibility to women and men in research careers," including allowing for grant postponement or suspension to care for children and greater ability for virtual panel reviews (NSF, 2011; White House, 2011).

Job Stability

Existing literature and data suggest a generally positive outlook for STEM jobs, as being in ample supply and offering above-average pay, even if disparities by gender and race/ethnicity remain, and the benefits may come with a cost in terms of work-life balance. However, the view that entering a STEM occupation offers a more stable, sustainable path to a good job in the twenty-first-century economy is not universally shared. Technology workers interviewed as part of a study on STEM jobs captured this sentiment well, commonly expressing the view that an IT occupation "was great for their generation but the ride is over, and they would not recommend an IT or engineering career to their sons and daughters" (Salzman, 2013).

Many factors can come into play in generating job instability. STEM start-up businesses can soar or crash, while government research budgets can grow or get slashed. Labor market bubbles can concentrate their impact on STEM workers—notably, the dot-com boom and bust around the turn of the century (Mann and Nunes, 2009). However, those who question the stability of STEM jobs often ascribe their less rosy outlook to the same factors poised to affect many other occupations in the economy but from which STEM work may be thought to be somewhat more insulated: globalization and technology. We focus in this section on these two potentially destabilizing factors.

Globalization has the potential to affect STEM job stability through several channels, which may affect those in the private sector disproportionately: employers could lose business to global competitors, to the detriment of U.S. workers in STEM fields; employers could offshore STEM jobs, or they could draw heavily on immigrant or guest-worker labor in competition with native-born STEM workers. The first possibility lies at the core of reports such as the NAS's *Rising Above the Gathering Storm* (2007), which warns that the U.S. risks ceding economic advantage to global competitors if it does not improve STEM training and domestic support for science.

With respect to offshoring, Hira (2010) writes that "rising risks for job loss in information technology, caused in part by offshoring," contributed to a decline in computer science degrees in the early 2000s. Blinder (2007) identified computer programmers as tied for the most offshorable occupation and included numerous other S&E occupations among those considered vulnerable to offshoring. Notably, Blinder (2007) wrote that while often "offshorability declines as skill level rises . . . in the sciences and engineering, we made just the opposite judgment." Salzman (2013) has connected offshoring with the use of guest workers, calling them a "necessary conduit for offshoring" because they liaise with the offshore team.

More generally, the use of guest workers on H-1B or other visas among STEM employers is a topic of considerable controversy. Data show that the overwhelming majority of H-1B visa requests are in STEM fields or otherwise require STEM knowledge (Ruiz, 2017), as are most F-1 Optional Practical Training visas (Ruiz and Budiman, 2018). Some argue that employers abuse these programs, and in particular the H1-B program, to draw on cheaper labor with little ability to negotiate on wages, and that this harms prospects for native-born workers or recent immigrants with comparable STEM skills (Hira, 2010; Matloff, 2013; Salzman, 2013; Salzman, Kuehn, and Lowell, 2013). Others dispute this characterization and find that employers use

H-1Bs to recruit workers in niche, hard-to-fill STEM positions, paying them the same or more than comparable native-born workers (Lofstrom and Hayes, 2011; Rothwell and Ruiz, 2013).

While the question of the impact of permanent immigrants on economic outcomes for native-born workers also stirs passions, it is different in the critical respect that these workers are expected to remain in the United States, have a greater ability to bargain with employers, and even may launch their own businesses that create opportunities for native-born workers (Kerr and Kerr, 2019). The presence of a large share of foreign-born workers in the STEM workforce, however, can contribute to labor supply challenges for employers that require U.S. citizenship—namely, the federal government. As of 2015, more than half of engineers and computer and mathematical occupations workers with doctorates were foreign born, as were about 45 percent of physical scientists and life scientists with doctorates (NSB, 2018b). More than half of master's degree–level computer and mathematics workers and about one-third of master's degree–level engineers were foreign born. These shares include those who have become citizens and are eligible for government employment—44 percent of foreign-born workers were naturalized citizens as of the 2010 Census (Grieco, et al., 2012). Hence, the shares of noncitizens in STEM occupations likely are closer to half the shares of the foreign born; nonetheless, the foreign-born shares shed light on the unique challenges the government faces.

A second major factor that may generate instability in STEM occupations, perhaps ironically, is technology itself. Put simply, the faster the pace of technological change, the more quickly skills can become obsolete. Several researchers have identified this as an impediment to job stability in STEM fields, and one that may result in diversion from STEM. Hira (2010) notes that "obsolescence may come swiftly," posing particular problems for STEM workers in the form of spells of unemployment. Deming and Noray (2018) write that "rapid technological change can lead to a short shelf life for technical skills." Hanushek et al. (2017) identify a trade-off between short- and long-term returns from vocational training and apprenticeship programs, often associated with middle-skills STEM jobs. And Deming (2017; 2018) argues that STEM work may be more vulnerable to automation and that social skills rather than technology skills may yield greater returns in the labor market. The risk of technological obsolescence or automation underscores the importance of lifelong learning (Selingo, 2018) while undercutting the idea that getting a STEM degree and entering a STEM occupation is a surefire path to a stable, family-sustaining job.

This Report

RAND's task is to compare the compensation of federal STEM workers to their counterparts in the private sector. Having reviewed existing literature and data on STEM employment—on compensation and benefits and a range of related topics of interest—we end this chapter by prefacing the analysis that follows in the remaining chapters. We will discuss the sources of data, the definition of STEM that we use in our analysis, and the organization of the report.

Sources of the Data

The OPM, the agency in charge of maintaining the civilian federal workforce, publishes a de-identified quarterly census of all federal workers that includes annual pay, grade, agency, and occupation, among other variables. The data set is named FedScope, and it includes data on employment, measured quarterly, as well as separate data on accessions and on separations of workers. As a means of studying federal worker compensation, FedScope has several advantages: it supports the identification of STEM workers, it includes features of compensation (such as grade and pay plan) that are unique to the federal government and therefore would not be included in other surveys that include a broader set of workers, and it has quarterly data from 2009 to 2018 and annual data from 2005 to 2018. Unless otherwise noted, we will report FedScope data from September of each year.

Unfortunately, FedScope also has significant limitations. First, in order to maintain de-identification, FedScope does not include a complete demographic profile of the worker in the microlevel employment data. For example, age is included, but not gender or race/ethnicity. Given the prior discussion of disparities within STEM along gender and racial/ethnic lines, this is a significant limitation. Second, FedScope data are not linked. Although each worker employed at the time is included in that quarter's data, the data are not linked across quarters, nor are they linked to the separations or accessions data sets. Without linked, person-level data, FedScope does not support longitudinal analysis of income over a worker's tenure, or tenure itself. Further, the lack of person-level linking also means that the separations and accessions data cannot be used in meaningful comparisons. The separations and accessions data report individuals hired (accessions) and the number of individuals that left the federal workforce (separations), the corresponding date of accession or succession, and other characteristics like occupation and agency. Therefore, these data sets provide an indication of the number of individuals entering or exiting the federal workforce but do not provide an accurate representation of turnover or retention.

Finally, FedScope does not include all federal workers. Notably, it does not include intelligence agencies such as the Central Intelligence Agency and the National Security Agency. These agencies likely employ large numbers of STEM workers. Hence, FedScope, while useful, does not support the level of analysis that we needed for our study.

However, we do have access to the Defense Manpower Data Center (DMDC) Civilian Master File. This data set provides microlevel employment data for the DoD civilian workforce. The DMDC Civilian Master File includes many variables included in FedScope, such as age, education level, occupation, pay plan, pay (income) variables, and tenure. It also includes many variables that are not included in FedScope, including gender and race/ethnicity. Additionally, the DMDC Civilian Master file provides linked data. Thus, it provides a more complete picture of employment and retention. While the DMDC Civilian Master File existed prior to 2010, we were most easily able to access data back to 2010. Based on knowledge of trends in the STEM workforce, we do not believe this to be a significant limitation. Unless otherwise noted, we will report DMDC data from September of each year back to 2010.

The key data used for the private sector is the U.S. Census Bureau's Current Population Survey (CPS). The CPS is a monthly survey sent to approximately 60,000 households designed to be representative of the U.S. population. Given that many households have more than one resident, the CPS sample averages around 105,000 individuals over age 15 each month. The CPS provides data on employment, unemployment, and earnings, among numerous other measures. Each month the CPS supplements its basic survey with additional, themed questions. The March supplement, referred the Annual Social and Economic Supplement (ASEC), collects additional and more detailed information on earnings, nonmonetary compensation, and hours for the year prior. Further, the American Time Use Survey (ATUS), which is given to a portion of the CPS sample and is better known for the minute-by-minute diaries that account for Americans' activities, includes a basic measure of whether an individual has paid time off. Critically, the CPS, in all its individual surveys and supplements, enumerates both occupation and industry, and hence supports analysis of both federal STEM and private STEM workers. STEM workers are a subset of all workers, and federal workers are only a subset of the total workforce; there are subgroups where the sample is too small to support analysis.

There are many other datasets that report income, earnings, and compensation that we do not use. One that is commonly used in the compensation setting is the Mercer Benchmark Database (MBD), a private database of titles, descriptions, responsibilities, and compensation details based on an annual survey of firms that describe select positions. The MBD survey typically includes 3,000–4,000 firms and has detailed data on positions and how they vary by industry and organization size. Unfortunately, the MBD is not well suited for broad analysis across occupations. It is a survey of positions, and not jobs or occupations, and is not designed to be a statistically representative sample (like the CPS) or a census (like FedScope or DMDC) of workers across occupations. Mercer data does not include demographic information, like race, gender, age, or education levels. The unit of observation is the job title; Mercer data enumerates what a position pays, but not what people earn. Given that STEM occupations have pay and employment disparities by gender and by race, this is an important omission. Hence, while Mercer is a better data set to examine compensation in a specific position, or small number of positions, it is not well suited to a study earnings differences between two groups because it does not allow for the comparison to reflect gender, race, ethnicity, or education compositional differences between the groups. As we will show, the federal government's STEM workforce differs from the private sector along all four dimensions. To ensure that our findings could generalize across occupations in the federal and private sectors, and speak to the differences in the demographic composition of STEM workers, we limited our analysis to representative data sets.

The Congressional Budget Office, in a recent analysis in which it compared the compensation of federal workers to that in the private sector, similarly chose to use the CPS. Due to the fact that it is a sample, the CPS combined years of data in order to have a sufficient number of observations (Congressional Budget Office, 2017). We will do the same.

We note throughout the report which data are used and the definition of the variable being measured. Table 1.5 details the data sources used for each metric for the private sector, public sector (federal government), and DoD.

Table 1.5. Data Sources Used for the Private Sector, Public Sector, and Department of Defense

Workforce Metric	Private-Sector Source	Public-Sector (federal government) Source	Department of Defense Source
Number of workers	CPS	FedScope[a]	DMDC
Mean annual income	CPS ASEC	FedScope[a]	DMDC
Unemployment rate	CPS	CPS	—
Number of hours worked	CPS	CPS	—
Health insurance benefits	CPS ASEC	CPS ASEC	—
Retirement benefits	CPS ASEC	CPS ASEC	—

[a] For gender and race/ethnicity we use CPS data because FedScope does not provide these variables at the microlevel.

The Definition of STEM

As the discussion at the beginning of this chapter noted, there is no one definition of STEM, whether describing the subjects that make up STEM fields of study or the occupations that make up the STEM workforce. For this report we are tasked with comparing the compensation of similar STEM workers in the federal government and the private sector. Hence, we not only need to define STEM but we need our STEM definition to be translated between two occupational numbering and naming systems: those systems used by statistical agencies, such as the U.S. Census Bureau in the CPS, to describe the overall workforce, and the system used by the OPM to describe the federal workforce. To do this, we constructed our own occupational numbering and naming system.

We group all STEM occupations into five broad categories: (1) social science; (2) IT, computer science, and mathematical science; (3) engineering; (4) life science; and (5) physical science. Within each category, we created more detailed occupations. Details of how we constructed this crosswalk between the CPS and the OPM, as well as how we determined which occupations to include in our definition of STEM, can be found in Appendix A, which provides a complete coding schema and crosswalk.[2] Table 1.6 presents each of the broad occupation categories, listing within those categories the more detailed occupations that we use to summarize our data, as well as the corresponding occupations in the CPS and OPM.

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[2] Appendix A details four sources of STEM: the detailed Census occupation list; the CPS occupation list, which is a simpler version of the Census list; the NSF; and the OPM.

Table 1.6. Occupations Included in This Study of the STEM Workforce

RAND Occupation	OPM Occupation	CPS Occupation
Physical Science Occupations		
Chemists	Chemists	Chemists and materials scientists Chemical technicians
Physicists	Astronomy and space science Physics	Astronomers and physicists
Food scientists	Food technology	Agricultural and food scientists
Other physical scientists	General physical science Health physics Physical science technician series Metallurgy Textile technology Photographic technology	Physical scientists, all other Nuclear technicians[a] Natural sciences managers
Life Science Occupations		
Conservation scientists	Forestry Forestry technician series Fire protection engineering Rangeland management Forest products technology series Range technician series Soil conservation Soil conservation technician series	Conservation scientists and foresters Fire inspectors
Environmental scientists	Hydrology Geophysics Hydrologic technician series Geology Oceanography Geodesy Geodetic technician series Ecology Plant protection technician series Botany Plant pathology Plant physiology Horticulture Soil science Agronomy Fish and wildlife administration Fish biology Wildlife refuge management Wildlife biology	Environmental scientists and geoscientists Geological and petroleum technicians[a]

RAND Occupation	OPM Occupation	CPS Occupation
Physical Science Occupations		
Biologists	Microbiology	Biological scientists
	Biological science technician series	Biological technicians
	Genetics	
	Animal science	
	Zoology	
	Clinical laboratory science series	
	Entomology	
Medical scientists	Pharmacology	Medical scientists[b]
	Physiology	
	Toxicology	
Other life scientists	General natural resources management and biological sciences	
IT and Computer Science Occupations		
Computer science	Computer science	Computer and information research scientists[c]
	Information technology management	Computer systems analysts[c]
		Information security analysts[c]
		Computer programmers
		Software developers, applications and systems software
		Web developers[c]
		Database administrators
		Network and computer systems administrators
		Computer network architects[c]
		Computer support specialists
		Computer occupations, all other[c]
		Computer and information systems managers
Actuaries	Actuarial science	Actuaries
Mathematicians, math scientists, and cryptanalysts	Mathematics	Mathematicians[d]
	Mathematical statistics	
	Mathematics technician series	
	Cryptanalysis	
Operations researchers	Operations research	Operations research analysts
Statisticians	Statistics	Statisticians
	Statistical assistant series	
Other math scientists	General mathematics and statistics	Miscellaneous mathematical science occupations[e]

RAND Occupation	OPM Occupation	CPS Occupation
Physical Science Occupations		
Engineering Occupations		
Architects	Architecture	Architects, except naval
	Landscape architecture	Surveyors, cartographers, and photogrammetrists
	Cartography	Drafters
	Survey technical series	Surveying and mapping technicians
	Land surveying	
	Cartographic technician series	
Aerospace engineers	Aerospace engineering	Aerospace engineers
Agricultural engineers	Agricultural engineering	Agricultural engineers[f]
Biomedical engineers	Bioengineering and biomedical engineering	Biomedical engineers[f]
Chemical engineers	Chemical engineering	Chemical engineers
Civil engineers	Civil engineering	Civil engineers
Computer engineers	Computer engineering	Computer hardware engineers
Electrical engineers	Electrical engineering	Electrical and electronic engineers
	Electronics engineering	
	Electronics technical series	
Environmental engineers	Environmental engineering	Environmental engineers
Safety engineers	Safety engineering	Industrial engineers, including health and safety engineers
	Industrial engineering technical series	
	Industrial engineering	
Naval engineers	Naval architecture	Marine engineers and naval architects
Materials engineers	Materials engineering	Materials engineers
Mechanical engineers	Mechanical engineering	Mechanical engineers
Mining engineers	Mining engineering	Mining and geological engineers, including mining safety engineers[g]
Nuclear engineers	Nuclear engineering	Nuclear engineers[f]
Petroleum engineers	Petroleum engineering	Petroleum engineers[g]
Other engineers	General engineering	Engineers, all other
	Engineering technical series	Engineering technicians, except drafters
	Construction analyst	Engineering managers[h]
Social Science Occupations		
Economists	Economist	Economists[i]
	Economics assistant series	
Sociologists	Sociology	Sociologists[j]
Psychologists	Psychology	Psychologists
	Psychology aid and technician series	

RAND Occupation	OPM Occupation	CPS Occupation
Physical Science Occupations		
Other social scientists	General anthropology Archeology Geography Social science Social science aid and technician series	Miscellaneous social scientists and related workers[k]

NOTE: The table shows occupations constructed by RAND and corresponding occupations in the OPM codes and CPS codes.

[a] In 2013, CPS merged this occupation with geological and petroleum technicians. For analysis in this report, we keep nuclear technicians with physical science occupations.

[b] In 2013, CPS changed the name of this occupation to Medical scientists, and life scientists, all other.

[c] In 2013, CPS merged this occupation and several others into a new occupation called Computer Scientists and Systems Analysts/Network Systems Analysts/Web Developers.

[d] In 2013, CPS merged mathematicians with other mathematical science occupations.

[e] In 2013, CPS changed the name of this occupation to Mathematical science occupations, all other.

[f] In 2013, CPS merged this occupation with the occupation named Engineers, all other.

[g] In 2013, CPS merged mining and geological engineers with petroleum engineers and renamed the occupation as Petroleum, mining and geological engineers, including mining safety engineers.

[h] In 2013, CPS changed the name of this occupation to Architectural and engineering managers.

[i] In 2013, CPS changed the name of this occupation to Economists and market researchers.

[j] In 2013, CPS merged sociologists with Social scientists, all other.

[k] In 2013, CPS changed the name of this occupation to Social Scientists, all other.

The Organization of This Report

The remainder of this report provides the results of our comparison of the compensation of STEM workers in the federal government and the private sector. The report is organized to provide context for each sector before digging into the comparison. In Chapter Two we analyze trends in the private-sector STEM workforce in employment, hours, income, and benefits. In Chapter Three we analyze trends in the federal STEM workforce in a similar framework. For both sectors, our analysis includes context and potential determinants of compensation. In Chapter Four we make direct comparisons of the STEM workforce by sector, first in adjusted comparison and then through regression analysis. In Chapter Five we use the DMDC data to make the federal-private STEM comparison in DoD only. Throughout our analysis, we present our findings as they vary by subgroups of interest: broad and detailed occupation groups, gender, race/ethnicity, and educational attainment. We end in Chapter Six with a discussion and limitations of our findings.

2. The Private-Sector STEM Workforce

This chapter analyzes compensation for STEM workers in the private sector. We begin by providing an overview of the number and distribution of these workers by several characteristics: occupation, educational attainment, age, gender, race/ethnicity, and nativity. We then consider several factors, as discussed in Chapter One, that shed light on the desirability of working in a given field and the extent to which a job is a "good" job. These include the unemployment rate and usual hours worked per week. We devote particular attention to levels and trends in average annual income. We conclude with a brief discussion of benefits. All analyses in this chapter are restricted to full-time workers.

In this chapter we often compare STEM workers in the private sector with their non-STEM counterparts. We make these comparisons both at the aggregate STEM level versus the non-STEM level, and also through more granular characteristics (e.g., by gender, race/ethnicity, and educational attainment), to the extent that sufficient data are available to make these comparisons.

On balance, our findings are similar to those in prior reports and literature about working in STEM. Private-sector STEM occupations tend to pay more than non-STEM occupations, the jobs are more likely to offer benefits, and unemployment rates are typically lower. However, there are sharp disparities in STEM participation and in pay by gender and race/ethnicity. Moreover, while better educated workers earn more, less educated workers tend to fare better relative to their similarly educated non-STEM counterparts. Many of these trends vary by occupation.

While our findings are broadly consistent with others in the literature, this chapter is not intended to replicate or verify past studies of STEM compensation. Our goal here is to provide an introduction to the size and composition of the STEM workforce in the private sector and identify any patterns or determinants of compensation that could prove crucial in later chapters, in which we make direct comparisons to the public sector. Our definition of STEM is enumerated in the previous chapter and documented in Appendix A.

Number and Distribution of Private-Sector STEM Workers

There were 8.8 million full-time STEM workers in the private sector in 2018—accounting for about one in 13 full-time private-sector workers—in social science; IT and computer science, which includes mathematics; engineering; life science; and physical science.[1] While remaining a small share of the full-time private-sector workforce of more than 114 million, the STEM

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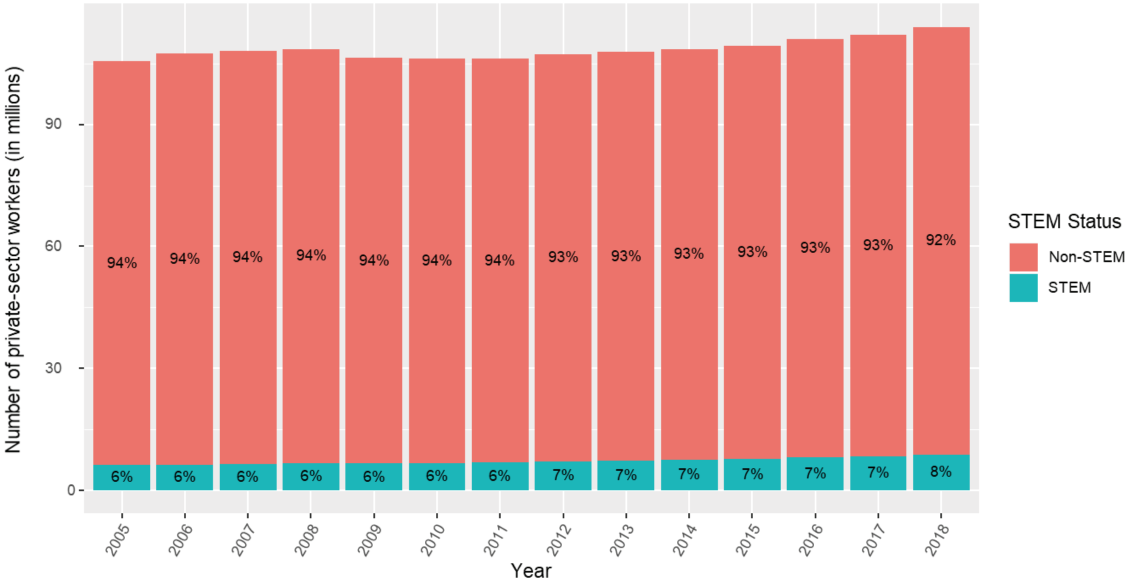
[1] These data are counts of observations from the CPS. Details of the STEM definition and the five broad STEM occupations can be found in Appendix A. Counts include all workers in the labor force, whether employed or unemployed.

workforce grew about six times faster than the non-STEM workforce over the period 2005–2018.[2] Annual STEM workforce growth was 2.5 percent over this period versus just 0.4 percent for the non-STEM workforce.[3] This trend held in the most recent years. Over the past five years (2013–2018), STEM occupations expanded by 3.2 percent per year, compared with growth of just 0.8 percent in non-STEM occupations. These sharply different growth rates resulted in STEM employment increasing as a share of the private-sector full-time workforce, from 5.9 percent in 2005 to 7.7 percent in 2018 (see Figure 2.1).

Figure 2.1. Number of Private-Sector Workers, by STEM Status, 2005–2018



SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Counts include both employed and unemployed workers.

For the remainder of this section, we describe in detail the composition of the STEM workforce—the distribution of workers in occupations across the STEM fields, age, educational attainment, gender, race/ethnicity, and nativity. For all but the occupational distribution (which is limited to those within STEM), we compare STEM workers to non-STEM workers. We do this primarily to provide context and support for understanding that STEM comprises a unique composition of workers. However, these comparisons to non-STEM workers

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[2] In this chapter we often report findings over the 2005–2018 period. We use these years because they align with the period for which data are available from FedScope, a principal data source for the findings on the federal STEM workforce that we report on elsewhere in this document. It also coincides with the publication *Rising Above the Gathering Storm* from the NAS, which in some ways inaugurated the contemporary policy focus on STEM. For further discussion, see Chapter One.

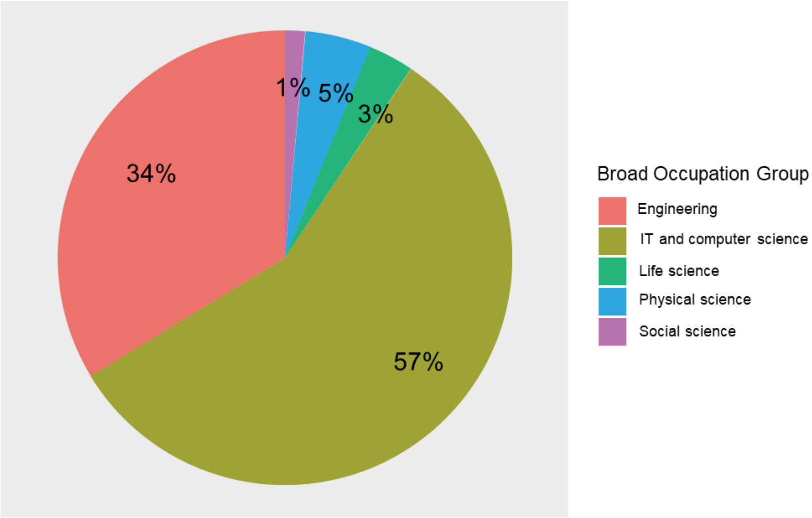
[3] Annual growth rates reported in this chapter are compound annual growth rates (CAGRs) unless stated otherwise.

should not be interpreted normatively. That is, we are not trying to say that STEM workers *should* look a certain way. This is especially important when we discuss gender and race/ethnicity. The non-STEM workforce provides a contrast to understand how the STEM workforce differs, not what it should or needs to look like.

Occupational Distribution

Our research grouped the hundreds of individual STEM occupations into five distinct disciplines: engineering science, IT and computer science, life science, physical science, and social science, which we refer to as occupational groups.[4] The overwhelming majority of private-sector STEM workers are in the broad occupation categories of IT and computer science and engineering—56.9 percent and 33.7 percent in 2018, respectively (see Figure 2.2). By contrast, just 9.4 percent of private-sector STEM workers were either life, physical, or social scientists.

Figure 2.2. Number of Private-Sector STEM Workers, by Broad Occupation Group, 2018



SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Counts include both employed and unemployed workers.

In addition to being the largest component of STEM in the private sector, IT and computer science is also growing quickly. Three-fourths of STEM workers added in the private sector from 2005 to 2018 were in this occupational field—nearly 2 million workers. The IT and computer science workforce grew at an annual rate of 3.6 percent from 2005 to 2018 and of 3.9 percent over the most recent five-year period (2013–2018). From 2005 to 2018, engineering added 500,000 jobs, at a 1.3-percent rate; physical sciences added 100,000 jobs, at a 2.1-percent

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[4] It is important to note again that our data did not include individuals who work in the medical and health disciplines. Please refer to Appendix A for more details on how we categorized STEM occupations.

rate; life sciences added 16,000 jobs, at a 0.4-percent rate; and social sciences added 16,000 jobs, at a 1.0-percent rate.

The grouping of all of the occupations into broad categories was necessary to facilitate comparisons with the public-sector STEM workforce in later chapters. As noted in the introduction, the critical requirement of the coding structure we use is that it must "crosswalk" between the private and public sectors. The crosswalk that we constructed takes occupations that are both (1) enumerated separately in the private-sector (BLS) data and (2) enumerated separately in the public-sector (OPM) data and aggregates them into relevant categories with a large enough sample size to support comparisons. Computer science–related workers are by far the most prevalent type of STEM workers in the private sector, accounting for nearly six in ten STEM workers overall. Given its importance in the private sector, we enumerate those occupations separately here, even though a more detailed comparison with similar public sector workers is not possible.[5]

In Table 2.1 we show the BLS specific occupations within the broad category of IT and computer science and each occupation's share of the total category. This includes the largest occupations in IT, software developers (30.9 percent) and computer scientists and systems analysts (30.8 percent); computer and information systems management (11.5 percent); computer support specialists (9.7 percent); computer programmers (8.3 percent); network and computer systems administrators (3.5 percent); and, finally, database administrators (1.9 percent).

Table 2.1. Distribution of Information Technology and Computer Science Occupations in the Private Sector, 2018

IT and Computer Science Occupation	Distribution of Total IT and Computer Science (Percentage)
Software developers	30.9
Computer scientists and systems analysts[a]	30.8
Computer and information systems managers	11.5
Computer support specialists	9.7
Computer programmers	8.3
Network and computer systems administrators	3.5
Database administrators	1.9
Operations research analysts	1.6
Mathematical science occupations, other	1.5
Actuaries	0.5

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: Both employed and unemployed workers are included when calculating shares. Because of the small number of statisticians in the 2018 CPS data, they are not listed in this table.
[a] The full title of this occupation is Computer scientists and systems analysts/network systems analysts/web developers.

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[5] It is not possible to create comparative subgroups within IT and computer science. In the private sector, IT and computer science–related workers span over a dozen occupations. However, in the federal government, they have a single occupation—or, at least, a single occupation in the OPM data.

Age

The age distribution differs somewhat for STEM versus non-STEM workers in the private sector, as we show in Table 2.2. STEM workers have higher shares among the middle of the age distribution of workers. In 2018, 74.9 percent of STEM workers were between the ages of 25 and 54, or "prime-age" workers, compared with 67.1 percent of non-STEM workers. By contrast, both younger and older workers compose a larger proportion of the private-sector non-STEM workforce. The share of non-STEM workers under age 25 was 2.8 percentage points higher than this share for STEM workers in 2018 (8.5 percent, versus 5.7 percent). Given that many STEM occupations require additional education beyond high school and some up to a Ph.D., it is not surprising that younger workers are less represented in STEM, as we expect that many are still in school. The share of non-STEM workers ages 55 and over was about 3 percentage points higher than this share for STEM workers (22.8 percent, versus 19.2 percent).

Table 2.2. Distribution of Private-Sector Workers, by Age Group and STEM Status, 2018

Age Group	Distribution of Non-STEM Workers (Percentage)	Distribution of STEM Workers (Percentage)	Percentage-Point Difference
20–24	8.5	5.7	–2.8
25–29	12.1	14.2	2.0
30–34	11.6	14.9	3.3
35–39	11.3	13.5	2.2
40–44	10.4	11.8	1.4
45–49	10.9	10.8	–0.1
50–54	10.6	9.7	–0.9
55–59	10.0	9.1	–0.9
60–64	7.2	6.6	–0.6
65 or older	5.1	3.5	–1.6

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: The table shows the shares of non-STEM and STEM workers in the private sector, by age; columns sum to 1. STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Counts include both employed and unemployed workers.

In general, the distributions in Table 2.2 indicate that although the age breakdown is slightly different between STEM and non-STEM workers, the two groups are more similar than they are different; the largest difference is for workers aged 30–34, at 3.3 percentage points. STEM does not evince any age bubble (i.e., a large mass of workers that are in a single age group). This is important to keep in mind as the perception of the STEM workforce, as noted in Chapter One, is often of younger workers, perhaps with unique compensation, location, or job preferences, but, as we show, just under half of STEM workers are over the age of 45.

Educational Attainment

STEM workers in the private sector are much more likely to be highly educated than are non-STEM workers (see Table 2.3). In 2018, about 75 percent of private-sector STEM workers had at least a bachelor's degree, versus about one in three non-STEM workers. The share of STEM workers with a master's or advanced degree was about three times this share for non-STEM workers (23.3 percent, versus 7.2 percent). Just 15.9 percent of private-sector STEM workers did *not* have a postsecondary degree, versus more than half of non-STEM workers.

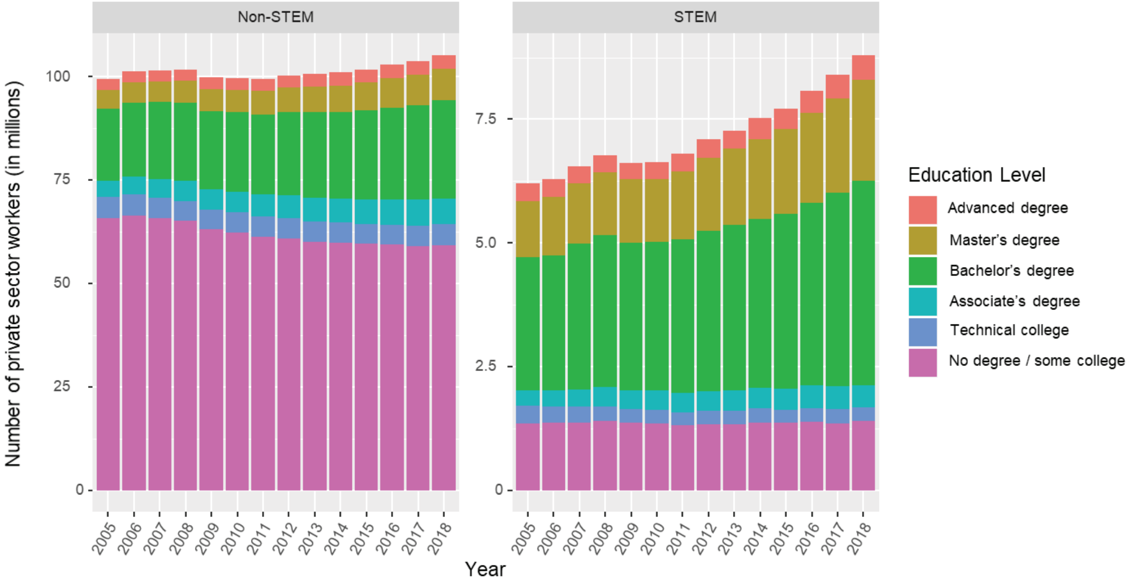
Table 2.3. Distribution of Private-Sector Workers, by Education Level and STEM Status, 2018

Terminal Education Level	Non-STEM Workers (Percentage)	STEM Workers (Percentage)
Advanced degree	3.3	5.7
Master's degree	7.2	23.3
Bachelor's degree	22.5	46.9
Associate's degree	6.0	5.2
Technical college	4.8	3.1
No degree/some college	56.2	15.9

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Advanced degrees include J.D.'s, M.B.A.'s, M.D.'s, and Ph.D.'s. Counts include employed and unemployed workers.

Workers with higher educational attainment are not only a strong majority of the private-sector STEM workforce but have also driven the growth in this workforce since 2005 (see Figure 2.3). More than 1.4 million of the nearly 2.6-million-worker growth in the private-

Figure 2.3. Number of Private-Sector Workers, by Education Level and STEM Status, 2005–2018



SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Advanced degrees include J.D.'s, M.B.A.'s, M.D.'s, and Ph.D.'s. Counts include employed and unemployed workers.

sector STEM workforce, or about 56 percent of this growth, was accounted for by workers with a terminal bachelor's degree, and the share of private-sector STEM workers at this education level increased from 43.2 to 46.9 percent. This represents an annual growth rate of 3.1 percent for these workers. Among non-STEM workers, though, the net loss in employment among workers with lower educational attainment boosted the contribution of terminal bachelor's degree holders. Over this period, non-STEM employment grew by 5.8 million workers, but bachelor's degree employment grew by 6.4 million, at an annual rate of 2.3 percent. For workers with more than a bachelor's degree, growth was also higher among STEM workers. Advanced degree holders grew at a 2.4-percent rate among STEM workers and a 2.0-percent rate among non-STEM workers, and master's degree holders grew at a 4.3-percent rate among STEM workers and a 3.6-percent rate among non-STEM workers. These categories were already a large share of the STEM workforce.

Gender and Race/Ethnicity

Private-sector STEM workers are overwhelmingly male. In total, 77.4 percent of the private-sector STEM workforce was male, compared with 57.2 percent of the private-sector non-STEM workforce. Among men, STEM workers are also disproportionately white or Asian (see Table 2.4).[6] More than half (52.8 percent) of the private-sector STEM workforce was white men in 2018, and another 14.1 percent was Asian men, compared with 36.0 percent white men and 2.9 percent Asian men among private-sector non-STEM workers. Black and Hispanic men, on the other hand, have much lower shares among STEM workers, at 4.6 percent and 6.1 percent, respectively.

Given that women are a smaller share of STEM workers, the shares of individual racial/ethnic groups of women are very low. However, one question is whether the racial and ethnic distribution of female workers, rather than all workers, differs between STEM and non-STEM workers. In other words, women in STEM have a smaller slice of the pie than women in non-STEM occupations, but is that smaller slice itself distributed differently across racial and ethnic groups? Notably, among women the share that is white is identical in both the STEM and non-STEM workforces—61.8 percent (for the STEM workforce, 13.9 percent divided by 22.6 percent, and for the non-STEM workforce, 26.4 percent divided by 42.8 percent). That is not true for the other races/ethnicities. Asian women account for 6.4 percent of the female non-STEM workforce, but 21.7 percent of the female STEM workforce, while black women's share of the female workforce is 14.1 percent outside STEM, versus 8.9 percent in STEM, and Hispanic women's share of the female workforce is 17.5 percent in non-STEM occupations, compared with just 7.5 percent in STEM. Of the total private-sector STEM workforce, black and Hispanic women together account for just 3.7 percent of all workers.

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[6] For the analyses in this chapter, we group together all workers who indicate their race to be Asian. As discussed in Allard, 2011, there is considerable variation among Asian Americans when disaggregated by Asian group. We also exclude from the table the "Other" race census category, which consists of Native Alaskans, Native Americans, and Pacific Islanders, because they represent a very small portion (<.5 percent) that is too small for comparison due to sample-size issues.

Table 2.4. Distribution of Private-Sector Workers, by Demographic Category, Nativity, and STEM Status, 2018

Group	Non-STEM Workers (Percentage)	STEM Workers (Percentage)
Male	57.2	77.4
Female	42.8	22.6
White	62.4	66.6
Hispanic	19.7	7.8
Black	12.1	6.6
Asian	5.7	19.0
White male	36.0	52.8
White female	26.4	13.9
Hispanic male	12.3	6.1
Hispanic female	7.5	1.7
Black male	6.1	4.6
Black female	6.0	2.0
Asian male	2.9	14.1
Asian female	2.8	4.9
U.S. born	79.7	73.7
Foreign born	20.3	26.3

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The table excludes the "Other" race Census category from calculations that are too small for comparison.

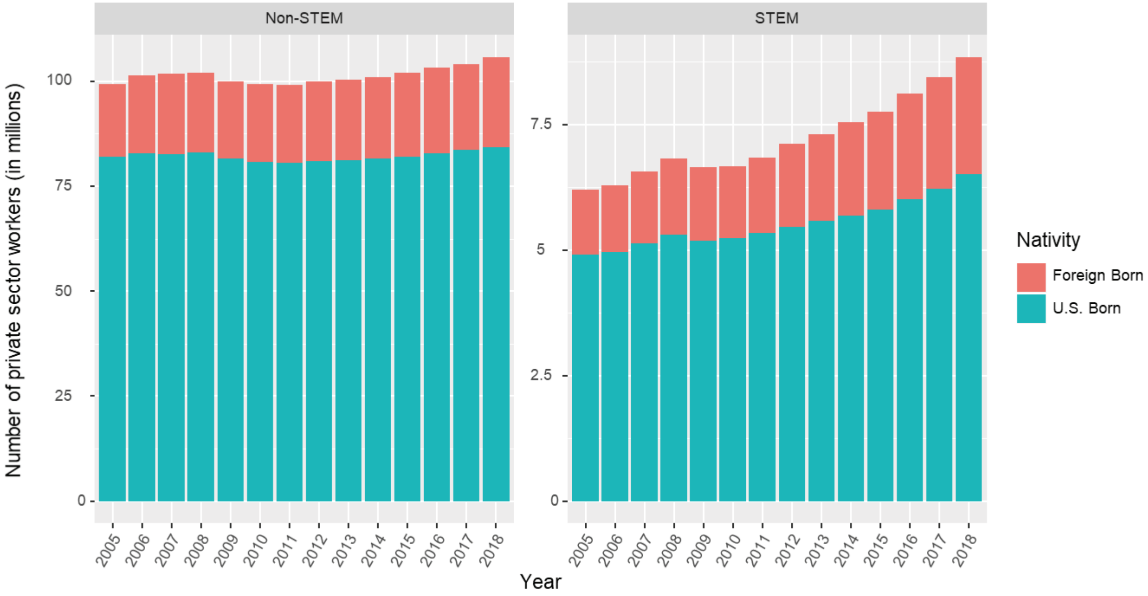
In most ways, underrepresentation in STEM has been lessening since 2005. STEM is now less white; the 2005 share of STEM workers comprising white men was 60.1 percent, and white women made up 15.5 percent. The share of black and Hispanic workers increased from 11.0 percent to 14.4 percent. However, the fastest-growing and largest increase was among Asian workers, which started in 2005 at 13.2 percent and increased to 19.0 percent. In addition, the male share has stayed relatively flat; it was 78.5 percent in 2005 and, as noted, 77.4 percent in 2018. All of this occurred over a time period in which increasing diversity of women and underrepresented minorities was an enumerated policy goal (NAS, 2011).

The non-STEM workforce was not stagnant in size or composition over this period, and is evolving differently from that of STEM. Within STEM, every gender and racial/ethnic group saw absolute increases in size. In sharp contrast to STEM, there were more than 3.4 million *fewer* white private-sector non-STEM workers in 2018 than there were in 2005, while there were 9.3 million more nonwhite workers in private-sector non-STEM employment. In other words, while the STEM workforce has become somewhat more diverse ethnically and racially compared with 13 years ago, it remains much less diverse than the non-STEM workforce, and the non-STEM workforce is also getting more ethnically and racially diverse, and is doing so at a much faster pace. As we noted previously, the comparisons with the non-STEM workforce are not intended to be interpreted as what the STEM workforce *should* look like but rather as context for just how much the STEM workforce differs.

Foreign-Born Workers

STEM workers in the private sector are more likely to be foreign born than their non-STEM counterparts (see Figure 2.4). About 26 percent of STEM workers are foreign born, compared with 20 percent of non-STEM workers. The foreign-born shares in both sectors have increased since 2005, from 20.7 percent of STEM workers and 17.5 percent of non-STEM workers.[7] In terms of growth rates, foreign-born workers in STEM grew at a 4.3-percent annual rate, and for non-STEM workers, growth was at 1.5 percent. This was faster than native-born growth rates of 2.0 percent and 0.2 percent, respectively.

Figure 2.4. Distribution of Private-Sector Workers, by Nativity and STEM Status, 2005–2018



SOURCE: CPS (via the U.S. Census Bureau).
NOTE: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A.

As was described in Chapter One, several visa programs draw foreign-born workers, and STEM workers disproportionately, into the U.S. workforce on a temporary basis, including H1-B and F-1 visas. Foreign-born workers include naturalized U.S. citizens in addition to these temporary workers and other noncitizen residents; 44 percent of the foreign-born population as of 2010 was naturalized (Grieco et al., 2012). Occupations with higher-than-average foreign-born shares logically would have higher-than-average shares of noncitizen workers, who are

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[7] Foreign-born status is reported in the CPS under the variable NATIVITY, which classifies each person as native born or foreign born (i.e., whether the person is a first-generation immigrant) and further specifies whether the parents of a native-born person were native born or foreign born (i.e., whether the person is a second-generation immigrant). NATIVITY is constructed from information in the BPL, FBPL, and MBPL variables, which respectively report the place of birth of the respondent, the respondent's father, and the respondent's mother. Persons born in outlying U.S. territories and possessions and those born abroad to U.S. parents are treated as foreign born in NATIVITY.

ineligible for federal employment, though data on the noncitizen share are unavailable. Hence, the higher share of foreign-born workers in STEM in the private sector suggests that there is a less robust labor pool of eligible hires for federal jobs in STEM fields versus outside of STEM. By broad STEM occupation, the highest foreign-born share in 2018 was among IT and computer science workers (29.7 percent), followed by life and physical scientists (about 26–28 percent), engineers (20.9 percent), and then social scientists (13.2 percent).

Summary of the Number and Distribution of Private-Sector STEM Workers

STEM workers represent a relatively small share of the full-time private-sector workforce (7.7 percent in 2018), but growth in this workforce has far outpaced growth in the private-sector non-STEM workforce in recent years. While partly reflective of the smaller size of the workforce, it is clear that STEM has grown disproportionately. Though just one in 13 private-sector workers (as of 2018) is a STEM worker, more than one in four workers added from 2005 to 2018 was in STEM. Within STEM, growth was driven by the IT and computer science broad occupation—accounting for about three-fourths of STEM workforce growth from 2005 to 2018—and currently representing more than half of the STEM workforce.

With respect to education, we found that STEM workers tend to have higher educational attainment in comparison with non-STEM workers. About 75 percent of private-sector STEM workers had at least a bachelor’s degree, compared with just about one-third of non-STEM workers. Workers with higher educational attainment also drove the growth in STEM: more than 95 percent of the net growth in the STEM workforce was by those with at least a bachelor’s degree.

Despite some modest progress toward greater racial diversity, we found that white workers continued to account for about two-thirds of private-sector STEM workers in 2018. Another nearly 20 percent were Asian. Just 14 percent were black or Hispanic, while more than 30 percent of private-sector non-STEM workers were black or Hispanic. More than half of private-sector STEM workers were white men, versus 36 percent of private-sector non-STEM workers. The share of women in STEM barely budged over the 2005–2018 period, suggesting that there remain substantial barriers and challenges to women pursuing and persisting in STEM. In addition, the foreign-born share is higher among STEM than non-STEM workers in the private sector.

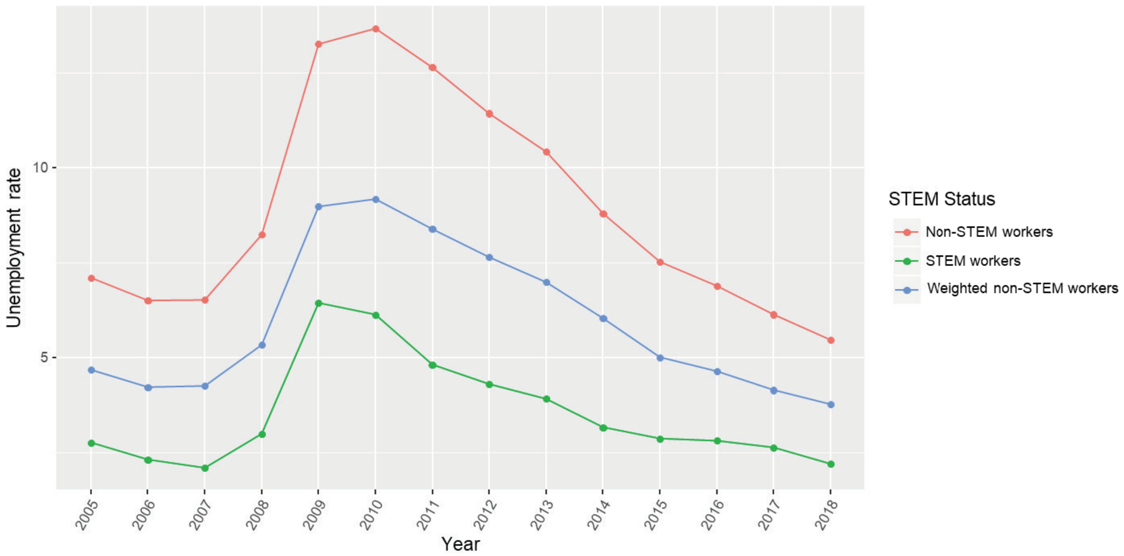
Unemployment Rate

The number and distribution of STEM workers among key occupation, education, and demographic categories, as we discussed in the previous section, is important for the compensation analysis that follows. These measures give a sense of what the stock of STEM workers looks like. However, workers are not immobile—they move in and out of specific jobs and in and out of employment generally. In this section we discuss the unemployment rate for STEM workers and compare it with unemployment for non-STEM workers.

Unemployment rates measure the share of individuals out of work and actively searching for a position as a share of the labor force (i.e., those who are employed or out of work and actively seeking employment). The unemployment rate is an important metric to consider when assessing compensation and benefits. Typically, there is an inverse relationship between unemployment and wages—in a tighter labor market with fewer people out of work, workers have more bargaining power to bid up wages. The occupation and industry of an unemployed worker is based on his or her most recent job. Therefore, in this analysis, we categorize unemployed workers as STEM or non-STEM workers based on the occupation of their last jobs prior to becoming unemployed, and we restrict the analysis to private-sector workers based on the sector of their last jobs. As Figure 2.5 shows, STEM workers consistently have a lower unemployment rate than non-STEM workers in the private sector, in both good and bad economic times. The STEM unemployment rate peaked at 6.4 percent during the Great Recession, a little more than half the non-STEM peak (13.7 percent), according to annual CPS data.[8] By 2018, STEM unemployment in the private sector had fallen to 2.2 percent, less than half the non-STEM rate of 5.5 percent.

In Figure 2.5 we also include a line that is labeled "Weighted non-STEM workers." This line shows what the unemployment rate of the non-STEM workforce would be if its

Figure 2.5. Unemployment Rate of Private-Sector Workers, by STEM Status, 2005–2018



SOURCE: CPS (via the U.S. Census Bureau).
NOTE: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. "Weighted non-STEM workers" is the unemployment rate of non-STEM workers adjusted to match the educational attainment rates of STEM workers.

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[8] Specifically, the data come from the Employee Status, or EMPSTAT, variable in the CPS. EMPSTAT indicates whether persons were part of the labor force—working or seeking work—and, if so, whether they were currently unemployed. In the CPS, individuals' employment status was determined on the basis of answers to a series of questions relating to their activities during the preceding week. Because the CPS is designed to measure unemployment in the civilian population, the original employment status variable in the survey classifies members of the armed forces as NIU, which stands for "not in universe."

educational attainment distribution were to match the distribution of STEM workers. Simply put, we know that more highly educated workers have lower unemployment rates and that STEM workers tend to be more highly educated. We wanted to see whether the lower unemployment rate in STEM holds when comparing with non-STEM workers who are similarly well educated. We find that, in the aggregate, it does, as the blue line for "Weighted non-STEM workers" remains above the STEM workers line.

Within STEM, we note that there is little difference between the broad occupation groups in unemployment. All of the groups had unemployment rates of 2.0–3.1 percent in 2018, compared with the STEM average unemployment rate of 2.2 percent. These rates are very low, and indicate that there is little variation in tightness across broad categories of STEM occupation.

In Table 2.5 we show the average unemployment rate of STEM and non-STEM workers by age groups over 2005–2018. We report an average of years because of sample-size concerns and because there is notably more fluctuation in unemployment rates than the other indicators we analyze in this chapter. At every age, STEM workers have lower rates. The largest differences are for younger workers. Non-STEM workers ages 20–24 have a 16.9-percent unemployment rate, compared with 4.8 percent for STEM workers, and non-STEM workers ages 25–29 have a 9.6-percent unemployment rate, compared with 3.1 percent for STEM workers. Recall that students who are not working or looking for work are not included in this calculation, and that the ages 20–24 make up a very small share of the STEM workforce. Between ages 30 and 54, non-STEM workers' rates range from 6.0 to 7.8 percent, while STEM workers' rates range from 2.6 to 3.5 percent. It is only among older workers that rates are similar between STEM and non-STEM workers, at 5.8 and 6.0 percent, respectively, for ages 60–64, and 7.1 percent for both STEM and non-STEM workers ages 65 and older.

Table 2.5. Unemployment Rate of Private-Sector Workers, by Age Group and STEM Status, 2005–2018 Average

Group	Unemployment Rate of Non-STEM Workers (Percentage)	Unemployment Rate of STEM Workers (Percentage)
20–24	16.9	4.8
25–29	9.6	3.1
30–34	7.8	2.6
35–39	7.0	2.7
40–44	6.5	3.1
45–49	6.3	3.1
50–54	6.1	3.5
55–59	6.0	4.8
60–64	6.0	5.8
65 or older	7.1	7.1

SOURCE: CPS (via the U.S. Census Bureau).
NOTE: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government.

In Table 2.6 we show the average unemployment rate between 2005 and 2018 in key demographic groups: by education, gender, race/ethnicity, and nativity. Looking within levels of educational attainment, private-sector STEM workers typically have lower unemployment rates than non-STEM workers. The most pronounced gap is among workers without a postsecondary degree, with STEM workers facing an unemployment rate that is less than half the non-STEM rate as of 2018 (5.1 percent, versus 11.4 percent). The disparity tends to shrink with more education, and there is a gap between STEM and non-STEM unemployment rates for bachelor's and master's degree holders of about 1–2 percentage points on average. Private-sector workers with advanced degrees are the only group that tends to have a higher unemployment rate among STEM workers versus non-STEM workers. However, both of these rates are very low—at 2.2 and 2.6 percent—and only trivially different. Hence, there appears to be little relationship between STEM and unemployment, or a STEM-specific unemployment buffer, for workers with higher educational attainment.

Table 2.6. Unemployment Rate of Private-Sector Workers, by Demographic Characteristics and STEM Status, 2005–2018

Group	Unemployment Rate of Non-STEM Workers (Percentage)	Unemployment Rate of STEM Workers (Percentage)
Advanced degree	2.2	2.6
Master's degree	4.1	2.8
Bachelor's degree	4.8	3.2
Associate's degree	6.4	3.9
Technical college	6.4	4
No degree/some college	11.4	5.1
Male	8.6	3.3
Female	9.4	4.3
White	7.3	3.3
Hispanic	10.4	4.3
Black	15.6	6.1
Asian	6.6	2.9
White male	7.2	3.2
White female	7.6	3.9
Hispanic male	9.4	3.9
Hispanic female	12.3	6
Black male	16.4	6.2
Black female	14.8	5.9
Asian male	6.7	2.4
Asian female	6.5	4.3
U.S. born	8.2	3.5
Foreign born	7.4	3.5

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The table excludes the "Other" race Census category from calculations, as it is too small for comparison.

Like STEM overall and STEM by education, for all racial and ethnic groups, STEM workers consistently have lower unemployment rates than non-STEM workers. However, there is considerable variation within STEM and within non-STEM workers by race/ethnicity. For workers in both STEM and non-STEM occupations, white and Asian workers experience lower unemployment rates than their black and Hispanic counterparts. The unemployment rate for black male STEM workers (6.2 percent) is only 1 percentage point lower than the rate for white male *non-STEM* workers (7.2 percent) and less than half a percentage point lower than the rate for Asian male non-STEM workers (6.7 percent). Indeed, the black unemployment rate, whether in STEM or non-STEM occupations, is roughly double the white unemployment rate. Black STEM workers fare better than black non-STEM workers, but STEM is not a leveler. Even within STEM, there are still racial and ethnic disparities. Finally, we find that although there are differences between native- and foreign-born unemployment rates for workers in non-STEM occupations, in STEM the two groups have identical employment rates.

Usual Weekly Hours

The typical number of hours worked per week is one signal of whether an occupation offers a good quality of life and an ability to balance work and home responsibilities. Among private-sector workers who work full-time (defined as 35 hours or more per week), there is little difference in the usual weekly hours between STEM and non-STEM occupations. In 2018, private-sector STEM workers worked 42.5 hours per week, on average, compared with 43.1 hours worked per week for non-STEM workers, according to data from the CPS ASEC.[9] Within STEM, hours worked per week were similar across the broad STEM occupational categories we analyzed, with IT and computer science workers averaging about 42 hours per week and all other broad occupations averaging about 43 hours per week in 2018.

In Table 2.7 we compare the hours worked per week of full-time workers in STEM and non-STEM positions across the same age groups used for the unemployment rates in Table 2.5. There is little difference between STEM and non-STEM workers. For both, the usual hours worked increases by age, from 41.6 hours among non-STEM workers 20–24 years of age to 43.8 hours for workers 65 and older and, for STEM workers, comparative increases of 41.8 to 42.7 hours. Within age groups there is some evidence that STEM workers work slightly less (under an hour's difference).

In Table 2.8 we compare the average between 2005 and 2018 in hours worked per week of full-time workers in STEM and non-STEM occupations across the same demographic groups examined in Table 2.6: by education, gender, race/ethnicity, and nativity. Again, we use an average of years to gain a larger sample size. In general we find that workers with higher

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[9] In ASEC, we use the UHRSWORKLY variable. This reports the number of hours per week that respondents usually worked if they worked during the previous calendar year. Individuals were asked this question if (1) they reported working at a job or business at any time during the previous year, or (2) they acknowledged doing "any temporary, part-time, or seasonal work even for a few days" during the previous year.

Table 2.7. Usual Weekly Hours of Private-Sector Workers, by Age Group and STEM Status, 2018

Age Group	Usual Weekly Hours of Non-STEM Workers	Usual Weekly Hours of STEM Workers
20–24	41.6	41.8
25–29	42.3	41.8
30–34	42.8	42.2
35–39	43.1	42.3
40–44	43.3	42.5
45–49	43.5	43
50–54	43.6	43.1
55–59	43.7	43.5
60–64	43.6	43.1
65 or older	43.8	42.7

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government.

Table 2.8. Usual Weekly Hours of Private-Sector Workers, by Demographic Characteristics and STEM Status, 2018

Group	Usual Weekly Hours of Non-STEM Workers	Usual Weekly Hours of STEM Workers
Advanced degree	47.2	43.9
Master’s degree	44.1	42.5
Bachelor’s degree	43.2	42.5
Associate’s degree	42.5	41.9
Technical college	42.8	42.2
No degree/some college	42.7	42.4
Male	44	42.7
Female	41.8	41.9
White	43.7	43.1
Hispanic	42.1	42.1
Black	41.9	41.7
Asian	42.7	41.2
White male	44.7	43.2
White female	42.2	42.4
Hispanic male	42.6	42.1
Hispanic female	41.1	42.1
Black male	42.6	42
Black female	41.2	41
Asian male	43.3	41.3
Asian female	42.1	40.8
U.S. born	43.1	43.2
Foreign born	42.2	41.8

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The table excludes the “Other” race Census category from calculations, as it is too small for comparison.

educational attainment work longer hours, but that non-STEM workers work longer than STEM workers within categories of educational attainment. In non-STEM positions, workers with advanced degrees work 47.2 hours per week. In STEM, however, advanced degree holders work 43.9 hours—3.3 hours less per week than those in non-STEM positions. In both STEM and non-STEM positions, hours for workers without a bachelor's degree average around 42.5 hours. One implication of this finding is that STEM workers may have better work-life balance, since they work fewer hours but, as we will show, earn considerably more.

By gender and racial or ethnic groups, there are two patterns to note. First, the pattern of STEM workers having shorter hours than non-STEM workers only holds for white men, Asian men, and Asian women; for the remaining groups, the hours are similar for workers in both STEM and non-STEM occupations. Second, within each racial or ethnic group, men work slightly more than women. This finding is consistent with more general findings from ATUS that show men working somewhat more than women, while women devote more time to household activities (BLS, 2019b). Within STEM, white men and white women work the longest hours, at 43.2 and 42.4 hours, respectively. By nativity, the native born in both non-STEM and STEM positions work about an hour longer per week, but there is no STEM-correlated difference in hours.

In summary, the most striking finding from the analysis of hours worked is that there are larger disparities in hours worked according to education levels for private-sector non-STEM workers than for STEM workers. STEM workers, regardless of level of education, tend to work about 42–44 hours per week, while non-STEM workers with master's degrees and, in particular, advanced degrees, work notably longer hours than non-STEM workers in other education categories (47.2 and 44.1 hours per week, respectively, versus 42.7–43.2 hours in other education categories).

Income

How much jobs pay is clearly at the core of a comparison of compensation and benefits—between STEM and non-STEM workers, as we discuss in the context of the private sector in this chapter, or between STEM workers in the private sector and in the federal government, as we consider in later chapters in this report. Pay can be influenced by the factors described in the sections above; for example, a low unemployment rate is suggestive of a tighter labor market in which workers have more bargaining power to command higher incomes now or in the future. Pay can also offset some of the less desirable aspects of working in a field, such as needing to work longer hours. In general, pay is a reflection of the worker's productivity, itself a reflection of a worker's skills.

A simple comparison of averages indicates that STEM workers make considerably more than non-STEM workers in the private sector, consistent with the literature discussed in Chapter One. In 2018 average annual income was $37,200 higher for STEM workers than non-STEM workers ($95,100 versus $57,900),[10] an earnings premium of 64 percent. This income measure is from the

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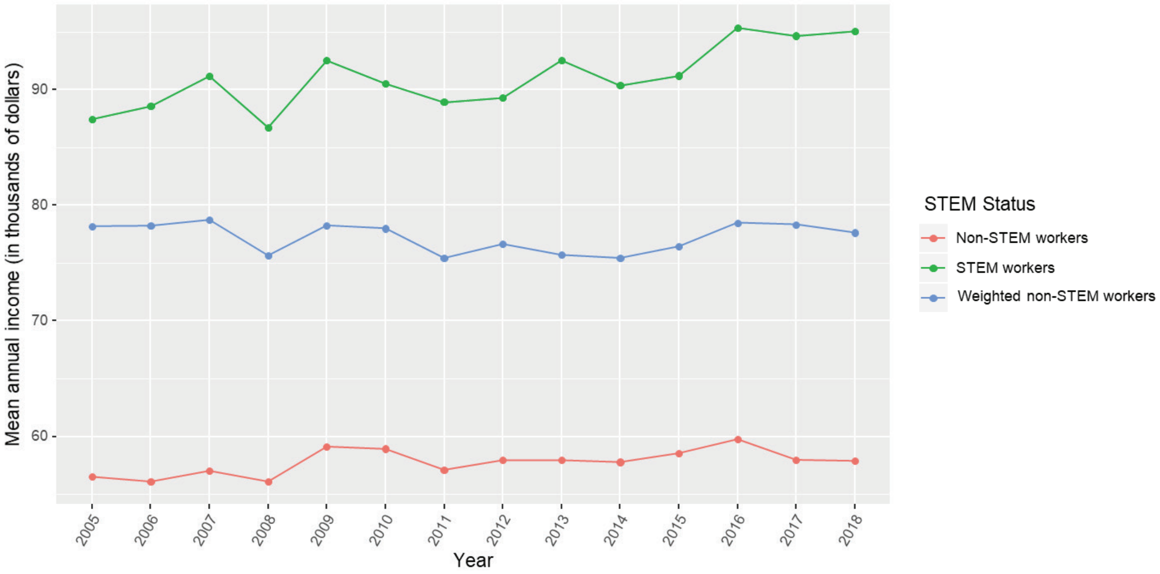
[10] For ease of reading in the text, we discuss dollar amounts rounded to the nearest thousand, but show exact numbers in the figures and tables.

CPS ASEC and includes pretax wage and salary income, excluding other forms of income.[11] Even after weighting the private-sector non-STEM workforce so that its educational attainment distribution matches that of the STEM workforce, there remains a large STEM earnings premium (see Figure 2.6).

Figure 2.6. Mean Real Annual Income for Private-Sector Workers, by Weighted STEM Status, 2005–2018 (in 2018 dollars)



SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. "Weighted non-STEM workers" weights by educational attainment such that the distribution of non-STEM workers matches the distribution of STEM workers across the six categories of educational attainment we consider: advanced degrees, master's degrees, bachelor's degrees, associate's degrees, technical credentials, and no postsecondary education. Advanced degrees include J.D.'s, M.B.A.'s, M.D.'s, and Ph.D.'s.

From 2005 to 2018, private-sector STEM earnings increased by $7,000 (in 2018 dollars), an annual growth rate over that period of about 0.6 percent. This growth rate was about 0.4 percentage points faster than the *unweighted* annual growth rate for private-sector non-STEM workers (0.17 percent). As a result, the pay premium associated with STEM jobs *grew* over this period—from a 55-percent ($31,000 in 2018 dollars) premium over non-STEM jobs in 2005 to the 64-percent premium in 2018. While this comparison does not control for other factors that are associated with differences in pay and have different distributions between STEM and non-STEM workers (e.g., gender, race/ethnicity, and geography), it is noteworthy. STEM workers earn more than non-STEM workers, and this gap appears to be growing.

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[11] Specifically, we use the INCWAGE variable from CPS ASEC, which indicates each respondent's total pretax wage and salary income—that is, money received as an employee—for the previous calendar year. Amounts are expressed as they were reported to interviewers. These estimates are not corrected for top-coding.

Within STEM, there are differences in income by broad occupation group. In 2018, engineers and IT and computer science workers each made more than $96,000 per year, on average, while physical scientists made about $86,000, and social scientists and life scientists each made about $78,000. All of these amounts reflect a premium to working in STEM occupations as compared with non-STEM occupations in the private sector (see Table 2.9). The rate of growth in real income since 2009, which we use as the base year since it was the trough of the last business cycle and recession, was largest in social science (2.48 percent per year), small and positive for engineering (0.15 percent) and IT and computer science (0.49 percent), but negative for physical science (–0.40 percent) and life science (–1.60 percent). Overall real income fell at a rate of –0.21 percent for non-STEM workers over this period.

Table 2.9. Mean Annual Income (2018) and Nine-Year (2009–2018) Annual Growth Rate in Real Income for Private-Sector Workers, by Broad Occupation Group, 2018

Broad Occupation Group	2018 Income	2009–2018 Compound Annual Growth Rate (CAGR) (Percentage)
Engineering	$96,080	0.15
IT and computer science	$96,636	0.49
Life science	$78,057	–1.60
Physical science	$86,397	–0.40
Social science	$77,752	2.48
Non-STEM occupations	$57,880	–0.21

SOURCE: CPS CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Income growth in real terms was adjusted using the consumer price index for all urban consumers from the BLS.

To be clear, these reflect changes, on average, for workers in these occupations over the years *in the aggregate*, not what an individual worker has experienced in earnings growth over the period analyzed. It is also important to note that these are not to be confused with the earnings growth for a worker with a degree in one of these fields. A worker with a degree in a particular field may or may not actually work in the field and may switch in and out of it over time.

In Table 2.10 we show the 2018 incomes and 2009–2018 growth rates in real income for workers by age groups. Both STEM and non-STEM workers follow a similar pattern. Earnings are lowest for the youngest workers, and the differences in earnings between age groups are largest between the ages of 20 and 40 and then much tighter between the ages of 40 and 60. In non-STEM positions, for example, workers ages 40–44 earn $67,000, more than double the $26,000 earned by workers ages 20–24, but about the same as workers ages 60–64 ($68,000). For STEM workers, these are $102,000, $49,000, and $116,000, respectively. Within each age group, STEM workers outearn non-STEM workers. As far as real income growth since

Table 2.10. Mean Annual Income (2018) and Nine-Year (2009–2018) Annual Growth Rate for Private-Sector Workers, by Age Group and STEM Status, 2018

Age Group	2018 Income of Non-STEM Workers	2009–2018 CAGR (Percentage)	2018 Income of STEM Workers	2009–2018 CAGR (Percentage)
20–24	$26,353	–1.04	$48,664	0.93
25–29	$43,747	0.33	$75,920	1.45
30–34	$53,443	–0.35	$89,960	1.03
35–39	$61,119	–0.43	$96,451	0.24
40–44	$67,345	0.13	$102,486	–0.48
45–49	$66,675	–0.02	$100,623	–0.70
50–54	$67,772	0.03	$106,674	0.50
55–59	$68,534	0.40	$112,453	0.63
60–64	$67,777	–1.14	$116,259	0.91
65 or older	$69,446	0.52	$98,382	–0.81

SOURCE: CPS CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government.

the trough of the last recession, nearly all of the age groups we examined have minimal or even slightly negative income growth, ranging from rates of –1.0 to 1.0 percent. The exception is STEM workers ages 25–29 and 30–34, who saw 1.45-percent and 1.03-percent growth, respectively.

In Table 2.11 we compare the incomes and growth rates of workers in non-STEM and STEM positions by the subgroups we have followed so far: education, gender, race/ethnicity, and nativity. Understanding what private-sector STEM jobs pay, and how income varies by gender, race/ethnicity, and educational attainment is critical for understanding the pay premium for STEM versus non-STEM workers. There is a private-sector STEM earnings premium at all education levels with the exception of workers with advanced degrees. Non-STEM advanced degree holders earned $149,000 in 2018, compared with $127,000 for STEM advanced degree holders. For all other education categories, STEM workers earn comfortably more than their non-STEM counterparts—$10,000 more for master’s degree holders, $20,000 more for bachelor’s degree holders, $26,000 more for associate’s degree holders, and $25,000 more for technical certificate holders and workers without a postsecondary degree. Indeed, the difference between STEM and non-STEM earnings grows with less education. Moreover, STEM workers see a much tighter earnings band: the difference between the highest educational attainment and lowest educational attainment in terms of earnings is $127,000 compared with $67,000, a range of $60,000. In the non-STEM workforce, the difference is $149,000 to $41,000, a range of $108,000.

Although the time period we examine is from the trough of the most recent recession, 2009, nearly all of the education categories we examined posted little annual real income growth, or negative rates of growth, over that nine-year period. The fastest growth was among STEM technical certificate holders, at 1.0 percent.

Table 2.11. Mean Annual Income (2018) and Nine-Year (2009–2018) Annual Growth Rate of Private-Sector Workers, by Demographic Characteristics and STEM Status, 2018

Group	2018 Income of Non-STEM Workers	2009–2018 CAGR (Percentage)	2018 Income of STEM Workers	2009–2018 CAGR (Percentage)
Advanced degree	$148,723	–1.10	$126,913	0.33
Master's degree	$101,022	–0.24	$110,445	–0.28
Bachelor's degree	$74,467	–0.63	$95,436	–0.03
Associate's degree	$50,697	–0.63	$76,463	0.66
Technical college	$50,809	–0.17	$74,630	1.01
No degree/some college	$41,238	–0.45	$66,840	–0.10
Male	$64,506	–0.47	$99,557	0.27
Female	$49,152	0.28	$79,571	0.46
White	$65,187	–0.08	$95,449	0.05
Hispanic	$41,147	0.28	$80,674	0.10
Black	$43,003	–0.06	$77,797	0.37
Asian	$68,900	0.29	$106,345	1.30
White male	$73,453	–0.40	$100,056	0.12
White female	$54,008	0.55	$78,667	0.04
Hispanic male	$43,990	0.34	$82,945	–0.26
Hispanic female	$36,564	0.33	$71,884	1.94
Black male	$46,960	–0.20	$82,330	0.37
Black female	$39,226	0.00	$66,066	0.06
Asian male	$77,360	0.46	$111,015	1.26
Asian female	$59,440	0.03	$92,134	1.41
U.S. born	$59,548	–0.26	$91,020	–0.06
Foreign born	$51,376	0.21	$105,541	0.95

SOURCE: CPS CPS ASEC (via the U.S. Census Bureau).
Note: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The table excludes the "Other" race Census category from calculations, as it is too small for comparison. Income figures are expressed in real 2018 dollars.

Income of private-sector STEM workers varies by gender and race/ethnicity—though each gender and racial/ethnic group earned more in STEM than in non-STEM positions. The highest STEM earners are Asian men, with an average income reaching $111,000 in 2018, followed by white men, who earned an average of $100,000. Within every racial and ethnic group, men earned more than women. The difference between the genders is roughly even among whites ($21,000 in STEM and $19,000 in non-STEM positions) and Asians ($19,000 in STEM and $18,000 in non-STEM positions), but is much larger in STEM for Hispanics and blacks. The earnings difference among male and female Hispanic or black non-STEM workers is around $7,500 for both, though in STEM these differences are $11,000 and $16,000, respectively.

There is a similar dispersion across the highest- and lowest-earning groups in non-STEM positions (in which Asian men earn $38,000 more than black women, who earn $39,000) as in STEM positions (in which Asian men earn $39,000 more than Hispanic women, who earn $72,000). Finally, by nativity, foreign-born workers earn less than their native-born counterparts in non-STEM positions ($51,000, compared with $60,000), but earn more in STEM positions ($106,000, compared with $91,000). The growth rates are not far from zero for most gender, racial, ethnic, or nativity groups, reflecting little gains in real earnings since the last recession. In STEM only Asian men, Asian women, and Hispanic women posted annual real income growth of more than 1 percent.

When considering these disparities in income by gender, race/ethnicity, and nativity, it is important to keep in mind that educational attainment varies within these groups. As described above, workers with higher educational attainment tend to earn more, and to the extent that a demographic group is more highly educated on average, this can contribute to the observed income gap. Of course, the disparities in educational attainment may themselves reflect opportunity gaps or challenges in the STEM pipeline for these groups.

There are three key takeaways from our analysis of income data. First, it is clear that private-sector STEM workers earn more than their non-STEM counterparts, and this gap appears to be expanding. Even after weighting the non-STEM group so that it mirrored the STEM group in educational attainment, STEM workers *still* earned about 30 percent more, on average, in 2018. Second, the extent of the STEM premium varies by education level, with workers of lower educational attainment earning a larger premium over their similarly educated non-STEM counterparts than those with more education. Third, while working in STEM is associated with higher earnings across all gender and race/ethnicity groups, STEM is far from an equalizer. Disparities by gender and race/ethnicity that are present in the private-sector non-STEM workforce are present in the STEM workforce as well.

Benefits

The benefits offered by employers are an important part of the total compensation package and in determining whether a job is desirable. While there are limited data on benefits, and sample sizes are insufficient to parse by more granular characteristics such as by gender, race/ethnicity, or educational attainment, below we consider three types of benefits and how they vary between STEM and non-STEM workers in the private sector: health insurance, access to an employer-sponsored retirement plan, and access to paid leave.

Health Insurance

STEM workers in the private sector are more likely to have employer-sponsored health insurance than their non-STEM counterparts.[12] In 2018, 76.2 percent of STEM workers had health insurance through their employers, compared with 50.9 percent of non-STEM workers. Neither of these estimates has changed considerably since 2005, when 79.8 percent of STEM

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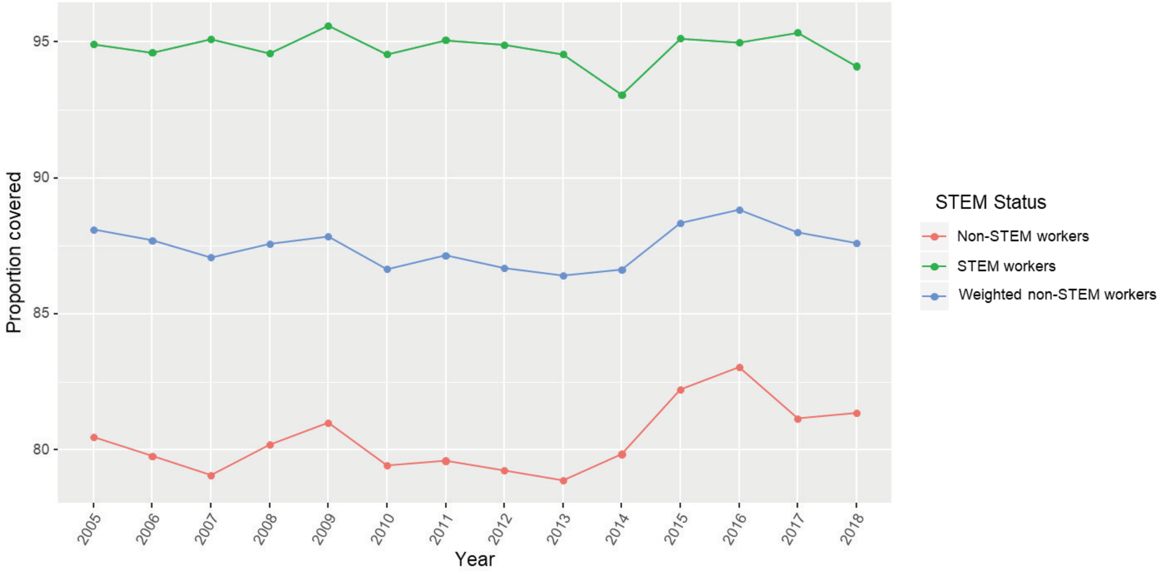
[12] Our data come from CPS ASEC. We use the INCLUGH variable, which indicates whether the respondent was included (i.e., was a policyholder) in a group health insurance plan related to a job that person held during the previous calendar year. Individuals who are not offered a plan or who do not take up an offered plan could still have health insurance, either privately or through a spouse's employer, but we do not tabulate that here.

workers and 52.7 percent of non-STEM workers had health insurance through their employers (see Figure 2.7). Overall, STEM workers have much higher rates of employer-sponsored health insurance. However, when non-STEM workers are weighted to have the same educational attainment distribution, the weighted non-STEM average is higher. It is important to keep in mind that these figures, from the CPS ASEC, reflect whether respondents were policyholders in health insurance plans related to their job; individuals could have been offered insurance and declined to enroll, and/or could have been insured through plans that were not through their employers. In addition, these are full-time workers; an examination of access to health coverage that includes part-time workers or nonworkers would express much lower rates.

Figure 2.7. Distribution of Private-Sector Workers with Health Insurance Through Their Employers, by Weighted STEM Status, 2005–2018



SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTE: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government.

Retirement Plans

STEM workers in the private sector are also more likely to have employer-sponsored retirement plans, with about 47 percent having such plans in 2018, compared with just 33 percent of non-STEM workers, according to data from the CPS ASEC.[13] Even among weighted non-STEM workers, retirement plan coverage is much lower than for STEM workers. As with the share for

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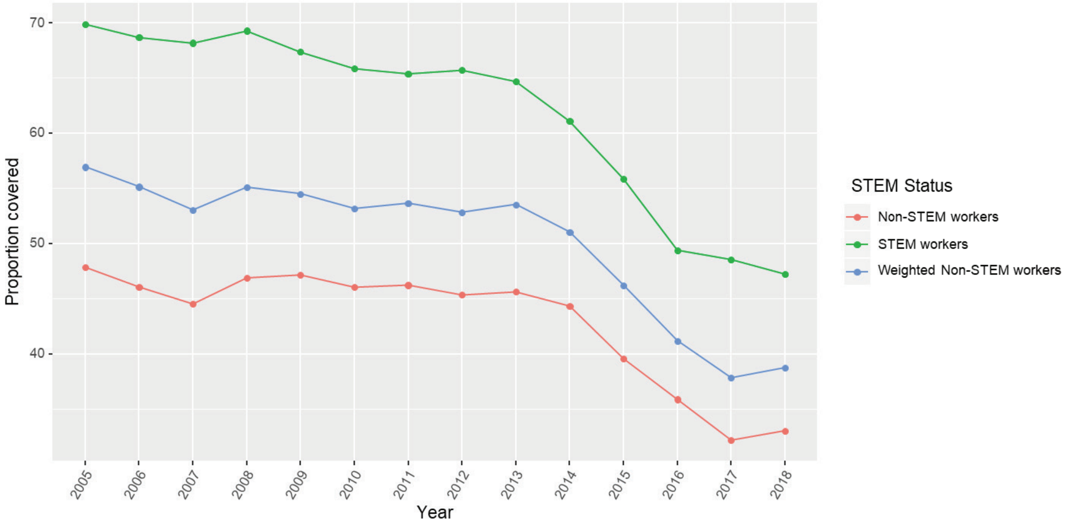
[13] We use the PENSION variable in CPS ASEC, which indicates whether the respondent's union or employer for his or her longest job during the preceding calendar year had a pension or other retirement plan for any of the employees and, if so, whether the respondent was included in that plan. The question specifically excluded retirement support from Social Security.

employer-sponsored health insurance, the share of workers with employer-sponsored retirement plans appears to have fallen over the 2005–2018 period for STEM, non-STEM, and weighted non-STEM workers, as shown in Figure 2.8. However, the sharp declines from 2013 to 2016 may be more reflective of changes in survey methodology than actual coverage changes (Copeland, 2018).

Figure 2.8. Distribution of Private-Sector Workers with Employer-Sponsored Retirement Plans, by Weighted STEM Status, 2005–2018



SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTE: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government.

Paid Leave

Data by occupation on access to paid leave are limited. The most current data come from the 2011 ATUS, and they do not identify whether the leave to which workers have access includes sick leave, family leave, or vacation time.[14] This survey found that 84 percent of STEM workers in the private sector had access to paid leave, compared with just 60 percent of workers in the private sector in non-STEM occupations.

Summary of Benefits

While there are limited data on access to benefits that can be parsed between STEM and non-STEM workers, the data we were able to obtain and analyze consistently showed that STEM workers were more likely to have access to benefits in the workplace. Both employer-sponsored health insurance and employer-sponsored pension rates fell from 2005 to 2018 for both STEM

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[14] The RCVPDLV variable in ASEC reports whether the respondent received paid leave for the job at which he or she worked the most hours in the previous week.

and non-STEM workers, but STEM workers fared better both then and now. Though we have just one data point on access to paid leave, this likewise showed that STEM workers were more likely to have access to this benefit than their non-STEM counterparts in the private sector.

Regression Analysis

Throughout this chapter we have compared the means of STEM workers in the private sector with non-STEM workers. We have found several trends:

- For workers with a college degree or more, STEM workers work shorter hours than non-STEM workers.
- STEM workers earn more than non-STEM workers when comparing workers with the same levels of educational attainment, genders, or races/ethnicities.
- There are disparities within STEM between the earnings of men and women, as well as between whites and underrepresented minorities (blacks and Hispanics).
- STEM workers are more likely to have health insurance and retirement plan coverage from their employers.

However, as we noted at the beginning of this chapter, the composition of the STEM workforce is very different from the non-STEM workforce in the private sector. It has higher educational attainment and is less diverse. The differences between STEM and non-STEM workers could still be attributed to the differences in composition within groups (i.e., the educational attainment of black workers) as well as difference in composition of groups (i.e., the share of workers who are black).

To account for the compositional differences of STEM and non-STEM workers, we use regression analysis, which estimates the statistical relationship between a dependent variable and a set of independent variables (often referred to as controls). A regression's output is a series of coefficients, which numerically define the relationship between the dependent variable and an independent variable, controlling for all others. In effect, regressions allow us to control for the compositional differences of STEM and non-STEM workers. They also allow us to control for the compositional difference *within* STEM workers, such as the difference between men and women. For these regressions, we use the CPS ASEC for the years 2009–2018.

Comparing STEM and Non-STEM Workers

In Table 2.12 we show the coefficients on being a STEM worker on dependent variables of interest—an indicator for whether an individual worked more than 45 hours in a usual week, annual income (in real 2018 dollars), an indicator for having a retirement plan through work, and an indicator for having health insurance.[15] For each dependent variable we show two STEM coefficients; the first is without any controls in the regression, which is just the mean difference

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[15] These variables in ASEC are UHRSWORKLY (usual hours of work per week at main job), INCWAGE (total pretax wage and salary income), PENSION (whether union or employer for the longest job held in the previous year has a pension or retirement plan), and INCLUGH (whether an individual has health insurance from his or her own employer).

Table 2.12. Regression Coefficients on an Indicator for Being a STEM Worker, Based on Four Dependent Variables

	STEM Coefficient—No Controls (Mean Difference Between STEM and Non-STEM Positions)	STEM Coefficient—with Controls (Difference Between STEM and Non-STEM Positions, Controlling for Composition)
Worked more than 45 hours in a usual week	0.036*** (0.002)	–0.041*** (0.002)
Real income (in 2018 dollars)	$39,728*** (362)	$13,455*** (376)
Has employer retirement plan	0.138*** (0.003)	0.181*** (0.001)
Has health insurance	0.085*** (0.002)	0.244*** (0.002)

SOURCE: CPS CPS ASEC (via the U.S. Census Bureau).
NOTES: The table shows the coefficients on a STEM dummy for two regressions for each of the four dependent variables listed in the first column. The first regression (left) includes no controls and only the STEM dummy; the second regression (right) includes controls for educational attainment, age, age squared, gender, region, urban/rural status, and year. Standard errors are shown in parentheses beneath coefficient estimates.
Stars indicate significance at the 10 (*), 5 (**), and 1 (***) percent level.

between the STEM and non-STEM groups, and the second is with a full set of controls. The controls are levels of educational attainment, gender, race/ethnicity, age,[16] geographic region, location (urban versus rural), and year.

In the first row of Table 2.12 we show the coefficient on being a STEM worker when the dependent variable indicates whether a worker works more than 45 hours in a usual workweek. The mean coefficient is 0.036; given that the dependent variable is a dummy, this coefficient can be interpreted as a percentage-point difference, or, a STEM worker is 3.6 percentage points more likely to report long hours. Because this does not include any controls, 0.036 is the difference in means between the two (STEM and non-STEM) groups. Controlling for the composition of the workforces, however, the coefficient changes sign to –0.041, or, a STEM worker is 4.1 percentage points *less likely* to report long hours. Although it is tempting to label this the "STEM effect," a regression alone does not signify causality but expresses a statistical relationship. Hence, we can say that STEM workers are less likely to work long hours, not that being in STEM reduces hours of work—a subtle, but key, difference.

In the second row of Table 2.12 we show the STEM coefficient on annual earned income. The mean difference in income between STEM and non-STEM workers is nearly $40,000 ($39,728). After including controls, this falls to $13,455, or, the "STEM premium" on wages is $13,455. Again, this is not to say that being in STEM increases wages $13,455 more than is expected, but that workers in STEM earn $13,455 more in wages.

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[16] In the regression, we include age and age squared, the preferred practice in wage-determinant regressions.

In the bottom two rows of Table 2.12 we show the STEM coefficients when the dependent variables are again binary, indicator variables: having a retirement plan through work and reporting health insurance coverage. For both, the mean difference is positive. STEM workers are 13.8 percentage points more likely to have an employer retirement plan, and 8.5 percentage points more likely to have health insurance. In both, the coefficient *increases* after controlling for composition of the STEM and non-STEM workforces, to 18.1 percentage points and 24.4 percentage points, respectively.

The aim of these regressions is to isolate how much of what we observe in the difference between STEM and non-STEM workers is associated with being a STEM worker versus a result of having, on average, higher levels of educational attainment, more male workers, more white workers, and workers of different ages. What they show is that there is indeed some kind of STEM premium—shorter hours, higher income, and more likelihood of having retirement benefits and health insurance—that while not necessarily caused by being in STEM are associated with being in STEM.

Comparing Groups of STEM Workers

A basic regression controls for the differences in compositions of groups—or, at least, the differences that are observed and measured. They estimate the mean relationship between variables. This would include, for example, controlling for education level in examining annual income controls for the average income return for having a bachelor's degree. In some cases, though, that average is insufficient, because the relationship between a bachelor's degree and income varies systematically by group. A more advanced regression technique—the Oaxaca-Blinder decomposition (Blinder, 1973; Oaxaca, 1973; Oaxaca and Ransom, 1994)—isolates how much of a difference observed between groups can be explained by the controls and how much is unexplained. Oaxaca-Blinder was developed, and is widely used, to understand labor market disparities and especially labor market discrimination.

We use Oaxaca-Blinder to examine the annual earnings of STEM workers as they vary by gender and race/ethnicity. In Table 2.13 we show the estimates from three decomposition regressions, in which we control for levels of educational attainment, age, geography, urban/rural status, and year. Because we are comparing gender and racial groups, we do not include controls on gender or race/ethnicity in any of the regressions. Further, because we are looking within the STEM workforce, we add controls for STEM occupation category and usual hours worked per week.

For each comparison group we show the estimated mean income for the groups being compared and the difference. We then decompose that difference into endowments and coefficients. The endowment estimate examines the question of whether one group's workers *had the same credentials* as the other group's workers—the same age, educational attainment, usual hours, and STEM occupation. The coefficient estimate examines the question of what would happen if the *return for those credentials* were the same for both groups. These are also sometimes referred to as the explained and unexplained differences, and the coefficient or

Table 2.13. Regression Coefficients from the Oaxaca-Blinder Decomposition of Earnings Differences Between Groups of STEM Workers

	Group Comparison: Female^ Versus Male	Group Comparison: Nonwhite^ Versus White	Group Comparison: Underrepresented Minorities^ Versus Whites and Asians
Group 1^ Mean	$74,704***	$87,377***	$74,372***
	(580)	(616)	(715)
Group 2 Mean	$93,943***	$90,432***	$91,694***
	(420)	(428)	(388)
Difference	–$19,239***	–$2,769**	–$17,322***
	(716)	(750)	(814)
Endowments	–$743*	$1,871***	–$6,407***
	(362)	(385)	(482)
Coefficients	–$17,888***	–$5,520***	–$10,706***
	(683)	(739)	(881)

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: The table shows select coefficients from three Oaxaca-Blinder decompositions. The linear estimate is the mean difference between the two groups being compared, and the decomposition of that difference is broken down into the endowment (if one group had similar observable characteristics) and the coefficients (if one group had similar return to coefficients). Not shown is the interaction term, which is not interpretable or significant; it is –$498 (209) for women, $879 (430) for whites, and –$63 (435) for underrepresented minorities. Each decomposition includes controls for education, stem occupation, age, age squared, region, urban/rural status, usual hours worked per week, and year. Standard errors are shown in parentheses beneath coefficient estimates.
^ Indicates Group 1, which is noted also in the column heads.
Stars indicate significance at the 10 (*), 5 (**), and 1 (***) percent level.

unexplained estimate is also sometimes referred to as the discrimination estimate (Elder, Goddeeris, and Haider, 2010; Fortin, Lemieux, and Firpo, 2011).

We first compare female and male STEM workers. Average female earnings are $74,704, and average male earnings are $93,943, a difference of $19,239. The endowment estimate—how much of the earnings difference is due to different education, age, or occupation between men and women in STEM—is small, at $743. The coefficient estimate—how much is due to the different returns from education, age, hours, or occupation—is nearly the size of the difference itself, or $17,888.[17] For the most part, lower female earnings among STEM workers cannot be explained by the educational attainment of women, their age, or their distribution within the broad five STEM groups.

We do not attribute all of the unexplained differences in earnings to discrimination against women. To start, there are many things we do not control for, such as experience (we only have age, an imperfect proxy), or the choices of men and women between firms within the private sector that may be more or less remunerative. There are many choices workers can make—

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[17] We do not discuss the interaction estimate, which when added with the coefficient and endowment estimate sums to the difference in means; it represents the simultaneity in the latter two and does not have a clear interpretation. The interaction estimate and standard error is –$498 (209).

conditional on having the same education, age, hours of work, and occupation—that could reduce earnings without any differential treatment of their productivity. However, prior research, which we discussed in Chapter One, has shown that women in STEM report discrimination in schooling and the workplace. Hence, interpreting the $17,888 decomposition is not entirely due to discrimination, but it is also not free of it.[18]

The next two groups we compare are racial and ethnic groups of STEM workers. We do this twice: first we compare majority-minority (white versus nonwhite—black, Asian, and Hispanic), and then we compare the represented and underrepresented (white and Asian versus black and Hispanic). Recall from our discussion earlier in this chapter that Asian workers are overrepresented in STEM compared with their share of the non-STEM workforce, but blacks and Hispanics are underrepresented.

Nonwhite STEM workers earn on average $87,573, compared with white STEM earnings of $90,343, a difference of $2,769. Notably, the endowment estimate is positive, at $1,871, but the coefficient estimate is negative, at –$5,520. If nonwhite workers had the same credentials—education, age, hours worked, and occupation—of white workers, they should earn $1,871 *more*, but with differing returns from those credentials, they earn $5,520 *less.* When we compare white and Asian STEM workers with underrepresented minorities, the mean earnings difference is $17,176, $6,407 of which is attributed to endowments and $10,706 of which is attributed to coefficients.[19] Again, we are careful in our attribution of the unexplained coefficient estimates entirely to discrimination given the unobserved and varying individual preferences for firms, industries, or work situations, but note that our previous discussion of the barriers and difficulties facing nonwhite workers in STEM would indicate that discrimination plays a role.[20]

Chapter Summary

In this chapter we analyzed the size and characteristics of the private-sector STEM workforce, exploring variation within it and comparing it with the non-STEM workforce in the private sector. We did so in isolation from our analysis of the federal STEM workforce that follows in Chapter Three and the comparison between these two workforces that we discuss in Chapter Four. Nonetheless, this deep dive into the private-sector STEM workforce is crucial for the analysis that follows—and for federal policymakers concerned with attracting STEM talent to

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[18] A complete discussion of market and individual preference determinants of women's earnings in the labor market and the gap between men's and women's earnings is beyond the scope of this study. For a history, see Goldin, 1992; for a review of recent work, see Goldin 2014; and for the most recent estimates, see Goldin et al., 2017.

[19] The interaction estimates and standard errors are $879 (430) and –$63 (435), respectively.

[20] As with the gender wage gap, a discussion of the racial wage gap and its many nuances is outside the scope of this report. For an overview, see Altonji and Blank, 1999; for issues in scope, see Chandra, 2000, and Chandra 2003; and for a discussion of preferences versus structural factors, see Grodsky and Pager, 2001.

fill jobs—for one core reason: private-sector employers are competitors for STEM workers, and private-sector STEM workers form the talent pool from which the government recruits.

To the extent that the private sector offers plentiful opportunities and strong compensation, the federal government would need to step up to match it. And if there are drawbacks to private-sector STEM work, or disparities that affect some groups more than others, these could present the government with opportunities to exploit them and attract workers to federal jobs. In our analysis, we found examples of both.

The private-sector STEM workforce is expanding at a faster rate than the private-sector non-STEM workforce—five times faster over the 2005–2018 period. The IT and computer science broad occupation drove about three-fourths of this growth and now accounts for more than half of private-sector STEM jobs. Engineers still represent about one in three private-sector STEM workers, but growth in this field was slower, and its share of the STEM workforce slipped in recent years as a result of the very strong growth in IT and computer science. Private-sector STEM workers have higher educational attainment than non-STEM workers, with about 75 percent holding at least a bachelor's degree versus just 30 percent of non-STEM workers. However, we find that STEM workers with lower educational attainment, while earning less than their better-educated STEM counterparts, enjoy larger earnings premiums over their similarly educated non-STEM counterparts. Thus, there are opportunities in STEM, up and down the educational attainment spectrum.

Average income, in the aggregate, is higher for STEM versus non-STEM workers in the private sector. The STEM premium, even when weighted for education levels of non-STEM workers, was 30 percent, suggesting that strong demand for STEM workers resulted in bargaining power for these workers to command higher pay. The consistently low unemployment rates in STEM versus non-STEM positions support the idea that the STEM labor market is tighter than the non-STEM labor market. Benefits also tip the scales toward STEM over non-STEM workers, as does our analysis of hours worked, with STEM workers putting in fewer hours per week than non-STEM workers, especially at the highest levels of education.

A persistent issue for the private-sector STEM workforce is the disparities in representation and pay by gender and race/ethnicity. More than three-fourths of private-sector STEM workers are men, and the share of women in STEM barely budged over the 13 years from 2005 to 2018. Outside of STEM, the share of women is more than 40 percent of the workforce. Racial and ethnic diversity has increased somewhat—a small improvement over the underrepresentation that prompted the NAS to warn that, without a more inclusive STEM workforce, the U.S. would fall behind in innovation (NAS, 2011). Yet the share of black workers and Hispanics in the private-sector STEM workforce remains low—just 14 percent in 2018, less than half the 32-percent share of black and Hispanic workers in private-sector non-STEM jobs.

Our regression analysis crystallized these findings by showing that, even controlling for compositional differences in the STEM and non-STEM workforces, STEM workers earn more, work less, and are much more likely to have retirement and health benefits through their employers. The decomposition analysis further showed that the makeup of groups *within* STEM cannot account for the disparities in pay that we have noted between men and women, whites and nonwhites, or represented and underrepresented groups.

In conclusion, the private sector does appear to offer plentiful and well-compensated jobs for STEM workers, but noted inequities persist. We now turn to our analysis of STEM workers in the federal government workforce.

3. The Federal Public-Sector STEM Workforce

This chapter analyzes compensation for STEM workers in the federal government. As in Chapter Two, in our discussion of STEM workers in the private sector, we begin by providing an overview of the number and distribution of these workers by several characteristics: occupation, educational attainment, gender, race/ethnicity, nativity, and age. We then consider several factors discussed in Chapter One that shed light on the desirability of working in a given field and the extent to which a job is a "good" job. These include the unemployment rate and usual hours worked per week. We devote particular attention to levels and trends in average annual income. We conclude with a brief discussion of benefits. All analyses in this chapter are restricted to full-time, permanent workers.

Unlike the private sector, which has a robust literature on the STEM premium, there is less evidence and understanding of how the STEM premium translates to the federal government. As an employer, the federal government has much more deliberate and enumerated hiring and pay policies that differ greatly from the private sector. To provide context, we give a brief overview of the most relevant hiring authorities in the next section. For further detail, we enumerate these policies in general and any that might have particular relevance to STEM in Appendix B. Given these policies, the strong prior assumption would be that there is little STEM premium in the federal government, which is associated with much tighter pay bands in its General Schedule (GS) pay scale (also discussed at length in Appendix B).

However, we find not only that STEM workers are a large part of the federal government but they have a significant premium over non-STEM counterparts with similar educational attainment. What is more, we also find that the equity issues in STEM in the private sector—underrepresentation of minorities and women with large pay disparities compared with white and Asian men—exists in the federal government, but to a much smaller degree.

The goal of this chapter is to provide an introduction to the STEM workforce within the federal government and, as in Chapter Two with the private sector, identify any patterns or determinants of compensation that could prove crucial in later chapters in which we make direct comparisons between the private and public sectors. Our definition of STEM is given in the previous chapter and documented in Appendix A.

Federal Hiring and Pay Authorities Related to STEM Fields

In Appendix B we detail the various hiring programs and authorities that the federal government uses to attract talented STEM employees. Due to their significance, we provide a brief summary of specialized hiring and payment authorities implemented by the federal government to target STEM talent.[1] These authorities are specific directives from the OPM that allow agencies to noncompetitively hire particular categories of individuals, whether based on attribute or expertise.[2] Four authorities highlight STEM fields, and thus present current opportunities for federal agencies to attract and retain STEM professionals:

- The Government-Wide Direct Hire Authority (GW-007). On October 11, 2018, the OPM issued this direct hire authority targeting GS-11 to GS-15 STEM-related positions. The authority seeks to streamline the hiring process for STEM positions to ideally make it easier to bring STEM professionals into federal agencies. It highlights ten STEM fields and positions for hiring, ranging from economists to civil engineers to biologists (OPM, undated c).
- The Critical Position Pay Authority (CPPA). This authority provides federal agencies with the power to set special pay rates for individuals in critical positions with specialized skills. Federal agencies may establish higher pay rates for individuals with specialized skills than those typically assigned for similar positions. This provides increased flexibility to provide incentives to individuals who may otherwise consider a private-sector position. While the authority can be applied broadly within federal agencies for all types of professional fields, the OPM issued a memorandum to federal agencies in 2014 stating that the critical position pay authority should be used to recruit individuals to fill critical STEM shortages. Arguing that the authority was underutilized in its 2014 memo, the OPM encouraged agencies to consider it specifically for STEM positions.
- Scientific or Professional Positions. This special category of positions represents the highest positions for scientists and professionals in the federal government that are not include in the executive level of service. There are currently 470 Scientific and Professional Positions across the federal government. Federal agencies have the opportunity to request additional positions or pools of positions to meet their agency's needs. In addition to requesting additional positions, agencies may offer salaries based on performance to attract talented individuals for advanced positions in STEM fields (OPM, undated x; OPM, undated y).
- The Federal Employees Pay Comparability Act (FEPCA): This act, passed in 1990, is best known for establishing locality pay for federal employees in an effort to more closely match private-sector earnings for comparable positions. However, the act's provisions also provide the President, and his or her pay agent, the power to establish special pay authorities and systems for occupations, including addressing gaps between federal and private-sector pay (Public Law 101-509, Sec. 5305, Special Pay Authority, and Sec. 5392, Establishment of Special Occupational Pay Systems). Though we were unable to find evidence of its implementation, this authority may offer another option for federal agencies seeking to attract talented individuals to STEM positions. The fiscal year (FY) 2020 budget of the Office of Management and Budget (OMB) includes a statement

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[1] Additional hiring and payment authorities that may be used to attract and retain STEM employees within the federal government are discussed in Appendix B.

[2] While assessment of these authorities and their use (or nonuse) is beyond the scope of this report, such assessments have been conducted. Examples include GAO, 2017; and Treasury Inspector General for Tax Administration, 2017.

that may allude to FEPCA authority and instructs the President's pay agent to analyze its use for hiring critical positions in STEM fields:

> In the coming year, the President's Pay Agent (consisting of the Directors of OMB and OPM and the Secretary of Labor) intends to exercise its authority to establish special occupational pay systems for occupations where the General Schedule classification and pay system are not aligned to labor-market realities. . . . In support of developing a workforce for the 21st Century under the PMA [President's Management Agenda], the President's Pay Agent will analyze use of this special authority to address challenges and develop new approaches for valuing and compensating work in high-risk, mission critical, and emerging occupations (e.g., economics, mathematics, information technology (IT), and other Science, Technology, Engineering, and Math (STEM) fields). (OMB, 2019, p. 71)

The central task of our report is to determine to what extent STEM workers in the federal government are competitively compensated; evaluations of these pay policies and their effect on pay, hiring, and retention of STEM workers was outside the scope of analysis. However, we note in the "Recommendations" section in Chapter Six that a full evaluation would be merited, and we note where relevant in this chapter that these and other pay plans may be attributing to the higher earnings that STEM workers within the federal government enjoy over their non-STEM counterparts.

Number and Distribution of Federal STEM Workers

There were approximately 320,000 STEM workers in the federal government in 2018, representing about 17 percent of the total federal workforce of 1.5 million workers, as shown in Figure 3.1.[3] The number of federal workers employed in STEM fields has remained fairly steady since 2005, hovering around 16–17 percent of federal workers over the 13-year period, even as the federal workforce grew.[4]

For the remainder of this section, we describe in detail the composition of the STEM workforce: the distribution of workers across agencies; by occupation across the STEM fields; and by age, educational attainment, gender, race/ethnicity, and nativity. As in the previous chapter, we compare STEM workers to non-STEM workers in order to provide context and support for understanding that STEM comprises a unique set of workers. Again, these comparisons should not be interpreted as prescriptive or what the STEM workforce should look like; they are comparative benchmarks rather than goals.

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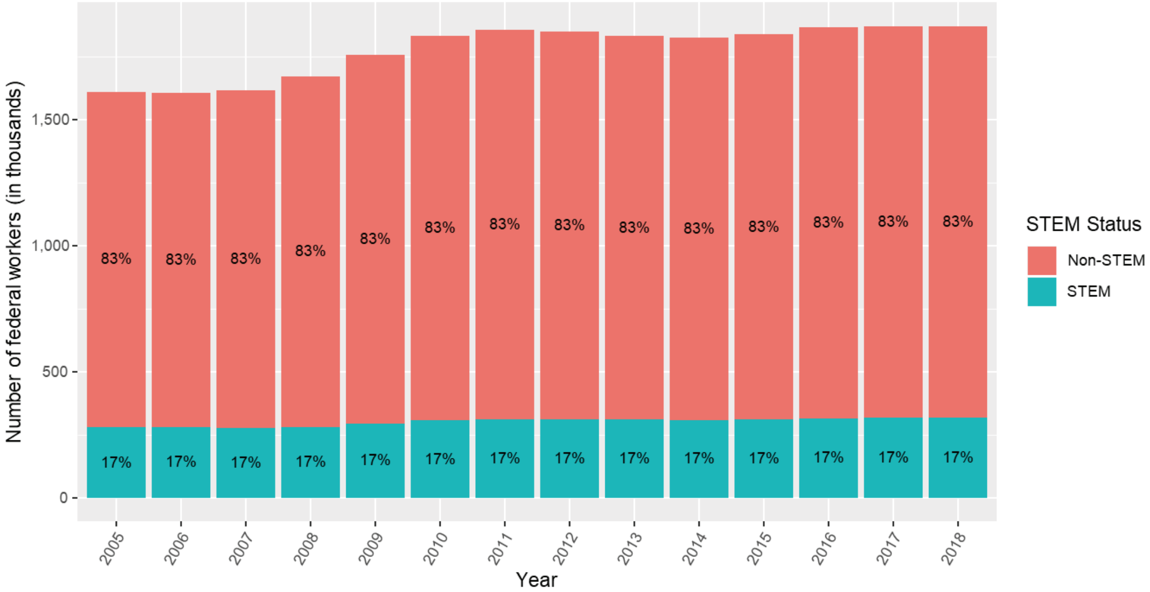
[3] The RAND definition of a STEM occupation does not encompass most health occupations, including career positions as nurses, medical officers, or pharmacists. These are considered non-STEM occupations.

[4] The following sections describing the composition of the federal STEM workforce primarily use three data sources. Data on the number of STEM employees and mean annual income, excluding gender and race/ethnicity, is from the OPM's FedScope database. From the FedScope database, we use individual-level records from September 2005 through September 2018. Data on unemployment, hours worked, and all demographic information are from the CPS, including its ASEC. Data on paid leave is from ATUS.

Figure 3.1. Number of Federal Workers, by STEM Status, 2005–2018



SOURCE: FedScope (via OPM).

STEM Workers by Federal Agency

In 2018, 102 of 124 federal agencies reported having at least some employees working in a STEM position.[5] As is shown in Figure 3.2, the 20 federal agencies with the highest number of STEM employees range from a low of 1,000 in the Nuclear Regulatory Commission to a high of 64,100 employees in the U.S. Navy. DoD agencies are clearly large federal employers of STEM workers, as the Departments of the Navy, Army, and Air Force all hold spots among the top five agencies for total STEM workers. The Department of Veterans Affairs, closely linked to DoD, holds the fourth spot. The third-largest employer of STEM workers within the federal government, the U.S. Department of Agriculture (USDA), is the only non-DoD-related agency in the top five.

While these agencies employ the largest numbers of STEM employees within the federal government, it is important to note that these large numbers may reflect the size of the agencies themselves, as larger agencies can employ more workers overall. Consequently, looking at the percentage of STEM employees within an agency provides a different perspective as to which agencies have a high concentration of STEM employees. Figure 3.3 displays the 20 agencies with the highest percentage of STEM employees in their workforce.[6] Important differences exist between these agencies and those depicted in Figure 3.2. The top agencies by share of

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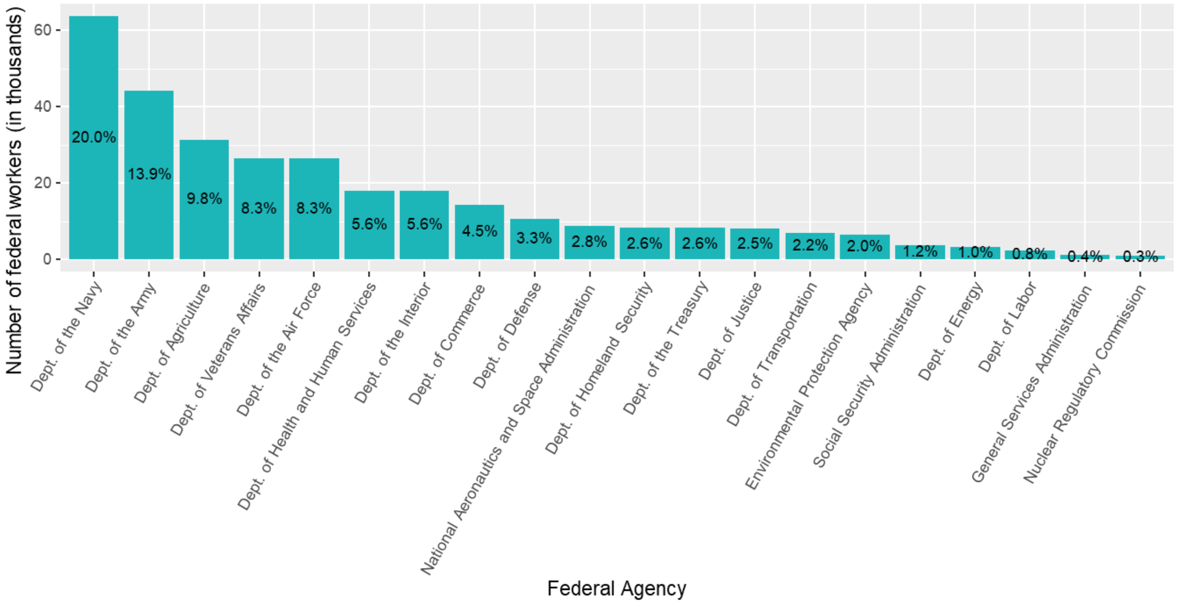
[5] The 124 agencies come from the OPM's classification of federal agencies within the FedScope data set.

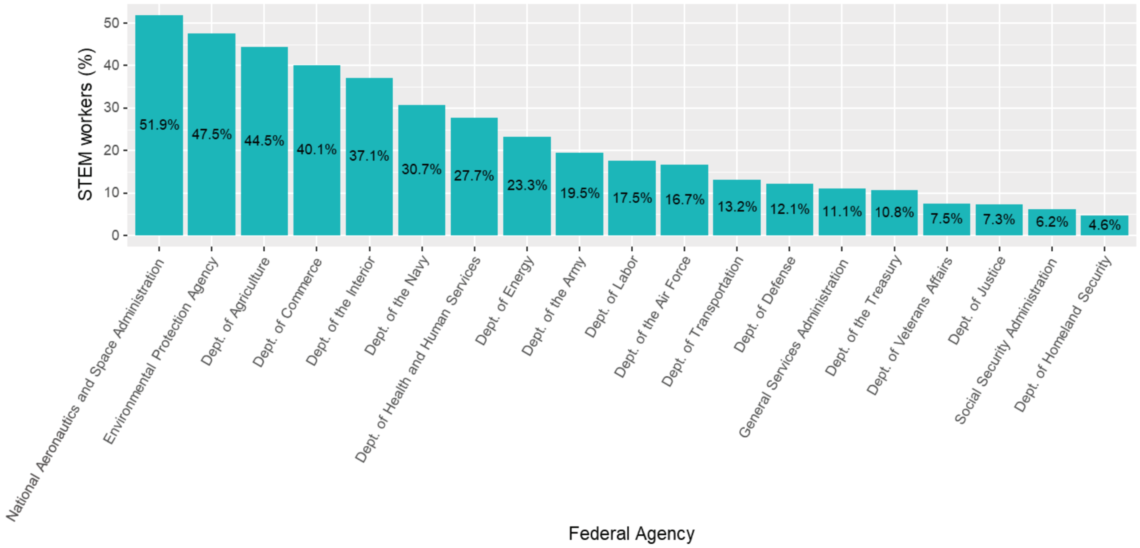
[6] Excluded from this list is the Court Services and Offender Supervision Agency for the District of Columbia, which has a very high share of STEM workers, likely because 56 percent of employees are classified by the OPM as "Social Science, Psychology, and Welfare—Social Science." These workers are likely social workers.

Figure 3.2. Number of Federal STEM Workers, by Federal Agency, 2018



SOURCE: FedScope (via OPM).

Figure 3.3. Distribution of STEM Workers, by Federal Agency, 2018



SOURCE: FedScope (via OPM).
NOTE: This figure only includes agencies that have 1,000 or more STEM employees.

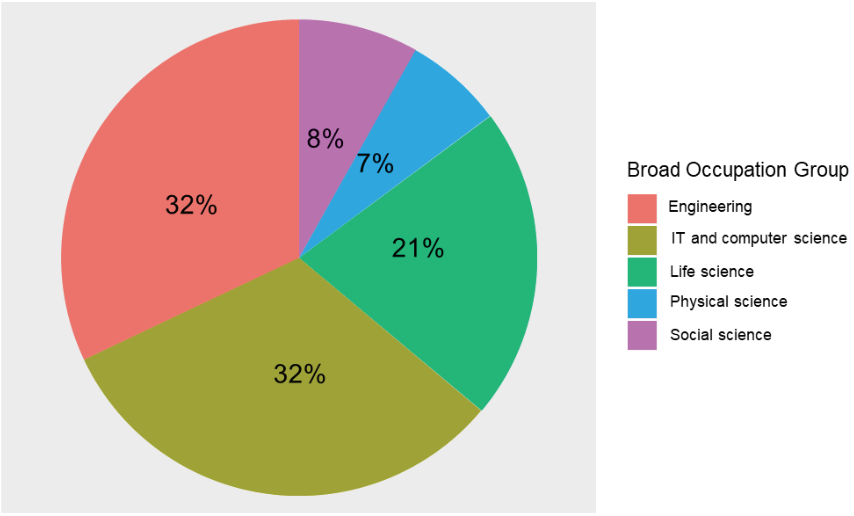
STEM workers are not DoD agencies, but rather those that have a STEM-related mission set, including the National Aeronautics and Space Administration, the Environmental Protection Agency, the Department of Commerce (where the National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology are housed), the NSF, the Department of the Interior, and the Nuclear Regulatory Commission. Notably, the USDA holds third place for both measures, thus serving not only as one of the largest employers of STEM workers, at 46,100 employees, but also one of the most concentrated STEM employers, with 45 percent of its workforce in STEM positions.[7] The Department of the Navy, the largest STEM employer, also has a high share, at 31 percent.

Overall, STEM workers are distributed widely and unevenly across the agencies of the federal government. Some agencies are prominent STEM employers in that they have a large number of individuals in STEM positions. Others are STEM oriented, in that a higher percentage of their agency's population hold STEM positions. This could be relevant for any STEM-related hiring policy in that it has to take into account that there are large STEM employers and concentrated STEM employers, and only a few—such as the USDA and the Department of the Navy—that are both.

Occupational Distribution

Our research grouped the hundreds of individual STEM occupations into five distinct disciplines, which we refer to as occupational groups: engineering science, IT and computer science, life science, physical science, and social science.[8] The two largest occupational groups are engineering science (32 percent) and IT and computer science (32 percent), followed by life science (21 percent), social science (8 percent), and physical science (7 percent); see Figure 3.4.

Figure 3.4. Distribution of Federal Workers, by Broad Occupation Group, 2018



SOURCE: FedScope (via OPM).

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[7] This may not be surprising given the rise of food and agriculture positions over the past few years. The USDA and Purdue University projected that the food and agriculture industry would expand from 2015 to 2020, with approximately 27 percent of those positions being in STEM fields. See Smith et al., undated.

[8] It is important to note again that our data did not include as part of the STEM field individuals who work in the medical and health disciplines.

The overall distribution among the five disciplines—shown for the most recent year of data, 2018—has not changed dramatically in the past 13 years, though there has been considerable growth in the absolute number of STEM workers in certain disciplines. The IT and computer science category saw the largest growth, with an average annual growth rate of 1.9 percent from 2005 to 2018, and a total growth of 24,000 jobs. This is unsurprising given the increased use and application of technology overall and within government operations. A smaller but steady growth can also be seen within the social sciences, which increased by 8,100 jobs over the same time period, at a 2.7-percent annual rate. Engineering science increased by 3,100 jobs, at a 0.2-percent annual rate; life sciences increased by 4,300 jobs, at a 0.5-percent annual rate, and physical science saw a decline by 124 jobs, at a 0.04-percent annual rate.

Age Distribution

The age distribution of both STEM and non-STEM workers within the federal workforce has remained relatively stable since 2005, the beginning year for our study. In Table 3.1 we show the age distribution in 2018, the most recent year of data, as well as the difference between non-STEM and STEM distribution in the final column. STEM workers have a higher share among the youngest workers (29 years of age and younger) and oldest workers (55 years of age and older) than in the federal non-STEM workforce, but slightly lower shares among the middle of the worker age distribution (30–54 years of age). However, these differences are minor. For both, prime-age workers (ages 25–54) make up just over two-thirds of the workforce, 69.8 percent of non-STEM workers, and 67.5 percent of STEM workers in the federal government.

Although the older and younger STEM workers are slightly more represented, these age distributions are very similar. There is no distinct age bubble for either STEM or non-STEM workers. We also found that no age group is far outpacing growth rates for any other age

Table 3.1. Distribution of Federal Workers, by Age Group and STEM Status, 2018

Age Group	Distribution of Non-STEM Workers (Percentage)	Distribution of STEM Workers (Percentage)	Percentage-Point Difference
20–24	1.2	1.9	0.71
25–29	4.7	5.4	0.75
30–34	9.9	9.7	–0.18
35–39	13.1	12.6	–0.47
40–44	12.0	11.8	–0.16
45–49	14.2	12.7	–1.47
50–54	16.0	15.2	–0.80
55–59	15.2	16.1	0.81
60–64	9.3	9.7	0.38
65 or older	4.4	4.9	0.46

SOURCE: FedScope (via OPM).
NOTE: The table shows the shares of non-STEM and STEM workers in federal government by age; columns sum to 1.

group, for either STEM or non-STEM workers. Among STEM workers in the federal government since 2005, workers under the age of 30 have grown at a 0.2-percent annual rate, workers ages 30–55 at a 0.6-percent annual rate, and workers ages 55 and over at a 2.6-percent rate, compared with rates of 0.8 percent, 0.1 percent, and 3.2 percent, respectively, for federal non-STEM workers. Again, the rates are slightly different, but mainly apace.

Education Level

STEM workers in the federal government are more educated than non-STEM workers. In Table 3.2 we compare the number of workers across seven educational levels, ranging from no degree/some college to advanced degrees. They have twice the share with an advanced degree, at 10.4 percent, compared with 5.9 percent, and much higher shares of those with master's degrees (24.3 percent, compared with 15.2) or bachelor's degrees (40.7 percent, compared with 27.0). Overall, 75 percent of STEM workers have at least a bachelor's degree, compared with 48.1 percent of non-STEM workers, while non-STEM employees have close to double the share of employees with no degree or some college (41.6 percent, compared with 19.4 percent).

Table 3.2. Distribution of Federal Workers, by Education Level and STEM Status, 2018

Terminal Education Level	Distribution of Non-STEM Workers (Percentage)	Distribution of STEM Workers (Percentage)
Advanced degree	5.9	10.4
Master's degree	15.2	24.3
Bachelor's degree	27.0	40.7
Associate's degree	7.2	4.4
Technical college	3.1	0.8
No degree/some college	41.6	19.4

SOURCE: FedScope (via OPM).
NOTES: Advanced degrees include J.D.'s, M.B.A.'s, M.D.'s, and Ph.D.'s. Counts include employed and unemployed workers.

Within the STEM workforce we see modest yet steady growth in the two highest levels of education since 2005 (see Figure 3.5). The share of advanced degree holders increased from 10.1 percent in 2005 to 12.1 percent in 2018, and the overall number of advanced degree holders employed in the federal government increased from about 72,000 in 2005 to 115,000 in 2018, a 60-percent increase. Over those years the share of master's degree holders increased as well. The percentage of master's degrees increased from 18.5 percent in 2005 to 23.1 percent of the federal STEM workforce in 2018. Similarly, the number of master's degree holders increased 48 percent, from about 56,000 in 2015 to 83,000 in 2018. Bachelor's degree holders have continually made up the largest share of STEM workers in the past 13 years. Yet despite a growth in the total number of federal STEM employees with bachelor's degrees since 2005, their share of the STEM population has actually decreased over the same time period as other degree levels increased in their share.

Figure 3.5. Number of Federal Workers, by Education Level and STEM Status, 2005–2018

SOURCE: FedScope (via OPM).

Overall, the federal government has and continues to hire STEM workers at every education level, but more so at the highest degree levels. Thus, the federal STEM workforce is more educated today than it was in 2005.

Gender and Race/Ethnicity

STEM workers in the federal government are less diverse than their non-STEM counterparts (see Table 3.3), and disproportionately white and male. Half of STEM workers are white men, compared with 33.7 percent of non-STEM workers, and in total, 70.2 percent of STEM workers are white, compared with 59.2 percent of non-STEM workers, and 68.7 percent of STEM workers are male, compared with 53.4 percent of non-STEM workers. Asian men are also overrepresented in STEM, at 5.7 percent, compared with 2.8 percent of non-STEM workers. Every other gender and racial/ethnic group has smaller STEM shares; most notably, black women comprise 13.1 percent of non-STEM workers and 7.1 percent of STEM workers.[9]

Given that women are a smaller share of STEM workers, the shares of individual racial/ethnic groups are very low. However, one question is whether the racial/ethnic distribution of female workers, rather than all workers, also changes within STEM. As we noted in Chapter Two's discussion of diversity in the private-sector STEM workforce, women in STEM have a small

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[9] The OPM data that were available publicly did not include information on the gender *and* race/ethnicity of workers. However, federal government workers are identifiable in the CPS, and these data and this discussion are drawn from CPS data.

piece of the pie, but do certain groups have a smaller piece of that pie? The federal STEM female workforce is 64.2 percent white, 6.3 percent Hispanic, 22.4 percent black, and 6.9 percent Asian, compared with shares of 55.1 percent, 10.7 percent, 28.4 percent, and 5.7 percent in the female non-STEM federal workforce. In other words, women are underrepresented in STEM relative to their share of the non-STEM workforce; however, among female STEM workers, white women and Asian women are overrepresented, again relative to their share of the federal non-STEM female workforce.

Table 3.3. Distribution of Federal Workers, by Demographic Characteristics and STEM Status, 2018

Group	Distribution of Non-STEM Workers (Percentage)	Distribution of STEM Workers (Percentage)
Male	53.4	68.7
Female	46.6	31.3
White	59.2	70.2
Hispanic	12.6	7.6
Black	22.8	14.2
Asian	5.4	7.9
White male	33.7	49.9
White female	25.5	20.3
Hispanic male	7.6	5.6
Hispanic female	5.0	2.0
Black male	9.6	7.1
Black female	13.1	7.1
Asian male	2.8	5.7
Asian female	2.6	2.2
U.S. born	87.4	85.2
Foreign born	12.6	14.8

SOURCE: CPS (via the U.S. Census Bureau).
NOTE: The table excludes the "Other" race Census category from calculations, as it is too small for comparison.

However, the federal STEM workforce has become more diverse since 2005, the year at the beginning of our study window. At that time, a full 80 percent of federal STEM workers were white. Over that period, the fastest growing groups were black women, at a 7.2-percent rate; black men, at a 5.9-percent rate; Hispanic women, at a 4.8-percent rate; Asian men, at a 3.6-percent rate; and Asian women, at a 2.9-percent rate. The employment of white men (0.1 percent), white women (1.1 percent), and Hispanic men (1.3 percent) grew at much slower rates. At the same time, white men, white women, black men, and Hispanic men experienced *negative* growth among federal non-STEM workers, and the fastest-growing non-STEM group was Hispanic women (at 2.3 percent).

Foreign-Born Workers

STEM workers in the federal government are only slightly more likely to be foreign born than their non-STEM counterparts. About 14.8 percent of federal STEM workers are foreign born, compared with 12.6 percent of non-STEM workers. The foreign-born share has also increased since 2005, with a 10.9-percent growth in STEM workers and a 10.7-percent growth in non-STEM workers.[10] It is important to note that 44 percent of the overall foreign-born population was naturalized as of 2010 (Grieco et al., 2012). In terms of growth rates, foreign-born workers in STEM grew at a 3.4-percent annual rate, and non-STEM workers grew at a 1.5-percent annual rate. For both, this was faster than native-born growth rates of 1.0 percent (STEM workers) and 0.3 percent (non-STEM workers).[11]

As was described in Chapter One, several visa programs (including H1-B and F-1 visas) draw foreign-born workers, and STEM workers disproportionately, into the U.S. workforce on a temporary basis. However, these visas do not apply to the federal government; federal workers are required to be naturalized citizens. Foreign-born workers include naturalized U.S. citizens in addition to these temporary workers and other noncitizen residents. If it is the case that a large share of STEM workers are the nonnaturalized foreign born, the federal government cannot compete for them as an employer. For many STEM disciplines, large proportions of students at U.S. universities are foreign nationals, and the proportion of foreign nationals is much higher in graduate, as compared with undergraduate, programs (National Research Council, 2012, pp. 89–90).

Summary of the Number and Distribution of Federal STEM Workers

STEM workers represent a relatively large share of the full-time federal workforce (17.7 percent in 2018), and growth in STEM jobs outpaces growth in non-STEM jobs. Within the federal government, the large agencies also tend to be large STEM employers—in particular, the Department of the Army, Department of the Air Force, the rest of DoD, and the Veteran's Administration. However, there are smaller agencies that have much higher concentrations of STEM employees, such as the National Aeronautics and Space Administration, the Environmental Protection Agency, and the Department of Commerce. The only two agencies that are both large and concentrated are the USDA and the Department of the Navy.

About two-thirds of STEM workers are split between the engineering field and IT and computer science. With respect to education, we found that STEM workers in the federal government tend to be highly educated in comparison with non-STEM workers—about

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[10] Foreign-born status is reported in the CPS under the "Nativity" variable, which classifies each person as native born or foreign born (i.e., whether the person is a first-generation immigrant) and further specifies whether the parents of a native-born person were native born or foreign born (i.e., whether the person is a second-generation immigrant). "Nativity" is constructed from information in the variables, which respectively report the place of birth of the respondent and his or her father and mother. Persons born in outlying U.S. territories and possessions and those born abroad to U.S. parents are treated as foreign born in "Nativity."

[11] As with race/ethnicity data, the OPM data that were available publicly did not include nativity. However, federal government workers are identifiable in the CPS, and these data and this discussion are drawn from CPS data.

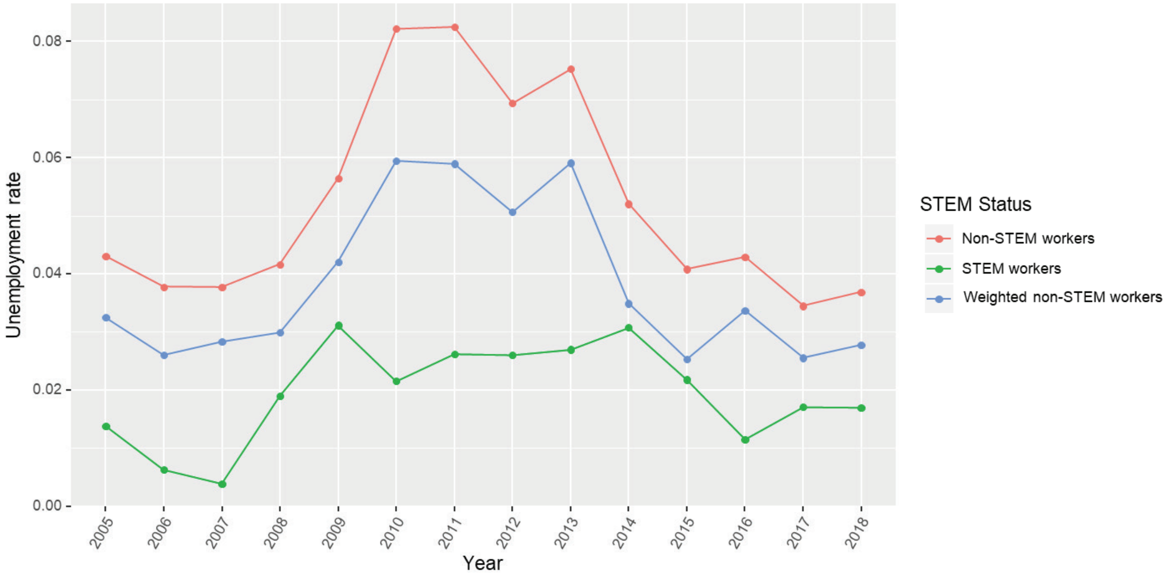
75 percent of STEM workers had at least a bachelor's degree, compared with just about 40 percent of non-STEM workers.

We also found that the federal government is not insulated from the diversity issues that were present in the private sector, and despite progress toward greater racial diversity, white male workers are overrepresented in the federal STEM workforce and women in general, but black and Hispanic women in particular, are underrepresented compared with the shares of the federal non-STEM workforce. However, the foreign-born share is higher among STEM than non-STEM workers in the federal government, at 14.8 percent, compared with 12.6 percent.

The Unemployment Rate

Unemployment rates measure the share of individuals out of work and actively searching for a position as a share of all of those out of work. As we noted in Chapter Two, unemployment rates are a key statistic in understanding the "tightness" of a labor market. From the workers' perspective, this indicates how much leverage they have to bid up wages, and from the employer's perspective, it indicates how much competition there is for workers. The occupation or industry—in this case, federal STEM workers—represents the last position an employee held before being unemployed. Figure 3.6 therefore shows the share of federal STEM workers who are not working but are currently looking for a job divided by all federal STEM workers (those working and not); note that this does not require that they be looking for a job in the sector or occupation in which they were last employed, but looking for any job. This measure provides a good indication of the number of individuals who have lost or quit their federal position and are seeking a new one. As Figure 3.6 shows, federal STEM employees experience a lower unemployment rate than federal

Figure 3.6. Unemployment Rate of Federal Workers, by STEM Status, 2005–2018



SOURCE: CPS (via the U.S. Census Bureau).
NOTE: "Weighted non-STEM workers" is the unemployment rate of non-STEM workers adjusted to match the educational attainment rates of STEM workers.

non-STEM employees in both recessions and economic expansions. Even when federal non-STEM workers are reweighted to reflect the educational attainment distribution of STEM workers, federal STEM unemployment rates are still lower.

Within STEM, we note that there is little difference between the broad occupation groups in unemployment. All of the groups have unemployment rates of 1.0–3.5 percent in 2018, compared with the average STEM unemployment rate of just under 2.0 percent. These rates are very low and indicate there is little variation in tightness across broad categories of STEM occupations. Moreover, the sample sizes within STEM, year, and occupation in the CPS get quite small, and the rates within category should not be interpreted meaningfully aside from the conclusion that they are all quite low.

Table 3.4 presents the average unemployment rate for federal STEM workers by age group from 2005 to 2018 to determine if unemployment affects workers at different stages of life. Overall, federal STEM workers experience a lower unemployment rate throughout their careers compared with their non-STEM counterparts. The biggest difference between these two groups occurs during the earliest stages of their careers, with only a 5.3-percent unemployment rate for those between the ages of 20 and 24 in STEM fields compared with a 21-percent unemployment rate for non-STEM workers. Both groups experience higher unemployment rates at the start and end of their careers, with their lowest rates occurring between the ages of 40 and 59. STEM workers are especially steady, with only two age groups experiencing more than a 4-percent unemployment rate, and the remaining groups falling under 3 percent.

Table 3.4. Unemployment Rate of Federal Workers, by Age Group and STEM Status, 2005–2018 Average

Age Group	Unemployment Rate of Non-STEM Workers (Percentage)	Unemployment Rate of STEM Workers (Percentage)
20–24	21.0	5.3
25–29	10.7	2.9
30–34	6.8	2.0
35–39	4.3	1.7
40–44	3.7	1.5
45–49	2.8	1.1
50–54	2.7	1.2
55–59	3.1	1.8
60–64	4.0	2.4
65 or older	8.0	4.6

SOURCE: CPS (via the U.S. Census Bureau).

NOTE: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government.

In Table 3.5 we show the average unemployment rate between 2005 and 2018 in key demographic groups: by education, gender, race/ethnicity, and nativity. Between STEM and non-STEM workers, STEM workers experienced lower unemployment rates across all

Table 3.5. Unemployment Rate of Federal Workers, by Demographic Characteristics and STEM Status, 2005–2018

Group	Unemployment Rate of Non-STEM Workers (Percentage)	Unemployment Rate of STEM Workers (Percentage)
Advanced degree	2.0	1.2
Master's degree	2.8	1.7
Bachelor's degree	3.6	1.8
Associate's degree	4.9	2.4
Technical college	4.7	3.7
No degree/some college	7.1	2.8
Male	5.4	1.9
Female	5.0	2.1
White	4.6	1.8
Hispanic	6.1	1.4
Black	6.5	2.6
Asian	3.6	2.5
White male	4.8	1.7
White female	4.3	2.1
Hispanic male	5.5	1.5
Hispanic female	7.0	0.9
Black male	7.2	3.1
Black female	6.0	2.0
Asian male	4.3	2.5
Asian female	2.7	2.6
Native born	5.3	1.8
Foreign born	5.0	2.9

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The table excludes the "Other" race Census category from calculations, as it is too small for comparison.

educational categories. The largest difference between STEM and non-STEM worker unemployment rates was for those individuals with no degree or some college. Non-STEM workers experienced a 7.1-percent average unemployment rate, compared with 2.8 percent for STEM workers. Within the federal STEM workforce, those individuals with a technical college degree faced the highest average unemployment rate, at 3.7 percent. Comparatively, individuals with advanced degrees only saw a 1.2-percent unemployment rate during that time.

Unemployment rates also differed by gender and race/ethnicity within the STEM workforce over the 13-year period. Black male STEM workers experienced the highest unemployment rate across all demographic categories, at 3.1 percent, compared with 1.7 percent for white men, 2.5 percent for Asian men, and 1.5 percent for Hispanic men. Among the female STEM population, white women faced the highest average unemployment rate at 2.1 percent, followed closely by black women at 2.0 percent. Hispanic women represented the lowest unemployment rate by gender and racial/ethnic category at 0.9 percent. These rates of federal STEM unemployment should not be interpreted too directly—despite being averages, they still represent very small samples. The firm conclusion is that STEM unemployment is lower for each gender and racial/ethnic group, and these rates are not too dissimilar within STEM. Finally, we find that whether workers are native born or foreign born, unemployment rates for both are much lower among STEM workers, around 2 percent, compared with around 5 percent among non-STEM workers.

Usual Weekly Hours

The basic workweek for full-time federal workers is 40 hours, which are not to extend over six days within a seven-consecutive-day period, according to OPM regulations.[12] Although working more than 40 hours should entitle federal workers to overtime, we find that most full-time workers report working slightly longer than 40 hours: the averages are 41.8 hours for non-STEM workers and 41.3 hours for STEM workers. Within the broad occupation groups of STEM, social scientists worked the most hours per week, averaging 42 hours, compared with IT and computer science professionals, who logged an average of 40.7 hours per week.

In Table 3.6 we compare the hours worked per week by age group. Overall, federal non-STEM workers tend to work more hours than their STEM counterparts across age groups, but it varies by age group and does not follow a clear age pattern. For example, STEM workers ages

Table 3.6. Usual Weekly Hours of Federal Workers, by Age Group and STEM Status, 2018

Age Group	Usual Weekly Hours of Non-STEM Workers	Usual Weekly Hours of STEM Workers
20–24	42.1	42.9
25–29	41.5	41.3
30–34	41.7	40.6
35–39	42.4	41
40–44	41.9	42.6
45–49	42.2	41
50–54	41.6	41.9
55–59	41.6	41.3
60–64	42.2	40.6
65 or older	41.3	40.7

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government.

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[12] The federal workweek and working-hour guidelines for federal employees are defined in the Code of Federal Regulations, Title 5, Part 610—Hours of Duty. The administrative workweek is defined as any seven consecutive 24-hour periods designated in advance by the head of an agency. Federal workweeks should be within the Monday–Friday time frame unless the work of an agency is unable to be completed during that time. The two days not included in the workweek should be consecutive, however, wherever in the week they lie. The overwhelming majority of STEM employees are in full-time, permanent positions, at 88.9 percent. The data in this section come from the CPS ASEC.

20–24, 40–44, and 50–54 work slightly longer hours than same-age non-STEM workers. Or, among STEM workers, the youngest (20–24) work the most, at 42.9 hours per week, but among non-STEM workers, 35–39-year-olds work the most, at 42.4 hours per week. The upshot is that both STEM and non-STEM workers tend to work more than the required 40 hours per week, each reaching over 42 hours per week at their peak, but these differences are small.

In Table 3.7 we compare the hours worked per week of full-time workers in STEM and non-STEM jobs across the same demographic groups: by education, gender, race/ethnicity, and nativity. Usual hours worked increase with educational attainment for both non-STEM and STEM workers. For both groups, workers without a bachelor's degree work between 40.2 and 41.6 hours per week. STEM bachelor's degree holders stay within that band, at 41.1, but non-STEM bachelor's degree holders inch up to 41.9, master's degree holders to 42, and advanced degree holders to 43.7 hours. In contrast, STEM master's degree holders work 41.4 hours and advanced degree holders work 42.5 hours. On average, federal non-STEM employees worked slightly more hours per week than federal STEM employees.

Little variation exists between demographic categories. White men and Hispanic men work the longest hours among federal non-STEM workers, at 42.7 hours and 42.2 hours, respectively,

Table 3.7. Usual Weekly Hours of Federal Workers, by Demographic Characteristics and STEM Status, 2018

Group	Usual Weekly Hours of Non-STEM Workers	Usual Weekly Hours of STEM Workers
Advanced degree	43.7	42.5
Master's degree	42.0	41.4
Bachelor's degree	41.9	41.1
Associate's degree	41.6	41.6
Technical college	41.3	40.2
No degree/some college	41.6	41.4
Male	42.3	41.5
Female	41.3	41.1
White	42.1	41.7
Hispanic	41.8	40.4
Black	41.3	41.0
Asian	41.3	40.8
White male	42.7	41.7
White female	41.5	41.5
Hispanic male	42.2	40.2
Hispanic female	41.2	41.0
Black male	41.6	41.7
Black female	41.0	40.4
Asian male	41.5	41.1
Asian female	41.0	40.1
Native born	41.8	41.9
Foreign born	41.4	41.0

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The table excludes the "Other" race Census category from calculations, as it is too small for comparison.

and on average male STEM employees work slightly longer in a week than female STEM employees within racial and ethnic groups; on average, male STEM workers work about one more hour per week than female STEM workers. There is also little difference between STEM and non-STEM workers by nativity. The real variation in hours is associated with education groups rather than gender, race/ethnicity, or nativity.

Income

We calculated and compared mean annual income across a number of variables to create a composite of the income structure for the federal STEM workforce. Before assessing these figures, it is important to note that mean annual income equals the average of all federal STEM workers and therefore is not indicative of any one group's or individual's income within the overall STEM population. Not all individuals start at the same salary rate, nor do they experience the same income growth over time, so some categories of workers may see increases while others may not. Additionally, the OPM sets a pay cap for individuals on the GS scale, thus potentially limiting federal employees' earnings potential within STEM fields. The GS pay cap for 2019 is $166,500.[13]

Overall, federal STEM employees have seen little increase in average annual earned real income over the past 13 years. Federal STEM employees also earn more on average than federal non-STEM employees. This is expected given the higher education levels of STEM employees on the whole. During the 2005–2018 time period, STEM workers consistently earned more on average than non-STEM workers. However, since education levels differ so broadly between federal STEM and non-STEM employees, we calculated an income figure that reweights the federal non-STEM workforce to have the same distribution of educational attainment as the federal STEM workforce (see Figure 3.7). While the gap between the two categories of employees narrows considerably when taking educational attainment into account, there is still a premium associated with STEM employees' income.

Since we only accounted for differences in education level in calculating the weighted non-STEM mean annual income, it is possible that other composition factors can help explain the income premium we see in Table 3.9, like the experience level or pay plan of employees.

As we have previously noted, the GS pay scale is a combination of education level and experience. Unless all STEM workers are more experienced within each education category than non-STEM workers, which seems unlikely, then there must be other means of compensating STEM workers with a premium. It is possible that STEM workers can enter at higher grades or steps, though we were not able to investigate this. In addition, not all workers for the federal government are on the GS plan, as we noted at the start of this chapter; agencies have the flexibility to offer qualified individuals pay incentives to fill critical positions through non-GS

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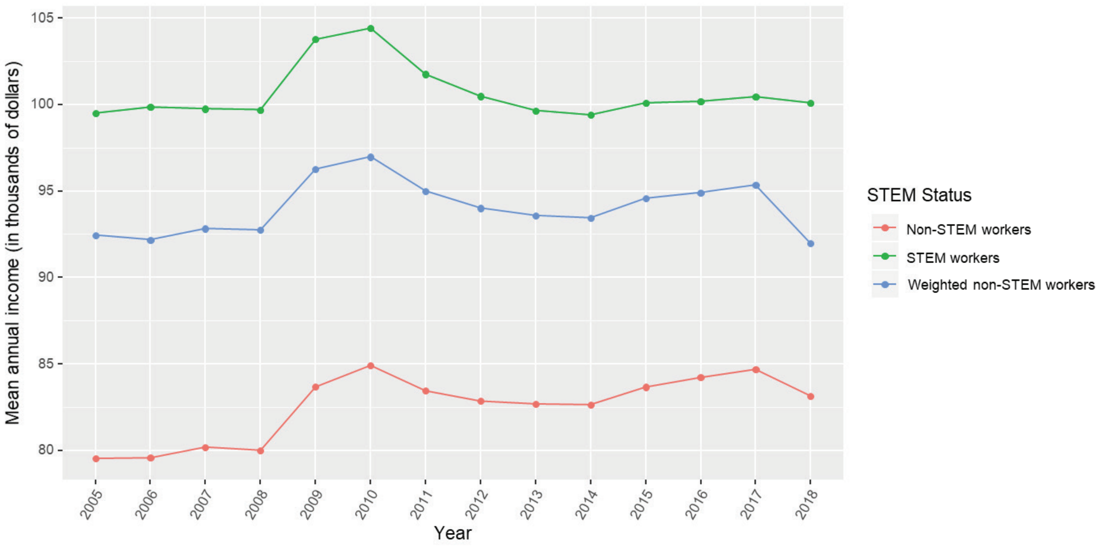
[13] According to the OPM, the maximum pay limitations for those on the GS scale inclusive of locality payment is equivalent to Level IV of the Executive Schedule, equal to $166,500 for 2019. See OPM, undated f; and OPM, undated w.

Figure 3.7. Mean Annual Income for Federal Workers, by Weighted STEM Status, 2005–2018 (in 2018 dollars)



SOURCE: FedScope (via OPM).

pay planes, which may contribute to this STEM premium. In 2018 about 276,000 (76.7 percent) of STEM workers worked under the GS pay plan, with about 32,000 (8.9 percent) working under one of three other pay plans: DB—Demonstration Engineers and Scientists; ND—Demonstration Scientific and Engineering; and NH—Business Management and Technical Management Professional. The average salary for GS STEM workers in 2018 was $95,700; in the same year the average for STEM workers was $122,400 in the DB pay plan, $108,700 in the ND pay plan, and $106,300 in the NH pay plan. The remaining 14 percent of STEM workers are in one of 60 additional pay plans, among which the lowest average within-plan salary for STEM workers was $60,000 and the highest was $265,000. This 14 percent therefore includes some of the highest-paid STEM workers in the federal government.

Income among federal workers is measured in both the CPS and FedScope. In Table 3.8 we show income from FedScope, but for the remainder of the chapter, we use the CPS. We note this here because, as we will discuss in more detail in the next chapter, there is a difference between OPM-reported income in FedScope and respondent-reported income in the CPS, with incomes being higher in FedScope. In FedScope in 2018, non-STEM workers earned around $80,000 and STEM workers around $96,000. In the CPS in the same year, the average salary of federal workers is $70,700 for non-STEM workers and $89,000 for STEM workers. Because incomes are not comparable across the two data sources, we use the CPS, which contains both federal and private-sector workers.[14]

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[14] As we discuss at the beginning of Chapter Four, FedScope does not include private-sector workers, so we could not use it to compare the incomes of private- and public-sector workers. We provide a detailed footnote explaining the differences in how each data source derives income information. We also direct the reader to the Chapter One section, “Sources of Data,” for more details on the different data sources that were used in our analyses.

Table 3.8. Mean Annual Income (2018) and Nine-Year (2009–2018) Annual Growth Rate for Federal Workers, by Broad Occupation Group

Broad Occupation Group	2018 Income	2009–2018 CAGR (Percentage)
Engineering	$ 89,185	0.11
IT and computer science	$ 85,152	–1.00
Life science	$ 88,390	1.18
Physical science	$ 95,756	1.25
Social science	$ 99,098	–0.65
Non-STEM occupations	$ 70,699	–0.06

SOURCE: ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Income growth in real terms was adjusted using the consumer price index for all urban consumers from the BLS.

Within STEM, there are differences in income by broad occupation group (see Table 3.8). In 2018, the highest-paid STEM workers in the federal government were social scientists, who earned $99,000, followed closely by physical scientists, who made $96,000; engineers and life scientists both made around $89,000, and IT and computer scientists made $85,000. All of these amounts reflect a premium to working in STEM as compared with non-STEM occupations; average non-STEM income was $70,700. The annual growth rate in real income since 2009, which was the trough of the last business cycle and recession, was largest among physical science, at 1.25 percent, and life science, at 1.18 percent. Federal STEM engineering income was roughly steady, at 0.11 percent, similar to the rates for federal non-STEM workers, also roughly steady, at –0.06 percent. Incomes for social science and IT and computer science both fell, at rates of –0.65 percent and –1.0 percent, respectively. However, even with negative growth rates, the rates for social science and IT and computer science are very small and very similar to each other. The highest-paying specific occupations within STEM are actuaries, economists, food scientists, computer engineers, and chemical engineers.

As we noted in the previous chapter, these reflect changes, on average, for workers in these occupations over the years *in the aggregate*, not what an individual worker has experienced in earnings growth over the period analyzed. It is also important to note that these are not to be confused with the earnings growth for a worker with a degree in one of these fields. A worker with a degree in a particular field may or may not actually work in the field and may switch in and out of it over time. Moreover, the composition of workers can change in terms of education level or experience, meaning that aggregate incomes can fall while individual incomes can rise.

Table 3.9 shows the average annual earnings of federal STEM and non-STEM workers in 2018 and across ten age groups. By calculating these averages, we can see whether STEM or non-STEM workers earn more as they progress through their careers, and how those earnings compare between them. Overall, and aligned with what we have seen throughout this chapter, federal STEM workers earn more on average than their non-STEM counterparts. This is consistent through nearly every age group, with the only exception being in the 40–44 age group. The greatest difference between STEM and federal non-STEM workers can be seen in the 60–64 age group, where STEM employees made $49,482 more on average than federal non-STEM employees of the same age in 2018. This rather sizable difference is in part explained by a low average income of $66,479 for federal non-STEM workers in this age range in 2018. STEM and federal non-STEM workers earned their highest average incomes at different times as well. STEM workers saw their highest earnings toward the later stages of their career at the ages of 60–64, while federal non-STEM workers received their highest at the ages of 40–44. Non-STEM workers also experienced more fluctuations in their income across age groups, while STEM employees' earnings gradually increased from age group to age group, with only two exceptions (the age groups 40–44 and 65 or older).

Table 3.9. Mean Annual Income (2018) and Nine-Year (2009–2018) Annual Growth Rate for Federal Workers, by Age Group, 2018

Age Group	2018 Income of Non-STEM Workers	2009–2018 CAGR (Percentage)	2018 Income of STEM Workers	2009–2018 CAGR (Percentage)
20–24	$31,833	–2.03	$57,882	2.93
25–29	$45,862	–1.37	$60,052	–2.23
30–34	$59,897	–0.65	$67,519	–1.49
35–39	$70,946	0.21	$87,255	1.06
40–44	$84,576	1.79	$80,279	–0.82
45–49	$76,492	0.68	$89,363	–0.75
50–54	$75,646	–0.80	$103,718	1.22
55–59	$83,757	0.36	$114,515	0.25
60–64	$66,479	–0.45	$115,961	2.30
65 or older	$79,966	1.77	$110,951	3.15

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. Income growth in real terms was adjusted using the consumer price index for all urban consumers from the BLS.

In Table 3.10 we compare the incomes and growth rates of workers in non-STEM and STEM positions according to the subgroups we have followed so far: education, gender, race/ethnicity, and nativity. Federal workers in STEM positions earn less income on average than those in non-STEM positions among workers with advanced degrees. Recall that the advanced degree includes both Ph.D. and professional degrees within that same category (e.g., law degrees). When these two types of degrees are broken out separately, STEM Ph.D. incomes are fairly competitive with non-STEM Ph.D. incomes, and the biggest difference lies between STEM and non-STEM professional degree holders. Thus, a higher professional degree income (e.g., that of a lawyer) explains the overall income difference for advanced degree holders. Regardless, in both non-STEM and STEM occupations, advanced degree holders also saw the fastest annual growth rate in real income since the trough of the last recession: 0.98 percent for non-STEM workers and 0.62 percent for STEM workers.

Table 3.10. Mean Annual Income (2018) and Nine-Year (2009–2018) Real Annual Growth Rate for Federal Workers, by Demographic Characteristics and STEM Status, 2018

Group	2018 Income of Non-STEM Workers	2009–2018 CAGR (Percentage)	2018 Income of STEM Workers	2009–2018 CAGR (Percentage)
Advanced degree	$143,113	0.98	$103,108	0.62
Master’s degree	$90,424	–0.87	$94,368	–0.41
Bachelor’s degree	$76,743	–0.32	$91,324	0.14
Associate’s degree	$51,862	–1.23	$87,002	0.65
Technical college	$62,654	0.54	$54,650	–1.30
No degree/some college	$53,938	–0.50	$61,153	–2.30
Male	$76,193	0.03	$94,509	0.08
Female	$64,628	–0.17	$78,545	0.04
White	$77,379	0.13	$91,188	–0.24
Hispanic	$59,015	–0.51	$85,127	0.91
Black	$63,929	0.77	$79,596	0.48
Asian	$70,896	–0.33	$75,775	–1.11
White male	$82,966	1.69	$99,080	1.75
White female	$70,396	1.82	$76,861	1.20
Hispanic male	$64,941	2.34	$85,985	2.26
Hispanic female	$50,921	–0.78	$83,162	2.90
Black male	$69,076	3.30	$87,393	2.90
Black female	$60,056	1.63	$72,169	1.19
Asian male	$64,648	–0.37	$78,246	1.08
Asian female	$79,155	3.03	$61,102	–2.43
Native born	$70,038	1.51	$87,483	1.45
Foreign born	$75,170	1.53	$95,702	1.74

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The table excludes the “Other” race Census category from calculations, as it is too small for comparison.

For the remaining educational categories, STEM workers have higher annual incomes and see higher growth rates in real income than their non-STEM counterparts, with the exception of workers with technical certificates. The smallest difference is for master’s degree holders: STEM workers earn just $4,000 more, at $94,300. The largest difference is for associate’s degree holders: STEM workers earn $35,000 more, at $87,000. However, STEM technical certificate holders earn about $7,000 less, at $54,700.

In general, within each racial or ethnic group, men outearn women, and STEM workers outearn non-STEM workers. White men are the highest paid among non-STEM ($83,000) or STEM ($99,000) federal workers. Recall that the average salary is $70,700 for federal non-STEM workers and $89,000 for federal STEM workers; white men make at least $10,000 above the average earnings for both. Among non-STEM workers, white women make about the average salary, though $13,000 less than white men; but among STEM workers, white women make $12,000 below average and $22,000 less than white men. This pattern holds for Hispanics

(STEM men make $86,000 and women $83,000, more than their non-STEM counterparts at $65,000 and $51,000, respectively); and for blacks (STEM men earn $87,400 and women $72,000, compared with $69,000 and $60,000, respectively), but not for Asians. Asian men earn more in STEM, $78,000 compared with $65,000 for a non-STEM worker, but Asian women earn more outside of STEM, $79,000 compared with $61,000 for a STEM worker. Asian women in non-STEM roles are the only female group to outearn their male counterparts. The widest gap between men and women is among white STEM workers.

There is less of an obvious pattern for gender or race/ethnicity when examining annual average growth rates in real income. Many are fairly close to zero, whether positive or negative, with the exception of negative rates of –2.43 percent for Asian women in STEM. Given that the federal government experienced a three-year pay freeze, it is not surprising that growth was low; however, negative rates are likely explained by shifting composition or workers within those categories. Finally, we see that foreign-born workers have larger incomes in both federal non-STEM and STEM jobs, making $5,000 more in non-STEM positions ($75,000, compared with $70,000 for native-born workers), and $12,000 more in STEM positions ($95,700, compared with $87,500).

These comparisons demonstrate that, in both data sets, and among virtually every group of workers that we examined, federal workers in STEM positions make more in the aggregate than workers in non-STEM positions. That does not mean that every STEM worker is highly—or higher—paid, but that they clearly make up a high-earning portion of the federal workforce.

Benefits

The federal government's full-time benefits program covers five main types of benefits: insurance programs, retirement programs, leave programs, educational programs, and life assistance programs.[15] Details of each benefit can be found in Appendix B. The key upshot, however, is that all full-time federal workers—regardless of their earnings or education level or occupation—have access to the entire array of federal benefits. In general, the benefits offered for full-time federal workers are expansive and generous. The one notable exception is that federal employees do not have access to paid family leave. Because benefits are offered to all full-time workers, we do not compare benefit use according to STEM or non-STEM positions, the assumption being that they would not differ in any meaningful way.

The federal government's overall health insurance package consists of three different programs: (1) the Federal Employee Health Benefits (FEHB) program, (2) the Federal Flexible Spending Account (FSAFEDS) program, and (3) the Federal Employee Dental and Vision

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[15] The OPM defines part-time employees as those working in positions for 16–32 hours per week (or between 32 and 64 hours per pay period) on a prearranged schedule. Part-time employees are eligible for the same benefits as full-time employees, but on a prorated basis. This includes leave, retirement, and health and life insurance coverage. See OPM, undated s.

Insurance Program (FEDVIP). The federal government also offers a retirement benefits program. Most federal employees fall under the Federal Employees Retirement System (FERS), which consists of three different programs: the Basic Benefits plan, the Thrift Savings Plan (TSP), and Social Security.[16] The Basic Benefits plan provides retirement, disability, and survivor benefits to employees and their families. The TSP essentially serves as the federal government's 401(k) plan, offering similar types of tax and savings benefits that private employees receive through their employers' plans. Finally, federal employees receive Social Security benefits. An analysis by the CBO has found that benefit costs for federal workers are, on average, higher than for private-sector workers, and particularly for less educated workers in comparison with their similarly educated counterparts in the private sector, which we discuss in detail in Appendix B.

Federal employees receive multiple types of paid leave. In addition to public holidays, federal employees partake in an annual leave program that provides paid leave accrued over time employed. The number of days accrued per year increases with years or service, starting with 13 days per year and reaching 26 days for workers with 15 or more years of experience. They also accrue 13 paid sick days per year, though this accrual rate does not increase with years of service. As of this writing, federal employees did not have access to paid family leave. However, the 2020 National Defense Authorization Act included the Federal Employees Paid Leave Act, which creates 12 weeks of paid family leave for full-time, permanent employees who have at least 12 months of service with the federal government and who will return to work for at least 12 weeks after the leave has ended. The Act is effective October 2020 (Public Law 116-92, 2019).

Federal employees also have access to a student loan repayment program and may receive benefits while working to attend a college or university, sometimes as a subsidized tuition rate. In addition, federal employees benefit from multiple life assistance programs. The first of these is the Employee Assistance Program (EAP), which is a free, voluntary service to help federal workers with potential issues that may affect an employee's personal health, job performance, or well-being. EAP offers these services through expert providers including psychologists, social workers, counselors, marriage and family therapists, alcohol and drug abuse counselors, attorneys, eldercare specialists, financial advisers, and childcare specialists.

The second life assistance program offered by the federal government is child and dependent care. The programs vary by what they provide, dependent on the employee's agency. Examples of the childcare services supplied to federal employees include on-site childcare at the agency's office location, federal childcare facilities, and childcare subsidies. Over 100 federal childcare facilities are run by the General Services Administration (GSA) across the country and are open to both federal employees' children and those within the local community (once the childcare facilities are filled to at least 50-percent capacity with federal employees' children). The GSA

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[16] Federal employees who began civil service before 1987 were (and, if still employed in federal government, are still) covered under the Civil Service Retirement System and not by Social Security. With the switch to the FERS in 1987, federal employees became covered under Social Security. See Social Security Administration, undated.

childcare centers provide additional childcare options for federal workers within different locales, increasing access to affordable, quality childcare for federal employees. Additionally, Congress passed legislation on March 24, 2003, that allows agencies to provide funding for childcare services to lower-income employees. The subsidies can be used for care for those children under the age of 13, or those with a disability under the age of 18.

Surveys indicate that federal workers highly value their benefits. The Federal Employee Benefits Survey included enrollment numbers for both the FERS and TSP programs. These two programs rank highest in terms of participation, with 97.2 percent of employees enrolled in the TSP, and 92.8 percent of employees enrolled in FERS in 2017. Employees also rated the programs highly in importance, whether or not they were enrolled in either of them. Ninety-six percent of employees regarded the TSP as extremely important or important, while 94.2 percent stated the same for the FERS program. In terms of recruitment and retainment, nearly 70 percent of employees stated that access to the TSP played a part in their decision to accept a position with the federal government, and 83 percent stated it encouraged them to remain in their position of employment.[17] Similar numbers are seen with FERS, as 78.3 percent stated the program played a role in their decision to take a job with the federal government, and 87.9 percent viewed the program as part of the reason they stayed in their positions. The TSP also received high satisfaction ratings. Over 93 percent of TSP participants indicated that the TSP met their needs (to a great or moderate extent), and nearly 90 percent of enrollees believed the program to be an excellent or good value (OPM, 2018a, pp. 12–14).

The OPM conducted its first work-life survey in 2017 to determine if work-life programs, including EAP, are meeting employee needs. According to the survey, 60 percent of employees that participated in EAP were satisfied with their agency's program. However, utilization of EAP's services was quite low, with only 13 percent of federal employees using an EAP service in the 12 months prior to the survey. Lack of program knowledge or interest, and hesitation to use programs due to concerns, prevented individuals from participating. Despite low utilization of the services, 55 percent of all federal employees expressed interest in participating in an EAP program. Access to and usage of EAP services also contributed to employee outcomes, including improved morale (48 percent), increased performance (41 percent), intent to stay (40 percent), improved health (40 percent), and better stress management (49 percent; OPM, 2018c, pp. 26–27).

The Federal Work-Life Survey also addressed family and dependent care programs. According to the survey, approximately 36 percent of federal employees have childcare responsibilities, while 14 percent have adult care responsibilities. Only 30 percent of employees stated that they were satisfied with the family and dependent care support provided by their employing agencies. The programs also rated much lower in terms of positive impact on employee outcomes, including improved morale (35 percent), increased performance (28 percent), intent to stay (34 percent), improved health (26 percent), and better stress management (35 percent; OPM, 2018c, pp. 31–35).

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[17] For both measures, responses indicated to a "great" or "moderate" extent.

Regression Analysis

Throughout this chapter we have compared the means of STEM workers in the federal government with non-STEM workers. We have found a few key trends:

- For any education level, STEM workers work slightly shorter hours than non-STEM workers.
- With a few exceptions, STEM workers earn more than non-STEM workers when comparing workers with the same levels of educational attainment, gender, or race/ethnicity.
- There are disparities within STEM between the earnings of men and women, as well as whites compared with underrepresented minorities (blacks and Hispanics).

However, as we noted at the beginning of this chapter, the composition of the STEM workforce is very different from the non-STEM workforce in the federal government. It has higher educational attainment and is less diverse. The differences between STEM and non-STEM earnings could still be attributed to the differences in composition within groups (i.e., the educational attainment of black workers) as well as a difference in the composition of groups (i.e., the share of workers who are black).

To account for the compositional differences of STEM and non-STEM workers, as well as the differences within groups of STEM workers, we use the same regression and decomposition analysis that we used in Chapter Two.[18] For these regressions, we use the CPS ASEC for the years 2009–2018.

Comparing STEM and Non-STEM Workers

In Table 3.11 we show the coefficients on being a STEM worker on dependent variables of interest—an indicator for whether an individual worked more than 45 hours in a usual week and annual income (in real 2018 dollars).[19] For each dependent variable we show two STEM coefficients; the first is without any controls in the regression, which is just the mean difference between the STEM and non-STEM groups, and the second is with a full set of controls. The controls are levels of educational attainment, gender, race/ethnicity, age,[20] geographic region, urban/rural status, and year. In the first row of Table 3.11 we show the coefficient on being a STEM worker when the dependent variable indicates whether a worker works more than 45 hours in a usual workweek. The mean coefficient is –0.004, and imprecise; there is no observable difference between STEM and non-STEM workers in the likelihood of working long

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[18] For an introduction to the regression methods, see the “Regression Analysis” section in Chapter Two.

[19] These variables in ASEC are UHRSWORK1 (usual hours of work per week at main job) and INCWAGE (total pretax wage and salary income); we do not run regressions on pension and health insurance, given that they are universally offered to all full-time, permanent federal employees.

[20] In the regression, we include age and age squared, the preferred practice in wage-determinant regressions.

Table 3.11. Regression Coefficients on an Indicator for Being a STEM Worker, Based on Four Dependent Variables

	STEM Coefficient—No Controls (Mean Difference Between STEM and Non-STEM Positions)	STEM Coefficient—with Controls (Difference Between STEM and Non-STEM Positions, Controlling for Composition)
Worked more than 45 hours in a usual week	–0.004	–0.047***
	(0.006)	(0.006)
Real income (in 2018 dollars)	$26,432***	$8,866***
	(966)	(1,106)

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: The table shows the coefficients on a STEM dummy for two regressions for each of the two dependent variables listed in the first column. The first regression (left) includes no controls and only the STEM dummy; the second regression (right) includes controls for education, age, age squared, gender, race/ethnicity, region, urban/rural status, and year. Standard errors shown in parentheses beneath coefficient estimates. Stars indicate significance at the 10 (*), 5 (**), and 1 (***) percent level.

hours. Controlling for the composition of the workforces, however, the coefficient changes to –0.047. Since the dependent variable here is binary, we can interpret this coefficient as a STEM worker being 4.7 percentage points *less likely* to report long hours than a non-STEM worker. A regression alone does not signify causality, but expresses a statistical relationship. Hence, we can say that STEM workers are less likely to work long hours, not that being in STEM reduces the number of hours of work.

In the second row of Table 3.11 we show the STEM coefficient on annual earned income. The mean difference in income between STEM and non-STEM workers is $26,432. After including controls, this falls to $8,866. Again, this is not to say that being in STEM increases wages $8,866 higher than expected, but that workers in STEM earn $8,866 more in wages. As we have previously discussed, the majority of the federal workforce is on the GS pay scale, which creates steps of annual income within education experience categories. These results indicate that even controlling for education level and age (an imperfect proxy for experience), STEM workers have higher earnings than their non-STEM counterparts. This could be, as we previously discussed, because STEM workers enter at a higher grade or step within a grade; STEM workers are more likely to be on higher-paying, non-GS pay plans; or a combination of both.

Comparing Groups of STEM Workers

We use Oaxaca-Blinder decomposition to examine the annual earnings of federal STEM workers as they vary by gender and race/ethnicity.[21] In Table 3.12 we show the estimates from

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[21] A discussion of the Oaxaca-Blinder method can be found in Chapter Two in the “Regression Analysis” section. For these regressions we control for levels of educational attainment, age, geography, urban/rural status, and year. Because we are comparing racial and gender groups, we do not include controls on gender or race/ethnicity in any of the regressions. Further, because we are looking within the STEM workforce, we add controls for STEM occupation category, and usual hours worked per week.

Table 3.12. Regression Coefficients from the Oaxaca-Blinder Decomposition of Earnings Differences Within Groups of STEM Workers

	Group Comparison: Female^ Versus Male		Group Comparison: Nonwhite^ Versus White		Group Comparison: Underrepresented Minorities^ Versus Whites and Asians	
Group 1^ Mean	$86,094***		$88,666***		$88,617***	
	(1,605)		(1,580)		(2,093)	
Group 2 Mean	96,415***		$95,062***		$94,337***	
	(1,033)		(1,042)		(960)	
Difference	–$10321***		–$6,396***		–$5,720*	
	(1,909)		(1,892)		(2,303)	
Endowments		–$3,220***		$273		-$1,247
		(939)		(994)		(1,041)
Coefficients		–$7,838***		–$6,677***		–$5,267*
		(1,936)		(1,987)		(2,214)

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: The table shows select coefficients from three Oaxaca-Blinder decompositions. The linear estimate is the mean difference between the two groups being compared, and the decomposition of that difference is broken down into the endowment (if one group had similar observable characteristics) and the coefficients (if one group had similar return to coefficients). Not shown is the interaction term, which is not interpretable or significant; it is $737 (762) for women, $8 (867) for whites, and $795 (949) for underrepresented minorities. Each decomposition includes controls for education, stem occupation, age, age squared, region, urban/rural status, usual hours worked per week, and year. Standard errors are shown in parentheses beneath coefficient estimates.
^ Indicates Group 1, which is noted also in the column heads.
Stars indicate significance at the 10 (*), 5 (**), and 1 (***) percent level.

three decompositions. For each comparison group we show the estimated mean income for the groups being compared and the difference. We then decompose that difference into endowments (how much of the difference is due to the different credentials of the two groups) and coefficients (how much of the difference is due to the different returns from credentials between the two groups).

We first compare female and male STEM workers. Average female earnings are $86,094 and average male earnings are $96,415, a difference of $10,321. The endowment estimate—how much of the earnings difference is due to different education, age, or occupation between men and women in STEM—is $3,220. The coefficient estimate—how much is due to the different returns from education, age, hours, or occupation—is $7,838.[22] Thus, just under a third of the female earnings differences can be explained by the educational attainment of women, their age, and distribution within the broad five STEM groups, but the remaining two-thirds is unexplained by those control variables.

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[22] We do not discuss the interaction estimate, which when added with the coefficient and endowment estimate sums to the difference in means; it represents the simultaneity in the latter two and does not have a clear interpretation. The estimate and standard error is $737 (762).

When comparing racial and ethnic groups of STEM workers in the federal government. We see a smaller difference in earnings—$6,396 between nonwhite (black, Asian, and Hispanic) and white workers, and $5,720 between underrepresented (black and Hispanic) versus represented (white and Asian) groups. The difference due to endowment is insignificant in explaining white and nonwhite differences ($273) and explains about one-fifth ($1,247) of the underrepresented versus represented group differences. For both comparisons, however, the coefficients estimate—or the differences due to varying returns from credentials—is large: $6,677 and $5,267, respectively.[23]

As we have noted previously, the unexplained differences in earnings between the two groups of STEM workers—the coefficients estimate—should not be thought of entirely as the result of, or entirely free of, discrimination. These decompositions are not perfectly formulated (we do not have a reliable measure of experience), nor can they account for differences in an individual's choices or preferences. However, it is interesting that the unexplained estimate here would be so large given that all of these workers have the same employer—namely, the federal government. A more detailed study could determine whether the discretion in GS scale or pay plan may favor certain workers, and why or how that is the case.

Chapter Summary

In this chapter, much as in Chapter Two, we have analyzed the size and characteristics of the federal STEM workforce, exploring variation within it and comparing it with the federal non-STEM workforce. We did so in isolation from our analysis of the private-sector STEM workforce (in Chapter Two) and the comparison between these two workforces (which we will discuss in Chapter Four). Again, we feel that this deep dive is necessary in order to contextualize the comparison that follows in Chapter Four. To the extent that the federal government—as the language in the NDAA suggests—has a difficult time hiring and retaining STEM workers, this chapter serves as a measure of progress so far.

STEM workers in the federal government span an array of ages, disciplines, agencies, and educational attainment. STEM workers are indeed far from being a uniform monolith in the federal government, and critically, they do vary from non-STEM workers in several ways. They are more educated on average, but are also less diverse in terms of gender and race/ethnicity. We reiterate that point here to note that any STEM policy must take into account the breadth of the STEM workforce and the challenges that remain in increasing diversity.

However, the key takeaway is that STEM workers are more highly compensated that non-STEM workers; the pay schemes of the federal government are not as rigid as one might expect. This is true when examining education, gender, race/ethnicity, or nativity groups. There is evidence that non-GS pay schemes assist in increasing salaries of STEM workers, but we did

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[23] The interaction estimates and standard errors are $8 (867) and $795 (949), respectively.

not fully test this. And in addition to being paid more, STEM workers also, like most federal workers, benefit from what has long established federal employment as a “good” job. They work reasonable hours—the longest working among them puts in 43 hours per week, but most work 41–42 hours—and enjoy very generous health, retirement, education, and other benefits.

Yet should they leave federal service, there is also evidence that STEM workers do not have to search long for a job. Their unemployment rates were extremely low, even in a time of low unemployment overall, and low unemployment rates typically indicate shorter length of unemployment. This suggests that the market for workers with STEM experience is very tight and that likely these workers are sought after. Whether the government can compete as an employer, and for whom, we discuss in Chapter Four.

4. Comparing Federal and Private-Sector STEM Compensation

This chapter compares the federal and private-sector STEM workforces, drawing on the analyses reported in Chapters Two and Three for each of these workforces separately. We begin by comparing the number and distribution of STEM workers in each sector, including how they break down by occupation, educational attainment, and race/ethnicity. We briefly consider variation in unemployment rates and usual work hours between federal and private-sector STEM workers, as these metrics may shed light on the stability and desirability of the jobs. We devote the bulk of our attention to a discussion of income, analyzing whether federal STEM workers earn more or less than their counterparts in the private sector and exploring variation by categories of workers. We conclude the chapter by describing findings from a regression analysis that controls for numerous factors commonly associated with differences in pay that the descriptive analyses reported in earlier portions of the chapter do not fully capture.

We restrict our analyses to metrics for which sufficient data are available to compare the federal and private-sector STEM workforces. In some cases this means that we do not make a comparison at all. In other cases we present the comparison at a higher level of aggregation, averaging across years to gain a large enough sample to make a meaningful comparison. Notably, this is the tack we take for the preponderance of our discussion of income—using 2009–2018 averages to compare the federal STEM workforce and the private sector STEM workforce. All analyses in this chapter are for full-time workers only. In Appendix C, we provide a more detailed comparison of occupations within the five broad groups.

Relatedly, it is important to note up front that the data source that offers the most granularity for an analysis of public-sector compensation, FedScope, does not allow for a direct comparison with private-sector workers, since it does not include them, and does not define income in precisely the same way as the private-sector income data source, the CPS.[1] FedScope also does not permit an analysis of compensation by gender and race/ethnicity, as these demographic characteristics are not included in the microlevel data. Hence, while we report the overall income levels using FedScope data, we also report public-sector metrics derived from the CPS, and we use the CPS data for our comparisons between the private and public sectors. Similarly, while in some instances we use FedScope data to describe the number and distribution of STEM workers in the public sector in the "Number and Distribution of Federal and Private-Sector STEM Workers"

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[1] In the OPM FedScope data, income is defined as an employee's adjusted basic pay, which is an annualized rate of pay; it is the sum of (1) an employee's rate of basic pay, plus (2) any locality comparability payment, and/or (3) special pay adjustment for law enforcement officers. Not all employees have all three components. FedScope excludes overtime, shift differentials, less than full-time work, and leave without pay. In the CPS, income is defined as the respondent's total pretax wage and salary income for the previous calendar year; amounts are expressed as they were reported to interviewers.

section below, we also present distributional estimates from the CPS, in order to set up the CPS-based income analysis later in the chapter. For the distributional analyses using CPS data, we report both a single year, 2018, from the CPS, as well as 2009–2018 averages, to assess the degree to which the smaller sample size in the single year affects the findings.

We find that—while the STEM workforce is, naturally, much larger in the private sector—the share of workers in STEM occupations is about twice as high in the federal government. Compared with the private sector, a notably larger share of the federal STEM workforce is in life science and social science, while a smaller share is in IT and computer science. The federal STEM workforce skews somewhat older and more educated than the private-sector workforce and has somewhat more gender diversity and representation of black and Hispanic workers. Federal STEM workers face slightly lower unemployment rates, on average, than their private-sector counterparts, and work about 1.5 fewer hours per week.

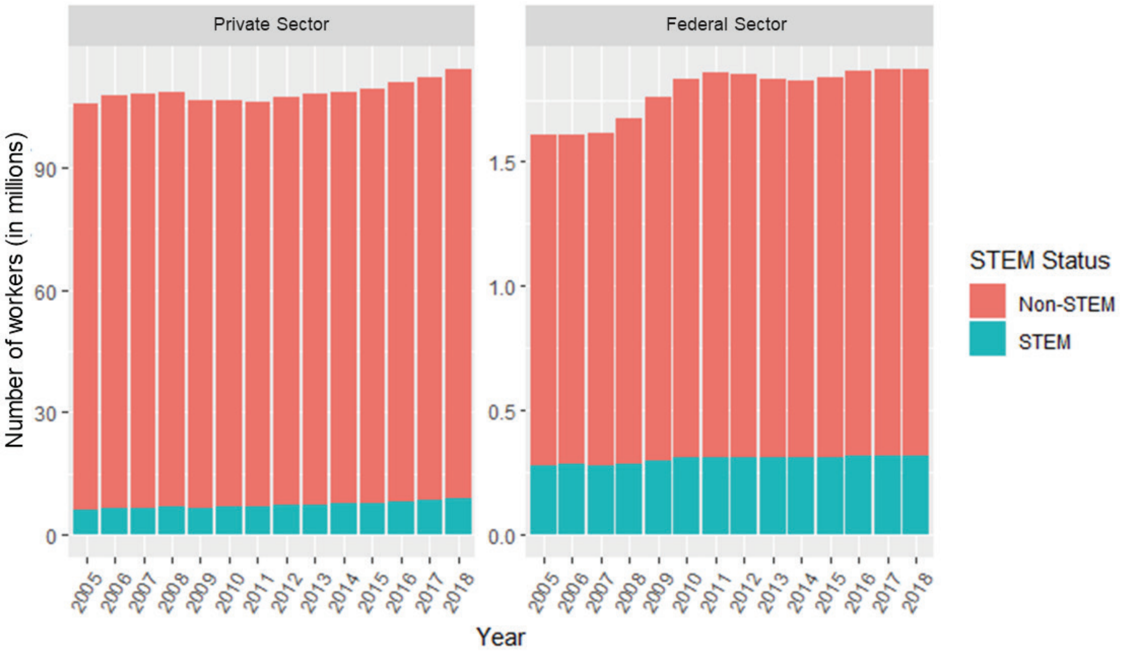
At first glance, federal STEM workers make about $3,700 more, on average, than STEM workers in the private sector. However, this summary finding obscures important differences within the groups. While some groups of federal STEM workers earn more, on average, than comparable private-sector STEM workers, others earn less. Indeed, for all age groups covering ages 30–55, there is a modest pay premium to private-sector STEM work, while younger and older STEM workers make more, on average, in federal STEM employment. Similar variation exists by other characteristics such as gender, race/ethnicity, educational attainment, geography, and broad or detailed occupation. Our regression analysis, which controls for these characteristics, finds that federal STEM workers earn about $2,600 less per year, on average, than similar private-sector STEM workers (on the observables), but that they are much more likely to have employer-based retirement coverage and tend to work fewer hours. Appendix C performs a similar analysis but for each of the five main occupation categories.

Number and Distribution of Federal and Private-Sector STEM Workers

Owing to its much larger size, there are, unsurprisingly, far more STEM workers in the private sector than in the federal STEM workforce. In 2018 there were about 8.8 million private-sector STEM workers versus about 320,000 included in FedScope’s tally of federal employment. However, as a share of the workforce, STEM workers are more than two times more prevalent in the federal government, as is shown in Figure 4.1. In 2018, 17.0 percent of federal workers were in STEM occupations, compared with 7.7 percent of private-sector workers. The private-sector STEM share grew steadily over the 2005 to 2018 period, up from 5.9 percent in 2005, while the federal STEM workforce share fluctuated within a narrow range around 17 percent.

In our discussion in Chapter Three of the STEM workforce in the federal government, we noted that we preferred FedScope as a data source because it included key public descriptors—such as agency and pay plan—that are important for understanding the composition and compensation of the STEM workforce, even though FedScope is a subset of all federal workers, excluding the congressional and judicial branches, as well as the intelligence agencies. Of course,

Figure 4.1. Number of Workers, by STEM Status and Sector, 2005–2018



SOURCES: CPS (via the U.S. Census Bureau); FedScope (via OPM).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Counts include both employed and unemployed workers.

federal workers are also included in the CPS, but the CPS measure of the size of the federal STEM workforce differs from the FedScope measure, as does the STEM share of the overall workforce. On average over the 2005–2018 period, 14.2 percent of federal workers were in STEM, according to the CPS, and the count of STEM workers in the federal workforce in 2018 exceeded a half million. The difference between the CPS and FedScope is due to (1) the difference in coverage of the data sources;[2] and (2) sampling variation in the CPS, which is a survey rather than the census of workers included in FedScope.

In this chapter, however, our goal is to compare the private sector and federal STEM workforces and their compensation. We will discuss in detail in the "Income Comparisons" section, but income comparisons are not supported across the data sets, as the OPM and CPS annual income measures have definitional differences. Since we will use the CPS only for income comparisons, we also present the number of distribution of workers from only the CPS, despite the fact that there are differences in the public-sector STEM workforce based on the source of the data. Although, to be clear, neither of these sources is wrong, or any more or less accurate, they describe two sets of workers that are mostly overlapping.

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[2] In general, FedScope is limited to the nonpostal executive branch of government. Some additional executive agencies are excluded, while certain legislative and judicial branch positions are included; see OPM, undated a. The CPS federal definition includes all nonpostal federal government workers, regardless of branch.

Occupational Distribution

In Table 4.1 we explore differences in the occupational distribution of STEM workers by sector using 2018 data from the CPS for the private and public sectors and FedScope for the public sector. First, comparing the two sectors within the CPS (in the first two columns), engineering accounts for one-third of both workforces, while IT and computer science makes up over half of the private-sector STEM workforce (56.9 percent) but 41.1 percent of the federal STEM workforce. Life scientists, physical scientists, and social scientists all have much higher shares in the federal government, where they account for 9.4 percent, 10 percent, and 6.7 percent, respectively, of the total STEM workforce, or about a quarter of all federal STEM workers combined. In the private sector they account for just under 10 percent of the total STEM workforce, with shares of 3.2 percent, 4.7 percent, and 1.5 percent, respectively.

Table 4.1. Distribution of STEM Workers, by Broad Occupation Group and Sector, 2018

Broad Occupation Group	Private Sector		Federal Sector (CPS)		Federal Sector (OPM FedScope)	
	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018
Engineering science	33.7	–4.9	32.8	–0.6	32.0	–1.8
IT and computer science	56.9	4.7	41.1	0.8	31.9	2.7
Life science	3.2	–0.5	9.4	–4.1	21.2	–1.6
Physical science	4.7	0.6	10.0	3.3	6.7	–0.6
Social science	1.5	0.0	6.7	0.6	8.2	1.3

SOURCES: CPS (via the U.S. Census Bureau); FedScope (via OPM).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Counts include both employed and unemployed workers.

Second, comparing public STEM workers from the CPS and FedScope (in the second two columns), we find that although there is roughly the same share of engineers (32 percent), the CPS has a larger share than FedScope for IT and computer science workers (41.1 percent, compared with 31.9 percent) and physical scientists (10 percent, compared with 6.7 percent), while FedScope has double the CPS share of life scientists (21.2 percent, compared with 9.4 percent) and a slightly higher share of social scientists (8.2 percent, compared with 6.7 percent).

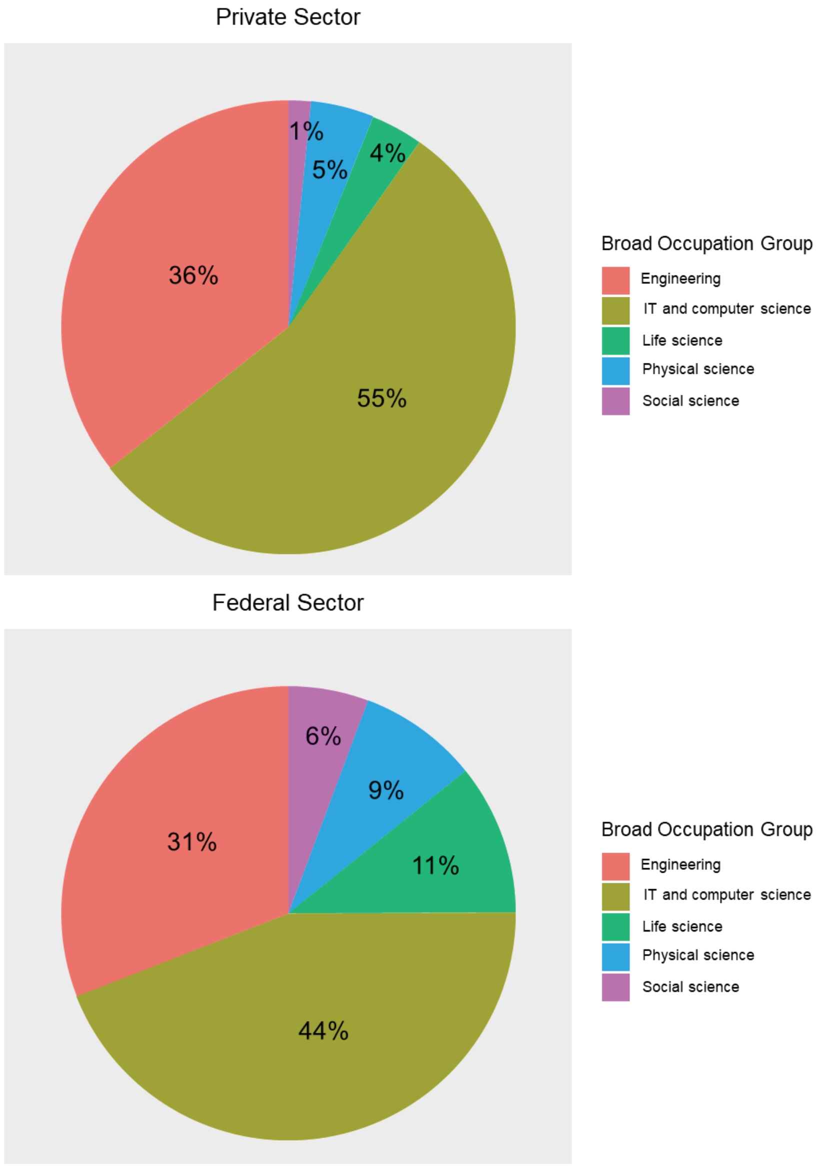
Again, neither of these should be considered wrong. They are describing different populations, relying on different methods, and, notably, using different occupational coding schemes so that a worker who is classified as a life scientist by the OPM could be a physical scientist in the CPS. These differences could affect our static income comparisons. For example, if IT and computer science workers are paid less, and the federal government has more of them in the CPS, then the CPS's average federal STEM income would be lower than the OPM's average STEM income.

However, our static income comparisons look within category (i.e., comparing income of IT and computer science workers in the private and federal sectors), and our key analysis of income comparisons uses regression techniques, which control for compositional differences.

For the remainder of this chapter we will use the CPS. And for the remainder of this section, we will describe the most recent estimate (2018) as well as a ten-year average (2009–2018).

Figure 4.2 shows the average distribution of STEM workers across occupations in the past ten years, which would exclude any yearly volatility. The results are similar to those in

Figure 4.2. Distribution of STEM Workers, by Broad Occupation Group and Sector, 2009–2018 Average



SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Counts include both employed and unemployed workers.

Table 4.1. The majority of private-sector STEM workers are in IT and computer science, over one-third are in engineering, and less than 10 percent are in the physical, life, or social sciences. The federal STEM workforce has a very similar distribution—a dominant share in IT and computer science, followed by engineering, with much lower in the remaining—but to a different degree. A quarter of the federal STEM workforce is in the physical, life, and social sciences.

Age

STEM workers in the federal workforce generally skew older than STEM workers in the private sector. In 2018, 36 percent of federal STEM workers were under age 40, versus 49 percent of private-sector STEM workers, as is noted in Table 4.2. Conversely, 29 percent of private-sector workers were over age 50, compared with 42 percent of federal STEM workers. However, both the private and federal sectors show similar trends in direction, if not degree, since 2009. Both mostly saw growth in the shares of younger workers (those under 40), though the private sector saw a small decline in workers ages 35–39, and the federal government saw a small decline in workers ages 25–29. Both mostly saw a decline in middle-age workers ages 40–54 and an increase in workers ages 55 and older. In general, the shifts in the distribution of the private-sector workforce were more pronounced: there was larger growth among young workers and older workers, and a larger decline among middle-age workers.

Table 4.2. Distribution of STEM Workers, by Age Group and Sector, 2018

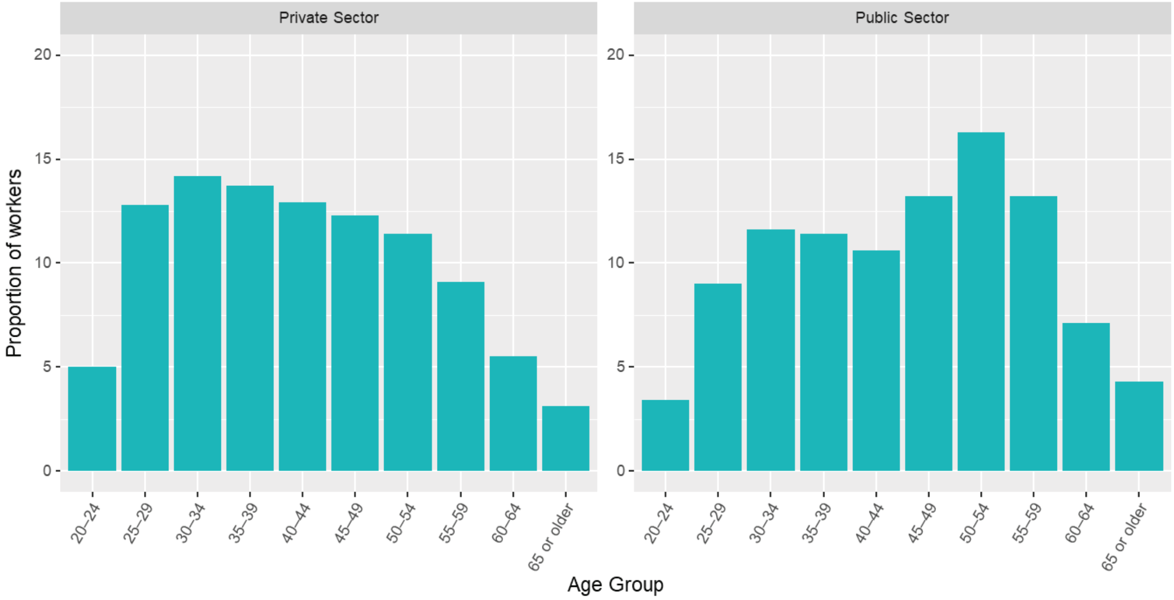
Age Group	Private Sector		Federal Sector	
	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018
20–24	5.7	1.2	4.2	0.5
25–29	14.2	1.2	9.0	–0.3
30–34	14.9	1.0	11.0	1.3
35–39	13.5	–0.7	11.5	1.0
40–44	11.8	–1.9	9.8	–1.7
45–49	10.8	–3.6	12.3	–4.5
50–54	9.7	–2.0	14.7	–0.1
55–59	9.1	1.3	15.7	3.1
60–64	6.6	2.3	7.5	0.2
65 or older	3.5	1.3	3.9	0.2

SOURCE: CPS (via the U.S. Census Bureau).

NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Counts include both employed and unemployed workers.

Figure 4.3 depicts the two distributions averaged between 2009 and 2018, as opposed to the most recent year of data. This average obviates the concern that any single year of data would be sensitive to annual swings in shares or volatility. The results are similar: the federal

Figure 4.3. Distribution of STEM Workers, by Age Group and Sector, 2009–2018 Average



SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Counts include both employed and unemployed workers.

STEM workforce comprises a larger share of older workers than does the private-sector STEM workforce. The private-sector STEM workforce peaks in the age distribution at ages 30–34; it is preceded by a quick run-up and followed by a steadily declining share through ages 65 and older. The federal STEM workforce, on the other hand, sees a similar run-up to ages 30–34, but then a large bump for ages 45–59; indeed, the peak of the federal STEM age distribution is ages 50–54.

We do not speculate as to why these age distributions look different, or why there is a mass of middle-age workers in the federal STEM workforce that is not present in the private STEM workforce. We discussed in Chapter One that one feature of STEM is quick turnover in the market demand for skills and, as a result, a quick erosion of individual skills; it could be the case that that type of erosion differentially affects federal and private workers. It is true that federal employees are eligible for generous education benefits that are rare in the private sector; these could potentially forestall that erosion in the federal sector. In general, it is critical to keep in mind the age distribution when discussing nonmonetary compensation in the form of workplace benefits, since the preference for, or value of, benefits (especially health care and retirement benefits) are likely to change with age. We can only speculate the extent to which this is occurring and the effect on the age distribution. Regardless, the difference in the age distribution is critical to keep in mind when comparing incomes between the federal and private-sector STEM workforces given that workers tend to earn more as they advance in their careers.

Educational Attainment

While STEM workers in both the federal workforce and the private sector are, on average, much more highly educated than their non-STEM counterparts, there are some notable differences in the distributions. As of 2018, the share for those with advanced degrees was double among federal STEM workers than in the private sector (12.6 percent, versus 5.7 percent). The master's degree share was also slightly higher in federal STEM employment (26 percent, versus 23.3 percent). However, the share for a terminal bachelor's degree was about 6 percentage points higher in the private sector, resulting in the total share of workers with at least a bachelor's degree being virtually identical across the sectors (75.9 percent in the private sector versus 78.9 percent in the federal government). The shares of STEM workers with an associate's degree, technical credential, or no postsecondary credential were all somewhat higher in the private sector.

Over the 2009–2018 period, both sectors shifted in the direction of more education. The private sector saw large increases in the share of those workers with bachelor's degrees (1.8 percentage points) and master's degrees (3.9 percentage points), with a smaller increase in advanced degrees (0.8 percentage points), and declines among all categories of sub-baccalaureate education. The federal sector increases were smaller, but positive for every category associated with a postsecondary degree, from associate's degrees (1.2 percentage points), to bachelor's degrees (0.4 percentage points), to master's degrees (0.8 percentage points), and advanced degrees (0.5 percentage points).

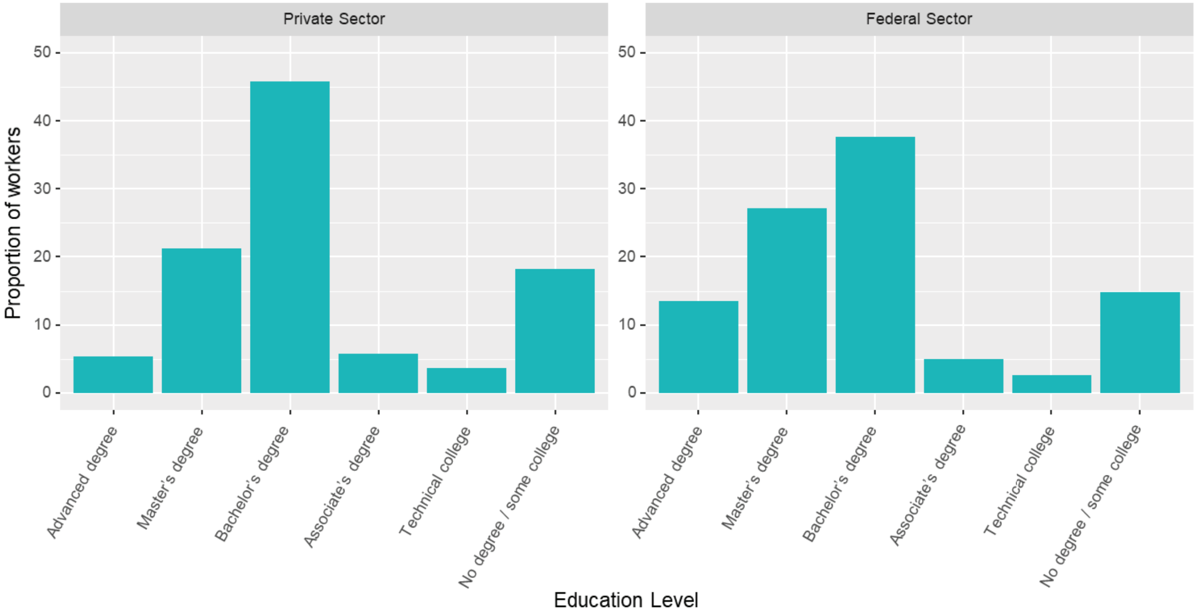
Table 4.3. Distribution of STEM Workers, by Education Level and Sector, 2018

Education Level	Private Sector		Federal Sector	
	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018
Advanced degree	5.7	0.8	12.6	0.5
Master's degree	23.3	3.9	26.0	0.8
Bachelor's degree	46.9	1.8	40.3	0.4
Associate's degree	5.2	–0.4	5.1	1.2
Technical college	3.1	–1.2	2.6	0.0
No degree/some college	15.9	–4.7	13.5	–2.7

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. Advanced degrees include J.D.'s, M.B.A.'s, M.D.'s, and Ph.D.'s. Counts include both employed and unemployed workers.

In Figure 4.4 we again show the average distribution over the 2009–2018 period to allay any concern of year-to-year fluctuations. The results are similar to the data in 2018. The private STEM workforce has a large mass of workers with terminal bachelor's degrees, high shares with master's degrees or no degrees, and very small shares with advanced degrees or sub-baccalaureate degrees. The federal STEM workforce, on the other hand, has more advanced degree and

Figure 4.4. Distribution of STEM Workers, by Education Level and Sector, 2009–2018 Average



SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. Advanced degrees include J.D.'s, M.B.A.'s, M.D.'s, and Ph.D.'s. Counts include both employed and unemployed workers.

master's degree holders and a comparatively smaller share of terminal bachelor's degree holders. Similar to the private sector, there are few sub-baccalaureate degree holders and a large share of workers without degrees.

The difference in the educational attainment of the two workforces could be indicative of the nature or scope of work in the two sectors; the extent of—and rewards to—on-the-job training or experience versus credentials; or any number of other factors. Critically, these distributions will be important to keep in mind when comparing STEM compensation between the private sector and the federal STEM workforce. In particular, averages that do not control for education level or restrict to within educational attainment groups will include a larger share of more highly educated workers in the public sector than in the private sector.

Gender and Race/Ethnicity

As described in earlier chapters, FedScope data do not include identifiers for gender or race/ethnicity. As a result, we base our comparison between the federal and private-sector STEM workers with respect to these demographic characteristics on the CPS. Table 4.4 compares the gender and race/ethnicity distribution between STEM and non-STEM workers in both sectors in 2018 and the percentage-point change in the distribution from 2009 to 2018. In both sectors there is considerably less gender and racial diversity in STEM than outside it.

White men make up about half of STEM workers in the private-sector STEM workforce, while they account for just 31.9 percent of workers in non-STEM occupations. In addition,

Table 4.4. Distribution of Workers, by Gender, Race/Ethnicity, Sector, and STEM Status, 2018

Demographic Group	Private Sector				Federal Sector			
	STEM Workers		Non-STEM Workers		STEM Workers		Non-STEM Workers	
	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018	2018 Distribution (Percentage)	Percentage-Point Change, 2009–2018	2018 Distribution (Percentage)	Percentage Point Change, 2009–2018
Male	77.4	–1.8	53.4	–1.0	68.7	–2.1	57.2	–0.9
Female	22.6	1.8	46.6	1.0	31.3	2.1	42.8	0.9
White	66.6	–7.0	59.3	–5.8	70.2	–5.8	62.3	–5.9
Hispanic	7.8	1.4	12.6	3.3	7.6	1.9	19.8	2.1
Black	6.6	0.3	22.7	0.7	14.2	4.8	12.2	2.2
Asian	19.0	4.7	5.4	1.3	7.9	–1.0	5.7	–0.2
White male	52.7	–6.3	33.8	–3.8	49.9	–5.8	35.9	–3.9
White female	13.9	–0.7	25.5	–2.0	20.3	0.0	26.4	–2.1
Hispanic male	6.1	1.1	7.6	1.7	5.6	1.8	12.3	1.6
Hispanic female	1.7	0.5	5.0	1.7	2.1	0.2	7.5	0.5
Black male	4.6	–0.1	9.6	0.4	7.1	1.6	6.1	0.5
Black female	2.0	0.3	13.1	0.3	7.1	3.2	6.0	1.8
Asian male	14.1	3.3	2.8	0.6	5.8	0.1	3.0	–0.2
Asian female	4.9	1.5	2.6	0.7	2.2	–1.1	2.8	0.0

SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The public sector refers to federal workers. Counts include both employed and unemployed workers. The table excludes the “Other” race Census category from calculations, as it is too small for comparison.

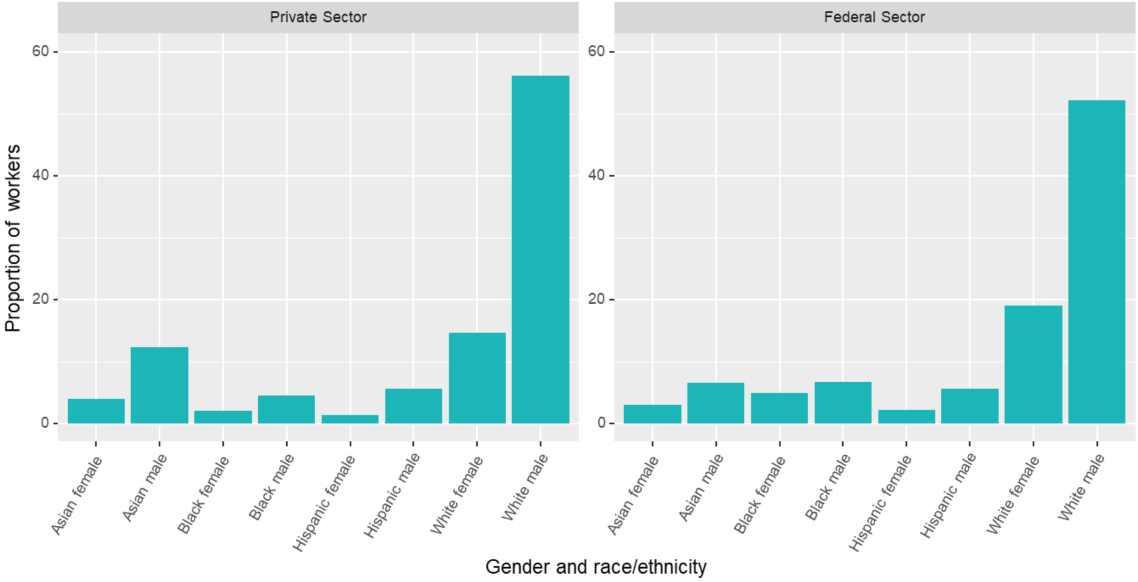
diversity in the private-sector STEM workforce comes more from the presence of Asian workers (18.6 percent of the private STEM workforce) and less from historically underrepresented minorities. Only 7.6 percent of private STEM workers are Hispanic, and 6.5 percent are black, though together they make up one-third of the non-STEM workforce. The federal government fares modestly better; it comprises 48.3 percent white men in STEM, compared with 35.1 percent in non-STEM positions. The federal STEM workforce has a higher share of women (31.3 percent), an even share of Hispanics (7.4 percent), and double the share of blacks (13.8 percent) compared with the private-sector STEM workforce.

However, both private-sector and federal STEM is becoming more diverse. Both sectors saw the white male share of the workforce fall in the past nine years—6.3 percentage points in the private sector and 5.8 percentage points in the federal sector. The declines were larger than the white male non-STEM decline for both sectors. The share of STEM workers who were white women stayed relatively constant for both, but the federal STEM workforce saw relatively large increases in the share of Hispanic men (1.8 points), black men (1.6 points), and black women (3.2 points). Indeed, the share of black women in the federal STEM workforce nearly doubled over this time period. Private-sector STEM did not mirror these changes. Despite modest increases in the share of Hispanic men (1.1 points), there was little change in the share of

Hispanic women (0.5 points), black men (–0.1 points), or black women (0.3 points), and relatively large gains in the share of Asian men (3.3 points).

Figure 4.5 shows the breakdown by demographic group for the STEM workforce in the private and public sectors averaged over the years 2009–2018 in the CPS. The story is little changed from looking at the most recent year of data only; as we noted in Chapter One, STEM has had issues with diversity and inclusion. The federal government has higher shares and has made larger gains in increasing diversity in its STEM workforce, in particular for underrepresented minorities, than private-sector STEM.

Figure 4.5. Distribution of STEM Workers, by Gender, Race/Ethnicity, and Sector, 2009–2018 Average



SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Counts include both employed and unemployed workers.

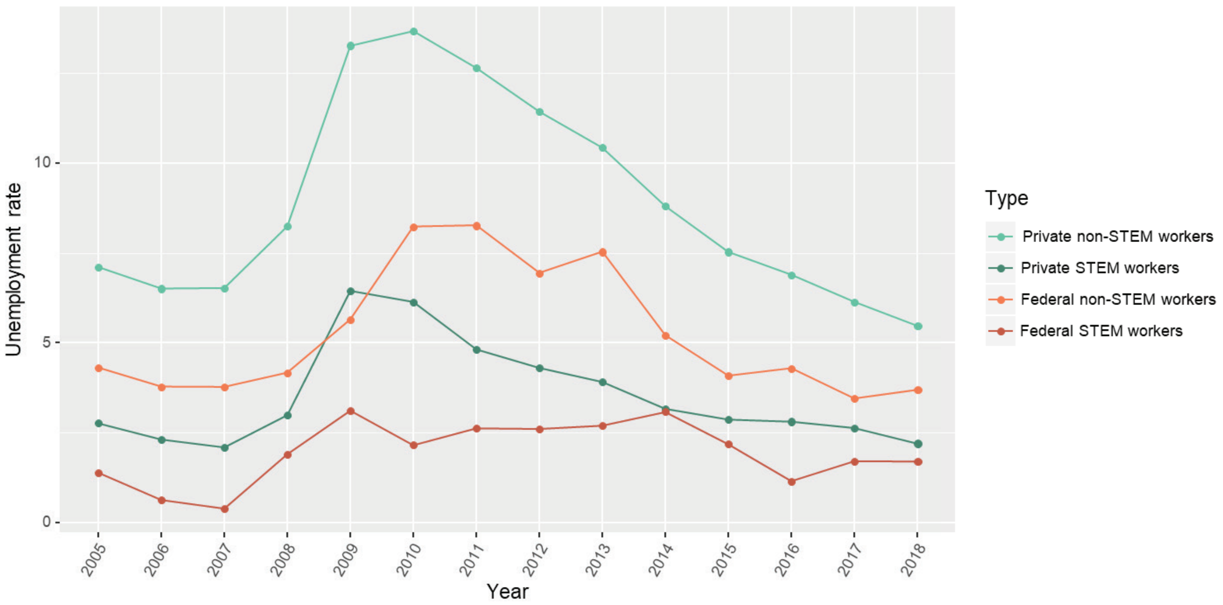
The Unemployment Rate and Hours Worked

In this section we briefly describe differences between the federal STEM workforce and private-sector STEM workers with respect to two key determinants of job quality and stability: the unemployment rate and usual hours worked. Unemployment rate data for both sectors are from the CPS, while hours worked for both sectors are from the CPS ASEC.

The Unemployment Rate

The unemployment rate trends, depicted in Figure 4.6, are clear: STEM workers face a lower unemployment rate than non-STEM workers in both sectors, and federal workers fare better than

Figure 4.6. Unemployment Rate, by STEM Status and Sector, 2005–2018



SOURCE: CPS (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers.

private-sector workers, in both STEM and non-STEM occupations. Moreover, with the exception of one year during the Great Recession (2009), private-sector STEM workers have lower unemployment than their federal non-STEM counterparts. Over the past ten years (2009–2018), federal STEM unemployment has averaged just 2.0 percent, a bit below private-sector STEM unemployment (2.7 percent), and about half the rate of federal non-STEM unemployment (4.1 percent). Non-STEM workers in the private sector had notably higher unemployment rates than the other groups considered: 7.0 percent over the 2009–2018 period.

Hours Worked

Usual hours worked varied little over the time period analyzed, and as with unemployment, the core finding is clear: federal STEM workers work a bit less, on average, than their private-sector counterparts. On average for the period 2009–2018, STEM workers in the federal workforce worked 41.5 hours per week, versus 43.0 hours per week for private-sector STEM workers. In both sectors, non-STEM workers put in slightly more hours than STEM workers, though the difference in both sectors was less than a half hour per week on average.

Income Comparisons

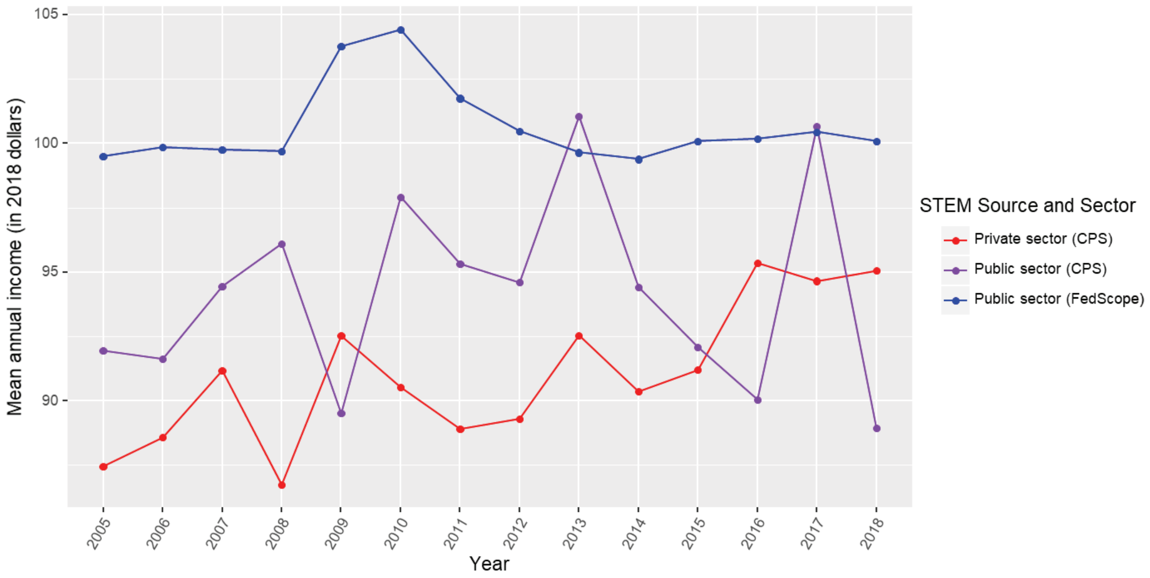
We devote the bulk of this chapter to a comparison of income between federal and private-sector STEM workers. In this section, we report descriptive comparisons, overall and for groups of STEM workers. Later in the chapter we conduct a regression analysis to control for various factors that are commonly associated with pay differentials in order to understand the degree to which federal and private-sector STEM compensation varies after including such controls.

As noted at the outset of this chapter, we draw on two different data sources for federal STEM income data: the CPS and the OPM's FedScope; however, only the CPS allows for a direct comparison to the private sector, since CPS data are available for both sectors. Therefore, for most of our discussion of income, and all of our comparisons by occupation, education, and demographic characteristics, we draw on CPS data, averaging the years 2009–2018 to build a sufficient sample size for a comparison. This period also reflects the ten years from the trough of the most recent recession through the most recent available data.

Figure 4.7 shows how income for federal STEM workers depends on the data source used. FedScope's measure of income results in federal STEM workers consistently appearing to earn more that private-sector STEM workers over the 2005–2018 period. However, when using a consistent data source for both sectors (the CPS), this apparent premium to STEM work in the federal government shrinks noticeably, though there is greater year-to-year variation owing to the small sample size of federal workers in the CPS.

The finding of higher average pay using the FedScope data may be somewhat surprising given that this data source excludes overtime and other categories of pay that would be included in the CPS. However, other factors could weigh in the direction of higher average income for public-sector workers in FedScope. First, it is an administrative data source, expected to fully and appropriately capture the income it is intended to measure, whereas the CPS data are self-

Figure 4.7. Mean Annual Income for STEM Workers, by Sector and Data Source, 2005–2018 (in 2018 dollars)



SOURCES: CPS ASEC (via the U.S. Census Bureau); FedScope (via OPM).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers.

reported survey data collected from respondents. Second, as noted above, the FedScope universe of public-sector STEM workers includes a notably smaller share of IT and computer science workers, who—as described in Chapter Three—make less on average than those in other STEM occupations in the federal government, based on FedScope data; they make the second-lowest earnings, according to the CPS income data. Third, sampling variation in the CPS could again be a factor. For example, in a couple of years shown in Figure 4.7, CPS average income matched or exceeded FedScope average income for public-sector STEM workers.

On average for the years 2009–2018 (the reference period we use for the comparisons for groups within STEM), CPS-derived average income in federal STEM jobs was $93,200, about $3,700 (or 4 percent) higher than the average in private-sector STEM jobs, $89,600. Put another way, federal STEM income as a percentage of private-sector STEM income was 104 percent, while private-sector STEM income as a percentage of federal STEM income was 96 percent. The CPS-derived premium to working in the federal government was much larger for non-STEM jobs. Federal non-STEM workers earned an average of $67,000 for 2009–2018, nearly $17,000 (34 percent) more than their private-sector non-STEM counterparts, who earned an average of $50,000. Pairing these findings, we further find that the STEM premium is notably larger in the private sector (see Table 4.5). On average for 2009–2018, private-sector STEM workers earned nearly 80 percent more than their private-sector non-STEM counterparts, while federal STEM workers earned about 40 percent more than their federal non-STEM counterparts.

Table 4.5. Average Annual Income in the Current Population Survey for STEM and Non-STEM Workers in the Private Sector and the Federal Government, 2009–2018

	Non-STEM Average Annual Income	STEM Average Annual Income	Difference (STEM Premium)
Private Sector	$50,000	$89,600	+$39,600
Federal Sector	$67,000	$93,200	+$26,200
Difference (federal premium)	+$17,000	+$3,700	

SOURCE: ASEC (via the U.S. Census Bureau).
NOTES: Income is rounded to the nearest hundred dollars; differences may not sum due to rounding. Income figures are expressed in real 2018 dollars.

Notably, none of the amounts in Table 4.5 or described above account for differences between the groups being analyzed. Variation within these workforces with respect to age, educational attainment, demographic characteristics, and other factors such as geography play a major role in driving the headline income findings. Moreover, some groups may fare better in federal STEM employment while others may fare worse. We explore these below.

Age

In our discussion about the distribution of the federal and private-sector STEM workforces, we noted that the federal STEM workforce skews older. Here we document how this distribution contributes to the slight overall pay premium observed for working in STEM in the federal government compared with working in the private sector. In both sectors average income increases with age—which is to be expected as workers gain more experience and advance in their careers—and the three highest-paid age groups are the three including workers ages 50 to 64 (see Table 4.6). However, in the federal STEM workforce, 40.9 percent of workers are at least age 50, versus just 29.0 percent in the private-sector STEM workforce.

Table 4.6. Mean Annual Income, by Sector and Age Group, 2009–2018 Average (in 2018 dollars)

Age Group	Private Sector		Federal Sector		
	Distribution of STEM Workers (Percentage)	Income	Distribution of STEM Workers (Percentage)	Income	Private Income Percentage of Federal Income
20–24	5.0	$45,442	3.4	$50,354	90.2
25–29	12.7	$66,717	9.2	$68,506	97.4
30–34	14.2	$81,416	11.7	$79,053	103.0
35–39	13.7	$96,529	11.4	$92,109	104.8
40–44	12.8	$100,423	10.6	$96,919	103.6
45–49	12.3	$104,549	12.7	$98,893	105.7
50–54	11.3	$104,778	16.4	$104,285	100.5
55–59	9.1	$106,061	13.1	$107,408	98.7
60–64	5.5	$102,621	7.2	$106,852	96.0
65 or older	3.1	$101,476	4.2	$102,600	98.9

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The public sector refers to federal workers. We do not report incomes for workers under 20 years of age, who account for less than 0.3 percent of STEM workers in both sectors.

For workers ages 30–54, accounting for about two-thirds of workers in both sectors, there is in fact a modest pay premium to private-sector STEM work compared with STEM work in the federal government. Only among the youngest and oldest workers is pay higher for federal STEM workers. This is a critical caveat to the overall average of 4-percent higher income for federal STEM workers; this apparent advantage is due in substantial part to the different age distributions of the two workforces, and it reverses in favor of the private sector when comparing within age groups that account for the majority of STEM workers. The pay premium to private-sector STEM work among workers in their prime working years, when their salaries are likely at about their lifetime peaks, may be due in part to the pay cap for federal workers ($166,500 in 2019, as was noted in Chapter Three). While this cap is less likely to be binding for younger workers establishing themselves in their careers, mid- and late-career workers in particular may have vastly higher earning potential in the private sector.

Educational Attainment

Workers with higher levels of educational attainment earn more, on average, than those with lower levels of educational attainment. This held true for both federal and private-sector STEM workers, as is documented in Table 4.7. However, the dispersion is clearly much wider in the private sector, with a larger premium for higher levels of education than exists among federal STEM workers. Federal STEM workers with advanced degrees earned about $33,000 more than federal STEM workers with no degrees, while this gap in the private-sector STEM workforce was more than $55,000.

Table 4.7. Mean Annual Income, by Sector and Education Level, 2009–2018 Average (in 2018 dollars)

Education Level	Private Sector		Federal Sector		Private Income Percentage of Federal Income
	Percentage of STEM	Income	Percentage of STEM	Income	
Advanced degree	5.4	$124,191	13.3	$108,551	114.4
Master's degree	21.5	$109,916	27.0	$104,696	105.0
Bachelor's degree	45.8	$92,350	37.6	$90,386	102.2
Associate's degree	5.6	$73,702	4.8	$86,104	85.6
Technical college	3.7	$73,799	2.4	$76,960	95.9
No degree/some college	18.1	$68,953	14.8	$76,015	90.7

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. Advanced degrees include J.D.'s, M.B.A.'s, M.D.'s, and Ph.D.'s.

Unsurprisingly, given the tighter distribution among federal STEM workers by educational attainment, more highly educated federal STEM workers earn less than their similarly educated private-sector counterparts, while less educated federal STEM workers earn more. The private-sector advantage is most pronounced for advanced degree holders, where private-sector workers earn 114.4 percent of what federal workers make, while associate's degree holders in the federal STEM workforce fare the best compared with their private-sector counterparts, with private-sector workers earning 85.6 percent of federal incomes, on average. Incomes for STEM workers with bachelor's degrees (only) were the closest when comparing between sectors, with private-sector workers making about $2,000 more on average.

In sum, the larger share of workers with master's or advanced degrees in the federal STEM workforce helps to explain why the overall average income for federal STEM workers is 4 percent higher than the average income for private-sector STEM workers, since more highly educated workers earn more in both sectors, and the share of these workers is higher in the federal government. However, among highly educated workers, earnings are higher, on average, in the private-sector STEM workforce. Earning potential for advanced degree holders is particularly high in the private sector relative to the federal STEM workforce. STEM workers with an advanced degree in the federal workforce earn slightly less than master's degree–level workers in the private sector. Again, the cap on federal pay likely contributes to this finding, with highly educated workers, in particular, being able to earn higher salaries outside the federal government.

Gender and Race/Ethnicity

Comparing federal versus private-sector STEM incomes by gender and race/ethnicity reveals four key findings: (1) white men earn about the same amount, on average, in both sectors; (2) women and minorities fare markedly better, on average, in federal STEM employment than in the private sector; (3) as a result, there are notably smaller income gaps between women and most minorities and white men in the federal STEM workforce than in the private sector; and (4) Asian men have higher average incomes in the private-sector STEM workforce.

Table 4.8 presents several metrics that quantify these findings. For each demographic group, for both the federal STEM workforce and the private sector, we report the share of the workforce in the demographic group and average income for 2009–2018. Women's income is reported as a share of men's income. Minorities' income is reported as a share of whites' income, and for gender by racial/ethnic groups, income is reported as a share of white male income. Then, in the rightmost column, we report federal income as a percentage of private-sector income for each group.

Table 4.8. STEM Worker Income, by Sector, Gender, and Race/Ethnicity, 2009–2018 Average

Demographic Group	**Private Sector**			**Federal Sector**			**Private Income Percentage of Federal Income**
	Distribution of STEM Workers (Percentage)	Income	Share of Male, White, or White Male Income (Percentage)	Distribution of STEM Workers (Percentage)	Income	Share of Male, White, or White Male Income (Percentage)	
Male	78.2	$96,013	—	70.9	$96,939		99.0
Female	21.8	$78,141	81.4	29.1	$88,757	91.6	88.0
White	70.3	$93,302	—	71.2	$95,855	—	97.3
Hispanic	6.9	$77,941	83.5	7.5	$90,287	94.2	86.3
Black	6.3	$75,011	80.4	11.8	$90,971	94.9	82.5
Asian	16.5	$98,760	105.8	9.4	$90,967	94.9	108.6
White male	55.9	$97,035	—	52.2	$98,445	—	98.6
White female	14.5	$79,091	81.5	19.1	$89,353	90.8	88.5
Hispanic male	5.5	$80,886	83.4	5.5	$94,451	95.9	85.6
Hispanic female	1.4	$67,406	69.5	2.0	$82,383	83.7	81.8
Black male	4.5	$78,762	81.2	6.8	$95,453	97.0	82.5
Black female	1.9	$66,337	68.4	5.0	$86,588	88.0	76.6
Asian male	12.4	$103,673	106.8	6.4	$88,956	90.4	116.5
Asian female	4.1	$83,939	86.5	3.0	$93,023	94.5	90.2

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Shares may not sum due to rounding. In the "Share of Male, White, or White Male Income" column, for women, we report their income as a share of male income; for minorities, we report their income as a share of white income; and for gender by racial/ethnic groups, we report their income as a share of white male income.

While there remain income gaps by gender and race/ethnicity in the federal STEM workforce, they are smaller than in the private sector. For example, while white women earned about 82 cents to the dollar of white men in the private sector, this amount was about 91 cents in the federal workforce. Black and Hispanic women earned about 88 cents and 84 cents, respectively, to the dollar of white men in the federal STEM workforce; these are sizable gaps, to be sure, but much narrower than the roughly 70 cents to the dollar earned by both of these groups in the private-sector STEM workforce. Black and Hispanic male incomes were within 3–4 percent of white male incomes in the federal STEM workforce, on average, while these workers earned just 81–84 cents to the dollar of white men in the private sector.

Asian men were the exception to the general rule that racial and ethnic minorities earned higher incomes in the federal STEM workforce—their incomes were lower, on average, in the federal workforce than in the private sector. They also accounted for a smaller share of the federal STEM workforce than the private-sector STEM workforce. Both factors may be attributable in part to the large share of foreign-born workers of Asian descent in the private-sector STEM workforce, which includes noncitizens who are ineligible for federal employment.

Geography

A potentially important but heretofore not explored contributor to the modest income premium to federal STEM work relative to private-sector STEM jobs is the geographic distribution of the workforce. Namely, if federal jobs are concentrated in higher-cost-of-living areas, this could result in these jobs tending to pay more overall without affording a better standard of living. The difference in pay between federal and private-sector STEM work also may vary by location. Table 4.9 lists income for each of the four U.S. Census regions, divided by sector and by whether workers live in urban or rural areas. Note that the District of Columbia, Maryland, and Virginia are included in the Census-designated South. A more precise comparison across regions would use region-specific price indices to adjust incomes to a common purchasing power; however, that was infeasible. We nonetheless include the average income for each region, by sector, because it is important to recognize that these amounts contribute to the overall income averages described above.

Table 4.9. STEM Worker Income, by Sector, Census Region, and Location (Urban Versus Rural), 2009–2018 Average

Region	Private Sector		Federal Sector		Private Income Percentage of Federal Income
	Distribution of STEM Workers (Percentage)	Income	Distribution of STEM Workers (Percentage)	Income	
Rural Northeast	1.6	$76,734	1.1	$84,256	91.1
Urban Northeast	16.1	$95,240	13.0	$89,182	106.8
Rural Midwest	5.0	$69,673	2.9	$70,643	98.6
Urban Midwest	17.5	$86,442	12.8	$90,975	95.0
Rural South	5.6	$75,937	5.1	$86,717	87.6
Urban South	31.6	$89,400	42.3	$97,956	91.3
Rural West	2.0	$76,930	2.7	$86,036	89.4
Urban West	21.0	$101,647	20.4	$93,635	108.6

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers.

At this level of analysis, federal STEM workers in the South fared better than their private-sector STEM counterparts, with private-sector workers earning 91.3 percent of federal incomes in urban southern areas and 87.6 percent of federal incomes in rural southern areas. However, this does not account for differences within this large region. For example, federal STEM workers could be expected to be concentrated disproportionately in the Washington, D.C., metropolitan area, while private-sector STEM workers would be more evenly distributed across the Census region. We are unable to parse the analysis to isolate the comparison to Washington-area workers.

Setting aside the South, there are a couple of notable findings from this geographic analysis. First, private-sector STEM workers outearned federal STEM workers in urban areas in both the Northeast and the West. Average incomes were highest of all sector-geographic groups among private-sector STEM workers in the urban West, home to both Silicon Valley and Seattle, with these workers earning an average of more than $100,000 per year, though we again note that this does not mean that these workers have higher purchasing power after accounting for differences in the cost of living. Second, while rural workers make up a small share of STEM workers in both sectors, federal STEM workers in rural areas earned more than their private-sector counterparts across all Census regions.

Occupation

The overall similarity in incomes, with federal STEM workers making, on average, 4 percent more than their private-sector counterparts, may mask differences by occupation. In this section we explore variation in income by occupation between the federal STEM workforce and the private sector. At the broad occupation level, as shown in Table 4.10, we find that STEM workers in the federal government in all five broad occupations made more, on average, over the years 2009–2018, than workers in the private sector. Physical scientists enjoyed by far the largest

Table 4.10. STEM Worker Income, by Sector and Broad Occupation Group, 2009–2018 Average

Broad Occupation Group	Private Sector		Federal Sector		Private Income Percentage of Federal Income
	Percentage of STEM	2009–2018 Income	Percentage of STEM	2009–2018 Income	
Engineering	35.5	$92,146	31.0	$95,862	96.1
IT and computer science	54.8	$92,780	44.1	$93,136	99.6
Life science	3.6	$84,661	10.7	$85,497	99.0
Physical science	4.5	$86,703	8.5	$103,366	83.9
Social science	1.6	$97,116	5.8	$105,553	92.0
Non-STEM occupations	—	$58,298	—	$71,152	81.9

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers.

premium to working in the federal government, with private-sector physical scientists earning 83.9 percent of what their federal counterparts earned. Social scientists in the private sector earned 92.0 percent, on average, of what federal social scientists made. The gaps in the other three broad occupations were less than 5 percent.

In the largest of the broad occupations in both sectors, IT and computer science, just $350 separated average earnings for federal and private-sector workers, with federal workers slightly outearning their private-sector counterparts. Below we delve into IT and computer science to identify if there are specific occupations with larger disparities that are hidden at the broad occupation level.

IT and Computer Science Workers

The IT and computer science broad occupation can be divided into 11 detailed occupations as identified by CPS codes. Table 4.11 displays the results of this analysis. Seven of these detailed occupations (rows two through eight in the table) directly relate to IT and computer science, and collectively account for more than 95 percent of private-sector STEM workers and about 75 percent

Table 4.11. STEM Worker Income, by Sector and by Detailed Occupation Within Information Technology and Computer Science, 2009–2018 Average

Occupation	Private Sector		Federal Sector		
	Share of IT and Computer Science (Percentage)	Income	Share of IT and Computer Science (Percentage)	Income	Private Income Share of Federal Income
IT and computer science (broad occupation)	100.0	$92,780	100.0	$93,136	99.6
Computer and information systems managers	13.9	$111,580	8.4	$98,120	113.7
Computer scientists and systems analysts	27.5	$84,805	28.8	$90,938	93.3
Computer programmers	9.9	$86,157	4.8	$81,874	105.2
Software developers, applications and systems software	28.0	$106,312	19.1	$95,407	111.4
Database administrators	2.3	$88,709	1.6	$132,678	66.9
Network and computer systems administrators	4.7	$78,793	5.0	$87,605	89.9
Computer support specialists	10.0	$63,894	9.5	$89,551	71.3
Actuaries	0.6	$145,822	0.1	N/A	—
Operations researchers	1.8	$84,682	18.6	$93,145	90.9
Statisticians	0.3	$92,821	1.1	$98,794	94.0
Other mathematical science occupations	1.1	$94,050	3.2	$105,954	88.8

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. N/A indicates insufficient sample size to report income for the occupation.

of federal STEM workers in the broad occupation. The remaining four detailed occupations—operations researchers, actuaries, statisticians, and "other" mathematical scientists (i.e., those who do not fit into one of the other categories)— are small in size, with the exception of operations researchers in the federal sector.

A core finding is that—while there is rough parity in the IT and computer science broad occupation, there are notable disparities in several specific suboccupations in computer science that account for a large share of the STEM workforce in both sectors. For example, computer and information systems managers in the federal government earned about $13,500 less, on average, than what these workers made in the private sector, while software developers earned about $11,000 less and computer programmers earned about $4,300 less. These three suboccupations collectively accounted for about one-third of the federal IT and computer science workforce and about half of the private-sector IT and computer science workforce.

Occupations with higher average pay for federal workers offset these occupations for which pay was higher in the private sector. All non–computer science occupations within the broad occupation for which sufficient data are available (the bottom three rows in Table 4.11) paid more in the federal government sector. However, these occupations constituted a small share of each sector's broad occupation workforce (about one-fourth, collectively, of the IT and computer science workforce in the federal government and just 5 percent of it in the private sector). Four core computer science suboccupations also paid better, on average, in the federal government: database administrators (with nearly 50-percent higher pay in federal employment than in the private sector), computer support specialists (with 40.2-percent higher pay), network and computer systems administrators (with 11.1-percent higher pay), and computer scientists and systems analysts (with 7.2-percent higher pay). These four suboccupations collectively accounted for about 45 percent of IT and computer science employment in both the federal government and the private sector.

Industry Comparisons

Finally, we note that while federal STEM workers are concentrated in the industry known as public administration (though some federal workers reported to the CPS that they work in a different industry, such as education or health services), private-sector STEM workers are dispersed more broadly across industries in the economy. Some of these industries may offer higher pay, on average, than federal STEM workers earn. Table 4.12 compares incomes for private-sector STEM workers in each of 12 industries with the average income for federal STEM workers. For the purposes of this analysis, we use the overall 2009–2018 average federal STEM worker income of $93,200 rather than an industry-level metric.

While federal STEM pay, on average, is higher than pay for private-sector STEM workers in most industries, there are a few exceptions. Mining, quarrying, and oil and gas extraction workers earned more in the private sector, with private-sector workers in the extraction industry making, on average, about 120 percent as much as the federal STEM average. Information workers and those in the manufacturing industry also fared a bit better with respect to pay, on average, than federal STEM workers.

Table 4.12. STEM Worker Income in the Private Sector and Private-Sector Industry, 2009–2018 Average

Industry	Private-Sector Income	Private-Sector Industry Average Income Share of Federal STEM Overall Average Income (Percentage)
Agriculture, forestry, fishing, and hunting	$71,594	76.8
Mining, quarrying, and oil and gas extraction	$111,562	119.7
Transportation and utilities	$92,494	99.2
Construction	$80,775	86.7
Manufacturing	$94,316	101.2
Wholesale and retail trade	$91,422	98.1
Information	$97,831	104.1
Financial activities	$97,011	99.1
Professional and business services	$92,377	83.4
Education and health services	$77,775	81.1
Leisure and hospitality	$75,543	74.4
Other services	$69,321	76.8

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: STEM workers are those in science, technology, engineering, and mathematics occupations; details of the STEM definition can be found in Appendix A. The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers.

Benefit Comparisons

A comparison of benefits offered to private-sector STEM workers and federal STEM workers has the twin challenges of variation and observation. The federal government is a large employer with the resources and reach to provide generous benefits to its employees, and it offers the same, full-suite benefits to all full-time permanent workers.[3] In Chapter Three we provided a discussion of benefits that full-time federal government workers receive, spanning five main types of benefits offered:

- Health insurance, which includes dental, vision, and a flexible spending account
- Retirement, which includes basic benefits, a savings plan similar to a 401(k), and Social Security
- Paid leave, which covers holidays and accrued vacation and sick leave
- Education, which includes loan repayment, loan forgiveness, and tuition assistance
- Life assistance, which covers a wellness program and caregiving assistance.

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[3] We note, however, that federal employee respondents to the CPS do not always report having health or retirement benefits. This could be the result of underreporting of benefits they do have, or idiosyncratic situations in which employees report being full-time federal workers when they are in fact part-time workers or contractors. Later in this chapter, our regression analysis of benefit offerings uses survey-reported data for both private- and public-sector STEM workers.

Although there is variation in who elects to take these benefits, or uses them, there is no variation in who among full-time, permanent federal workers is offered this suite of benefits. In contrast, in the private sector, employers are not required to offer benefits to all of their employees, nor do the benefits have to be the same for all employees, if offered. STEM workers, who tend to be higher earning, also tend to have benefits on the job. In Chapter Two we highlighted three key findings with respect to private-sector STEM workers. They are more likely than their non-STEM counterparts to have employer-sponsored health insurance, employer-sponsored retirement accounts, and access to paid leave. We found, overall, that more than 75 percent of full-time private-sector STEM workers had employer-sponsored health insurance in 2018, about half had an employer-sponsored retirement accounts in 2018, and 84 percent had access to paid leave (according to the 2011 ATUS). However, we only compared STEM and non-STEM; there is inevitably significant variation within private-sector STEM employers with respect to benefit offerings—in their scope, availability, and generosity.

Given that we know the five main benefits offered by the federal government, but cannot observe individual-level observations of benefits for STEM workers in the private sector, we can compare benefits for STEM workers through two questions: first, what are the benefits that *may* be offered in the private sector that are not offered by the federal government and second, how important are those benefits? For example, and obvious reasons, the federal government cannot offer stock options. In answering these questions, we cannot examine STEM workers or STEM employers, but private sector workers more broadly.

The other workplace benefit in which the federal government may be falling behind the private sector is teleworking. Teleworking, or telecommuting, is a component of workplace flexibility. Depending on the size of the employer, SHRM estimates that 68–71 percent of private sector employers offer some form of ad hoc telecommuting, 39–50 percent offer part-time telecommuting, and 22–36 percent offer full-time telecommuting. Again, this is not necessarily a benefit offered to all workers at firms which have telecommuting options, but policies that exist in the company. The flexibility in work hours and work arrangements has been consistently rated high in surveys that ask respondents to rank benefits, however, these are second to a generous health insurance plan (Jones, 2017). Other benefits that private companies might offer, like free snacks or free company outings, are not rated as highly.

For federal employees, the teleworking policy is dictated by the Telework Enhancement Act (Public Law 111–292, 2010), which requires each agency to establish its own teleworking policy as part of Continuity of Operations (COOP) planning (OPM, undated ac). According to OPM's 2019 report to Congress on the status of teleworking in the federal government, 42 percent of federal workers are eligible to telework, but use of the telework program remains lower (OPM, 2019b). However, the 2020 coronavirus pandemic led to much wider use of teleworking. On March 17, 2020, the acting director of OPM issued a memorandum that ordered agencies to immediately adjust operations in order to "minimize face-to-face interactions," through maximizing telework capacity (OPM, 2020). As of writing, federal employees had not been recalled to in-person work, but there had not been any further changes made to the pre-existing telework policy.

One of the few nonmonetary benefits in which the federal government was falling behind the private sector is paid family leave. As noted in Chapter One, many private-sector workplaces, especially in the tech sector, are expanding access to paid maternity and paternity leave. According to the 2019 annual survey of the Society for Human Resource Management (SHRM), 34 percent of employers offer paid maternity leave and 30 percent offer paid paternity leave (Society for Human Resource Management, 2019). However, SHRM's report is based on a survey of HR officers at firms, and is not intended to be representative of all employers or workers in the U.S. The Bureau of Labor Statistics estimates that it is only 20 percent of full-time workers in the private sector had access to paid family leave through their jobs as of 2018 (BLS, 2018a). Still, reported increases in paid family leave are noteworthy, since this is a benefit likely to be valued by prime-age workers, who we already show are likely to be earning less in the federal government, or could be a benefit that certain workers, such as women, especially prize. Prior research has found that up to 43 percent of women leave full-time STEM work after the birth of their first child (Cech and Blair-Loy, 2019). Previously, workers with sufficient years of service in the federal government who accrued sizable amounts of other forms of paid leave offset the lack of paid family leave and benefit prime-age workers. However, the 2020 National Defense Authorization Act includes the Federal Employees Paid Leave Act, which establish 12 weeks of paid family leave for all permanent employees, effective October 2020 (Public Law 116-92, 2019).

Our conclusion is that public sector workers have more access to a more generous suite of benefits. That is not to say that all federal STEM workers have better benefits than any private-sector STEM worker; many private sector employers may offer more generous non-wage packages to their employees. But, this will vary by firm and by position within the firm. Prior comparative analyses of the private and federal sectors that were not limited to STEM have reached similar conclusions. Reilly (2013) finds that public-sector compensation is higher than private-sector compensation, driven by the more generous retirement benefits; however, the public sector's retirement benefits also have less flexibility, which may be more less attractive to certain types of workers. Bewerunge and Rosen (2013) have examined the relative benefits by age and found that older workers have higher nonmonetary benefits in the public sector. However, these two studies examine public workers in general, not just federal employees.

The CBO (2017), in an analysis of whether federal workers in general are competitively compensated, finds that overall the federal government pays a 47-percent premium in benefits, meaning that the value of federal benefits are 47 percent higher than in the private sector. However, this varies from a 93-percent premium for workers without a postsecondary degree to a 0-percent premium, or comparable benefits, for workers with an advanced degree. Of note, this CBO study took place before the 12-week paid family policy was passed. The CBO recognized a number of data limitations in its benefits comparison, which mainly estimates the value of nonmonetary benefits through the cost of providing them.

First, the CBO recognized that the cost of providing benefits varies across different businesses in the private sector, let alone between the private and public sectors. Second, smaller employers may offer fewer benefits compared with larger employers, especially in terms of health care. Other smaller employers cannot provide benefits to their employees at all. This results in a disparity between the public and private sector, as the private sector has a greater number of small firms with less ability to provide benefits to their employees. Third, many benefit programs are based on employees' wages, so that characteristics that affect employees' wages, such as education, occupation, and experience, will subsequently affect their benefits. Fourth, while other benefits may not be tied directly to wages, employees' individual choices may affect the degree of benefits received. For example, federal employees can choose their own health care plans, which directly contribute to the cost to the federal government of those benefit programs.

Hence, federal employees have higher-value benefits, but this can be a function of multiple things. Moreover, the monetary value of benefits—which, as in the CBO study, are often the basis of these type of premium derivations—is not the same as the worker's value of benefits, which Dulebohn et al. (2009) note are typically different; they also find that how workers value benefits change with many circumstances, including age.

While the paucity of data in our study precludes a definitive analysis of the comparison of benefits, what is clear is that the private sector has more variation while the federal government offers a consistent, generally strong benefits package to all of its full-time employees. Some private-sector employers offer more generous benefits, or types of benefits and workplace flexibilities that are simply unavailable to federal workers. Others offer none at all. We assess the variation in benefits available across and within firms in the private sector to be a detriment, rather than a strength, in comparison to the federal government. And when comparing two large employer types, this is appropriate—on average, the federal government offers more in benefits. However, the federal government cannot respond to an individual's preferences in benefits offered the way a private employer could. Federal benefits are determined by Congress, and are not singularly negotiable.

Regression Analysis

The previous comparisons of income, hours, and benefits provide useful context for how, in general, compensation and benefits vary between federal and private-sector STEM workers. We have found that, for the most part, private-sector workers work longer hours and, because federal benefits are universally offered, are less likely to have nonmonetary benefits than federal workers. But the group comparisons of income were less straightforward. Federal STEM workers appeared to have a wage advantage among the youngest and oldest workers, the less educated, workers who are not white men (with the exception of Asian men), and workers in rural areas and the urban South and urban Midwest regions. Private-sector STEM workers have a wage advantage among midcareer workers, the highly educated, white and Asian men, and those working in urban areas in the West and Northeast.

However, within-group compositional differences may affect these group-level comparisons. For this reason we also perform regression analysis to control for several observable characteristics of workers at the same time and isolate the average "government effect" on STEM worker compensation and benefits. For these regression analyses, we use the CPS ASEC for the years 2009–2018.

Comparing Federal and Private-Sector STEM Workers

In Table 4.13 we show the coefficients on being a federal government worker on dependent variables of interest: an indicator for whether an individual worked more than 45 hours in a usual week, annual income (in real 2018 dollars), an indicator for having a retirement plan through work, and an indicator for having health insurance.[4] For each dependent variable we show two federal coefficients: the first is without any controls in the regression, which is just the mean difference between federal and private-sector STEM workers, and the second is with a full set of controls. The controls include levels of educational attainment, STEM occupation, gender, race/ethnicity, age,[5] geographic region, urban/rural status, and year. The asterisks on the estimates indicate whether the coefficient is statistically significant at the 1 (***), 5 (**), and 10 (*) percent levels.

In the first row of Table 4.13 we show the coefficient on being a government worker when the dependent variable indicates whether a worker works more than 45 hours in a usual workweek. The mean coefficient estimate is –0.081; given that the dependent variable is a dummy, this coefficient can be interpreted as a percentage-point difference, or, a federal STEM worker is 8.1 percentage points less likely to report long hours. Controlling for the composition of the workforces, however, the coefficient increases in magnitude to –0.091, or, a federal STEM worker is 9.1 percentage points *less likely* to report long hours than a private-sector STEM worker. Again, a regression alone does not signify causality, but expresses a statistical relationship. Hence, we can say that federal STEM workers are much less likely to work long hours, not that being a federal worker reduces hours of work. It could be the case that the causality is indeed there, but a regression does not show or prove it.

In the second row of Table 4.13 we show the federal coefficient on annual earned income. The mean difference in income between STEM workers in the federal government and the private sector is $3,712. After including controls, this falls to –$2,585. In effect, federal STEM workers on average earn more than private-sector STEM workers, but when controlling for

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[4] These variables in ASEC are UHRSWORK1 (usual hours of work per week at main job), INCWAGE (total pretax wage and salary income), PENSION (whether union or employer for the longest job held in the previous year has a pension or retirement plan), and PHIOWN (whether an individual has health insurance in their own name).

[5] In the regression, we include age and age squared, the preferred practice in wage-determinant regressions.

Table 4.13. Regression Coefficients on an Indicator for Being a Federal STEM Worker, Based on Four Dependent Variables

	Federal Coefficient—No Controls (Mean Difference Between Federal and Private-Sector STEM)	Federal Coefficient—with Controls (Difference Between Federal and Private-Sector STEM, Controlling for Composition)
Worked more than 45 hours in a usual week	–0.081***	–0.097***
	(0.006)	(0.006)
Real income (in 2018 dollars)	$3,712***	–$2,585***
	(931)	(916)
Has employer retirement plan	0.212***	0.189***
	(0.008)	(0.008)
Has health insurance	0.042***	0.034***
	(0.007)	(0.007)

SOURCE: ASEC (via the U.S. Census Bureau).
NOTES: The table shows the coefficients on a STEM dummy for two regressions for each of the four dependent variables listed in the first column. The first regression (left) includes no controls and only the STEM dummy; the second regression (right) includes controls for educational attainment, STEM occupation, age, age squared, gender, region, urban/rural status, and year. Standard errors are shown in parentheses beneath coefficient estimates. Stars indicate significance at the 10 (*), 5 (**), and 1 (***) percent level.

observable characteristics, federal STEM workers earn less. Finally, in the bottom two rows of Table 4.13 we show the federal coefficients when the dependent variables are again binary indicator variables: having a retirement plan through one's employer and reporting health insurance coverage. For both the mean difference is positive. Federal workers are 21.2 percentage points more likely to have an employer retirement plan, and 4.2 percentage points more likely to have health insurance. Similarly, the coefficient for both decreases slightly after controlling for composition of the federal and private-sector STEM workforces, to 18.9 percentage points and 3.4 percentage points, respectively.

There are several caveats when interpreting these coefficients. First, we are controlling for observable characteristics in the CPS to account for the compositional differences of the federal government and the private sector, but that still leaves out numerous worker characteristics and preferences. There is no measure here, for example, for worker quality, ability, or productivity, and similarly no measure for job satisfaction or job security. Moreover, these regressions cannot take into account nonwage components of federal government employment, such as mission-driven work or the satisfaction of working in public service, or nonwage components of private sector employment, such as bonuses or stock options. In addition, it does not take into consideration other benefits, such as telecommuting, paid time off, or paid family leave. In addition, the measure of income we use in the CPS does not separately enumerate regular salary versus bonuses or earnings from a secondary job, and bonuses are not a feature of federal compensation. We cannot discuss where the higher earnings come from.

With those caveats in mind, the conclusion is that STEM workers in the federal government work shorter hours and have better benefits than STEM workers in the private sector, for only slightly less ($2,600) in annual pay. This is the "government pay penalty" for STEM workers.

Note that we specify that it is a *pay penalty*, describing only the differences in earnings, and not a *compensation penalty*, since it does not include benefits and is not adjusted for average hours. However, as we noted in our comparison of average STEM income, the difference between federal and private-sector pay—and which one is higher—varies with education. The $2,600 estimate controls for the difference in levels of educational attainment across the two sectors, but we also want to know *within* levels of attainment what the associated difference in pay is. In Table 4.14 we show a series of seven regressions. In each regression we regress average annual income on being a government worker and controls for age, STEM occupation, region, urban/rural status, gender, race/ethnicity, and year, but we limit the sample to workers of a specific level of educational attainment. For these regressions, we split the previously enumerated advanced degree category in two, professional degrees (J.D.'s, M.B.A.'s, and M.D.'s) and Ph.D.'s. The first column in Table 4.14 shows the mean difference between the two groups, and the second column shows the difference controlling for composition of the variables enumerated.

Table 4.14. Regression Coefficients of Annual Income on an Indicator for Being a Federal STEM Worker, by Level of Educational Attainment

	Federal Coefficient—No Controls (Mean Difference Between Federal and Private-Sector STEM)	Federal Coefficient—with Controls (Difference Between Federal and Private-Sector STEM, Controlling for Composition)
No postsecondary degree	$10,414***	$6,277***
	(1,680)	(1,603)
Technical certificate	$10,752	$8,981
	(9,412)	(9,696)
Associate's degree	$13,864***	$8,917*
	(3,548)	(3,660)
Bachelor's degree	–$1,710	–$2,635*
	(1,185)	(1,093)
Master's degree	–$3,908*	–$5,825**
	(1,947)	(1,893)
Professional degree	$7,006	$936
	(11,911)	(13,211)
Ph.D.	–$13,806***	–$9,268*
	(3,944)	(3,823)

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: The table shows the coefficients on a STEM dummy for two regressions on each of the seven enumerated subgroups of educational attainment, listed in the first column. Professional degrees include J.D.'s, M.B.A.'s, and M.D.'s. The first regression (left) includes no controls and only the STEM dummy; the second regression (right) includes controls for STEM occupation, age, age squared, gender, region, urban/rural status, and year. Standard errors are shown in parentheses beneath coefficient estimates.
Stars indicate significance at the 10 (*), 5 (**), and 1 (***) percent level.

For the lower levels of educational attainment, the federal government pays a premium: $6,300 for workers without any postsecondary degree and $8,900 for workers with an associate's degree. Technical certificate holders show a positive estimate, but it is not statistically significant (meaning that it is not large or precise enough to be different from zero). For workers with higher levels of educational attainment, however, the federal government is associated with lower earnings—$2,600 for workers with bachelor's degrees, $5,800 for workers with master's degrees, and $9,300 for workers with Ph.D's. Workers with a professional degree appear to earn more in the federal sector, but these estimates were not significant. The same caveats apply here: we do not have a measure of experience or tenure (only age), and we do not have any measure of worker quality, productivity, or preference.[6]

In previous Chapters Two and Three we used an Oaxaca-Blinder decomposition to understand the difference in earnings between groups of STEM workers by gender and race/ethnicity. Here we perform a similar decomposition, instead comparing STEM workers by employer type—the federal government or the private sector.

The results from the Oaxaca-Blinder decomposition are shown in Table 4.15. Mean annual income of STEM workers in the private sector is $89,548, compared with $93,360 in the federal government, for a difference of $3,712. This is identical to the first row of regressions in Table 4.13. The endowments, however, show an even larger estimate of –$7,300; recall that by *endowments* we mean the credentials (control variables) of the two groups. In other words, if private-sector workers had the same education, age, and STEM occupation, then we would expect them to earn $7,300 less, instead of $3,712 less. The coefficients estimate, the unexplained portion, is $4,930. One way to interpret the results of this decomposition is to say that private-

Table 4.15. Regression Coefficients from the Oaxaca-Blinder Decomposition of Earnings Differences Within Groups of STEM Workers

	Group Comparison: Private Sector^ Versus Federal Sector	
Group 1^ Mean	$89,548*** (352)	
Group 2 Mean	$93,260*** (872)	
Difference	–$3,712*** (940)	
Endowments		–$7,300*** (613)
Coefficients		$4,930*** (907)

SOURCE: CPS ASEC (via the U.S. Census Bureau).
NOTES: The table shows select coefficients from an Oaxaca-Blinder decomposition. The linear estimate is the mean difference between the two groups being compared, the decomposition of that difference is broken down into the endowment (if one group had similar observable characteristics) and the coefficients (if one group had similar return to coefficients). Not shown is the interaction term, which is not interpretable or significant; it is –$1,342 (517). The decomposition includes controls for education, stem occupation, age, age squared, region, urban/rural status, usual hours worked per week, and year. Standard errors are shown in parentheses beneath coefficient estimates.
^ Indicates Group 1, which is noted also in the column heads.
Stars indicate significance at the 10 (*), 5 (**), and 1 (***) percent level.

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[6] Some workforce characteristics, such as worker quality, might not directly relate to income. However, such characteristics would relate to factors that should directly relate to income, such as promotions.

sector workers in STEM should be making less than federal workers; they do not have the same credentials or experience. However, there is an unexplained premium to being a private-sector worker.

The overall estimates can seem contradictory. Just comparing the average wages of the two STEM workforces, we found that federal employees earn $3,700 more than STEM workers in the private sector. When we controlled for the composition of the STEM workforce in the regular linear regression, we found that federal workers earn about $2,600 less. When we decomposed the $3,700, we found that private-sector workers have an unexplained increase to their wages of about $4,900. So do federal STEM workers earn more or less? They earn less. The linear regression and the Oaxaca-Blinder decomposition are measuring different things. The linear regression controls for the differences in composition between federal and private STEM workforces to isolate the relationship between earnings and being a federal government employee, while the Oaxaca-Blinder decomposition uses that difference in composition to understand how earnings may be differentially determined for federal and private workers.

Taking these regression results from all of the dependent variables together, there is clear evidence of a federal-sector pay penalty for STEM workers, but it is unclear how much this pay penalty is offset by shorter hours and more generous benefits. Moreover, it is clear that the overall earnings differences are driven by the larger differences for workers with higher educational attainment.

Chapter Summary

In this chapter we compared the federal and private-sector STEM workforces. We began by describing the size and composition of these two workforces and found that STEM workers account for about twice the share of federal workers as they do private-sector workers. Federal STEM workers tend, on average, to be somewhat older than their private-sector counterparts and to have higher educational attainment. The federal STEM workforce has a higher share of women and black and Hispanic workers *relative* to the private-sector STEM workforce, but both sectors' STEM workforces evince a notable lack of diversity when compared with their respective non-STEM workforces.

The bulk of this chapter presented descriptive analyses of compensation and benefits for STEM workers in each sector. We determined that federal STEM workers face slightly lower unemployment rates, on average, than their private-sector counterparts, while working somewhat fewer hours per week and being more likely to have access to nonmonetary benefits such as employer-sponsored retirement plans and paid leave.

With respect to income, while simple descriptive comparisons suggest a modest pay premium to *federal* STEM work, this obscures significant variation by group (i.e., for those with advanced degrees, or in a particular occupational field), and in particular the *pay penalty* to federal STEM work that we calculate using regression analysis. Our descriptive comparisons show that federal workers in their prime working years (ages 30–55) earn a bit less than their private-sector counterparts, as do federal STEM workers with advanced degrees and those working in urban areas in the West and Northeast. Our regression results ultimately identify a nontrivial pay penalty in excess of $2,600 per year for federal STEM workers compared with similar private-sector STEM workers. While greater access to nonmonetary benefits coupled with shorter hours may offset this disparity in the eyes of STEM workers, the gap suggests that lower pay may contribute to difficulty in recruiting and retaining federal STEM workers.

Critically, this $2,600 varies with educational attainment. STEM workers with no postsecondary degree or an associate's degree earn considerably more in the federal government, with premiums of $6,300 and $8,900, respectively. But with more educational attainment comes larger estimated pay penalties associated with being a federal worker, starting with $2,600 for workers with bachelor's degrees, $5,800 for workers with master's degrees, and $9,300 for workers with Ph.D.'s. Our findings are similar to those of the CBO (2017), which found that federal pay is higher than private-sector pay for workers with lower educational attainment and lower for workers with higher educational attainment. Since, as we have shown, the STEM workforce has more educational attainment, then the average federal pay difference for STEM workers being negative is consistent with the CBO's findings, as are the education-specific estimates.

5. The Department of Defense STEM Workforce

In Chapter Four we found that although group comparisons suggest a small federal premium for STEM worker income, controlling for individual worker characteristics reveals an approximate $2,600 federal pay penalty for STEM workers.

In this chapter we step back from the overall comparisons of the public and private sectors to provide a deeper dive into the STEM workforce within DoD. We offer this more in-depth look of the DoD STEM population for two main reasons: (1) the large size of the DoD STEM workforce, and (2) the critical role of technology in DoD's national security missions. Regarding the first reason, DoD (inclusive of all agencies) employs the largest segment of federal STEM workers, at 41.5 percent.[1] Regarding the second, DoD also plays a critical role in U.S. national security, which relies on technological advances for improving military capabilities.

These technological advances require STEM workers. For example, the Defense Innovation Board cited the need for DoD to develop "new mechanisms" for "attracting, educating, retaining, and promoting digital talent" that can "procure, deploy, and update software that works for its users at the speed of mission need, executing more quickly than our [U.S.] adversaries" (McQuade et al., 2019, pp. 1–2).

In addition to these reasons, we also have richer data on DoD STEM employees that allows more in-depth analyses than what is available through the OPM's general federal workforce database. Specifically, the DMDC data we reference in Chapter One allow us to track individual employees over time and can combine various characteristics (gender, race/ethnicity, etc.) on those employees in ways not available in the OPM's FedScope data. The DMDC data also allow us to look at geographic factors because of the agency location information in the files.

We are interested in two key questions in this chapter:

1. How does the DoD STEM workforce compare to the non-DoD federal STEM workforce in terms of general characteristics and employment trends?
2. How does DoD compare to the private sector in terms of employment and compensation factors for STEM workers?

This chapter is organized along the lines of these two questions. However, as we noted in Chapter Four, income is not comparable across data sources. We cannot make comparisons of private-sector income in the CPS with public-sector income in the OPM—and now, in this case,

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[1] For the numbers of STEM workers by federal agency, see Figure 3.2 in Chapter Three, which shows estimates for the three military departments (Air Force, Army, and Navy), as well as DoD as a stand-alone entity. The stand-alone DoD estimate reflects those agencies (e.g., the Defense Logistics Agency) that are not part of any of the military service departments but within DoD. Collectively, these non-military-service agencies are known as the "fourth estate."

the DMDC. Hence, answering the second question is not possible to the fullest extent we would prefer, and we will mainly rely on making comparisons between the rest of federal government and DoD, and how the $2,600 federal penalty may differ. Further, if we had additional data, we would like to make comparisons of how hours and overtime vary by agency, but the data were not available for DoD. Hence, we have omitted that discussion.

A Comparison of DoD and Non-DoD Federal STEM Workers

We begin by comparing the number and distribution of DoD STEM workers to non-DoD federal STEM workers in terms of occupational groups, educational levels, and other characteristics such as age, gender, race/ethnicity, and pay scale. These comparisons are meant to provide context for interpreting findings for the overall public-sector (federal) STEM workforce in Chapter Three and comparisons between public- and private-sector STEM workforces in Chapter Four.

To conduct these comparisons, we use the DMDC data for DoD workers and the OPM FedScope for the rest of the federal government, even though DoD workers are also in the OPM.[2] We focus on STEM workers, and reference data sources in text for consistency, unless otherwise noted. We follow the DoD and non-DoD overview with a brief discussion of DoD (and national security) considerations for employing STEM workers.

Number and Distribution of DoD and Non-DoD STEM Workers

To get a sense of the size of the DoD STEM workforce compared with the remaining federal STEM workforce, we compare the number and distribution of STEM workers within each of these categories. Table 5.1 shows the number and percentage of STEM and non-STEM workers within DoD and the federal government generally. Overall, non-STEM positions make up the majority of both DoD and other federal agencies' workforces, but STEM positions represent a substantial share of both DoD and non-DoD agencies. Comparing DoD with the rest of the federal agencies, the share of STEM workers is higher within DoD. Of DoD's workforce, 20.5 percent of the employees work in STEM fields, compared with 14.6 percent within the rest of the federal agencies. The DoD STEM workforce includes employees across the DoD components (Air Force, Army, and Navy) and the remaining DoD agencies.[3] The Navy and Army have the

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[2] We also ran our comparisons with the OPM data on DoD workers and found that the OPM FedScope and DMDC figures were either the same or similar. Many of the tables in this chapter include OPM FedScope figures for additional context.

[3] The DoD's "fourth estate" agencies outside the Departments of the Air Force, Army, and Navy include agencies such as the Defense Acquisition University, Defense Advanced Research Projects Agency, Defense Information Systems Agency, Defense Technical Information Center, and Defense Technology Security Administration. For simplicity, we will refer to these agencies collectively as DoD when discussing our findings. We will also use the term *agency* to broadly reflect the three military service departments and the collection of DoD agencies in the fourth estate.

Table 5.1. Distribution of Federal Non-DoD and DoD STEM Workers, 2018

	Federal Non-DoD (OPM) (Percentage)	Federal DoD (DMDC) (Percentage)
STEM Workers	14.6	20.5
Non-STEM Workers	85.4	79.5

SOURCES: DMDC (made accessible to the authors); FedScope (via OPM).

largest portions of STEM employees out of the entire DoD, at 42.9 percent and 31 percent, respectively. This should not be surprising, as we saw in Chapter Three that the Navy and Army are two of the three largest STEM employers out of all the federal agencies. Table 5.2 shows the distribution of DoD STEM employees within the department, broken up by component.

Table 5.2. Distribution of DoD STEM and Non-STEM Workers, by DoD Agency, 2018

Agency	Distribution of STEM Workers (Percentage)		Distribution of Non-STEM Workers (Percentage)	
	Federal DoD (OPM)	Federal DoD (DMDC)	Federal DoD (OPM)	Federal DoD (DMDC)
Army	30.5	31.0	34.2	35.6
Navy	43.9	42.9	26.8	25.5
Air Force	18.2	18.7	24.6	25.2
DoD	7.3	7.4	14.4	13.7

SOURCES: DMDC (made accessible to the authors); FedScope (via OPM).
NOTE: We use the term *agency* to describe large federal organizations but recognize that DoD uses different terminology, particularly when referring to the Departments of the Air Force, Army, and Navy.

Occupational Distribution

Comparing DoD and non-DoD STEM workers by STEM discipline allows us to see different agencies' priorities and demand within STEM fields. Similar to the overall federal workforce, DoD STEM employees work across the five measured STEM disciplines. As Table 5.3 shows, DoD STEM workers primarily concentrate in two disciplines: engineering science and IT/computer science. Engineering science represents 50.5 percent of the DoD STEM population, while IT/computer science represents 34.6 percent of the population. The remaining three disciplines each include 5 percent or less of the DoD STEM worker population. Compared to the non-DoD federal STEM workforce, the DoD STEM population has a much higher share of workers in engineering science, making up over half of the DoD population compared with just 16 percent of the non-federal STEM workforce. The non-DoD federal STEM workforce, on the other hand, has a much higher share of life scientists (34.6 percent), compared with the DoD STEM population (5.3 percent). This is most likely due to the share of non-DoD workers employed by the USDA, which, as we saw in Chapter Three, is the second largest STEM employer in the federal government. Finally, by a smaller margin, more social scientists work for non-DoD federal agencies compared with DoD. Only 3.9 percent of the DoD STEM population consists of social scientists, compared with 11.9 percent of the non-DoD federal workforce.

Table 5.3. Distribution of DoD and Federal Workers, by Broad Occupation Group and Data Source, 2018

Broad Occupation Group	Federal Non-DoD (OPM) (Percentage)	Federal DoD (OPM) (Percentage)	Federal DoD (DMDC) (Percentage)
Engineering	16.0	51.3	50.5
IT and computer science	30.0	34.1	34.6
Life science	34.6	5.3	5.3
Physical science	7.6	5.7	5.6
Social science	11.9	3.7	3.9

SOURCES: DMDC (made accessible to the authors); FedScope (via OPM).

Educational Distribution

We calculated the distribution of STEM and non-STEM workers across educational levels to compare the educational attainment of DoD and non-DoD federal workers. As Table 5.4 shows, DoD STEM and non-STEM workers are distributed across all of the educational levels we measured; this is similar to STEM and non-STEM workers in other federal agencies. The DoD has a smaller share of STEM positions held by employees with advanced degrees, compared with STEM workers in the rest of the federal government; the same holds true of non-STEM workers, though with smaller shares for both. Of the DoD STEM workforce, approximately 5.3 percent of employees hold advanced degrees, compared with 14.8 percent for the non-DoD STEM workforce. Of the DoD non-STEM workforce, only 2.2 percent hold advanced degrees, compared with 7.9 percent for the remaining federal agencies. However, DoD has a higher share of STEM workers with master's and bachelor's degrees compared with the rest of the federal government. Approximately 25.5 percent of DoD STEM employees hold master's degrees and 44.3 percent hold bachelor's degrees. By comparison, in the non-DoD STEM workforce, 23.1 percent hold master's degrees, while 37.3 percent hold bachelor's degrees. This does not hold true for non-STEM DoD workers, who make up smaller shares of master's and bachelor's degree holders compared with workers in other federal agencies.

Table 5.4. Distribution of DoD and Federal Workers, by STEM Status and Educational Level, 2018

Education Level	Distribution of STEM Workers (Percentage)		Distribution of Non-STEM Workers (Percentage)	
	Federal Non-DoD (OPM)	Federal DoD (DMDC)	Federal Non-DoD (OPM)	Federal DoD (DMDC)
Advanced degree	14.8	5.3	7.9	2.2
Master's degree	23.1	25.5	13.8	17.5
Bachelor's degree	37.3	44.3	28.9	22.8
Associate's degree	4.3	4.6	7.0	7.3
Technical college	0.8	0.7	3.7	1.7
No degree/ some college	19.7	19.6	38.6	48.5

SOURCES: DMDC (made accessible to the authors); FedScope (via OPM).

This is due to the fact that nearly half of the non-STEM DoD population has no degree or some college.

Age Distribution

Measuring the age of the DoD STEM population allows us to see whether the population has been, and continues to be, consistently hiring across age categories, and how that may differ in comparison to the non-DoD federal STEM workforce. Overall, DoD STEM employees are spread across all age ranges measured, from age 20 to over 65 years of age, as can be seen in Table 5.5. The DoD STEM population has a similar distribution of employees across the age categories to that of non-DoD federal employees, and both are similar to the age distribution of non-STEM employees. The most notable difference between the two STEM populations rests within the 30–34 age range, with 11.3 percent of the DoD population in this category, compared with 8.6 percent in non-DoD agencies. Non-STEM DoD workers also seem to be slightly older than STEM DoD workers on average.

Table 5.5. Distribution of DoD and Federal Workers, by Age Group, 2018

Age Group	Distribution of STEM Workers (Percentage)		Distribution of Non-STEM Workers (Percentage)	
	Federal Non-DoD (OPM)	Federal DoD (DMDC)	Federal Non-DoD (OPM)	Federal DoD (DMDC)
20–24	0.6	3.6	1.0	2.1
25–29	3.6	7.8	4.6	5.6
30–34	8.6	11.3	10.2	10.0
35–39	12.7	12.7	13.7	12.3
40–44	12.8	10.8	12.7	10.8
45–49	14.0	11.3	14.7	13.1
50–54	15.5	14.8	15.3	16.8
55–59	15.9	15.8	14.0	16.7
60–64	10.6	8.3	9.1	8.9
65 or older	5.8	3.6	4.6	3.7

SOURCES: DMDC (made accessible to the authors); FedScope (via OPM).

Gender and Racial/Ethnic Distribution

To see if any differences exist in terms of gender and racial/ethnic diversity between the DoD and non-DoD STEM and non-STEM workforces, we measured their respective populations according to these characteristics. The non-DoD federal STEM and DoD STEM populations, like the overall federal workforce described in Chapter Three and the non-STEM workforce captured in Table 5.6, consist primarily of white men. Between DoD and the non-DoD federal agencies, however, a couple of notable differences arise among STEM workers. First, women represent a larger share of the non-DoD federal workforce, making up 29.4 percent of the population in 2018, compared with 20.5 percent for DoD. Second, the non-DoD workforce also has a lower share of white employees, and higher shares of minorities across the board except for Asians, the numbers of whom are nearly equal to those in the DoD population.

Comparing the DoD STEM population to the two non-STEM populations shows that the DoD STEM population is not only less diverse than the general federal non-STEM population but also less diverse than the non-STEM DoD population. While white men make up 61 percent of the DoD STEM population, they make up around 47 percent for both the non-DoD STEM and non-STEM DoD workforces, compared even more acutely to just 33.7 percent of the federal non-STEM workforce. Thus, across the board, the DoD STEM population is less diverse in terms of gender and race/ethnicity than the rest of the federal workforce.

Table 5.6. Distribution of DoD and Federal STEM Workers, by Gender and Race/Ethnicity, 2018

Demographic Group	Distribution of STEM Workers (Percentage)		Distribution of Non-STEM Workers (Percentage)	
	Federal (CPS)	Federal DoD (DMDC)	Federal (CPS)	Federal DoD (DMDC)
Male	70.6	79.5	55.0	65.4
Female	29.4	20.5	45.0	34.6
White	66.0	74.9	58.1	68.0
Hispanic	8.3	5.4	11.1	7.1
Black	11.4	8.9	20.0	16.6
Asian	11.1	8.1	6.0	4.7
White male	47.8	61.0	33.7	47.0
White female	18.2	13.8	24.4	21.0
Hispanic male	6.2	4.2	6.6	4.6
Hispanic female	2.0	1.2	4.5	2.5
Black male	7.0	5.9	8.9	8.7
Black female	4.4	2.9	11.1	7.9
Asian male	7.4	6.3	3.4	2.9
Asian female	3.7	1.8	2.5	1.9

SOURCE: DMDC (made accessible to the authors); CPS (via the U.S. Census Bureau).
NOTES: Gender and race/ethnicity data are not available from the OPM, and thus we report data on the federal workforce from the CPS. Information on the DoD civilian workforce is not available from the CPS. The table excludes the “Other” race Census category from calculations, as it is too small for comparison.

Pay Scale Distribution

As we discussed in Chapter Three, the federal government pays the majority of its employees along the GS scale. The GS levels represent different increments of salaries, and an individual’s position along the GS scale is determined at his or her initial appointment to a federal position and includes such considerations as experience and education level. Measuring the share of DoD and non-DoD federal STEM workers across the GS scale provides another perspective on the distribution of income for each population.

Comparing the two, the populations share a similar overall distribution along the GS pay scale from GS levels 1–11, as Table 5.7 shows. The higher an employee moves up the scale, however, the bigger the differences between the two populations. More non-DoD federal STEM employees receive pay at the GS-13, GS-14, and GS-15 levels than the DoD STEM population. The only exception is for the GS-12 level, where the DoD workforce (at 21.7 percent) holds a slight edge over the non-DoD STEM population (at 17.5 percent).

The STEM populations in both the non-DoD and DoD agencies differ from non-STEM employees in their distribution along the GS scale. Non-STEM employees, on the whole, are more widely distributed across the GS scale. The share of employees at the GS-5 to GS-8 levels are much higher than those in STEM positions. Consequently, smaller shares of non-STEM employees receive pay at the higher levels of the GS-scale compared with the two STEM populations. However, DoD employees, whether in STEM or non-STEM positions, have a similar share of workers paid through alternative pay plans.

Table 5.7. Distribution of DoD and Federal STEM Workers, by General Schedule Level, 2018

GS Level	Distribution of STEM Workers (Percentage)		Distribution of Non-STEM Workers (Percentage)	
	Federal Non-DoD (OPM)	Federal DoD (DMDC)	Federal Non-DoD (OPM)	Federal DoD (DMDC)
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.2	0.2
4	0.2	0.0	0.9	1.1
5	0.7	0.4	4.1	3.9
6	0.9	0.2	6.2	4.3
7	3.4	2.3	6.3	7.0
8	2.4	0.3	3.9	1.6
9	7.8	5.8	5.7	7.8
10	0.7	0.7	0.9	0.6
11	12.9	12.9	7.9	11.0
12	17.5	21.7	14.0	13.3
13	23.0	14.0	12.8	8.8
14	14.6	4.0	7.0	3.1
15	7.0	1.2	3.6	1.3
Other	8.9	36.7	26.6	36.1

SOURCES: DMDC (made accessible to the authors); FedScope (via OPM).

However, it is critical to note that a large share of the DoD STEM workforce is not compensated through the GS pay scale, which means these comparisons do not reflect the full DoD STEM population. This major difference helps to explain the disparities between the DoD and non-DoD STEM workforces at the higher pay levels. As Table 5.8 shows, beyond the GS scale, other pay plans account for an additional 37 percent of DoD STEM workers. More DoD STEM workers with higher levels of education are also paid through other pay plans, compared with their less educated counterparts. This helps explain the larger share of non-DoD federal workers, compared with DoD STEM workers, at the highest GS levels.

When incorporating the average annual income by pay plan and educational level in Table 5.9, we see that DoD STEM workers on other pay plans earn more on average than DoD STEM workers on the GS pay scale. The overall average annual earnings for DoD STEM workers on the GS pay scale are $89,619, compared with $110,182 for workers on other pay plans. The largest difference between pay plans for DoD STEM workers is at the advanced degree level, with those on other pay plans earning an average of $19,623 more than their GS counterparts. As Table 5.9 shows, this is consistent with federal non-DoD STEM workers,

Table 5.8. Distribution of Non-DoD and DoD Federal STEM Workers, by Pay Plan and Education Level, 2018

Education Level	Federal Non-DoD (OPM) (Percentage)		Federal DoD (OPM) Share (Percentage)	
	GS	Other Pay Plans	GS	Other Pay Plans
All	89.8	10.2	63.3	36.7
Advanced degree	87.4	12.6	36.2	63.8
Master's degree	88.9	11.1	54.6	45.4
Bachelor's degree	90.3	9.7	61.7	38.3
Associate's degree	93.7	6.3	78.9	21.1
Technical college	93.0	7.0	81.8	18.2
No degree/some college	90.5	9.5	81.5	18.5

SOURCE: FedScope (via OPM).
NOTE: We use OPM FedScope data instead of DMDC data for the DoD population because we use this table in conjunction with Table 5.9, which compares annual income between these two populations. For income, we believe it is important to use the same data source to ensure comparability.

Table 5.9. Mean Annual Income and Nine-Year (2009–2018) Annual Growth Rate of Non-DoD and DoD Federal STEM Workers, by Education Level and Pay Plan (in 2018 dollars)

Education Level	Federal Non-DoD (OPM)				Federal DoD (OPM)			
	GS Income	2009–2018 GS CAGR (Percentage)	Other Pay Plans' Income	2009–2018 Other Pay Plans' CAGR (Percentage)	GS Income	2009–2018 GS CAGR (Percentage)	Other Pay Plans' Income	2009–2018 Other Pay Plans' CAGR (Percentage)
All	$99,268	–0.18	$130,161	0.15	$89,619	–0.06	$110,182	–0.11
Advanced degree	$122,689	–0.52	$151,990	–0.58	$111,518	–1.09	$131,141	–0.51
Master's degree	$79,288	–0.57	$114,296	0.61	$81,635	–0.33	$94,752	–0.24
Bachelor's degree	$95,906	–0.18	$124,885	0.16	$88,386	–0.48	$105,080	–0.34
Associate's degree	$105,028	–0.39	$136,964	0.07	$98,761	–0.16	$116,830	–0.28
Technical college	$86,409	–0.14	$112,654	0.58	$83,059	–0.11	$98,103	0.01
No degree/ some college	$84,125	–0.49	$104,065	–0.10	$80,371	–0.73	$98,118	–0.19

SOURCE: FedScope (via OPM).
NOTES: We use OPM FedScope data instead of DMDC data for the DoD population to ensure that the annual income values are comparable. Additionally, we did not have access to DMDC data for the years prior to 2010.

who also earn more on average with other pay plans. However, with the exception of master's degree holders on the GS scale, non-DoD STEM workers earn more on average than their DoD counterparts.

Special DoD Considerations

In this section we discuss two factors that may also contribute to differences between DoD and non-DoD STEM workforces: veteran status and the need for security clearances. While these factors are not unique to DoD, they may differentially affect the supply of STEM workers who can be employed by DoD.

Veteran Status

Whether or not individuals have previously served in the U.S. military affects the potential pathways through which they can be hired into a federal government position. Pathways exist that provide alternate opportunities for hiring veterans, allowing them to bypass some of the hurdles of the traditional federal hiring processes. One potential consequence of these authorities is an increased number of veterans across the federal workforce, and especially within DoD. According to DMDC data, we found that, in 2018, 32 percent of DoD STEM employees had some prior military service, compared with 18.3 percent in non-DoD federal agencies. A similar gap in military service between DoD and non-DoD agency hiring has existed since 2010.

The federal government provides special authorities and programs through which agencies may more easily hire veterans into civilian positions. There are four special veterans hiring authorities:

- The 30% or More Disabled Veteran Appointing Authority allows agencies to make a noncompetitive temporary appointment to any veteran with an official Department of Veterans Affairs disability rating of at least 30 percent.[4]
- The Veterans Employment Opportunities Act of 1998 provides a special hiring authority to permit veterans to apply for positions normally limited to current federal employees.
- The Veterans Recruitment Appointment Authority permits agencies to appoint eligible veterans to positions without competition.
- Through the Disabled Veterans Enrolled in VA Training Program, veterans participate in a training program with a federal agency, and at the end of the training receive a certificate that allows agencies to appoint these veterans noncompetitively under a status quo appointment that can then be transferred to a career position. (Feds Hire Vets, undated; Schulker and Matthews, 2018, pp. 3–4)

In addition to these special hiring authorities, the federal government applies veterans' preference during the hiring process for all federal positions. Federal agencies essentially must grant preference to veterans over other candidates for competitive service and excepted service

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[4] The Department of Veterans Affairs rates disability on a 0–100 percent scale, with 0 having no disability, and 100 having total disability. See Schulker and Matthews (2018).

positions.[5] Prior to the terrorist attacks of September 11, 2001, veterans' preference was often limited to specific campaign experience, meaning veterans must have participated in a particular war or operation to be considered a veteran for hiring purposes. However, after 9/11 and the ensuing wars, veterans' preference now includes any person who served for more than 180 consecutive days from 2001 to the end of Operation Iraqi Freedom in 2010. The implementation of veterans' preference inevitably means that DoD and other federal agencies tend to hire veterans more often than do their private-sector counterparts. This may contribute to the underrepresentation of women in the federal government, especially within DoD, as higher shares of veterans are male (Schulker and Matthews, 2018, p. 4).

The Need for Security Clearances

Another consideration that can affect the hiring process and supply of individuals to DoD is the need for security clearances. DoD positions often require security clearances, ranging from confidential to top secret. According to DMDC data, approximately 84 percent of DoD STEM employees held sensitive positions in 2018. This can cause challenges for hiring in two primary ways: extending the amount of time required for the hiring process, and decreasing the eligible pool of applicants. Individuals may need to wait an extended period of time for a security clearance to be issued, thus preventing them from starting in their positions for months or years. While improvements have been made over the years to speed up the process, highly talented individuals may decide to accept an offer from private industry to avoid the long process of acquiring a security clearance. For fields with a large share of foreign nationals, DoD may simply have a smaller pool of applicants to choose from, especially for those STEM fields where a lot of qualified individuals are not from the United States. For many STEM disciplines, large proportions of students at U.S. universities are foreign nationals, which poses a challenge since acquiring a security clearance requires U.S. citizenship. This is especially true for those positions that require a graduate degree, such as engineers, because the proportion of foreign nationals is much higher in graduate, as compared with undergraduate, programs (National Research Council, 2012, pp. 89–90). Thus, the combination of security clearance requirements and increased foreign nationals within STEM fields at the graduate level may contribute to increased difficulty for DoD in hiring talented individuals within the STEM fields.

A Comparison of DoD and Private-Sector STEM Workforce Trends

Comparing DoD with the private sector allows us to see how DoD differs across characteristics and employment outcomes of interest to the broader population. To provide a sense of DoD workers in comparison to those in the private sector, we examine their distribution across multiple characteristics, including occupational discipline, educational level, age, gender, and race/ethnicity. We end our comparison with a brief discussion of income considerations.

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[5] For a discussion of the types of federal positions, see Chapter Three.

The data used for these comparisons come from two primary sources. Data on the DoD workforce come from the DMDC, and data on the private sector come from the CPS. All figures discussed herein come from these two sources unless otherwise noted. As with the earlier sections in this chapter, we included data from the OPM on the DoD workforce for information and comparison purposes where applicable. By completing these comparisons, we intend to show how the two sectors differ most, which may help inform future hiring practices for DoD.

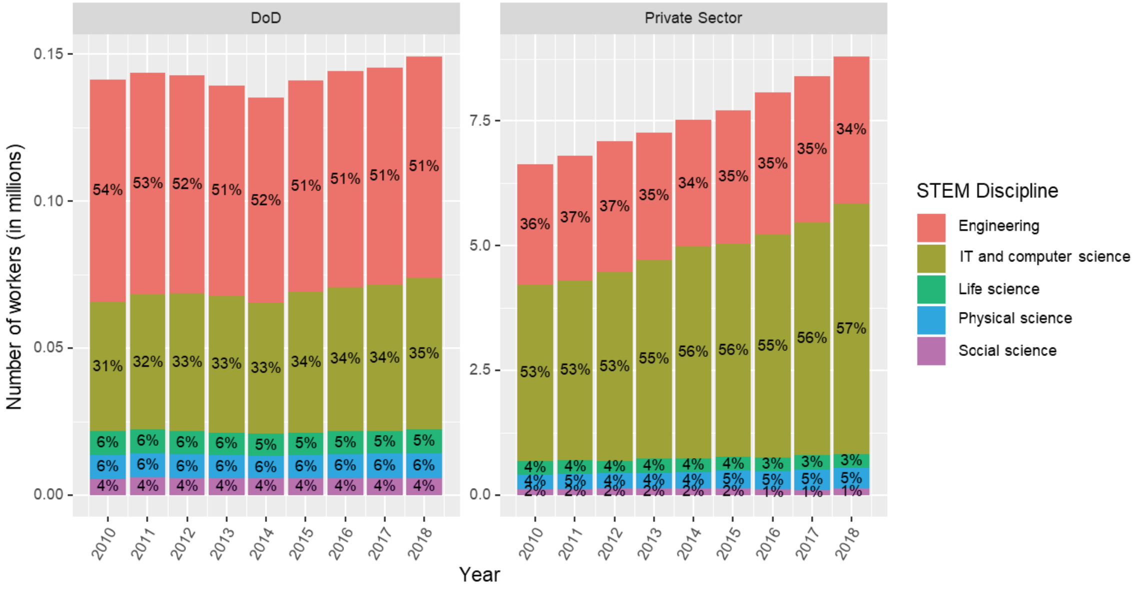
Number and Distribution of STEM Workers

Comparing the number and distribution of STEM workers between DoD and the private sector provides a general understanding of the size and scope of each population. Overall, and unsurprisingly, the DoD STEM population is much smaller than the private-sector STEM population. However, when comparing the share of STEM workers among each population, STEM workers make up a larger share of the DoD workforce than they do in the private sector. The DoD workforce consisted of 20 percent STEM workers in 2018, compared with just 7 percent in the private sector.

Occupational Distribution

To better understand which STEM occupational disciplines are of import to DoD and the private sector, and what differences may exist between them, we measured the distribution of STEM workers across five disciplines: engineering science, IT and computer science, life science, physical science, and social science. As can be seen in Figure 5.1, both the DoD and

Figure 5.1. Number and Distribution of DoD and Private-Sector STEM Workers, by STEM Discipline, 2010–2018



SOURCES: DMDC (made accessible to the authors); CPS (via the U.S. Census Bureau).
NOTE: We did not have access to DMDC data for the years prior to 2010, so we only include data from the years 2010–2018.

private-sector workforces are dominated by two fields: engineering science, and IT and computer science. These two fields represent 86 percent of the DoD STEM population and 91 percent of the private-sector STEM population. The shares of these fields within each sector essentially mirrors the other. In 2018, 51 percent of the DoD STEM population came from engineering science positions, while 35 percent of the population held IT and computer science positions. Comparatively, the private sector nearly flips these figures, as 34 percent of the private-sector STEM population held engineering science positions, while 57 percent of the population held IT and computer science positions. The remaining three disciplines, life science, physical science, and social science, represent about 9–15 percent of each population, with slightly higher percentages for all disciplines within DoD. This is especially true for social science, as social scientists made up around 4 percent of the DoD population in 2018, compared with only 1 percent for the private sector.

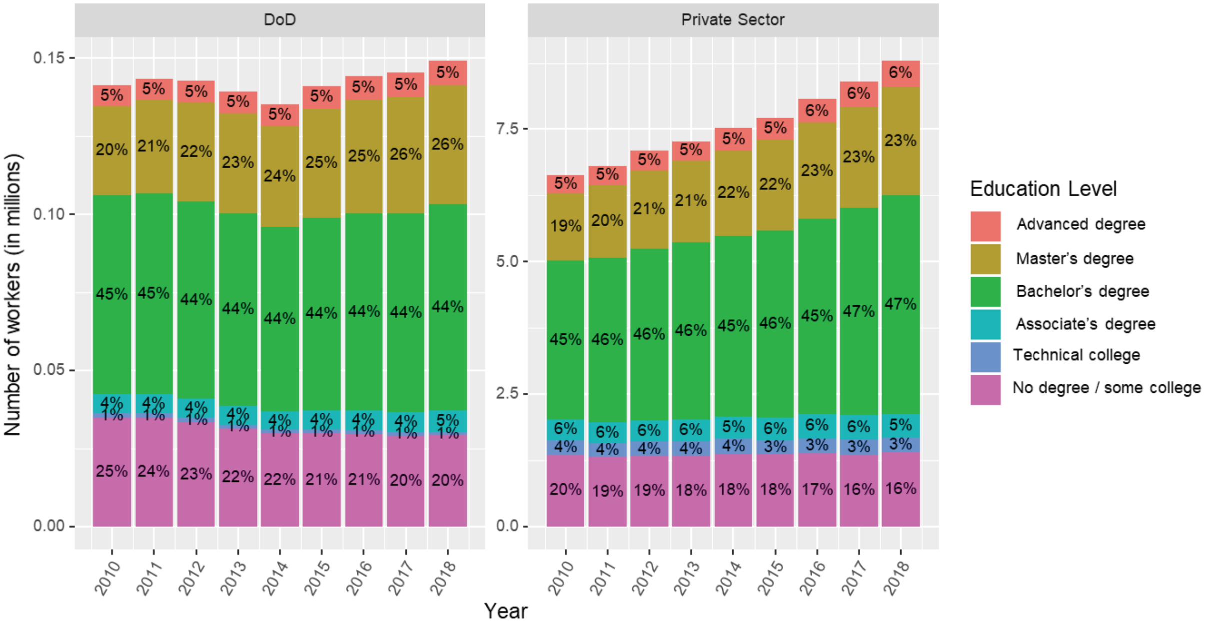
The DoD and private sector experienced complementary shifts during 2010–2018 in their major discipline categories of engineering science and IT and computer science. For instance, between 2010 and 2018 the percentage of DoD workers in the engineering science field declined from 54 percent to 51 percent, while the share of DoD workers in the IT and computer science field increased from 31 percent to 35 percent. Similar shifts occurred within the private sector: engineering science saw a decline in its share of employees from 36 percent to 34 percent, while IT and computer science saw an increase from 53 percent to 57 percent of the STEM worker population.

Education-Level Distribution

We calculated the distribution of STEM employees across six education levels to determine the educational attainment of both populations (Figure 5.2). Both DoD and private-sector STEM workers vary in their levels of educational attainment. The two sectors are similar in terms of their distribution across the different education categories; the most notable difference between the two is within their respective shares of employees with no degrees/some college. Twenty percent of the DoD population had no degrees/some college in 2018, while 16 percent of the private sector had this lowest level of education.

The distribution of educational levels has also remained quite steady for both the DoD and private-sector populations over the past eight years. The largest shift for the DoD population was an increase in the share of employees with master's degrees, from 20 percent in 2010 to 26 percent in 2018, and the decline of the share of workers with no degrees/some college, from 25 percent in 2010 to 20 percent in 2018. The private sector saw the same shift, with an increase in the share of workers with master's degrees, and a decrease in the population of those workers with no degrees/some college. These shifts suggest an increased interest in higher-education degree holders for positions in STEM fields across both sectors.

Figure 5.2. Number of DoD and Private-Sector STEM Workers, by Education Level, 2010–2018



SOURCES: DMDC (made accessible to the authors); CPS (via the U.S. Census Bureau).
NOTE: We did not have access to DMDC data for the years prior to 2010, so we only include data from the years 2010–2018.

Age Distribution

Similar to the entire federal STEM worker population we described in Chapter Three, the DoD and private-sector STEM populations are distributed widely across all age categories. Overall, as Table 5.10 shows, the private sector has a younger workforce compared with the DoD STEM population, with over 60 percent of its population under the age of 44 in 2018. In contrast, 46.2 percent of the DoD population was under the age of 44 in 2018. The youth differential is especially prominent in the 25–29 age bracket, with 14.2 percent of the private sector falling in this age range in 2018, while the DoD workforce had only 7.8 percent in this age range. As the private-sector STEM workforce is younger, the DoD had a higher share of employees within all age brackets 45 years of age and older in 2018, with the largest difference in employee populations being in the ages 50–59.[6]

The non-STEM populations follow a similar pattern, with a younger private sector when compared with DoD. However, the margins are smaller between the non-STEM populations, so that private-sector workers are only slightly younger than DoD workers, with 53.8 percent of the private-sector population under the age of 44, compared with 40.8 percent for DoD. Comparing

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[6] In a previous section of this chapter, we noted that the federal government (particularly DoD) has a sizable number of military veterans among its STEM workforce. On average, veterans may be older than their civilian peers without military service because veterans spent time in the military before joining the federal civilian workforce. This may partly explain why DoD's STEM workforce skews older than the private-sector STEM workforce.

Table 5.10. Distribution of DoD and Private-Sector STEM Workers, by Age Group, 2018

Age Group	Distribution of STEM Workers (Percentage)		Distribution of Non-STEM Workers (Percentage)	
	Private Sector (CPS)	Federal DoD (DMDC)	Private Sector (CPS)	Federal DoD (DMDC)
20–24	5.7	3.6	8.4	2.1
25–29	14.2	7.8	12.1	5.6
30–34	14.9	11.3	11.6	10.0
35–39	13.5	12.7	11.3	12.3
40–44	11.8	10.8	10.4	10.8
45–49	10.8	11.3	10.9	13.1
50–54	9.7	14.8	10.6	16.8
55–59	9.1	15.8	10.0	16.7
60–64	6.6	8.3	7.1	8.9
65 or older	3.5	3.6	5.1	3.7

SOURCE: DMDC (made accessible to the authors); CPS (via the U.S. Census Bureau).

the DoD STEM and non-STEM populations, there are similar distributions across the age groups.

Gender and Racial/Ethnic Distribution

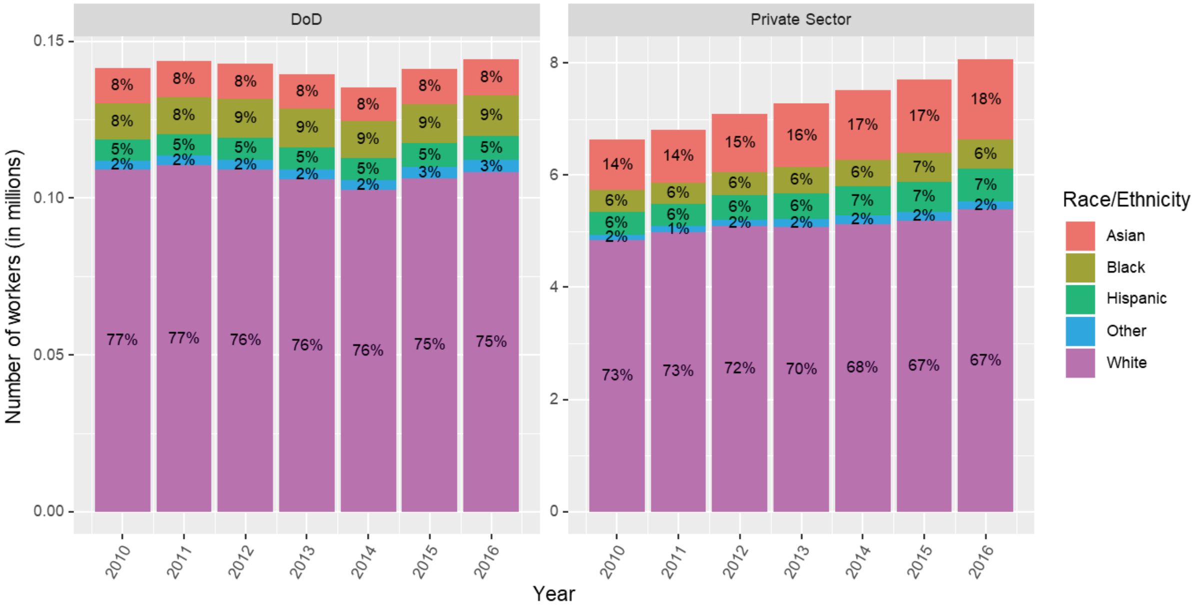
We determined the distribution of DoD and private-sector STEM employees across gender and five racial/ethnic categories: Asian, black, Hispanic, “other,” and white. In comparing these two populations, we hoped to ascertain the level of demographic diversity of each population within the STEM fields and the relative level of diversity between the two populations. Similar to what we saw in Chapter Three with the overall federal workforce, the DoD STEM population is predominantly male and white (Figure 5.3). This is true in the private-sector workforce as well. However, the private sector does have a slightly higher share of women than the DoD. In 2018, the private-sector STEM population included 23 percent women, compared with 21 percent within the DoD STEM population. As Figure 5.3 depicts, the private sector also has a smaller share of white STEM workers, in contrast to DoD, though the private sector includes a higher share of Asian workers instead. However, in 2018 the DoD STEM workforce included a slightly higher share of black employees (9 percent) compared with the private sector (6 percent).

The DoD STEM population’s distribution among gender and racial/ethnic categories has remained relatively stable over the past eight years. The private-sector STEM workforce has also been fairly stable during the 2010–2018 time frame, with some small shifts of note. The private sector saw an increase in the share of Asian employees, from 14 percent to 18 percent, and a decline in the share of white employees, from 73 percent to 67 percent.

Geographic Distribution

The DMDC data from DoD allowed us to geographically place the department’s STEM population and compare that with the locations of private-sector STEM workers. We compared the

Figure 5.3. Number of DoD and Private-Sector STEM Workers, by Race/Ethnicity, 2010–2018



SOURCES: DMDC (made accessible to the authors); CPS (via the U.S. Census Bureau).
NOTE: We do not have access to DMDC data for the years prior to 2010, and the DMDC did not provide ethnicity data in 2017 and 2018; thus, we only provide data for the years 2010–2016.

two populations across five geographic areas: the Midwest, the Northeast, the South, and the West (the four designated U.S. Census regions), and for any individuals serving in positions outside of the continental United States. This final category is an important distinction, as some DoD employees may be deployed overseas. STEM employees in both DoD and the private sector reside across all four Census regions of the continental United States. The private sector, in fact, is nearly evenly distributed across the four regions, with slightly higher numbers in the South and West compared with the Midwest and Northeast. The DoD STEM workforce, on the other hand, is much more concentrated in the South, which has 51.1 percent of the STEM population. This should not be surprising, because the Washington, D.C., metropolitan area is included in the Census's South designation, and is a critical hub for the federal government, including DoD. DoD also had a small portion of its STEM workforce located overseas in 2018, representing approximately 2.6 percent of the population, while the private sector had no employees reported outside of the United States.

Considerations of Income Comparisons

As we noted at the beginning of this chapter, income comparisons and analyses are not recommended across the two data sets at our disposal. The differences in income are at least partially due to differences in how income is reported, and since we cannot systemically control for it, we cannot determine how much difference in income is due to reporting versus actual earnings disparities. But we make a few notes here about how to think of the $2,600 earnings difference.

Given that federal workers who work on a pay plan other than the GS plan have higher earnings on average, and they are a higher share of the DoD STEM workforce, the $2,600 difference might be less for DoD. On the other hand, even with better data, regression analysis could still prove difficult because of the numerous special circumstances and situations of the DoD civilian workforce. For example, there are many service members with extensive training in STEM fields who do not have college degrees but whose service experience is sufficient for roles in DoD that may otherwise require bachelor's degrees. There are numerous ways to control for returns from educational attainment that take into account service experience, but the types of hiring pipelines that are unique to DoD should be studied on their own in terms of competitive compensation.

6. Discussion

In this report, we have aimed to develop a broad understanding of compensation for workers in STEM occupations in both the federal government and the private sector. We began by describing findings from previous literature on the STEM workforce, including the observed pay premium for STEM workers (Chapter One). We then discussed the results of our analyses of how STEM workers in the private sector (Chapter Two) and federal government (Chapter Three) compare to their non-STEM counterparts. Subsequently, we paired these analyses to compare private-sector and federal STEM workers directly (Chapter Four). Finally, we analyzed how DoD STEM workers compare with STEM workers in other parts of the federal government (Chapter Five).

In our analyses we examined an array of measures: the number of workers, the unemployment rate, usual hours worked per week, annual income, and nonmonetary compensation in the form of benefits. We presented data both for the STEM workforce overall and, where data allowed, through a variety of demographic and occupational characteristics. These more granular comparisons underscored that the distribution of the federal and private-sector STEM workforces with respect to age, gender, race/ethnicity, and occupation contributes meaningfully to the overall findings. This is especially important to keep in mind when analyzing compensation: comparing how much STEM workers in the federal government and the private sector are paid requires not only comparing their earned income, but understanding who works in those sectors and how those jobs may differ.

In this concluding chapter we summarize our findings on compensation for STEM workers in the federal government versus the private sector, and between DoD and non-DoD federal STEM workers. We also consider two exploratory questions that are not directly in scope for this study but that we view as important considerations for policymakers seeking to recruit and retain workers:

- What factors beyond compensation are important to recruiting and retaining STEM workers?
- Is the focus on STEM workers the most useful way to understand the dynamics underlying recruitment, compensation, and retention trends?

We recognize that the pay and compensation policy of the federal government requires much more in-depth analysis than we are able to accommodate in this report using the data sources available to us. However, where possible and supported by our findings, we discuss policy implications and recommendations and areas for future research.

Who Makes More: Federal or Private-Sector STEM Workers?

Determining who is better compensated for STEM work—private-sector workers or federal workers—first requires understanding if and how those workers differ. We found that the federal STEM workforce has a much higher share of advanced degree and master's degree holders than the private-sector workforce, which has a larger share with terminal bachelor's degrees. Federal STEM workers are also engaged in different occupations. More than half of the private-sector workforce is in the IT and computer science occupation, and roughly another one-third is in engineering, with marginal shares in the life, physical, and social sciences. The federal STEM workforce is similarly made up of one-third engineering, but has only one-third in IT and computer science, with higher shares in the life, physical, and social sciences. In both the private sector and the federal workforce, diversity is lacking in STEM workers relative to non-STEM workers; however, there is *relatively* more gender and racial diversity in the federal STEM workforce when compared with the private sector. The federal government has a higher share of female, black, and Hispanic STEM workers, though it has a smaller share of Asian and foreign-born workers, perhaps owing in part to restrictions on noncitizen employment at federal agencies.

At first, when we compared average income for private and federal STEM workers overall, we found a small federal premium. When taking into account the combined nonmonetary benefit scheme for retirement, health, and other benefits that outpaces the private sector, and lower average hours, it appears that federal workers' combined compensation, or hourly compensation, is higher. However, the federal premium did not hold for all groups we analyzed. Prime-age workers and those with higher levels of education, in particular, tended to fare better in the private sector. Further, even these within-group comparisons are not sufficient. Engineers may make more in the federal government, but they may also have more experience or more education. We conducted regression analysis to control for individual characteristics, in effect controlling for the differences in the composition of the two workforces.

What starts as a premium ends as a penalty. Using regression analysis, we found that the federal government pays $2,600 less than the private sector for STEM workers when controlling for observable characteristics such as age, education level, and occupation. With average salaries in the federal STEM workforce of $93,200, this means that federal STEM workers earn on average 2.8 percent less than their private-sector counterparts. Moreover, from the decomposition regressions we learned that there is an unexplained private-sector bump to being a STEM worker of nearly $5,000. This bump should not be added to the estimated earnings difference, but considered in tandem; we find evidence that, conditional on the composition of the two workforces, private-sector STEM workers earn $2,600 more, and further find that, when isolating the separate effects of composition and how components of composition are compensated, there is an unexplained premium of $5,000 for private-sector STEM workers.

It is hard to say how large or small the $2,600 penalty is perceived to be by workers—or, similarly, how large or small the $2,600 penalty is for bachelor's degree holders, the $5,800 penalty is for master’s degree holders, or the $9,300 penalty is for Ph.D. holders. That is, how lower annual income trades off with shorter hours and a much higher likelihood of receiving health and retirement benefits likely depends on how workers value nonmonetary compensation. Moreover, hours and whether a worker had retirement or health benefits are just the components of compensation that we could observe. Full-time federal employees are eligible for additional benefits that could have high value, such as continuing education and student loan repayment.

The regression analysis controls for what we can observe—age, gender, race/ethnicity, educational attainment, and region. But private-sector and federal STEM workers may be different in ways that we cannot observe. For example, we have no measure of worker quality or productivity, and therefore no way to assess whether workers with the same skills and productivity on the job make more in one sector or the other. On the flip side, we do not have a measure of job quality. We also do not have a measure of worker preferences and values—for example, the degree to which workers prize some aspects of compensation or job quality over others. It could be the case that workers are willing to be paid less for a job they value or enjoy more, or that workers need to be paid more for a job of lower quality.

If workers in the federal government were to value monetary compensation less than they value the mission of the job and employer (and if they were indeed to value the mission of a federal employer more than a potential private-sector employer), or if they were to value current monetary compensation less than they value retirement security or other benefits associated with federal employment, this could offset any current compensation premium to private-sector STEM work. Conversely, if workers in the private sector value different workplace environments or cultures, or different pay structures, such as bonuses or stock options, this might outweigh the longer hours or lower likelihood of having retirement plans through their employers. In sum, we can comment on levels of compensation given observed features but not how that compensation is valued.

However, even if we could observe all of this—preferences for types of work, value of nonmonetary benefits—a difference in $2,600 in expected pay is based on realized choices. We know the wages of private-sector workers and federal workers, but we do not know what an individual federal worker might make if he or she moved to the private sector, or vice versa. The estimate of $2,600 thus cannot be interpreted as the differential in pay for the same worker offered the same job in both the federal government and the private sector.

Moreover, our finding of the $2,600 penalty has limitations to interpretation. There are key variables that we could not include because we did not observe them, such as experience. Relatedly, the estimates are based on point-in-time observations of workers, not by comparing careers or career trajectories. It could be that the federal penalty grows with tenure, that the tenure in certain jobs and occupations is quite different in the two sectors, or that promotion into certain jobs and occupations is quite different. Even though our estimate is robust, there’s considerable nuance remaining.

Finally, it is worth noting that the comparison we make throughout this report implicitly assumes that private-sector compensation of STEM workers is "right" and that the onus is on the federal government to catch up or be competitive. However, as we discussed in Chapter One in our introduction to STEM, as well is in our analysis of the private-sector STEM workforce in Chapter Two, there are many aspects to private-sector STEM compensation that the federal government should not emulate. For example, women and certain racial/ethnic groups are much more underrepresented in the private sector. This lack of diversity is the result of a confluence of factors, but discrimination is one of them. We showed the extent to which women and underrepresented minority groups have large, unexplained pay differences in private-sector STEM through the Oaxaca-Blinder decompositions. In thinking about what the federal government should be paying STEM workers, we show evidence here that simply mirroring the private-sector pay and distribution of pay is problematic.

Comparing DoD and Private-Sector STEM Workers

The DoD is an important STEM employer; only the USDA compares in terms of both employing a large number and a high share of STEM workers. In certain key ways, the DoD STEM workforce looks more similar to the private sector than it does to the rest of the federal government. There is an overwhelming share of engineers and IT and computer science workers, with only a fraction of workers in the remaining sciences. The DoD STEM workforce is also less educated, on average, than the rest of federal STEM workers, with a distribution much closer to the private sector. With respect to diversity, DoD struggles more than the federal STEM workforce overall—which, while less diverse than the federal non-STEM workforce, is more diverse than the private-sector STEM workforce. The DoD is more male and more white than the rest of the federal STEM workforce, and this mirrors the private sector more closely than it does the federal STEM workforce outside DoD. However, one key difference in composition between DoD and the private sector is that the DoD STEM workforce has a higher share of older workers: 40 percent of DoD STEM workers are over the age of 50, compared with 30 percent of private STEM workers.

Unfortunately, due to data limitations we cannot make income comparisons of DoD STEM workers with workers in the private sector. The income differences would reflect differences in measurement, in addition to differences in income, and would thus prohibit interpretable conclusions. All we can say is that there is a federal penalty in pay for STEM workers in general once conditioning on observable characteristics. The regression coefficient estimates are the preferred method of interpreting earnings differences because they control for the compositional differences of the federal and private-sector workforces, and the CPS data do not separately identify DoD workers to support a regression analysis.

Recommendations

Our analysis found that, controlling for observable characteristics, STEM workers earn $2,600 less than private-sector STEM workers. Again, the implications of that $2,600 difference for recruitment and retention is contingent on numerous things, about which we can say little. Though income tends to be lower among federal STEM workers after controlling for observable characteristics that influence pay, access to nonmonetary compensation is somewhat higher, and hours tend to be shorter. We are unable to determine how these factors balance out for individual workers weighing STEM job opportunities in one sector versus the other. Hence, the analysis in this report neither supports nor refutes the hypothesis that inadequate compensation prevents the federal government from competing with private-sector employers for capable STEM workers.

However, we did find evidence to motivate a continued interest in understanding opportunities and impediments to STEM hiring and retention in the federal government. Notably, we found that the federal STEM workforce skews older than the private-sector STEM workforce—nearly *half* of federal STEM workers are at least 50 years of age. As these workers retire, it will be incumbent on federal employers to replace them with new STEM talent, competing with potential private-sector employers for these younger workers. Our analysis revealed findings that may merit further exploration, as well as opportunities for improving data collection to support further analyses. Future studies might also consider utilizing alternative research methodologies to complement the approach taken in this study and provide a fuller understanding of drivers of workers' decisions related to entering and remaining in the federal STEM workforce. We present our recommendations below.

Topics in Compensation That May Merit Further Exploration

Our regression analysis found that there is a pay penalty, on average, for federal STEM workers versus their private-sector counterparts. Our descriptive analyses suggest that the penalty may be especially pronounced for certain groups of workers. Noteworthy groups—all of whom make roughly 15 percent less on average in federal employment than in the private sector (based on within-group descriptive comparisons)—are those with advanced degrees, Asian men, and STEM workers in urban areas in the West. Some suboccupations within the IT and computer science broad occupation field also experience notable private-sector pay premiums, on the order of about 15 percent. These observed disparities may merit further exploration, in particular to identify whether recruitment and retention challenges are especially acute for workers in these groups. Further research could explore drivers of these disparities, as well as the extent to which these groups may overlap.

Our research also revealed disparities *within* the federal government STEM workforce by gender and race/ethnicity that may merit deeper investigation. While we found that women and minorities faced much smaller pay disparities in federal employment relative to the private sector, these disparities remain present. Understanding the causes and implications of these gaps could be the subject of future research.

We also noted in our discussion of the federal workforce in Chapter Three that the federal government does have alternative, non-GS pay plans at its disposal to hire and compensate with more flexibility. Some of these are directed specifically at STEM workers. Assessments of these authorities have been conducted,[1] which have found that implementation and adoption of the authorities have had issues. A dedicated implementation study that identifies barriers to use of these policies could help with wider adoption.

Further, exploring the motivations and values of workers in the federal STEM workforce or those considering entering it could inform the conversation around compensation and benefits. Such a study would likely draw on alternative research methodologies (such as focus groups) in addition to quantitative analysis, and would seek to understand the extent to which any observed disparities in compensation and benefits between federal and private-sector STEM work influence workers' decisions. These disparities could be in pay or nonmonetary compensation. Critically, we found that the federal STEM workforce has a large share of workers—nearly half—who are over age 50, and a smaller share who are under 30. Exploring motivations and values of workers in federal STEM employment and how they vary by the age of the worker, or the age at which a worker was hired, can help federal employers understand how to be competitive with key age groups.

Finally, we note that we have focused on the current state of the STEM workforce in the federal government, trends in the recent past, and some indicators of the supply of STEM workers that could fill STEM positions. Aside from our look at unemployment rates, we have not explored the demand for STEM workers, now or in the future, and how that relates to the evolving demand for STEM skills. Future work might explore approaches to analyze the demand for STEM workers as an indicator of potential upward or downward pressure on compensation.

Ways to Improve Data Collection

Data limitations influenced the manner in which we conducted our study and in some areas impeded our ability to draw definitive conclusions. Notably, differences in how the data sets with the best coverage for each sector (the CPS for the private sector and OPM FedScope for the federal government) conceptualize, collect, and report income precluded us from basing our principal conclusions on a comparison using both of these data sets. Rather, we relied on the CPS for a consistent comparison, despite the comparatively smaller sample size for federal workers in that survey relative to the FedScope data (and to the sample size for the private-sector STEM workforce in the CPS). Moreover, FedScope did not include demographic information in the microdata, forcing us to rely on the sparser CPS data for all demographic analyses of the public sector. Finally, neither CPS nor FedScope data supported a longitudinal study of job tenure and retention—which, if possible, would have provided an important indicator for the desirability of STEM jobs in each sector.

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[1] Examples include GAO, 2017; and Treasury Inspector General for Tax Administration, 2017.

While the OPM's FedScope will never mirror the CPS precisely (nor should it, as one is a survey of respondents while the other includes administrative data), more could be done to develop a consistent measure of income across these two sources. For example, the OPM data might be expanded to include all income a worker receives in a given year (including overtime and shift differentials) to more closely match the pretax wage and salary income collected in the CPS. In addition, the OPM could consider including gender and race/ethnicity indicators in the individual microdata to facilitate analyses of pay disparities according to these demographics. The OPM also could consider ways to make its individual data linkable over time to allow for longitudinal analyses of workers moving in and out of the federal STEM workforce.

Theoretically, the most direct comparison possible, both outside the scope of this study and not feasible with existing data resources, would be the pay difference that individual workers see when they leave private-sector STEM jobs to join the federal government workforce, the pay difference between competing federal and private-sector offers for workers in or contemplating federal government STEM positions, and the pay difference for workers who leave the federal government workforce for private-sector STEM jobs. This kind of information would enable comparisons of *individual* differences in pay, whereas our study compares *group* differences in pay. An analysis of individual differences in pay would control for the unobserved preferences that we have noted throughout this report, at least to the extent that these preferences are unchanged over time.

To enable such an analysis, individual agencies or the OPM could consider approaches to systematically collect data on income both before and after federal employment, at least for new hires and departures. Even if collecting individual income data is not feasible on a large-scale, systematic basis, agencies may be able to shed light on the extent to which compensation and benefits sway decisions to enter or exit federal employment by including questions related to it in entry or exit surveys of the workforce, or in an individual study of compensation competitiveness that collects data, which our study did not. Collecting such information could help workforce managers gain an understanding of where the pressure points are, which occupations or fields are facing especially stiff competition from the private sector with respect to compensation offerings, or how "poachable" certain workers are.

Alternative Approaches to Analyzing STEM Compensation and Benefits

Even if data collection were improved, a research approach that is restricted to analyzing administrative data or data from surveys such as the CPS is necessarily going to offer an incomplete picture of the degree to which compensation and benefit differentials between the private sector and the federal government influence worker decisions. In particular, when it comes to hard-to-quantify aspects of the total compensation and benefit package such as work environment and work-life balance, the numbers can only go so far.

Therefore, we recommend that future studies supplement data-grounded methods with qualitative approaches such as interviews and focus groups—to understand what motivates workers, how compensation influences their decisions, and what other factors matter. Future efforts might also draw on original surveys of workers in the private sector and the federal government, both to gain information in its own right and to inform the development of interview and focus group protocols to elicit key themes that may be of interest to policymakers. The scope and time frame for the present study did not permit the use of these methods, but we believe they would be valuable for developing a deeper understanding of drivers of recruitment and retention challenges the federal government faces for STEM workers.

Summary of Recommendations Relating to Compensation

We recommend the following policy changes, primarily around data collection:

- Improve FedScope along an array of measures (e.g., linked longitudinally, including gender and race/ethnicity) to enable more research.
- Collect salary information both before and after federal employment for arriving or departing workers.

We also recommend the following studies to further understand federal compensation competitiveness:

- Investigate key STEM worker compensation differences between the public and private sectors—especially those in which the federal government pays notably less on average (e.g., advanced degree holders, Asian men, urban workers in the West).
- Investigate the source of gender and race/ethnicity disparities in the federal government.
- Conduct a thorough implementation analysis of current pay plans and why they are not more widely used.
- Conduct focus groups and interviews with federal STEM workers to understand the motivations and values of those workers, how they view their compensation and benefits packages, and how this varies by age.

What Other Factors May Influence Worker Recruitment and Retention?

The analysis presented in this report was constrained by: (1) the instructions and mandate from the NDAA to focus on compensation and benefits, and (2) the data that were immediately available to enable completion in the time frame provided. However, the NDAA itself lays out the motivation for its mandate of comparing federal salaries with those in the private sector: “The committee believes the Department of Defense must develop new and innovative methods to attract and manage talent with highly valuable technical skills” (U.S. Senate Committee on Armed Services, 2018, p. 283). Although pay is critical, it is but one component of attracting workers to jobs. If total compensation (pay and benefits) is roughly comparable for federal and private-sector STEM workers (as we find in our analysis) and not clearly and conclusively advantaging one sector over the other, it suggests that other factors may be contributing to any existing recruitment and retention challenges.

In this section we briefly discuss three other factors—outside the scope of this study on compensation and benefits—that could be critical to hiring and retaining workers: (1) the hiring process itself; (2) the potential for policy-driven disruptions that affect the federal workforce;

and (3) leadership changes that influence the nature of the job. All of these broadly fall under the umbrella of job quality. For most of this discussion, we examine federal employment in general and not factors specific to STEM workers. While we are unable to draw firm conclusions from this exploratory discussion, we believe that future research should consider the extent to which these factors influence worker decisions.

We also note that both the federal government and the private sector may be facing similar difficulties in finding and retaining STEM talent given historically low unemployment rates. This does not change the imperative to ensure that the federal government can compete with the private sector for these workers, but it does affect the frame of the conversation. It may be less about the federal government currently being outgunned relative to private-sector compensation and benefits offerings and more about overall supply and demand for STEM workers. This topic is also outside the scope of this study.

In addition, it is important to note that the GAO has had "Strategic Human Capital Management" on its High Risk List since 2001; the High Risk List consists of federal programs and operations that the federal auditor finds to be at high risk due to vulnerabilities to fraud, waste, abuse, and mismanagement, or that need transformation (GAO, 2019c). The GAO has produced numerous reports, testimony, and recommendations—many that we cite throughout this report—in the area of federal workforce management as it relates to STEM. To a certain extent, the scope of this report and the recommendations we discuss have some overlap and complementarities with GAO's prior work; however, the mandates and mission are different. Our recommendations reflect this, but we think it is important to note that they are not meant to supplant or comment on GAO's recommendations and findings.

The Hiring Process

The hiring process can affect the desirability of a job. If it is too onerous, it may serve as a deterrent to applying at all. It can also affect the likelihood that workers end up in a given job, even if that job is equally or more desirable on its merits. For example, if job postings are not readily accessible and comprehensible, it could keep some prospective workers from seeing them at all or applying for the positions. And if the hiring process is too lengthy, workers may land and start a new job—somewhere else—before the process is complete. These workers may be loath to leave their new jobs even if they might otherwise have preferred the job with the employer with the lengthy hiring process. Thus, documented difficulties in navigating the federal government's USAJOBS website, and the length of the federal hiring process, which according to the PMA averages 98 days (Hershman, Rigas, and Warren, 2019), could contribute to federal challenges in recruiting STEM workers.

USAJOBS serves as a central portal for viewing and applying for positions across the federal government, and may help a worker interested in federal employment *in general* find a match. But there may be drawbacks to using a large, centralized system to target specific occupations. A key feature of USAJOBS is that prospective employees can use it to search for similar jobs across all federal agencies. That might be a less relevant feature if prospective employees in certain occupations rely on other, unique sites for job search, or if they are accustomed to employers searching for them.

For example, economists who are finishing their Ph.D.'s rely exclusively on a job portal run by the American Economic Association called JOE: Job Openings for Economists (American Economic Association, undated). JOE was established in 1974 as a job clearinghouse for new economist positions; its market has evolved so that all graduates participate in this centralized market, and JOE has developed features to streamline the application process. Federal employers who want to hire an economist must, and do, participate in this job portal and then introduce USAJOBS after the fact.

Another example is that of web developers and coders. The specific skills within web development are highly varied; it is not necessarily the case that two web developers, each with 20 years of experience, know how to perform the same tasks or evince the same skills. HackerRank was developed to help match employers and developers using observable coding challenges (HackerRank, undated). Employers can set challenges on the website that require the skills of interest to them in order to find specific workers. On the other hand, workers can participate in challenges that demonstrate their skills to assist headhunters or employers. In the case of both HackerRank and JOE—which target two STEM occupations—the labor market for the specific occupations evolved to feature unique means of job search and job postings.

USAJOBS performs a similar function for the labor market for federal workers—unique job search and postings aimed to increase efficiency—but the federal government is just one employer in any occupation's total labor market. During the last major revamp of USAJOBS in 2016, it was found that the website is difficult to navigate successfully, even for interested workers (OPM, 2016a). When the alternative is a tailored job search site, the challenges of navigating USAJOBS may seem insurmountable to prospective workers.

Next there is the question of timing and length of application. Both the OPM and USAJOBS post information in the Frequently Asked Questions or Help sections of their websites on how long it takes to hear back after a job offering is posted, and both acknowledge that the federal hiring process can be lengthy. The OPM's own internal findings have found that the length of time between application and start date for federal jobs has only gotten worse, and averaged 98 days in FY 2018, compared with the overall U.S. average of 23 days (Chamberlain, 2015; Katz, 2018). Although the mechanics in practice would likely work differently, in theory this means that a worker could apply, interview, and start four private-sector jobs in the length of time it would take to apply, interview, and start a federal job.

There are policy tools at agencies' disposal to aid with hiring in a timely manner, including special appointing authorities to bypass the traditional competitive hiring process.[2] Moreover, some special hiring recruitment programs are targeted to STEM workers. Among these are the

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[2] Current government-wide direct-hire authorities include those for medical, information technology management, veterinary medical officer, STEM, and cybersecurity-related positions, as well as positions involved in Iraq reconstruction efforts.

American Association for the Advancement of Science (AAAS) fellowships, the DOE's Energy Efficiency and Renewable Energy (EERE) Science, Technology, and Policy (STP) program and student volunteers, and the DOE Scholars Program. The Pathways for Students and Recent Graduates to Federal Careers initiative also has other targeted hiring programs through which STEM workers may pass, including the Internship Program, the Presidential Management Fellowship (PMF) Program, and the Recent Graduates Program. In addition, there are non-GS hiring authorities and pay plans that are targeted or can be used for STEM workers. Despite the existence of these mechanisms, challenges remain, and recent reports by both the GAO (2019b) and the OPM (2018d) have identified opportunities for improvements in how agencies utilize special hiring authorities to build and manage their workforces.

Hence, we believe that further evaluations or investigations of the following topics could inform the understanding of how the hiring process affects the likelihood that prospective workers persist to land a federal job:

- the relationship between specialized, occupation-specific labor market practices and USAJOBS in filling hard-to-fill or high-priority positions
- the causes and consequences of time-to-hire delays in federal employment
- the effectiveness of special hiring authorities (e.g., direct-hire) in hiring hard-to-fill or high-priority positions
- the effectiveness of special hiring programs (e.g., AAAS fellowships) in recruiting talented workers into federal government
- whether alternatives to USAJOBS, such as résumé-based hiring, are in use at federal agencies and whether they are more effective in hiring STEM talent.

Hiring is a very nuanced and competitive process for both workers and employers; having a better understanding of where the federal government succeeds or fails can help with directing policy.

Work, Hiring, and Pay Disruptions

While workers in the private sector can face job instability—driven by fluctuations in the economy and the potential for layoffs or business closures—federal government employment comes with its own sort of policy-driven instability that may dissuade potential workers. Over the years, under the administrations of both the Democratic and Republican Parties, these disruptions have included shutdowns, pay freezes, and hiring freezes, which affect work and pay but are unrelated to an individual worker's performance. For the most part, the relationship of these disruptions to hiring and retaining high-quality talent, whether STEM or otherwise, is not understood. And the effect could be twofold—first, in the direct effect on current and prospective employees, and second, on the perception of what it is like to work for the federal government. For example, a shutdown may have a *tangible* effect on hiring and retention—applications cannot be reviewed and applicants may move to other jobs in the meantime, while current employees who are not being paid and not working may seek a new job. Or, it could affect perceptions of federal work and whether federal employees are valued. We do not know to what extent either is occurring, and we believe that careful, nonpartisan research could improve our understanding of these factors and their effects.

The topic is not wholly without a base of evidence. For example, a previous RAND study found that pay freezes that endure for a period of years are harmful to worker retention (Asch, Mattock, and Hosek, 2014). While it is less clear that temporary shutdowns and worker furloughs that result in short-term hardships such as missed paychecks demonstrably affect retention, and we cannot assess the extent to which these disruptions or perceptions surrounding federal government work affect recruitment and retention of STEM workers, we believe that future studies should consider these factors. In particular, studies might consider

- whether certain categories of workers are more likely to leave in the period after a shutdown, pay freeze, or hiring freeze
- whether certain positions become more difficult to hire for in the period after a shutdown, pay freeze, or hiring freeze.

If these disruptions are to occur, which they have periodically throughout history, agencies can be better prepared in managing their workforces if they have a deeper understanding of the workforce consequences.

Leadership

Changes in leadership that occur with each new administration—or within administrations—are an indelible feature of federal service. Our concern in terms of the attraction and retention of high-quality workers is that frequent changes to leadership, or prolonged vacancies in leadership, may make entering or remaining in federal service less desirable. A 2009 law review article lends support to this concern, offering arguments and available evidence that leadership vacancies may lead to "agency inaction, confusion among nonpolitical workers, and decreased agency accountability" (O'Connell, 2009, pp. 937–938). Concerns about leadership vacancies in the federal government are not new: For example, in its 2003 report, the National Commission on the Public Service (also known as the Volcker Commission) cited concerns and offered recommendations to address leadership appointment processes as a way to improve federal government functioning. Unfortunately, as the GAO notes (and as we describe in more detail in Appendix B), we do not have data on turnover and vacancies of political appointees, and therefore cannot determine if leadership changes, or frequent leadership changes, affect hiring or retention (GAO, 2019a).

We hypothesize that leadership turnover or prolonged vacancies for leadership positions in federal agencies could affect federal hiring and retention in three ways. First, they could lead to policy uncertainty, which can in turn erode job quality. Agencies operationalize congressional mandates, and it could be the case that putting forward effort toward one policy or implementation protocol that is then changed, suspended, or ended could instill the feeling that an individual's prior contribution was not meaningful. Or, waiting to implement policy until leadership approves can be prolonged if there is interim, acting leadership and work is delayed. (O'Connell [2009, pp. 941–943] refers to this situation as “agency confusion,” which is created by high-level leadership vacancies.) Second, they could lead to a shift in mission focus, which could reduce the nonmonetary benefits of a job if mission was a large motivator in joining, or if a worker’s job was in service to a prior mission focus that is no longer being pursued. Third, they could have more direct, tangible impacts on workers in terms of actions like reductions in force and physical relocations of agency offices.

Given these potential issues with changes and vacancies in federal agency leadership, we recommend evaluations and investigations of the relationship between political appointee turnover and prolonged vacancy with bureaucratic, nonpolitical staff hiring and tenure. In particular, studies may, for various levels of political appointees, consider

- whether certain categories of workers are more likely to leave in the period after a prolonged appointee vacancy or high or low political appointee turnover
- whether certain positions become more difficult to hire for in the period after such a vacancy or turnover.

It is important to stress that this relationship should not have a party affiliation. The question is whether changes to leadership—agnostic of political direction—have workforce consequences. Again, the result is not to make a completely infeasible policy solution (e.g., to stop political appointments) but to help agency staff develop targeted workforce policy, if necessary, to enable hiring and retention around known risk factors.

Is the Focus on STEM Workers the Right One for Understanding Dynamics Underlying Recruiting, Compensation, and Retention Trends?

In this report we examined whether STEM workers in the federal government were competitively compensated compared with their private-sector counterparts. It is also worth considering whether the focus on STEM is the correct one, or whether a more targeted level of analysis would better address the challenges facing recruiters and workforce managers at DoD and elsewhere in the federal government.

From an educational perspective in which STEM is often discussed, a broad focus is more likely to be appropriate. While there clearly are differences between courses of study in STEM, and ways to parse the STEM educational pipeline that mirror categories into which the STEM workforce can be parsed, many STEM skills are transferrable across fields of study. Moreover, students, especially in college, can switch interests or majors but retain the same technical introduction if they have a solid grounding in core aspects of STEM. Therefore, for educational purposes, there may be more logic to analyzing STEM in the aggregate—as a category of education and training that provides highly valued technical skills—even if there are differences in individual fields of study within STEM.

But in the labor market, focusing on STEM workers—or, as the NDAA has defined it, on “scientists and engineers”—as a group becomes more problematic. As we discussed in

Chapter One, there is no single definition of what constitutes STEM jobs, or which occupations, workers, or educational levels should be included. Furthermore, there is little evidence that one STEM occupation's labor market overlaps with another. In other words, a focus on an area of education with similar skills can be approached broadly, but the same cannot be said for such a broad approach to understanding labor markets. To put a point on it, a hiring manager is likely less interested in how to attract and retain STEM workers in the aggregate and more interested in drilling down into impediments to filling and retaining quality workers in a specific job, requiring a specific skill set, in a specific location.

We note throughout the report how much compensation varies by occupation or education level. We also cite examples of different recruiting and hiring practices across STEM occupations (e.g., the use of HackerRank by web developers and JOE by economists). First, we recommend that federal government agencies map out which specific occupations federal practice currently tailors hiring, compensation, or retention policies toward and evaluate if those tailoring practices are successful. (Again, our emphasis in recommendations throughout this report is in gaining a better understanding of the effect of current practices and policies.) Second, conditional on the findings of any recommended analysis, we recommend that, going forward, federal agencies frame hiring, compensation, and retention policies to *specific occupations* or, further, to *specific labor markets* (e.g., advanced degree holders in the West). Broad categorizations (e.g., the federal government needs to pay STEM workers more) may result in inefficient policies compared with targeted practice (e.g. the federal government agencies wishing to hire web developers should have authority to use HackerRank). Moreover, this examination of specific labor markets and occupations need not, and likely *should* not, be limited to STEM. The federal government has data on vacancies and hiring needs; targeting occupations for pay plans or authorities could be supported through analysis of this data.

In sum, STEM is important, but it is also not a uniform monolith, and therefore in the aggregate may not be the best indicator of need or pay disparities between the federal government and the private sector. Rather, disparities may vary by labor market, occupation, or other factors. Further research that seeks to pair quantitative and qualitative methods, including efforts to identify and analyze individual-level compensation changes upon entering or exiting the federal workforce, could yield more accurate bellwethers of compensation-related and other causes of hiring and retention difficulties across employers of STEM workers in the federal government.

Appendix A. STEM Occupations and Crosswalks

This project had two tasks that facilitated the majority of the analysis: defining STEM occupations, and creating a crosswalk between different data sets of those occupations. The crosswalk includes three numeric coding systems that classify occupations that come from three sources: (1) Standard Occupational Classification (SOC) codes from the U.S. Census Bureau, (2) federal civilian occupational category codes from the OPM, and (3) CPS occupation codes from the BLS. We created a new numeric system specifically for STEM, the RAND Code, and matched the SOC, CPS, and OPM codes to it. In this appendix, we describe our approach to each of those tasks and provide detailed reference information of the occupations lists.

Defining STEM

There have been numerous attempts to define what STEM is and just as many admissions that the definition varies; we discuss these various definitions and their implications in Chapter One. For this analysis, defining the set of STEM occupations ostensibly should not have posed great difficulty. The scope of the analysis is to compare the compensation of STEM workers in the federal government to their counterparts in the private sector. The OPM, the agency overseeing the federal workforce and a key source of data for our analysis, has a list of occupations that it flags as being STEM occupations.

However, the Census Bureau, which is the other key source of data for this analysis, also produces a list of STEM occupations, and the two lists do not cohere. Moreover, this study was authorized and ordered by Congress, which has, in effect, produced a definition of STEM through the scope and language of prior legislation. In the 2010 reauthorization of the America COMPETES Act (Public Law 110–69, 2007), Congress mandates and funds the study of STEM education and development by the NSF. The NSF definition of STEM has a broader scope in fields and training than what is reflected in the OPM's or the Census's occupation lists (NSF, undated). Hence, there are three definitions of STEM that could be relevant to the project: a list of occupations from OPM, a list of occupations from the Census, and the fields and training levels that encompass STEM according to the NSF. Our approach to creating a definition of STEM for this analysis was to use the OPM list as the basis for our STEM definition, and augment or take away from it as appropriate. Specifically, we aimed to

1. start with the OPM occupation list
2. add occupations to the OPM list to reflect the NSF definition of STEM
3. remove occupations from the OPM list to reflect the NSF definition of STEM
4. create a crosswalk between the OPM list and SOCs
5. create a crosswalk between SOCs and occupation codes used in key surveys (such as the CPS).

We detail our steps in this appendix.

Additions to the Office of Personnel Management STEM List

The key way in which the OPM occupation list diverged from the NSF definition is that the OPM excluded all technicians and assistants. For example, included in STEM is occupation 457—Soil Conservation, which, the OPM defines,

> This series covers positions involving the performance of professional work in the conservation of soil, water, and related environmental resources to achieve sound land use. Conservation work requires knowledge of: (1) soils and crops; (2) the pertinent elements of agronomy, engineering, hydrology, range conservation, biology, and forestry; and (3) skill in oral and written communication methods and techniques sufficient to impart these knowledge to selected client groups. (OPM, 2018d)

But, the list does not include 458—Soil Conservation Technician, which, the OPM defines,

> This series covers all positions that require a practical knowledge of the methods and techniques of soil, water, and environmental conservation as they relate to agricultural operations and land use measures. Soil conservation technicians advise property holders on the effectiveness of applying soil and water conservation practices or assist in research efforts. (OPM, 2018d)

The technician series covers the same subject matter, but in a different capacity, and likely with less formal education or training.

Our interpretation is that this is at odds with the NSF's view of STEM. Within the NSF's Directorate for Education and Human Resources is the Division of Undergraduate Education, which covers two- and four-year education, and the Division of Graduate Education, which covers master's degree and Ph.D. education. In other words, the NSF considers STEM to encompass all levels of postsecondary training, and not just the highest education levels. Indeed, the NSB recently referred to sub-baccalaureate STEM workers as "technical STEM" and acknowledged that they could account for up to 25 percent of the total STEM workforce; it also noted that this "blue collar" STEM workforce was a critical component to the STEM workforce (NSB, 2015; NSB, 2018a).

The OPM occupations do not, for the most part, list in their occupation descriptions any educational requirements. It could be that the occupations comprise many education levels. However, there are some occupations for which there are separately enumerated technician or assistant series. We add to the OPM list those occupations. Table A.1 presents, in the left column, the original OPM list, and in the right column, any added technicians or assistant occupations, within the OPM's occupational groups.

Table A.1. The List of Office of Personnel Management STEM Occupations, and Occupations Added

Original OPM List	OPM List with Technician Occupations Added
100—Social Science, Psychology, and Welfare Group	
101—Social science	102—Social science aid and technician series
150—Geography	119—Economics assistant series
180—Psychology	181—Psychology aid and technician series
184—Sociology	
190—General anthropology	
193—Archeology	
110—Economist[a]	
400—Natural Resource Management and Biological Sciences Group	
401—General natural resources and biological sciences	404—Biological science technician series
403—Microbiology	421—Plant protection technician series
405—Pharmacology	455—Range technician series
408—Ecology	458—Soil conservation technician series
410—Zoology	462—Forestry technician series
413—Physiology	
414—Entomology	
415—Toxicology	
430—Botany	
434—Plant pathology	
435—Plant physiology	
437—Horticulture	
440—Genetics	
454—Rangeland management	
457—Soil conservation	
460—Forestry	
470—Soil science	
471—Agronomy	
480—Fish and wildlife administration	
482—Fish biology	
485—Wildlife refuge management	
486—Wildlife biology	
487—Animal science	

Original OPM List	OPM List with Technician Occupations Added
800—Engineering and Architecture Group	
801—General engineering	802—Engineering technical series
803—Safety engineering	809—Construction control technical series
804—Fire protection engineering	817—Survey technical series
806—Materials engineering	856—Electronics technical series
807—Landscape architecture	873—Marine survey technical series
808—Architecture	895—Industrial engineering technical series
457—Soil conservation	
810—Civil engineering	
819—Environmental engineering	
828—Construction analyst	
830—Mechanical engineering	
840—Nuclear engineering	
850—Electrical engineering	
854—Computer engineering	
855—Electronics engineering	
858—Bioengineering and biomedical engineering	
861—Aerospace engineering	
871—Naval architecture	
880—Mining engineering	
881—Petroleum engineering	
890—Agricultural engineering	
893—Chemical engineering	
896—Industrial engineering	
1300—Physical Sciences Group	
1301—General physical science	1311—Physical science technician series
1306—Health physics	1316—Hydrologic technician series
1310—Physics	1341—Meteorological technician series
1313—Geophysics	1371—Cartographic technician series
1315—Hydrology	1374—Geodetic technician series
1320—Chemistry	1380—Forest products technology series
1321—Metallurgy	
1330—Astronomy and space science	
1340—Meteorology	
1350—Geology	
1360—Oceanography	
1370—Cartography	

Original OPM List	OPM List with Technician Occupations Added
1372—Geodesy	
1373—Land surveying	
1382—Food technology	
1384—Textile technology	
1386—Photographic technology	
1500—Mathematical Sciences Group	
1501—General mathematics and statistics	1521—Mathematics technician series
1510—Actuarial science	1531—Statistical assistant series
1515—Operations research	
1520—Mathematics	
1529—Mathematical statistics	
1530—Statistics	
1541—Cryptanalysis	
1550—Computer science	
2200—Information Technology Group	
2210—Information technology management	

SOURCE: OPM, 2018d

NOTES: The left column lists the STEM occupation codes and titles as defined by the OPM. The right column lists codes and titles of technicians and assistant occupations added to the initial STEM list.

[a] Economists were not included in the STEM list from the OPM, but are included in the social sciences.

In addition, there were cases in which we debated whether other, nontechnician occupations should be added to the STEM list. These omissions were primarily federal workers in the U.S. Patent and Trademark Office, safety inspectors, and various air traffic workers. In the end we did not augment the OPM STEM list with these occupations. First, we could not confirm whether the workers in these occupations used STEM skills or had STEM training; the OPM data gives the level of education of the worker, but not the major or discipline. It could be the case that patent advisers, for example, or aviation safety workers, often come from an engineering background, but we did not have the data to confirm that. The description of the occupation had elements of STEM, but without further detail, we could not confirm this. Second, many of these positions have no clear counterpart in the private sector. There are virtually no air traffic controllers, for example, who do not work for the Federal Aviation Administration. Adding these occupations to the STEM analysis would both break with the OPM's list and, by virtue of the occupations, not be supported in the Census Bureau's STEM list. In effect, adding them to the analysis would create analytical challenges in comparisons of the federal and private sectors that could introduce bias or superfluous assumptions. For these reasons, we did not add the occupations. We enumerate in Table A.2 those potential STEM or STEM-adjacent occupations.

Table A.2. Occupations Excluded from the Office of Personnel Management STEM List and This Analysis That Are Potentially STEM or STEM-Adjacent Occupations

1200—Copyright, patent, and trademark group
1202—Patent technician series
1221—Patent adviser series
1223—Patent classifying series
1224—Patent examining series
1226—Design patent examining series
1800—Inspection, investigation, enforcement, and compliance group
1815—Air safety investigating series
1822—Mine safety and health inspection series
1825—Aviation safety series
1850—Agricultural warehouse inspection series
1862—Consumer safety inspection series
1863—Food inspection series
2100—Transportation group
2121—Railroad safety series
2123—Motor carrier safety series
2125—Highway safety series
2130—Traffic management series
2152—Air traffic control series
2154—Air traffic assistant series
2181—Aircraft operations series
2183—Air navigation series
2185—Air technician series

SOURCE: OPM, 2018d.
NOTE: The table lists OPM occupations and occupation codes of professions that likely require STEM skills but are excluded from the OPM's STEM list.

Removals from the Office of Personnel Management STEM List

The key way in which the OPM STEM list differed from the Census Bureau's list is that the OPM included the health sciences professions, such as doctors and nurses. Although medicine and the health sciences are included in certain aspects of the NSF, such as for certain scholarships and fellowships, they are often excluded from studies of the STEM pipeline. In addition, the text from the NDAA that motivated this study did not highlight doctors, who have been the subject of previous analysis by Congress and by RAND. For this reason, we remove from the OPM STEM list health science and medical occupations, as enumerated in Table A3. Note that medical scientists, researchers within the field of medicine, are still included.

Table A.3. Occupations Included in the Office of Personnel Management STEM List but Excluded from This Analysis

0600—MEDICAL, HOSPITAL, DENTAL, AND PUBLIC HEALTH GROUP
601—General health science
602—Medical officer
610—Nurse
620—Practical nurse
630—Dietitian and nutritionist
631—Occupational therapist
633—Physical therapist
635—Kinesiotherapy
637—Manual arts therapist
638—Recreation/creative arts therapist
639—Educational therapist
651—Respiratory therapist
660—Pharmacist
662—Optometrist
665—Speech pathology and audiology
667—Orthotist and prosthetist
668—Podiatrist
670—Health system administration
682—Dental hygiene
685—Public health program specialist
690—Industrial hygiene
696—Consumer safety

SOURCE: OPM, 2018d.
NOTE: The table lists OPM occupations and occupation codes of professions that are listed as STEM occupations according to the OPM's definition but that are excluded from this analysis.

Three STEM Lists

After the additions and removals described above, we have two lists of STEM occupations: one from the OPM and one from the Census Bureau. However, in order to conduct analysis, we must produce a third STEM list, one that coheres with the survey that we will use to support most of our analysis, the CPS. The Census Bureau's list of STEM occupations is enumerated in the SOC list, which is, in practice, the master list of all occupations in the United States. However, many surveys that the Census Bureau conducts use a separate occupation numeric system, either because the SOC list is too detailed or because the survey predates the SOC schema. The survey we rely on most in our analysis is the CPS, which is managed by the BLS; there is a ready crosswalk available between the SOC and CPS occupations.

Hence, we have three lists of STEM occupations:

1. one from the OPM and in OPM codes, amended as described
2. one from the Census Bureau and in SOC codes, amended as described
3. from the BLS and in CPS codes, crosswalked from item 2, above.

There is some detail lost between the Census Bureau's SOC codes and the BLS CPS codes. Notably, the Census Bureau enumerates postsecondary instructors by their field of instruction in the SOC list, but the BLS does not, and instead lists all postsecondary instructors as a single occupation in the CPS. This means that we cannot compare Ph.D. scientists in the federal sectors to professors in the private sector. There are other instances of BLS amalgamation of detail in the CPS, which will be apparent in the crosswalk tables below.

Creating a Crosswalk

In order to conduct our analysis, we must create a crosswalk that groups the individual occupations from each list into a category that supports a comparison. To our knowledge, there is no existing crosswalk between the OPM occupation coding system and the Census Bureau's occupation coding system. If there were, we could apply the crosswalk to the subset of occupations of interest, and there would be little else to do. Because it does not exist (or is not publicly available), we have had to construct one.

Our first inclination was to comb through all three lists of occupations and match them by hand. For example, each list contained an occupation titled "economist" and an occupation equivalent to "civil engineer." However, these matches were the exception, rather than the rule, and just under 40 percent of the total STEM list in the OPM had a single match in the SOC and the CPS codes. Many of the matches were lopsided—either one profession in the OPM could apply to multiple in the CPS and SOC (and in some cases, over a dozen), or there were multiple occupations in the OPM that could match to a single occupation in the SOC. In other instances, there were no matches to the OPM occupation. For example, within physical science, the OPM lists the occupations "Textile Technology" and "Photographic Technology," which have no similarly titled equivalents in the private sector.

Moreover, in creating the crosswalk, we had concerns about definitional differences and selection differences that create education imbalances. For example, all three lists contain "Civil Engineers" but the OPM includes "Civil Engineering Technicians." Is it the case that the census description encompasses less educated workers within civil engineering, which the OPM divides, or is it the case that the Census Bureau groups them together as "Engineering Technicians." To check this, we would need to go into the data and measure the educational attainment of "Civil Engineers" in each data set and "Civil Engineering Technicians" and "Engineering Technicians" in their respective data sets. However, this is important because labor markets are stratified by skill and its proxy, educational attainment, and we want to be clear that we are comparing similarly educated workers.

Yet, this introduces an additional problem. On the one hand, occupations could be defined differently that create educational differences, and this makes creating the crosswalk a careful exercise. On the other hand, what if there is selection across sectors that creates educational differences in the groups? The nature or scope of federal civil engineering jobs may require more education, for example. Is a crosswalk that takes education into account in classifying occupations reflecting differences in the occupations or in the job requirements? It is unclear how to handle that, or if we are imposing bias in how we assign occupational matches.

Finally, STEM is only a fraction of the total workforce. Even if we were to create a matched crosswalk for each occupation, the sample-size constraints require that we aggregate the occupations so that we have sufficient sample for comparison. Given these concerns about the lack of one-to-one matches and the issues introduced in trying to match on education, compounded with the need for categories larger than at the occupation level, we abandoned the matching approach in favor of a "roll-up" method. For this method, we created a new numeric system specifically for STEM, the RAND Code, and matched the SOC, CPS, and OPM codes to it.

The RAND code consists of five broad categories that have two-digit prefixes:

- Physical science, 11-
- Life science, 13-
- IT and computer science, 15-
- Engineering, 17-
- Social science, 19-.

Each of the occupations in each of the three coding systems were grouped, regardless of education or title, into these five categories. The third number of the code indicates education level. For example, in social science (19-):

- Advanced degree (J.D., M.D., Ph.D.), 191
- Master's degree, 192
- Bachelor's degree, 193
- Associate's degree, 194
- Technical certificate, 195
- No postsecondary degree, 196.

Within each "broad five," as we called them, we created more detailed categories to identify one-to-one matches that existed. For example, in social science (19-):

- Economists, 19x01
- Sociologists, 19x02
- Psychologists, 19x04
- Other not specified, 19x99.

And each third digit *x* specifies the education level. For example, for economists:

- Ph.D. economists, 19101
- Master's degree economists, 19201
- Bachelor's degree economists, 19301
- Associate's degree economists, 19401
- Technical certificate economists, 19501
- No postsecondary degree economists, 19601.

It is certainly the case that some of our codes may in fact comprise empty cells; there may be few individuals whose are economists but who only have a technical certificate. However, the strength the of this coding system is that it allows for an easy comparison of fields of interest within STEM (e.g., physical science versus life science), and it puts most weight on classifying by the educational attainment of the worker within the field (e.g., a Ph.D. physical scientist) regardless of the specific occupation name. In effect, it is a way to guard against bias that may cloud comparisons of a more detailed level in which differing occupational differences may lead to comparing relatively dissimilar workers. Table A.4 enumerates the RAND crosswalk in its entirety.

Table A.4. The Complete RAND, Office of Personnel Management, Standard Occupational Classification, and Current Population Survey Crosswalk of STEM Occupations

Broad RAND Code	Detailed RAND Code	OPM Code	OPM Occupation	SOC Code	SOC Occupation	CPS Code	CPS Occupation
11-	11x01	1320	Chemistry	192031	Chemists	1720	Chemists and materials scientists
				194031	Chemical technicians	1920	Chemical technicians
	11x02	1330	Astronomy and space science	192011	Astronomers	1700	Astronomers and physicists
		1310	Physics	192012	Physicists		
	11x03	1340	Meteorology	192021	Atmospheric and space scientists	1710	Atmospheric and space scientists
		1341	Meteorological technician series				
	11x04	1382	Food technology	191012	Food scientists and technologists	1600	Agricultural and food scientists
	11x99	1301	General physical science	192099	Physical scientists, all other	1760	Physical scientists, all other
		1306	Health physics	194051	Nuclear technicians	1940	Nuclear technicians[a]
		1311	Physical science technician series	194099	Life, physical, and social science technicians, all other	360	Natural sciences managers
		1321	Metallurgy	192032	Materials scientists		
		1384	Textile technology	119121	Natural sciences managers		
		1386	Photographic technology				
13-	13x01	460	Forestry	191031	Conservation scientists	1640	Conservation scientists and foresters
		462	Forestry technician series	191032	Foresters	3750	Fire inspectors
		804	Fire protection engineering	194093	Forest and conservation technicians		
		454	Rangeland management	322022	Forest fire inspectors and prevention specialists		
		1380	Forest products technology series				
		455	Range technician series				
		457	Soil conservation				
		458	Soil conservation technician series				

Broad RAND Code	Detailed RAND Code	OPM Code	OPM Occupation	SOC Code	SOC Occupation	CPS Code	CPS Occupation
	13x02	1315	Hydrology	192041	Environmental scientists and specialists, including health	1740	Environmental scientists and geoscientists
		1313	Geophysics	192042	Geoscientists, except hydrologists and geographers	1930	Geological and petroleum technicians[a]
		1316	Hydrologic technician series	192043	Hydrologists		
		1350	Geology	194041	Geological and petroleum technicians		
		1360	Oceanography	191013	Soil and plant scientists		
		1372	Geodesy	194091	Environmental science and protection technicians, including health		
		1374	Geodetic technician series				
		408	Ecology				
		421	Plant protection technician series				
		430	Botany				
		434	Plant pathology				
		435	Plant physiology				
		437	Horticulture				
		470	Soil science				
		471	Agronomy				
		480	Fish and wildlife administration				
		482	Fish biology				
		485	Wildlife refuge management				
		486	Wildlife biology				
	13x03	403	Microbiology	191022	Microbiologists	1610	Biological scientists
		404	Biological science technician series	194021	Biological technicians	1910	Biological technicians
		440	Genetics	191011	Animal scientists		
		487	Animal science	191023	Zoologists and wildlife biologists		
		410	Zoology	191021	Biochemists and biophysicists		
		644	Clinical laboratory science series				
		414	Entomology				
	13x04	601	General health science	191041	Epidemiologists	1650	Medical scientists[b]
		405	Pharmacology	191042	Medical scientists, except epidemiologists		
		413	Physiology	191099	Life scientists, all other		
		415	Toxicology				
	13x99	401	General natural resources management and biological sciences	191029	Biological scientists, all other		

Broad RAND Code	Detailed RAND Code	OPM Code	OPM Occupation	SOC Code	SOC Occupation	CPS Code	CPS Occupation
15-	15x01	1550	Computer science	151111	Computer and information research scientists	1005	Computer and information research scientists[c]
		2210	Information technology management	151121	Computer systems analysts	1006	Computer systems analysts[c]
				151122	Information security analysts	1007	Information security analysts[c]
				151131	Computer programmers	1010	Computer programmers
				151132	Software developers, applications	1020	Software developers, applications and systems software
				151133	Software developers, systems software	1030	Web developers[c]
				151134	Web developers	1060	Database administrators
				151141	Database administrators	1105[d]	Network and computer systems administrators
				151142	Network and computer systems administrators	1106	Computer network architects[c]
				151143	Computer network architects	1050[e]	Computer support specialists
				151151	Computer user support specialists	1107	Computer occupations, all other[c]
				151152	Computer network support specialists	110	Computer and information systems managers
				151199	Computer occupations, all other		
				113021	Computer and information systems managers		
	15x02	1510	Actuarial science	152011	Actuaries	1200	Actuaries
	15x03	1520	Mathematics	152021	Mathematicians	1210	Mathematicians[f]
		1529	Mathematical statistics	152091	Mathematical technicians		
		1521	Mathematics technician series				
		1541	Cryptanalysis				
	15x04	1515	Operations research	152031	Operations research analysts	1220	Operations research analysts
	15x05	1530	Statistics	152041	Statisticians	1230	Statisticians
		1531	Statistical assistant series	152099	Mathematical science occupations, all other		
	15x99	1501	General mathematics and statistics			1240	Miscellaneous mathematical science occupations[f]

Broad RAND Code	Detailed RAND Code	OPM Code	OPM Occupation	SOC Code	SOC Occupation	CPS Code	CPS Occupation
17-	17x01	808	Architecture	171011	Architects, except landscape and naval	1300	Architects, except naval
		807	Landscape architecture	171012	Landscape architects	1310	Surveyors, cartographers, and photogrammetrists
		1370	Cartography	171021	Cartographers and photogrammetrists	1540	Drafters
		817	Survey technical series	171022	Surveyors	1560	Surveying and mapping technicians
		1373	Land surveying				
		1371	Cartographic technician series	173031	Surveying and mapping technicians		
				173011	Architectural and civil drafters		
	17x02	861	Aerospace engineering	172011	Aerospace engineers	1320	Aerospace engineers
				173021	Aerospace engineering and operations technicians		
	17x03	890	Agricultural engineering	172021	Agricultural engineers	1330	Agricultural engineers[9]
	17x04	858	Bioengineering and biomedical engineering	172031	Biomedical engineers	1340	Biomedical engineers[9]
	17x05	893	Chemical engineering	172041	Chemical engineers	1350	Chemical engineers
	17x06	810	Civil engineering	173022	Civil engineering technicians	1360	Civil engineers
				172051	Civil engineers		
	17x07	854	Computer engineering	172061	Computer hardware engineers	1400	Computer hardware engineers
	17x08	850	Electrical engineering	172071	Electrical engineers	1410	Electrical and electronic engineers
		855	Electronics engineering	172072	Electronics engineers, except computer		
		856	Electronics technical series	173023	Electrical and electronics engineering technicians		
				173024	Electro-mechanical technicians		
				173012	Electrical and electronics drafters		
	17x09	819	Environmental engineering	173025	Environmental engineering technicians	1420	Environmental engineers
				172081	Environmental engineers		
	17x10	803	Safety engineering	172111	Health and safety engineers, except mining safety engineers and inspectors	1430	Industrial engineers, including health and safety
		895	Industrial engineering technical series	173026	Industrial engineering technicians		
		896	Industrial engineering	172112	Industrial engineers		
	17x11	871	Naval architecture	172121	Marine engineers and naval architects	1440	Marine engineers and naval architects

Broad RAND Code	Detailed RAND Code	OPM Code	OPM Occupation	SOC Code	SOC Occupation	CPS Code	CPS Occupation
	17x12	806	Materials engineering	172131	Materials engineers	1450	Materials engineers
	17x13	830	Mechanical engineering	172141	Mechanical engineers	1460	Mechanical engineers
				173027	Mechanical engineering technicians		
				173013	Mechanical drafters		
	17x14	880	Mining engineering	172151	Mining and geological engineers, including mining safety engineers	1500	Mining and geological engineers, including mining safety engineers[h]
	17x15	840	Nuclear engineering	172161	Nuclear engineers	1510	Nuclear engineers[g]
	17x16	881	Petroleum engineering	172171	Petroleum engineers	1520	Petroleum engineers[h]
	17x99	804	General engineering	172199	Engineers, all other	1530	Engineers, all other[i]
		802	Engineering technical series	173019	Drafters, all other	1550	Engineering technicians, except drafters
		828	Construction analyst	173029	Engineering technicians, except drafters, all other	300	Engineering managers[j]
				119041	Architectural and engineering managers		
19-	19x01	110	Economist	193011	Economists	1800	Economists[k]
		119	Economics assistant series				
	19x02	180	Psychology	193031	Clinical, counseling, and school psychologists	1820	Psychologists
		181	Psychology Aid and Technician Series	193032	Industrial		
				193039	Psychologists, all other		
	19x03	184	Sociology	193041	Sociologists	1830	Sociologists[l]
	19x99	190	General anthropology	193091	Anthropologists and archeologists	1860	Miscellaneous social scientists and related workers[m]
		193	Archeology	193092	Geographers		
		150	Geography	193099	Social scientists and related workers, all other		
		101	Social science				
		102	Social Science Aid and Technician Series				

NOTES: The table shows the generated RAND occupation code, both broad and detailed, and the corresponding occupations and codes from the OPM, the Census Bureau (SOC), and the BLS (CPS).

[a] In 2013, CPS combined nuclear technicians (code 1940) with geological and petroleum technicians (code 1930).

[b] In 2013, CPS changed this occupation label to Medical scientists, and life scientists, all other.

[c] In 2013, CPS merged this occupation with several others and renamed the occupation to Computer Scientists and Systems Analysts/Network Systems Analysts/Web Developers. Prior to 2010, CPS also included occupations called Computer scientists and systems analysts (code 1000) and Network and data communications analysts (code 1110), which were removed and are now subsumed under the new occupation.

[d] Prior to 2010, CPS included an occupation with this name but which had code 1100. That code was dropped by CPS, but the same occupation was later adopted with code 1105.

[e] Prior to 2010, CPS included an occupation with this name but which had code 1040. That code was dropped by CPS, but the same occupation was later adopted with code 1050.

[f] In 2013, CPS renamed this occupation to Mathematical science occupations, all other.

[g] In 2013, CPS merged this occupation with the occupation named Engineers, all other (code 1530).

[h] In 2013, CPS added petroleum engineers (code 1520) to the occupation Mining and geological engineers, including mining safety engineers (code 1500) to create a new occupation called Petroleum, mining and geological engineers, including mining safety engineers.

[i] In 2013, CPS added agricultural engineers (code 1330), biomedical engineers (code 1340), and nuclear engineers (code 1510) to this occupational category.

[j] In 2013, CPS changed the name of this occupation to Architectural and engineering managers.

[k] In 2013, CPS changed the name of this occupation to Economists and market researchers.

[l] In 2013, CPS merged the sociologist category with the occupation titled Social scientists, all other (code 1860).

[m] In 2013, CPS changed the title of this occupation to Social scientists, all other.

Appendix B. Federal Policy Background

In Chapter Three we noted that the federal workforce has hiring and pay practice policies that may be relevant to STEM workers. And in Chapter Six we explored three topics that are not directly related to compensation and benefits but that may affect job quality and, therefore, decisions to enter or remain in the federal STEM workforce. In this appendix we provide detailed summaries of those policies, including the federal GS Pay Scale, hiring processes, hiring programs, hiring and payment authorities, policy-related disruptions, and leadership changes. We also provide additional background information on each of these topics.

The Federal General Schedule Pay Scale

The GS pay scale has 15 different pay grades (GS-1 through GS-15), and each pay grade corresponds to a different starting salary. Every pay grade is further broken down into ten steps. Every step is approximately a 3-percent salary increase, and step increases can be achieved through length of employment (e.g., after working for one year at Step 1, an employee is automatically upgraded to Step 2) or exemplary performance (limited to one per year). Agencies determine the pay grade or range of pay grades appropriate for a position based on job requirements (education, past experience, skills) and responsibilities. Typically, individuals with high school diplomas qualify for GS-2, those with bachelor's degrees for GS-5, and those with master's degrees for GS-9. Theoretically, all new employees start at Step 1 of their pay grade; however, there are a number of factors that can lead an agency to offer an employee a starting salary at a higher step. These include an applicant's salary at a previous position and his or her qualifications (OPM, undated o).

An employee's salary on the GS scale is additionally affected by factors such as locality pay, special pay rates, and across-the-board increases. *Locality pay* means that employees are automatically paid a set percentage higher than their base GS pay rate based on where they work. Federal employees working outside of an otherwise designated locality fall into the "Rest of the United States" locality. Locality pay rates are determined by the wage gap between private- and public-sector workers in a given region rather than cost of living. For example, in 2019 the locality adjustment for the San Francisco/San Jose/Oakland area was 40.35 percent, the state of Alaska 28.89 percent, the Seattle/Tacoma area 26.04 percent, and "the Rest of the United States" 15.67 percent (GeneralSchedule.org, undated, table for 2019). Special pay rates also raise employee salaries above the basic GS scale and can be applied to occupational categories, GS grades, geographic area, or any other category of employee for which the agency is having difficulty recruiting. Typical reasons for a special rate are remote location, undesirable work, or significantly higher private-sector wages by comparison (OPM, undated z).

The final factor that can change the GS scale is a universal pay raise implemented by Congress or the President. Every year, Congress reviews GS pay rates and locality adjustments to determine whether federal wages, on average, are keeping pace with those of the private sector. Congress may choose to pass legislation increasing GS salaries across the board or to alter certain locality rates. If Congress does not pass legislation on the matter, the President may sign an executive order to increase federal pay. Otherwise, the GS and locality rates will remain the same into the next year (GeneralSchedule.org, 2017).

The Hiring Process

Individuals who want to work for the federal government are hired through "unique hiring paths" that include the general public and 11 other categories: federal employees, veterans, military spouses, National Guard and Reserve members, students and recent graduates, senior executives, individuals with disabilities, family members of overseas employees, Native Americans, Peace Corps and AmeriCorps VISTA workers, and an additional category of very unique individuals such as those who previously served in the Office of the President or Vice President (USAJOBS, undated b).

The federal government primarily uses the central portal, USAJOBS, through which applicants can view job postings and apply for positions.[1] Administered by the OPM, USAJOBS connects interested applicants with federal employment opportunities within and outside of the United States. Since its launch in 1996, the website has served as the central hub for employment information for hundreds of federal agencies. On the site's 20th anniversary in 2016, the OPM stated that USAJOBS holds more than 14,000 job postings every day, 22 million applications are started each year, and 1 billion searches are conducted on the site each year (OPM, 2016d; USAJOBS, undated a).

With respect to USAJOBS, there are persistent obstacles. The OPM held focus groups with job applicants who reported their dissatisfaction with the site's performance and ease of use across a variety of features (Davidson, 2016; Rein, 2014). Even with the redesign, numerous blogs and websites exist to give job seekers advice about how to navigate the specific challenges of USAJOBS, nearly always suggesting that individuals interested in a job with the federal government write a *separate, government-specific résumé*, such as the recent article "How to Escape the USAJOBS.gov Resume Black Hole," among others (Krasnow, 2015; McManus, undated; Roberts, undated a; Roberts, undated b; "Stop Using Your Private Industry Resume to

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[1] Individuals applying to work for the federal government are hired into three different services: the Competitive Service, the Excepted Service, and the Senior Executive Service (SES). The majority of candidates apply to work in the Competitive Service, which consists of most federal government positions. Candidates for these positions must be evaluated in some manner, and this can include examinations, assessments of their experience and education, and/or evaluation of their overall attributes for the position. The Excepted Service includes those positions not in the Competitive Service or the SES. Such exceptions include those under special hiring authorities created by the OPM, or in specific positions designated as excepted by the OPM. The SES deals with those positions just under presidential appointees, as established by law through the Civil Service Reform Act of 1978. The OPM allocates SES positions to each agency on a two-year rotational basis. Agencies then review applications for the positions, and the OPM's Qualification Review Board supplies the final, independent review of initial SES applicants.

Apply for Government Jobs on USAJobs.gov," undated). There is even a secondary market for private companies to handle a federal job application for an individual in exchange for a fee to create a résumé that is more likely to be scored highly on USAJOBS. In other words, at the same time that occupation-specific labor markets are evolving to be more efficient and less burdensome, the federal labor market is viewed as posing a steep application burden.

The same holds true for time to hire. Again, several sites and blogs offer advice on how to speed up the process, or how to handle the long wait after filing a federal application (Roberts, 2019; "How Long Does It Take to Get Hired from Start to Finish at United States Department of Defense?" 2017). Yet, in wider press coverage, the federal hiring process is described as "broken" (Rein, 2016). Often the concern is that in order for a federal agency to hire a worker, that worker would have to turn down any other job that he or she secures in the interim, or take another job and then quit. Both make hiring more difficult. Also, as we showed in Chapters Two and Three, STEM workers have lower unemployment rates than non-STEM workers, even when controlling for education; these are workers who statistically do not have trouble finding a job when they start to look for one.

As part of the overall hiring process, federal agencies implement several programs to attract and retain a talented workforce to fulfill the missions and meet the needs of the U.S. government. The majority of these programs target employees from all backgrounds, which may or may not include STEM disciplines based on the agency and/or the position. These hiring programs can, however, lead to STEM hires. Other programs exist that specifically target STEM workers to fill mission critical positions. The programs include special hiring programs, specialized hiring and payment authorities, and benefit programs.

Special Hiring Programs

To attract a diverse and capable workforce, including those individuals with STEM backgrounds, federal agencies implement several hiring programs and authorities. These programs and authorities aid in addressing the critical skills gaps seen across the government, as is evident by the GAO's consistent placement of strategic human capital management on its annual High-Risk List. As stated in the March 2019 High-Risk List report, GAO, "along with OPM and individual agencies, [has] identified skills gaps in such government-wide occupations in the fields of science technology, engineering, mathematics, cybersecurity and acquisitions" (GAO, 2019c, p. 75). The first two programs that assist the federal government in hiring generally, which also includes hiring STEM-educated individuals, reside within the Pathways for Students and Recent Graduates to Federal Careers initiative. Established by Executive Order 13526 in 2010, the program offers clear paths to federal employment for students from high school through college. The order states that "exposing students and recent graduates to Federal jobs through internships and similar programs attracts them to careers in the Federal Government and enables agency employers to evaluate them on the job to determine whether they are likely to have successful careers in Government." (Executive Order 13562, 2010). The Pathways initiative recognizes the competitive disadvantage of the federal government when compared with the private sector, which provides more opportunities for persons just beginning their professional careers. By offering these "pathways," the federal government seeks to overcome this disadvantage. The initiative includes three unique programs: the Internship Program, the PMF Program, and the Recent Graduates Program (OPM, 2016b, p. 3).

First, the Internship Program provides students with opportunities to work within federal agencies while still in school. If individuals successfully complete the Internship Program, then they can become eligible for a full-time position with the government once their schooling is complete.[2] To be eligible for the program, individuals must be current students (half- to full-time), enrolled in high school, college, a professional school, a technical school, a vocational school, a trade school, advanced degree programs, or another qualifying educational institution pursuing a qualifying degree or certificate, and must maintain student status throughout the duration of the Internship Program.[3] Each federal agency manages its own Internship Program, and the internships are full- or part-time paid positions. The individuals' assigned positions must align with their related fields of study, so those studying under STEM majors or programs would need to be assigned to STEM-related federal positions. Agencies administer and hire interns through the USAJOBS website, as they do for other full-time positions (OPM, undated l).

Second, the Recent Graduates Program allows individuals who have recently graduated to gain experience within the federal government and insight into possible career paths moving forward. Successful applicants are "placed in a dynamic, developmental program with the potential to lead to a civil service career in the federal government."[4] To be eligible, individuals must have graduated within the previous two years from an associate's, bachelor's, master's, professional, doctorate, vocational, or technical degree or certificate program issued by a qualifying institution.[5] The yearlong internship programs are run by individual agencies, and

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[2] Federal interns can be given full-time positions within 120 days of the end of their internships. To be eligible for conversion to a full-time position, interns must have worked for at least 640 hours in their internship position, received their degree, fulfilled any educational program requirements; they must also meet the standards for the proposed full-time position, any agency-specific requirements, and performance expectations. Up to 320 of the 640 required hours of service can be waived by the agency if an intern is deemed to be exceptional in a position, he or she works with a third-party provider, and/or he or she has previously held a federal government position. For more information, see OPM, undated s.

[3] The list of "qualifying educational institutions" for all federal programs discussed in this section can be found at U.S. Department of Education, undated.

[4] Once participants complete the program, they may be able to convert to a full-time, permanent federal position. To be eligible to convert to a permanent position, recent graduates must complete the full Recent Graduates Program (for a year or longer, depending on the position), fulfill all requirements of the program as assigned, achieve successful job performance during their time in the program, and hold the qualifications for their new permanent position. See OPM, undated s; and OPM, 2016b.

[5] Veterans interested in applying to the program may extend the two-year limit to six years if their delay in applying is due to service commitments.

applicants apply to the positions via agency postings on the USAJOBS website (OPM, undated v; OPM, 2016b).

Participants in the Recent Graduates Program receive several benefits from their experience. Participants go through an extensive orientation program to learn about and acclimate to the federal government. In addition to orientation, members in the program receive at least 40 hours of interactive training for each year they participate.[6] Participants also receive dedicated mentorship throughout the yearlong program, and they develop Individual Development Plans to establish and track their respective career planning, professional development, and training activities. Finally, the positions and experience offer the opportunity for career development, especially within the federal government (OPM, undated v; OPM, 2016b).

The PMF Program serves as a leadership development program for recent graduates with advanced degrees. It seeks individuals "who demonstrate academic excellence, possess management and leadership potential, and have a clear interest in and commitment to public service." To be eligible for the PMF Program, students must have met within the past two years, or will meet by August 31 of the application year, all requirements for their advanced degree.[7]

PMF Program participants benefit from their participation in several ways. First, they receive full-time pay and benefits; compensation may be at the GS-9, GS-11, or GS-12 levels, depending on their skill and experience levels. Second, members of the program receive 160 hours of formal, interactive training. Third, participants receive challenging assignments and consistent feedback on their performance in order to mature and grow within their positions. Fourth, they receive the opportunity for at least one four- to six-month developmental assignment outside of the agency into which they were hired. The developmental assignment allows for additional exposure to the federal government, increasing participants' knowledge and understanding of its inner workings. Fifth, participants may be eligible for promotions and take steps along the federal career ladders during their time within the fellowship. Sixth, they can receive the Federal Student Loan Repayment or Public Service Loan Forgiveness benefits depending on their home agency's policies. Finally, participants may convert to a term or permanent, full-time position upon successful completion of the PMF Program (OPM, 2016b; PMF Program, undated).

From 2014 to 2017 the PMF Program included a STEM pilot that hired fellows through a special lane for STEM workers. The program required applicants to be considered for STEM-related positions only. After the program's three-year pilot, the PMF Program discontinued it in

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[6] While most of the Recent Graduates Programs are a year in length, some may extend beyond a year if more training is required.

[7] The types of advanced degrees covered by the PMF include master's degrees, J.D.'s and Ph.D.'s. Students must attend or have attended a qualifying educational institution. For Ph.D. students, meeting all degree requirements includes the successful completion and defense of the doctoral dissertation. Participants must also be U.S. citizens unless they are eligible to work under U.S. immigration laws and are eligible for and in pursuit of U.S. citizenship. An agency may also appoint noncitizens if it is under the agency's authority to do so. See OPM, 2016b; PMF Program, undated.

order to allow applicants to apply and be considered for positions outside of STEM-related fields (PMF Program, 2016).

The OPM assessed the effectiveness of the Pathways initiative only once since its establishment, in a report issued in August 2016. The report used data from FY 2014 and found that federal agencies were using the program to supplement their competitive hiring programs as intended, and that individuals participating in the programs often remained employed by the federal government. Approximately 14.4 percent of permanent hires in FY 2014 came through the Pathways initiative, while 85.6 percent of employees came through the traditional competitive examining process. Of those employees hired through the Pathways initiative, 86.9 percent stayed on board for at least two years, compared with 79.8 percent of those employees hired through the competitive process (OPM, 2016c). While these data do not represent the most current figures, they at least provide a baseline from which to gauge the effectiveness of the Pathways initiative. A new examination of these programs would, however, help ensure the programs' continued utilization and effectiveness as the Pathways initiative reaches its ten-year mark.

All of the Pathways programs present unique opportunities to bring STEM-educated and experienced individuals into the federal government. Each of these programs could work to identify areas where they may be able to target STEM applicants, using the opportunity to grant experience to students with the aim of either bringing them directly into the federal government after program completion or providing them with an introduction to government and policy they may otherwise never consider. While the STEM pilot of the PMF Program did not last beyond its initial three years, its implementation shows that these programs provide critical pathways through which agencies may recruit STEM employees. The Internship Program allows agencies to reach students directly and tailor their selected interns to agency needs. The Recent Graduates program offers agencies the opportunity to develop young professionals right out of school, across all degree programs. And the PMF Program grants agencies access to top-tier, talented individuals, many of whom may also be pursued by private-sector industries. By strategically using these programs, agencies and the federal government as a whole can target STEM-educated individuals from a wide variety of backgrounds, all while bypassing the typical competitive service process.

Additional Programs Providing Federal STEM Experience

Agencies and external organizations also provide several opportunities for STEM-educated individuals to gain federal government work experience. While these programs differ from the above in that they are not specific hiring programs targeting STEM workers, they do offer STEM-educated individuals the experience of working for a federal entity and may lead to full-time federal employment:

- AAAS Fellowships: The AAAS offers Science and Technology Policy Fellowships, which provide scientists and engineers the opportunity to work in the federal government.

The fellows participate in a yearlong program with the intent to "connect science with policy and foster a network of science and engineering leaders who understand government and policymaking and are prepared to develop and execute solutions to address societal challengers." The program began in 1973 through a collaborative effort of the AAAS, the American Physical Society, the American Society of Mechanical Engineers, and the Institute for Electrical and Electronic Engineering. The program hosts 300 fellows each year across the three branches of the federal government. While the program is not managed by the OPM or another federal agency for the purpose of recruiting a talented workforce, like the other programs presented in this appendix, the AAAS Fellowships do provide a source of educated and experienced science workers for the federal government.[8]

- The DOE's EERE STP program is organized each year with the goal of scientists and engineers gaining experience in policy-related areas in the DOE's Golden, Colorado, and Washington, D.C., offices.[9,10] The program provides three different levels of participation, allowing individuals with a wide variety of experience, ranging from recent graduates to advanced professionals, to participate. The intent of the EERE STP program is to bring participants' expertise and skills into the DOE and to spread policy knowledge through participants to research facilities around the country while providing policy experience and professional and educational development to participants.
- The DOE Scholars Program seeks to provide opportunities to expose individuals to the work conducted by the DOE.[11] The program encourages participants, through their experience, to apply for positions either with the DOE or those research facilities that support the DOE's mission. The appointments are specifically targeted to the STEM disciplines, as the program aims to develop individuals suited for scientific, technological, and policy-related careers.[12] Participants gain real-world experience working with scientific and policy issues, while the DOE benefits from the skills and knowledge of the participants, both during and after the program (DOE, undated).
- The DOE's EERE Student Volunteer Internship Program offers volunteer internships for students pursuing their undergraduate studies. Students participate in a wide variety of tasks, including collecting and analyzing data, assisting with research projects, composing communications materials, and attending meetings and conferences. The internship provides students with the chance to see the DOE's work up close and gain valuable policy experience within the federal government. The DOE states that this experience can aid students in networking for positions both within and outside the federal government after completion of their studies.

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[8] For more information on the AAAS Science and Technology Fellowships, see AAAS, undated.

[9] The DOE partners with the Oak Ridge Institute for Science and Education, which administers and implements the program.

[10] Participants begin the program with a one-year assignment and, dependent on performance, may be renewed for an additional four years. The program encompasses 13 different DOE offices, all of which are based in STEM and offer a wide variety of options for participants.

[11] Similar to the STP Program, the Scholars Program is administered by the Oak Ridge Institute for Science and Education in partnership with DOE.

[12] Participants must be pursuing or must hold a degree in a STEM field to participate.

Hiring and Payment Authorities

In addition to the programs described above, the federal government also offers specialized authorities and positions aimed at attracting and hiring talented employees, including those within STEM fields. Authorities are specific directives from the OPM that allow agencies to noncompetitively hire specific categories of individuals, whether based on attribute or expertise. This differs from hiring programs that seek to bring individuals into the federal government by offering them a unique introductory work experience within federal agencies and departments. First, the OPM issued the Government-Wide Direct Hire Authority (GW-007) on October 11, 2018, specifically targeting GS-11 through GS-15 STEM-related positions. The authority sought to provide a simple, streamlined process for agencies to hire candidates into critical STEM positions. The positions explicitly address identified severe shortages and critical hiring needs across the federal government. The current authority lasts for five years, with an end date of October 10, 2023. The authority identified the following positions and areas as eligible for this special hiring: economist, biological science fishery biologist, general engineer, civil engineer, the physical sciences, actuary, mathematics, mathematical statistician and statistician, and acquisitions (OPM, undated c).

Second, the federal government offers special payment authorities that are unique categories of pay and incentives for the recruitment and retainment of specifically qualified individuals:

- The CPPA allows agencies to offer special pay rates to individuals in critical positions with specialized skills. The authority provides agencies with the power to fix the basic rate of pay for positions at a higher rate than they would otherwise offer to an incoming employee. The authority can be used to both recruit and retain. The OPM issued a special memorandum in 2014 to encourage agencies to use the CPPA to recruit and retain individuals for STEM positions. The memorandum recognized that the CPPA was being underutilized by agencies and thus should be considered by those agencies facing critical skills gaps with STEM fields (OPM, 2014b).
- Agencies can request that the OPM create a special higher pay rate for a specific occupation or group of occupations for which they believe it will be difficult to recruit and/or to retain employees (GAO, 2017, p. 4).
- Agencies may provide monetary recruitment incentives for position(s) that they believe will be difficult to fill without such incentives. The additional monetary compensation cannot be more than 100 percent of the position’s base rate of pay (GAO, 2017, p. 4).
- Agencies may offer relocation incentives to employees who are being asked to move to a new geographic location for their current position. The incentives are intended to keep these individuals in the position when the agencies believe that it would be difficult to replace the individuals’ talent and expertise. The incentives cannot exceed more than 100 percent of the employee’s annual rate of pay (GAO, 2017, p. 4).
- Agencies may pay retention incentives to specific employees or particular groups of employees to retain individuals with unusually high levels or unique types of skills and/or knowledge. Incentives are to be used to keep employees when they might not otherwise stay in their positions (GAO, 2017, p. 4).

- Agencies may establish superior qualifications and special needs pay settings—that is, starting basic pay rates at higher than the typical rates to attract either specific individuals for positions or to fill specific positions that require specialized skills and qualifications (GAO, 2017, p. 5).

Third, the federal government's hiring structure includes special categories for the highest positions within the government that are not considered to be at the executive level. These include the category of Scientific or Professional Positions, representing workers at the GS-15 level who are not part of the federal government's SES. Workers in Scientific or Professional Positions perform "high-level research and development in the physical, biological, medical, or engineering sciences, or a closely related field. Many of the federal government's most renowned scientists and engineers serve in [Scientific or Professional] positions." Currently, there are approximately 470 of these positions available across the federal government. Scientific or Professional Positions provide the agencies with more options to acquire the kind of advanced scientific knowledge and expertise they need. To meet their mission requirements, agencies can request additional targeted positions and/or pools of positions, or agencies may offer compensation based on performance, granting them even more flexibility in what they can offer to attract top talent (OPM, undated x; OPM, undated y).

Fourth, FEPCA is best known for establishing locality pay for federal employees in an effort to more closely match private-sector earnings for comparable positions. However, the act's provisions also provide the President, and his or her pay agent, the power to establish special pay authorities and systems for occupations for multiple reasons, from geographic location to desirability of work conditions to pay differentials between the federal and private sectors (Public Law 101-509, Sec. 5392, Establishment of Special Occupational Pay Systems). The law grants the President and the pay agents discretion in determining the occupations in need of special pay by stating that they may do so based on "any other circumstances which the President (or an agency duly authorized or designated by the President . . .) considers appropriate" (Public Law 101-509, Sec. 5305, Special Pay Authority). Though we were unable to find evidence of these provisions' implementation, this authority may offer another option for federal agencies seeking to attract talented individuals to STEM positions. The FY 2020 budget of the OMB includes a statement that may allude to FEPCA authority and instructs the President's pay agent to analyze its use for hiring critical positions in STEM fields:

> In the coming year, the President's Pay Agent (consisting of the Directors of OMB and OPM and the Secretary of Labor) intends to exercise its authority to establish special occupational pay systems for occupations where the General Schedule classification and pay system are not aligned to labor-market realities, . . . In support of developing a workforce for the 21st Century under the PMA, the President's Pay Agent will analyze use of this special authority to address challenges and develop new approaches for valuing and compensating work in high-risk, mission critical, and emerging occupations (e.g., economics, mathematics, information technology (IT), and other Science, Technology, Engineering, and Math (STEM) fields). (OMB, 2019, p. 71)

Policy-Related Work Disruptions

Since the creation of the modern federal fiscal year in 1977, there have been 21 federal funding gaps, as detailed in a report from the CRS (2019). About half of these gaps were brief, lasting fewer than three days. In those instances, the funding gap may not have time to result in an actual federal government shutdown, because appropriations were forthcoming and operations were instructed *not* to cease by the OMB. If a funding gap does not resume in time to continue operations, however, or if the OMB does not instruct operations to continue, then the agency, according to the Antideficiency Act, must cease operations, an event we commonly known as a shutdown (CRS, 2018). The most recent shutdown, in 2018–2019, was also the longest, lasting 34 days, besting the previous 21-day record set by the 1995–1996 shutdown.[13]

One key component of a shutdown is that with ceased operations federal workers are either (1) immediately furloughed without pay, or (2) in agencies or roles where "the safety of human life or the protection of property" is involved, continue working but receive no pay. When a shutdown ends, it requires an act of Congress to institute back pay; back pay is not guaranteed in any other legislation.

Shutdowns are not the only type of disruption. Since 1969, there have been five fiscal years with federal pay freezes that affected all GS employees: in 1983, 1986, 2011, 2012, and 2013 (FederalPay.org, undated; Purcell, 2010). Pay freezes reduce the real earnings of workers regardless of their own individual performance or contributions. Similarly, there have been numerous hiring freezes to the federal government, in March 1977–June 1977, October 1978–February 1979, March 1980–March 1981, and January 2017–April 2017.[14] This last hiring freeze was surprising given that a GAO review (1982) of the four previous hiring freezes found that they did not contribute to the stated goal of reducing the size of the federal government, did not result in savings, and in some cases resulted in increased cost of operation and a reduction in both efficiency and effectiveness (GAO, 1982).

Even for highly paid workers in STEM occupations who may find that gaps in pay or work are inconvenient but not catastrophic to their household finances, unpredictable periods of shutdown, raises, hiring, or other operations can only decrease job quality. Critically, these disruptions are uncorrelated with an individual's (or even and agency's) performance.

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[13] The two shutdowns occurred from December 21, 1995 to January 6, 1996, and from December 21, 2018 to January 25, 2019.

[14] Some of these freezes affected employees who had been hired but had not started in their positions. The 1980–1981 freeze was started under the administration of President Jimmy Carter but continued under the administration of President Ronald Reagan, so it is referred to as two separate freezes.

Leadership Changes

According to a GAO analysis of the OPM *Plum Book*, a document published after every presidential election, there are about 4,000 presidential appointees in the federal government, and they fall within four categories, as defined by the OPM:

- 1,242 presidential appointees requiring Senate approval (e.g., cabinet members and agency heads) at the top of the federal hierarchy
- 472 presidential appointees who do not require Senate approval, generally in high-level executive positions, such as in the Executive Office of the President
- 761 noncareer SES positions (e.g., chiefs of staff) that are high-level positions beneath cabinet or agency heads
- 1,538 Schedule C appointments, which are positions of a confidential or policy-determining nature subordinate to presidential appointees requiring Senate approval (GAO, 2019a).

Some of these appointments are intended to serve the Office of the President, but the bulk are aimed at federal agency leadership. The GAO report focused on the ethics disclosures on these positions (2019a) noted that publicly available data on the appointments—who filled the appointment, what the job title associated with the appointment was, and if there were appointment vacancies—was nonexistent, though the last three administrations maintained internal databases of these workers.

The Federal Employee Health Benefits Program

The FEHB provides comprehensive health insurance coverage for employees, their spouses, and their children under the age of 26. The program does not apply waiting periods, restrictions, or preexisting conditions. All programs offered by the federal government cover preventative services at no cost (OPM, undated j; OPM, undated p). Employees have a wide variety of plans to choose from, including consumer-driven plans; health maintenance organizations; fee-for-service organizations, including preferred- and nonpreferred-provider organizations; and high-deductible health plans (OPM, undated u). According to the OPM, regardless of an employee's location, he or she should have 11 or more individual health plans to choose from that cover a wide range of services. The cost for the FEHB for each employee varies by plan and depends on the employee's choice of plan at the start of federal employment. To cover the cost of the insurance, employees pay 30 percent of their health premiums, while agencies pay the remaining 70 percent (OPM, undated j).

Federal employees cite the FEHB as a positive benefit of working for the federal government.[15] According to the most recent Federal Employee Benefits Survey (OPM, 2018a), 83.7 percent of federal employees enrolled in FEHB.[16] Ninety percent of federal employees stated that having access to health care through the FEHB was extremely important or important to them, regardless of enrollment status. Seventy-one percent of employees also stated that having access to health care through the FEHB encouraged them to take a position with the federal government, while 81 percent indicated that FEHB influenced their decision to remain with the federal government both to a great or moderate extent. Federal employees also view the program positively, with 96.1 percent of enrollees stating that the FEHB met their needs to a great or moderate extent. Additionally, 73.4 percent of enrollees believe the FEHB is a good value for the money invested (OPM, 2018a, pp. 4, 8–9).

Federal Flexible Spending Accounts

Federal employees can participate in the Federal Flexible Spending Account Program as a supplement to the coverage provided through the FEHB. The flexible spending accounts are optional for employees to use and allow them to set aside pretax funds for additional health care costs that are not already covered by their health, dental, or vision plans. Examples of these costs include co-pays, co-insurance, contact lenses and glasses, chiropractor appointments, prescription drugs, and over-the-counter health care items. FSAFEDS gives employees the opportunity to set aside pretax funds for these types of purchases, allowing them to save on additional out-of-pocket expenses and their overall taxes. The FSAFEDS program estimates that employees save about 30 percent on average for these types of health-related costs. Within the flexible accounts, employees may also select to establish a separate balance that can be used toward the purchase of child and eldercare, through a distinct Dependent Care account (FSAFEDS, undated; OPM, undated m).

The Flexible Spending Accounts program routinely sees lower enrollment among the federal benefit programs. In 2017, only 27.9 percent of federal employees participated in the program. While employees may not participate in the program as much as other benefit options, nearly 40 percent of employees stated that having access to the program was either extremely important or important to them. Of those who do participate in the program however, 92.1 percent of employees believed the program met their needs to a great or moderate extent. The flexible

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[15] The OPM also has a program to evaluate the carriers that provide the plans and care within the FEHB, focusing on "clinical quality, customer service, resource use, and contract oversight." Since 2016, the OPM has worked with providers to acquire measures from the Healthcare Effectiveness Data and Information Set and the Consumer Assessment of Healthcare Providers and Systems; the performance assessment completed each year is meant to compare the OPM's plans to national standards to understand what improvements need to be made to enhance the care provided through the FEHB program. See OPM, 2019.

[16] The majority of those not enrolled in the FEHB are covered by the military service health insurance agency TRICARE.

spending account program received the highest rating for value, with 91 percent of employees stating that the program offered an excellent or good value for what they invested (OPM, 2018a, pp. 16–17).

The Federal Employee Dental and Vision Insurance Program

Agencies also provide federal employees with dental and vision health plans. The supplemental plans cover employees, retirees, and their dependents, based on the specific plan chosen by the employee. FEDVIP is an enrollee-pay-all program in which participants buy into group insurance plans. This translates into competitive premiums, and all the plans have no preexisting condition limits. The premiums are withheld from employees' salaries, which means that premiums are paid with pretax funds. In terms of specific dental plans, FEDVIP offers multiple options from which employees can choose, including six nationwide and four regional plans. Employees have the option to choose from Self Only, Self Plus One, and Self Plus Family plans. The Self Plus One plan includes either a spouse or one dependent child under the age of 22, while the Self Plus Family plan includes one's spouse and all dependent children under the age of 22. Costs for the dental plans vary both by the plan chosen and the number of individuals being covered. FEDVIP offers four national vision plans for employees to choose from. The same coverage options apply for vision plans as dental, with Self Only, Self Plus One, and Self Plus Family plans available. The costs to the employee for the vision plans depends on the plan chosen by the employee, but the OPM estimates that premiums start at $3 per pay period, or $7 per month, for a Self Only vision plan (OPM, undated b; Benefits.gov, undated).

According to the Federal Employee Benefits Survey, many federal employees take advantage of the FEDVIP program; 64.7 percent are enrolled in a dental plan, and 51.9 percent are enrolled in a vision plan. A majority of federal employees agreed that having access to dental (76.6 percent) and vision (66.2 percent) insurance was either extremely important or important to them. Participants within FEDVIP indicated a high level of satisfaction with the program, as over 80 percent of them stated that the program met their needs to a great or moderate extent. Many also believe that the program provides value for their investment, with 72.5 percent of vision enrollees and 62.9 percent of dental enrollees stating the program was an excellent or good value (OPM, 2018a, p. 15).

The federal government provides its employees with life insurance through the Federal Employees' Group Life Insurance Program (FEGLI). Established in 1954, FEGLI is the largest life insurance program in the world, with over 4 million members. FEGLI offers group life insurance for its subscribers, meaning that it does not accrue value over time. All federal employees are automatically included in the basic coverage plan once they begin their federal positions unless they opt to waive coverage. Employees pay for two-thirds of the basic coverage plan, while their agency employers cover the remaining third. Coverage for the basic plan is not based on an employee's age. The basic life insurance plan provides coverage to federal employees in the amount of their annual salary, rounded up to the nearest $1,000, plus $2,000 or

$10,000, whichever is greater.[17] In addition to the basic coverage plan, employees may elect to increase their coverage from three options, for which they are responsible for the full premium amounts:

- Option A (the standard plan) provides an additional $10,000 in coverage.
- Option B (the additional plan) provides one to five times the amount of an employee's salary based on the employee's personal selection; the amount is rounded to the nearest $1,000.
- Option C (the family plan) provides coverage for the spouse and eligible dependents of the employee in multiples of one through five, with multiples equaling $5,000 for the spouse and $2,500 for the dependents.

Additionally, once employees are over the age of 45, they automatically receive additional coverage without paying a difference in premium (OPM, undated q; OPM, 2014a, pp. 2–3).

According to the Federal Employee Benefits Survey, 80.4 percent of employees were enrolled in the FEGLI program in 2017, a reported increase of 2.5 percent from 2015. Seventy percent of employees stated that access to FEGLI was either extremely important or important to them, whether or not they were actually enrolled in the program. Of those enrolled in the program, approximately 82 percent of participants stated that their needs were met to a great or moderate extent. Participants were somewhat less satisfied with the program's value, as 68.9 percent of participants believed the program offers an excellent or good value (OPM, 2018a, pp. 4, 15).

The federal government also offers long-term care plans for its employees. The Federal Long-Term Care Insurance Program (FLTCIP) provides coverage for care at employees' homes, nursing homes, or other long-term care facilities. The coverage is optional, serving as a supplement to health care plans that do not provide long-term care. Those who may benefit from the program include employees, annuitants, and qualified relatives, including current spouses, parents of employees, adult children of employees and annuitants, and same- or opposite-gender domestic partners of employees and annuitants. The OPM manages the FLTCIP, working to ensure competitive rates and updating the program as needed, which it claims is not always done by other organizations. The coverage is provided by the John Hancock Insurance Company, which has offered long-term care plans for over 20 years. The coverage plans offered to employees are portable, meaning they can be transferred to different geographic locations or taken with employees should they leave federal service. The plans are guaranteed renewable and cannot be canceled for any reason. The program also offers a waiver of premium, so that employees do not pay premiums while receiving their benefit services. The FLTCIP offers a wide variety of service providers and amenities from which employees can take advantage (FLTCIP, undated).

The FLTCIP represents one of the least-used benefits programs for federal employees. In 2017, just under 10 percent of employees stated that they participated in the program. Despite the

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[17] The U.S. Postal Service covers 100 percent of the basic life insurance plan for its employees.

low participation rates, more than four times the number of employees (42 percent) stated that having access to the program was extremely important or important to them. Of those enrolled in the program, 84.3 percent believed it met their needs to a great or moderate extent, yet only 60.6 percent believed it provided an excellent or good value for their investment (OPM, 2018a, p. 16).

Federal Retirement Programs

The federal government offers the retirement benefits program FERS. Congress passed a law creating FERS in 1986, and the program began in 1987.[18] FERS comprises three different programs: the Basic Benefits plan, the TSP, and Social Security. Two of the three programs, Social Security and the TSP, are transferrable and can move with employees should they leave federal service. The Basic Benefits plan provides retirement, disability, and survivor benefits to employees and their families. Employees pay a share of the plan from their paycheck each pay period, with most employees contributing about 0.8 percent of their pay. Employing agencies also contribute to employees' accounts, with contributions totaling 10.7 percent or more of employees' salaries. The basic benefit for each employee is calculated based on his or her length of service in the federal government and the highest average of their basic pay during any three-year period while working for the federal government (OPM, undated l; OPM, undated aa).

The second part of the retirement benefits package for federal employees is the TSP, which essentially serves as the federal government's 401(k) plan, offering similar types of tax and savings benefits that private employees receive through their employer plans.[19] To provide employees with the best benefits, the TSP is managed by the Federal Retirement Thrift Investment Board, which comprises five members and an executive director who are required by law to prudently manage the TSP investments. To further protect the TSP's funds, the program is audited on an annual basis. As in the Basic Benefits plan, agencies and their employees both make contributions to the TSP. Federal agencies provide 1 percent of employees' salaries each pay period as a baseline contribution. Federal employees can then determine how much additional funding they would like to contribute each pay period through a defined contribution plan. Their employing agencies then make matching contributions based on the defined amount.

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[18] Prior to 1984, federal employees were covered by the Civil Service Retirement System and not by Social Security. Employees before 1984 therefore did not pay Social Security taxes or receive the program's benefits.

[19] An employee may choose to invest in an "L fund," which is a life cycle fund with a special mix of stocks, bonds, and government securities put together for employees by the TSP from the TSP's five investment funds: the Common Stock Index Investment Fund, the Fixed Income Index Investment Fund, the Government Securities Investment Fund, the International Stock Index Investment Fund, and the Small Capitalization Stock Index Investment Fund. The types of investments are based on the employee's starting withdrawal date. Alternatively, an employee may choose an "individual fund," which allows him or her to decide on the mix of investment types from the TSP's five investment funds. See TSP, 2019.

Contributions made to TSP accounts by employees are also tax deferred (OPM, undated l; TSP, 2019, pp. 1–4).

Finally, federal employees receive Social Security benefits.[20] Federal employees must pay Social Security taxes, like their private-sector counterparts, and federal agencies make their own contributions. Thus, federal workers receive full Social Security benefits in addition to the Basic Benefits plan and the TSP, which includes Old Age, Survivors, and Disability Insurance, as well as Medicare hospital insurance. The amount and types of Social Security benefits that federal employees receive depends on the same conditions that exist for all other Social Security recipients. These conditions include average earnings for which one has paid Social Security taxes, family composition, and Consumer Price Index changes (OPM, undated l).

The Federal Employee Benefits Survey included enrollment numbers for both the FERS and TSP programs. These two programs rank highest in terms of participation, with 97.2 percent of employees enrolled in TSP, and 92.8 percent of employees enrolled in FERS in 2017. Employees also rated the programs high in importance, whether or not they were enrolled in either of them. Ninety-six percent of employees regarded the TSP as extremely important or important, while 94.2 percent stated the same for FERS. In terms of recruitment and retainment, nearly 70 percent of employees stated that access to the TSP played a part in their decision to accept a position with the federal government, and 83 percent stated it encouraged them to remain in their position of employment.[21] Similar numbers are seen with FERS, as 78.3 percent stated the program played a role in their decision to take a job with the federal government, and 87.9 percent viewed the program as part of the reason they remained in their positions. The TSP also received high satisfaction ratings. Over 93 percent of TSP participants indicated that the TSP met their needs to a great or moderate extent, and nearly 90 percent of enrollees believed the program to be an excellent or good value (OPM, 2018a, pp. 12–14).

Paid Leave

The Annual Leave Program

Federal employees partake in an annual leave program that provides paid leave accrued over time employed. For those workers with less than three years of service, they earn one-half day of leave per pay period, which totals 13 days per year assuming 26 pay periods per year. For workers with three to 15 years of federal service, they accrue three quarters of a day, or six hours, per pay period, with ten hours for the last pay period of their working year. This allotment totals 20 days of annual leave per year. For employees with 15 or more years of federal employment,

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[20] Prior to 1984, federal employees were covered under the Civil Service Retirement System and not by Social Security. With the switch to the FERS in 1984, federal employees became covered under Social Security. See Social Security Administration, undated.

[21] For both measures, responses indicated to a “great” or “moderate” extent.

they earn one day of leave per pay period, resulting in 26 days of annual leave per year. Employees may also carry over unused leave days from year to year, allowing them to have more leave available in any given year. Employees in the United States may carry over 30 days of leave each year; employees overseas can bring 45 days of leave from one year to the next. Employees with Scientific and Professional, Senior-Level, and SES positions may carry over as many as 90 days of leave (OPM, undated d).

The Sick Leave Program

Federal employees receive paid time off to address physical and mental health needs. They may use sick leave to take care of themselves and their family members, for adoption-related purposes, and for bereavement periods. Employees earn paid sick leave hours as they work, accruing increments each pay period. Full-time employees earn one-half day of leave each pay period, equaling 13 days of paid sick leave each year, assuming 26 pay periods. Federal employees may carry their balance over from year to year. Sick leave may also be granted in advance of time worked so as to address employee needs. Unlike paid annual leave, employees' sick leave balance has no limit (OPM, undated g). Relatedly, federal workers receive family and medical leave. This type of leave is unpaid and allows employees to take up to 12 weeks of leave during any single 12-month period. In order to take family and medical leave, an employee must meet certain conditions, such as the delivery or receipt of a new child or a serious health condition faced by either the employee or a family member (OPM, undated e).

The Family Leave Program

The 2020 National Defense Authorization Act included the Federal Employees Paid Leave Act, which creates 12 weeks of paid family leave for full-time, permanent employees who have at least 12 months of service with the federal government and who will return to work for at least 12 weeks after the leave has ended. The Act is effective October 2020 (Public Law 116-92, 2019). The final rules for the act were still in the comment period on the Federal Register as of writing. However, early reporting on the implementation noted that the 12 weeks of paid leave covers the birth or adoption of a child and employees eligible to take the leave were those that were eligible for unpaid FMLA leave, with minimum service requirements before parental leave could be taken and service requirements after parental leave is taken (Ogrysko, 2020a; Ogrysko, 2020b).

Federal Educational Programs

Federal employees have the opportunity to partake in two educational benefit programs offered by their employing agencies. The first and most prominent is the federal government's student loan repayment program. The program allows agencies to repay employees' student loans for both recruitment and retainment purposes. Established by law, 5 U.S.C. 5379 grants agencies the authority to establish their own loan repayment programs to attract and retain talent. As of FY 2016, the last year the OPM issued an annual report on the program to Congress, 34 federal agencies participated, issuing benefits to 9,868 employees, totaling more than $71.6 million (OPM, 2018b).

All federal employees are eligible to partake in the program, except for those under Schedule C (OPM, undated t). Certain types of loans may be repaid through the program,[22] including:

- Federal Family Education Loans
    - Subsidized and Unsubsidized Federal Stafford Loans
    - Federal PLUS Loans
    - Federal Consolidation Loans
- William D. Ford Direct Loan Program
    - Direct Subsidized and Unsubsidized Stafford Loans
    - Direct PLUS Loans
    - Direct Subsidized and Unsubsidized Consolidation Loans
- Federal Perkins Loan Program
    - National Defense Student Loans
    - National Direct Student Loans
    - Perkins Loans
- Loans made or insured under the Public Health Service Act
    - Loans for Disadvantaged Students
    - Primary Care Loans
    - Nursing Student Loans
    - Health Professions Student Loan
    - Health Education Assistance Loans. (OPM, undated h)

Payments are made by the agencies on behalf of the employees, meaning that the loans are not considered forgiven. Payments may be made in various amounts, up to $10,000 per calendar year, and no more than $60,000 paid in total for a single employee. To take part in the program and receive these benefits, employees must sign a service commitment to the agency saying they will work for the agency for at least three years to receive the benefit. This three-year commitment may include time spent on military duty and while on qualified disability. If an employee chooses to leave an agency voluntarily, or is removed from a position for misconduct, unacceptable performance, or negative suitability determination, the employee must repay the benefits paid by the agency. Employees must also meet the performance requirements of their positions to keep receiving the benefits (OPM, undated t). Since STEM employees are more likely to have earned a college or postbaccalaureate degree, they may also be more likely to have accumulated student

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[22] According to law, these loans are described as those loans made, insured, or guaranteed under Parts B, D, or E of Title IV of the Higher Education Act of 1965, and health education assistance loans made or insured under Part A of Title VII or Part E of Title VIII of the Public Health Service Act.

loan debt during their educational pursuits. Hence, programs like the Student Loan Repayment Program may attract and maintain more STEM educated individuals to federal government positions.

Employees may also receive benefits to attend college or a university while serving in the federal government. The Federal Academic Alliance comprises 15 schools that partner with the federal government to provide reduced tuition options to federal employees. The OPM views the alliance program as a strong incentive to attract and retain high-value talent to federal agencies. This is especially true for bringing individuals into high-demand critical positions, including those within STEM careers. The 15 schools offer both in-person and online courses to meet the needs of federal employee populations in the nation's capital and across the country. The Federal Academic Alliance includes the following institutions:

- Catholic University of America, Metropolitan School of Professional Studies
- Central Michigan University
- Champlain College
- College for America at Southern New Hampshire University
- Drexel University Online
- Excelsior College
- Georgetown University School of Continuing Studies
- Pace University (iPace Program)
- Park University
- Penn State University, World Campus
- Saint Mary's University of Minnesota
- University of Maryland Francis King Carey School of Law
- University of Maryland Robert H. Smith School of Business
- University of Maryland University College
- Utica College. (OPM, undated r)

All federal employees are eligible to use the reduced tuition benefits provided through the Federal Academic Alliance. Twelve of the 15 educational institutions also allow spouses and dependents to participate in their offered programs.[23] The tuition discount amounts also vary by institution. For example, Catholic University of America provides a 10-percent tuition discount for online and in-person courses and waives its application fees. Excelsior College offers a 20-percent tuition discount for its undergraduate courses, and 15 percent for its graduate courses. Penn State University's World Campus extends a 5-percent tuition discount for all courses, regardless of the level of study or whether students reside in or out of state (OPM, undated i).

STEM employees may require additional training and educational courses throughout their careers, as programming, data, and computer needs and skills change with time. Prospective and current STEM-oriented employees may therefore be more likely to take or retain a position in the

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[23] Definitions of these terms vary by institution.

federal government with the continuation, promotion, and even expansion of these types of programs.

Life Assistance Programs

In addition to the medical and educational benefits provided by federal agencies, they also provide multiple life assistance programs. The first of these is EAP, which is a free, voluntary service to help federal workers with potential issues that may affect an employee's personal health, job performance, or well-being. Provided by all federal agencies, the program offers several services, including

- assessments, counseling, and referrals for additional services, for such challenges as
    - stress
    - financial issues
    - legal issues
    - family problems
    - office conflicts
    - alcohol or substance abuse
- advanced planning for such events as
    - organizational changes
    - legal considerations
    - emergency planning
    - unique events.

EAP offers these services through expert providers, including psychologists, social workers, counselors, marriage and family therapists, alcohol and drug counselors, attorneys, eldercare specialists, financial advisers, and childcare specialists. The OPM and federal employing agencies contend that EAP's services not only benefit employees, but also their families, communities, and the agencies themselves. Of particular interest and relevance to this study, they believe that EAP improves productivity and employee engagement and reduces employee turnover and replacement costs (OPM, undated ab; U.S. Department of the Interior, Office of Human Resources, undated).

OPM conducted its first work-life survey in 2017 to determine if the work-life programs, including EAP, are meeting employee needs. According to the survey, 60 percent of employees who participated in EAP were satisfied with their agency's program. However, utilization of EAP's services was quite low, with only 13 percent of federal employees using an EAP service in the 12 months prior to the survey. Lack of program knowledge or interest, and hesitation to use programs due to "privacy concerns" and "other concerns," prevented individuals from participating. Despite low utilization of the services, 55 percent of all federal employees expressed interest in participating in an EAP program. Access to and usage of EAP services also contributed to employee outcomes, including improved morale (48 percent), increased performance (41 percent), intent to stay (40 percent), improved health (40 percent), and better stress management (49 percent; OPM, 2018c, pp. 26–27).

The second form of life assistance programs offered by the federal government is child and dependent care. These programs vary by what they provide, dependent on the employee's agency. Examples of the childcare services supplied to federal employees include on-site childcare at the agency's office location, federal site childcare facilities, and childcare subsidies. Over 100 federal childcare facilities across the country are run by the GSA and are open to both federal employees' children and those within the local community (once the childcare facilities are filled to at least 50-percent capacity with federal employees' children). The GSA childcare centers provide additional childcare options for federal workers within different locales, increasing access to affordable, quality childcare for federal employees.

Additionally, Congress passed legislation on March 24, 2003, to allow agencies to provide funding for childcare services to lower-income employees. The subsidies can be used for care for those children under the age of 13, or those with disabilities under the age of 18. Funding for the subsidies comes from agency-revolving funds that are typically used for salaries and expenses. Consequently, not all agencies may offer this benefit for their employees, since agencies are allowed to use this type of funding at their own discretion. The agencies also have wide flexibility to determine who is considered to be of low income and thus eligible to partake in the benefit program. In addition to the benefits of the childcare subsidy program provided to enrollees, agencies also benefit from the program. The benefits to agencies are threefold: (1) the program allows agencies to attract and retain talented workforce; (2) it establishes and maintains a family-friendly culture within the agency; and (3) it helps to improve employee engagement by reducing distractions and disruptions from being called away from work due to children's needs.

The Federal Work-Life Survey also addressed family and dependent care programs. According to the survey, approximately 36 percent of federal employees have childcare responsibilities, while 14 percent have adult care responsibilities. Only 30 percent of employees stated that they were satisfied with the family and dependent care support provided by their employing agencies. The programs also rated much lower in terms of positive impact on employee outcomes in terms of improved morale (35 percent), increased performance (28 percent), intent to stay (34 percent), improved health (26 percent), and better stress management (35 percent; OPM, 2018c, pp. 31–35).

Appendix C. Detailed Pay, Income, and Comparisons for Federal and Private-Sector STEM Workers

In this appendix, we provide more detail on STEM worker pay in both the federal government and the private sector. We first enumerate the pay plans that federal STEM workers are classified in, compare federal and private-sector STEM workers within the broad occupation groups, and perform a regression analysis that calculates a similar earnings difference between federal and private-sector STEM workers for each of the five occupation groups.

Pay Plans for Federal STEM Workers

This section provides descriptive information[1] about federal STEM workers across different pay plans, to include those in the General Schedule (GS) system but expanded to non-GS plans. We used two sources of data: (1) publicly available FedScope data from the U.S. Office of Personnel Management (OPM) and (2) Defense Manpower Data Center (DMDC) Civilian Master File data. The former data source provides information on federal workers both within and outside DoD, whereas the latter offers details on DoD civilian STEM employees. Regardless of the data source, we present results for pay plans with the largest shares of federal (including DoD) STEM workers using a cutoff of 1,000 workers per pay plan.[2] Collectively, the pay plans we present cover about 97 percent of federal STEM workers.

We first provide information on the distribution of federal STEM workers by GS and non-GS pay plans. Table C.1 provides the distributions of STEM workers in federal STEM (first column of numbers) and within DoD STEM (second column of numbers), using OPM FedScope data. We organize the pay plans into three categories: (1) those used by both DoD and non-DoD federal agencies (GS and GG), (2) those used only by DoD (ND, NH, DB, DP, NT, DR, NO, and NP), and (3) those used by non-DoD federal agencies but not DoD (ZP and FV). Within each of those three categories, we sort pay plans from highest to lowest concentrations of workers.

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[1] By "descriptive information," we mean quantitative results (e.g., percentages of workers) not adjusted for other factors such as demographics, occupation, and geographic region. We therefore caution readers in overinterpreting results that suggest differences between STEM workforces.

[2] Pay plans used for STEM workers but not presented here include (but may not be limited to) the following: AD-Administratively determined rates, not elsewhere specified; DE-Demonstration engineers and scientists technicians; DJ-Demonstration administrative; DO-Business management and professional career path, Air Force Research Laboratory; DS-Demonstration specialist; DT-Demonstration technician; DX-Technician career path, Air Force Research Laboratory; ES-Senior Executive Service; GM-Employees covered by the performance management and recognition system (PMRS) termination provisions; IE-Senior intelligence executive services (SIES) program; IP-Senior intelligence professional (SIP) program; NJ-Technical management support; NM-Supervisors and managers; NR-science and engineering technical; SI-Senior level positions; and, ST-Scientific and Professional.

Table C.1. Distribution of Federal STEM Workers and DoD STEM Workers, by Pay Plan, 2018

Pay Plan	Percent of Federal STEM Workers	Percent of DoD STEM Workers
Across federal agencies		
GS-General schedule	77.7	63.3
GG-Grades similar to general schedule	1.3	2.1
DoD only		
ND-Demonstration scientific and engineering	4.6	10.0
NH-Business management and technical management professional	3.2	7.1
DB-Demonstration engineers and scientists	1.9	4.2
DP-Demonstration professional	1.8	4.0
NT-Demonstration administrative and technical	0.9	1.9
DR-Demonstration Air Force scientist and engineer	0.8	1.7
NO-Administrative specialist/professional	0.6	1.2
NP-Science and engineering professional	0.5	1.2
Non-DoD only		
ZP-Scientific and engineering professional	1.7	N/A
FV-Federal Aviation Administration core compensation plan	1.6	N/A

SOURCE: FedScope (via OPM).

NOTES: The table shows pay plans with at least 1,000 federal STEM workers (inclusive of DoD). Since DoD makes up a sizable portion of the federal STEM workforce, these pay plans also include least 1,000 DoD STEM workers. Since these pay plans do not include all possible plans, the column percentages will not add up to 100. N/A indicates a pay plan that is not relevant to the DoD workforce.

As of 2018, 36.7 percent of DoD STEM workers were in non-GS pay plans, compared to 22.3 percent of the overall federal STEM workforce. Although these data are descriptive, they suggest that the DoD STEM workforce leans more toward non-GS pay plans than the federal STEM workforce does overall, with several DoD pay plans focused on science and engineering workers (e.g., ND). However, the majority of federal STEM workers still fall within the GS pay plan.

For completeness, Table C.2 provides similar information on DoD STEM workers by pay plan but using the DMDC civilian master files. The percentages are very similar (within tenths of a percentage point) to the values in the DoD STEM column in Table C.1. This lends confidence to the use of the OPM FedScope data for capturing DoD STEM worker information on pay plans.

In Table C.3, we provide the distributional breakouts of federal STEM workers by pay plan and the five broad occupational groups. Among non-GS plans focused on science, engineering, and technical professions (ND, NH, DB, etc.), the majority of STEM workers are in engineering occupations. Many of these pay plans are used only by DoD, which has a STEM workforce with

Table C.2. Distribution of DoD STEM Workers, by Pay Plan, 2018

Pay Plan	Percent of DoD STEM Workers
GS-General schedule	63.3
GG-Grades similar to general schedule	2.1
ND-Demonstration scientific and engineering	9.8
NH-Business management and technical management professional	6.9
DB- Demonstration engineers and scientists	4.5
DP- Demonstration professional	3.9
NT- Demonstration administrative and technical	1.9
DR- Demonstration Air Force scientist and engineer	1.7
NO-Administrative specialist/professional	1.2
NP-Science and engineering professional	1.1

SOURCE: DMDC Civilian Master File data.
NOTES: The table shows pay plans with at least 1,000 DoD STEM workers. Since these pay plans do not include all possible plans, the column percentages will not add up to 100. The gray shaded cells are the GS and GG plans, which are also used by other federal agencies as well as DoD.

Table C.3. Distribution of Federal STEM Workers, by Pay Plan and Broad Occupation Group, 2018

Pay Plan	Engineering (percent)	IT and Computer Science (percent)	Life Science (percent)	Physical Science (percent)	Social Science (percent)
Across federal agencies					
GS-General schedule	25.9	32.1	25.9	6.4	9.7
GG-Grades similar to general schedule	32.5	52.7	2.0	11.4	1.4
DoD only					
ND-Demonstration scientific and engineering	69.5	23.9	0.7	5.6	0.3
NH-Business management and technical management professional	61.8	34.4	0.6	2.5	0.7
DB-Demonstration engineers and scientists	67.6	12.0	7.9	10.4	2.0
DP-Demonstration professional	73.8	20.9	0.2	4.5	0.5
NT-Demonstration administrative and technical	67.7	32.2	<0.1	0.1	0.0
DR-Demonstration Air Force scientist and engineer	65.8	13.1	3.8	14.1	3.1
NO-Administrative specialist/professional	<0.1	99.3	<0.1	<0.1	0.7
NP-Science and engineering professional	46.1	11.8	6.6	34.5	0.9
Non-DoD only					
ZP-Scientific and engineering professional	13.9	24.3	31.3	23.2	7.3
FV-Federal Aviation Administration core compensation plan	60.2	36.7	0.4	0.8	2.0

SOURCE: FedScope (via OPM).
NOTES: The table shows pay plans with at least 1,000 federal STEM workers.

a large percentage of those in engineering occupations.[3] For the non-DoD pay plan "ZP-Scientific and Engineering Professional," the largest shares of STEM workers are not in engineering but in life science (31.3 percent), IT and computer science (24.3 percent), and physical science (23.2 percent).

Table C.4 provides similar information as in Table C.3 but focuses only on DoD STEM workers, meaning there are fewer pay plans covered and the percentages are based on the DoD STEM workforce, not the federal STEM workforce more generally. Based on Table C.4, higher proportions of DoD STEM workers in non-GS/GG pay plans are in engineering occupations. Given that over half of DoD STEM workers are in engineering occupations, their larger shares across pay plans are not surprising. IT and computer science make up the second-largest portion of the DoD STEM workforce at 34.6 percent so they tend to have sizeable shares across pay plans after accounting for engineering workers. One notable exception is the NO pay plan, which IT and computer science workers dominate at 99.3 percent. IT and computer science workers also take up a majority share of the GG pay plan, which is used by the intelligence community. The other three occupational groups take up smaller shares of pay plans given their relatively smaller population sizes compared to engineering and IT and computer science. Physical science workers take up a relatively larger share of NP and DR pay plans compared to their shares within

Table C.4. Distribution of DoD STEM Workers, by Pay Plan and Broad Occupation Group, 2018

Pay Plan	Engineering (percent)	IT and Computer Science (percent)	Life Science (percent)	Physical Science (percent)	Social Science (percent)
GS-General schedule	44.2	38.0	7.1	5.3	5.5
GG-Grades similar to general schedule	27.4	63.0	1.3	7.3	1.1
ND-Demonstration scientific and engineering	69.4	23.9	0.7	5.6	0.3
NH-Business management and technical management professional	61.7	34.4	0.7	2.5	0.7
DB-Demonstration engineers and scientists	67.0	12.1	8.8	10.1	2.1
DP-Demonstration professional	73.8	20.9	0.2	4.5	0.5
NT-Demonstration administrative and technical	67.6	32.3	<0.1	0.1	<0.1
DR-Demonstration Air Force scientist and engineer	65.8	12.9	4.0	14.2	3.1
NO-Administrative specialist/professional	<0.1	99.3	<0.1	<0.1	0.7
NP-Science and engineering professional	46.1	11.8	6.7	34.4	1.0

SOURCE: DMDC Civilian Master File data.
NOTES: The table shows pay plans with at least 1,000 DoD STEM workers. The gray shaded cells are the GS and GG plans, which are also used by other federal agencies as well as DoD.

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[3] As noted in Chapter 5, 50.5 percent of DoD STEM workers were in engineering occupations as of 2018. The second largest occupational group of DoD STEM workers in 2018 were IT and computer science occupations (34.6 percent).

other pay plans. Life science workers' largest share is within the DB pay plan at 8.8 percent, followed by GS at 7.1 percent. Social science workers' largest shares are within GS at 5.5 percent and DR at 3.1 percent.

Before providing a table on income, we also provide federal STEM worker distributions by pay plan and educational level. Table C.5 shows these percentages, with pay plans broken out into the three categories used in previous tables (all federal; DoD only; non-DoD federal). Although patterns are not easy to discern, pay plans with science or engineering tend to lean more toward higher education levels (bachelor's, master's, and advanced degrees), whereas more general pay plans like GS and GG, as well as those with "administrative" in the title, have larger percentages of STEM workers with lower education levels (e.g., 45.3 percent of STEM workers in NT plan have no college degree/some college).

Table C.5. Distribution of Federal STEM Workers, by Pay Plan and Education Level, 2018

Pay Plan	Advanced Degrees (percent)	Master's (percent)	Bachelor's (percent)	Associate's (percent)	Technical College (percent)	No Degree/ Some College (percent)
Across federal agencies						
GS-General schedule	10.2	22.6	39.8	4.9	0.9	21.6
GG-Grades similar to general schedule	5.7	34.7	38.3	3.6	0.3	17.4
DoD only						
ND-Demonstration scientific and engineering	5.6	31.8	61.8	<0.1	<0.1	0.8
NH-Business management and technical management professional	2.0	41.0	50.6	1.1	0.1	5.2
DB-Demonstration engineers and scientists	21.1	40.0	38	<0.1	<0.1	0.8
DP-Demonstration professional	3.7	29.3	66.5	0.1	<0.1	0.4
NT-Demonstration administrative and technical	0.1	9.0	24.0	18.8	2.7	45.3
DR-Demonstration Air Force scientist and engineer	38.2	44.1	17.6	<0.1	<0.1	0.1
NO-Administrative specialist/professional	0.5	17.8	43.4	7.9	0.7	29.7
NP-Science and engineering professional	53.6	23.5	22.6	0.1	<0.1	0.2
Non-DoD Only						
ZP-Scientific and engineering professional	30.1	29.4	30.2	1.0	0.3	9.0
FV-Federal Aviation Administration core compensation plan	2.2	16.2	49.8	4.1	0.8	26.9

SOURCE: FedScope (via OPM).
NOTES: The table shows pay plans with at least 1,000 federal STEM workers.

For comparison purposes, we provide a similar table as Table C.5 but for DoD STEM workers only, using DMDC data. Table C.6 shows some similar patterns to Table C.5, with higher education categories (bachelor's, master's, and advanced degrees) associated with engineering and science-related pay plans and those with no degree or some college having larger shares of GS and GG pay plans as well as two of the pay plans with "administrative" in the title, NT and NP.

Table C.6. Distribution of DoD STEM Workers, by Pay Plan and Education Level, 2018

Pay Plan	Advanced Degrees (percent)	Master's (percent)	Bachelor's (percent)	Associate's (percent)	Technical College (percent)	No Degree/ Some College (percent)
GS-General schedule	2.9	22.0	43.2	5.7	0.9	25.3
GG-Grades similar to general schedule	4.3	34.8	36.1	4.5	0.2	20.2
ND-Demonstration scientific and engineering	5.6	31.8	61.9	<0.1	<0.1	0.8
NH-Business management and technical management professional	2.0	41.1	50.5	1.1	0.1	5.2
DB-Demonstration engineers and scientists	21.6	38.8	38.6	<0.1	<0.1	1.0
DP-Demonstration professional	3.7	29.3	66.5	0.1	<0.1	0.4
NT-Demonstration administrative and technical	0.1	9.0	24.0	18.8	2.7	45.3
DR-Demonstration Air Force scientist and engineer	38.8	43.7	17.4	<0.1	<0.1	0.1
NO-Administrative specialist/professional	0.4	18.0	43.2	7.8	0.7	29.8
NP-Science and engineering professional	53.5	23.5	22.7	0.1	<0.1	0.2

SOURCE: DMDC Civilian Master File data.
NOTES: The table shows pay plans with at least 1,000 DoD STEM workers. The gray shaded cells are the GS and GG plans, which are also used by other federal agencies as well as DoD.

The final tables in this section provide income and workforce size information broken out by pay plan and education level. Specifically, Table C.7 provides mean annual income and the nine-year (2009–2018) annual growth rate of federal STEM workers by pay plan and three education levels. We show only three education levels because the sample sizes for other education levels were too low for most pay plans to calculate mean annual incomes. Table C.8 provides similar information as Table C.7 but for DoD STEM workers only.

As shown in Table C.7, federal STEM workers in non-GS plans (including GG) tend to have higher mean annual incomes than federal STEM workers in the GS system, based on the years 2009 through 2018. Also, federal STEM workers with higher education levels tend to have higher mean annual incomes than federal STEM workers with lower education levels, regardless of pay plan.

Table C.7. Mean Annual Income and Nine-Year (2009–2018) Annual Growth Rate of Federal STEM Workers, by Education Level and Pay Plan (in 2018 Dollars)

	Advanced Degrees		Master's		Bachelor's	
Pay Plan	2018 Income	2009–2018 CAGR (percent)	2018 Income	2009–2018 CAGR (percent)	2018 Income	2009–2018 CAGR (percent)
Across federal agencies						
GS-General schedule	$121,482	–0.6	$102,731	–0.5	$92,862	–0.4
GG-Grades similar to general schedule	$126,034	–1.6	$116,276	–1.5	$106,874	–1.4
DoD only						
DB-Demonstration engineers and scientists	$134,164	–0.8	$121,919	–0.7	$116,637	–0.4
DP-Demonstration professional	$122,609	—	$119,167	1.2	$101,157	0.5
DR-Demonstration Air Force scientist and engineer	$125,879	–1.0	$119,487	–0.8	$105,547	–0.5
ND-Demonstration scientific and engineering	$123,912	–0.9	$116,062	–0.7	$103,766	–1.0
NH-Business management and technical management professional	$121,942	–1.1	$111,095	–1.3	$102,413	–1.4
NO-Administrative specialist/professional	$123,328	–0.2	$110,757	0.1	$107,296	–1.4
NP-Science and engineering professional	$136,847	–0.5	$128,299	–0.5	$117,998	–0.7
NT-Demonstration administrative and technical	$111,008	–1.6	$110,207	–0.7	$102,158	–0.6
Non-DoD only						
ZP-Scientific and engineering professional	$136,203	–0.6	$123,041	–0.3	$116,505	0.2
FV-Federal Aviation Administration core compensation plan	$142,105	–0.4	$133,499	–0.1	$120,340	–0.4

SOURCE: FedScope (via OPM).
NOTES: The table shows pay plans with at least 1,000 Federal STEM workers. — indicates that there were no individuals in 2009, thus we were unable to calculate the 2009-2018 compound annual growth rates (CAGR).

Similar patterns regarding education level and GS versus non-GS pay plans are observed in Table C.8 for DoD STEM: DoD STEM workers with higher education levels and those in non-GS pay plans tend to have higher mean annual incomes than those with lower education levels and in the GS system. Among DoD STEM pay plans, the highest mean annual income in 2018 dollars was for workers in the NP pay plan, followed by the DB pay plan. Both are science-and-engineering pay plans, which have large shares of engineers in the case of DB (65 percent from engineering occupations, per Table C.4) and engineering (46.1 percent from Table C.4) and physical science (31.4 percent from Table C.4) in the case of NP. The one pay plan dominated by the IT and computer science occupational group, NO, has somewhat lower mean annual income

Table C.8. Mean Annual Income and Nine-Year (2009–2018) Annual Growth Rate of DoD STEM Workers, by Education Level and Pay Plan (in 2018 Dollars)

	Advanced Degrees		Master's		Bachelor's	
Pay Plan	2018 Income	2009–2018 CAGR (percent)	2018 Income	2009–2018 CAGR (percent)	2018 Income	2009–2018 CAGR (percent)
GS-General schedule	$113,110	–1.1	$ 99,781	–1.1	$90,373	–1.2
GG-Grades similar to general schedule	$117,899	0	$109,104	0	$100,750	0
DB-Demonstration engineers and scientists	$132,247	–1.0	$123,211	–0.7	$115,171	–0.6
DP-Demonstration professional	$122,269	0	$119,333	0	$98,509	0
DR-Demonstration Air Force scientist and engineer	$124,128	–1.2	$119,814	–0.8	$103,665	–0.7
ND-Demonstration scientific and engineering	$124,243	–1.1	$118,255	–0.8	$104,930	–1.2
NH-Business management and technical management professional	$122,282	0	$112,745	0	$103,401	0
NO-Administrative specialist/professional	$118,749	0	$107,790	0	$106,243	0
NP-Science and engineering professional	$137,542	–0.6	$128,306	–0.7	$117,267	–1.0
NT-Demonstration administrative and technical	$108,711	–2.8	$112,207	–0.7	$103,592	–1.0

SOURCE: DMDC Civilian Master File data.
NOTES: The table shows pay plans with at least 1,000 DoD STEM workers. The gray shaded cells are the GS and GG plans, which are also used by other federal agencies as well as DoD.

than other pay plans, GS excepted. The NO pay plan has a sizeable share of workers with no college degree (29.8 percent per Table C.6), which might contribute to the lower income level.

Summary of Pay Plans for Federal STEM Workers

In this section, we provide descriptive information about pay plans used for federal STEM workers, including those in DoD. Although a majority of federal workers fall within the GS system, over 20 percent of federal STEM workers overall and over a third of DoD STEM workers are in non-GS pay plans. Many of the non-GS pay plans we present are used only by DoD. Because DoD's STEM workforce is 50.5 percent engineering and 34.6 percent IT and computer science, STEM workers in engineering occupations represent the majority of STEM workers in many non-GS plans, followed by IT and computer science. There are some exceptions, such as the NO pay plan, which is almost exclusively used for IT and computer science workers in DoD.

Pay plans focused on science and engineering, as opposed to those that are more general like GS and GG or have "administrative" in the title, tend to lean more toward STEM workers with higher education levels. These same pay plans are also associated with higher mean annual incomes over the 2009–2018 period we analyzed. Those with lower education levels, particularly those with no college degree or some college, and those in non-GS pay plans with "administrative" in the titles tend to have lower mean annual income levels over the same time period.

Income for Federal and Private-Sector STEM Workers by Occupational Category

This section offers descriptive information on annual incomes for federal and private-sector STEM workers broken down by more granular occupational categories available in the CPS.[4] We caution that these estimates are purely descriptive in nature and do not control for factors that may explain differences in incomes such as education, age, gender, or geographic area. We organize the results along the lines of Table 4.11; Table 4.11 provides more granular occupational information for the IT and computer science broad occupational category. We replicate Table 4.11 as Table C.9 here. The other four occupational groups are in Tables 2.2 through 2.5.

Table C.10 presents results for engineering occupations. As was the case for the IT and computer science broad occupation, the rough parity at the broad occupational group level masks variation across the detailed occupations within engineering. Average incomes for architectural and engineering managers in the private sector were highest relative to incomes for their federal counterparts, with these workers earning about 17 percent more. Computer hardware engineers earned about 13 percent more in the private sector. At the other end of the spectrum, surveying and mapping technicians earned nearly 30 percent more in the federal sector than in the private sector. Architects (except naval), engineering technicians (except drafters), and surveyors, cartographers, and photogrammetrists in the federal government also had average incomes more than 10 percent larger than their private-sector counterparts. For workers in the detailed occupation accounting for the largest share of engineers in both sectors—the catch-all "other" engineers category—federal incomes were a little over 5 percent higher than private-sector incomes on average.

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[4] The five occupational categories were developed after extensive review of occupational codes used by OPM, the U.S. Census Bureau's Standard Occupational Classification (SOC) codes, and codes used in the Current Population Survey (CPS), as managed by the Bureau of Labor Statistics (BLS). As outlined in Appendix A, we elected to develop and use these five broad categories for comparative analyses because of concerns about occupational definitional differences across the data sources, sample size restrictions when using granular occupation-level information for STEM workers, and differences in the educational levels across federal and private-sector STEM populations. Use of the five broad categories allowed us to have more confidence in results than had more granular occupational information been used. In this appendix, we do not report income when the sample size for the detailed occupation in the CPS over the 2009 to 2018 period is fewer than 10 workers.

Table C.9. STEM Worker Income, by Sector and by Detailed Occupation within Information Technology and Computer Science, 2009 to 2018 Average

	Private		Federal		
Occupation	**Share IT and Computer Science (percent)**	**Income**	**Share IT and Computer Science (percent)**	**Income**	**Private Income Share of Federal Income (percent)**
IT and computer science (broad occupation)	100.0	$92,146	100.0	$95,862	99.6
Computer and information systems managers	13.9	$111,580	8.4	$98,120	113.7
Computer scientists and systems analysts	27.5	$84,805	28.8	$90,938	93.3
Computer programmers	9.9	$86,157	4.8	$81,874	105.2
Software developers, applications and systems software	28.0	$106,312	19.1	$95,407	111.4
Database administrators	2.3	$88,709	1.6	$132,678	66.9
Network and computer systems administrators	4.7	$78,793	5.0	$87,605	89.9
Computer support specialists	10.0	$63,894	9.5	$89,551	71.3
Actuaries	0.6	$145,822	0.1	N/A	—
Operations researchers	1.8	$84,682	18.6	$93,145	90.9
Statisticians	0.3	$92,821	1.1	$98,794	94.0
Other mathematical science occupations	1.1	$94,050	3.2	$105,954	88.8

SOURCE: CPS's Annual Social and Economic Supplement (ASEC) (per the U.S. Census Bureau).
NOTE: The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Certain occupations are not classified in CPS in all years, thus we do not report income for all occupations. N/A indicates insufficient sample size to report income for the occupation.

Table C.10. STEM Worker Income, by Sector and by Detailed Occupation within Engineering, 2009 to 2018 Average

	Private		Federal		
Occupation	**Share Engineering (percent)**	**Income**	**Share Engineering (percent)**	**Income**	**Private Income Share of Federal Income (percent)**
Engineering (Broad Occupation)	100.0	$92,146	100.0	$95,862	96.1
Aerospace engineers	4.8	$107,134	5.8	$108,769	98.5
Architects, except naval	6.2	$92,344	2.6	$118,064	78.2
Architectural and engineering managers	4.3	$133,437	2.4	$113,698	117.4
Chemical engineers	2.7	$107,484	1.4	$102,139	105.2

Occupation	Private		Federal		Private Income Share of Federal Income (percent)
	Share Engineering (percent)	Income	Share Engineering (percent)	Income	
Civil engineers	11.0	$93,374	11.3	$94,890	98.4
Computer hardware engineers	2.8	$110,227	1.7	$97,875	112.6
Drafters	4.8	$56,151	0.7	N/A	—
Electrical and electronics engineers	11.0	$105,104	10.8	$106,470	98.7
Engineering technicians, except drafters	13.0	$61,068	16.6	$71,891	84.9
Engineers, all other	13.8	$100,568	26.8	$106,791	94.2
Environmental engineers	1.1	$93,380	1.5	$90,670	103.0
Industrial engineers, including health	7.0	$84,887	3.0	$83,003	102.3
Marine engineers and naval architects	0.5	$91,626	0.9	N/A	—
Materials engineers	1.4	$88,405	0.8	N/A	—
Mechanical engineers	10.7	$93,253	9.6	$97,585	95.6
Petroleum, mining and geological engineers	1.7	$126,904	0.9	N/A	—
Surveying and mapping technicians	2.2	$55,555	1.6	$71,640	77.5
Surveyors, cartographers, and photogrammetrists	1.0	$67,000	2.0	$75,609	88.6

SOURCE: CPS's Annual Social and Economic Supplement (ASEC) (per the U.S. Census Bureau).
NOTE: The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Certain occupations are not classified in CPS in all years, thus we do not report income for all occupations. N/A indicates insufficient sample size to report income for the occupation.

Table C.11 presents results for life science occupations. Again, although incomes were roughly the same on average in the broad occupational group (within 1 percent), we see variation across detailed occupations within life science. Biological technicians fared better on average in the private sector, earning more than 30 percent more than their federal government counterparts. However, for workers in all other detailed occupations for which sufficient data were available to make a comparison, average income was higher in the federal sector. Fire inspectors earned nearly 35 percent more in the federal government and conservation scientists and foresters earned about 15 percent more. Average incomes were very similar in the two sectors for biological scientists, environmental scientists and geoscientists, and workers in the "medical scientists, and life scientists, all other" category. Collectively, these three categories with very similar incomes accounted for about 80 percent of life science workers in both the private sector and the federal government.

Table C.11. STEM Worker Income, by Sector and by Detailed Occupation within Life Science, 2009 to 2018 Average

Occupation	Private Share Life Science (percent)	Private Income	Federal Share Life Science (percent)	Federal Income	Private Income Share of Federal Income (percent)
Life science (broad occupation)	100.0	$84,661	100.0	$85,497	99.0
Biological scientists	19.0	$83,528	31.5	$84,423	98.9
Biological technicians	5.8	$56,354	2.2	$42,881	131.4
Conservation scientists and foresters	3.3	$71,647	15.3	$82,105	87.3
Environmental scientists and geoscientists	24.0	$88,645	19.7	$90,604	97.8
Fire inspectors	1.2	$59,303	3.8	$79,921	74.2
Geological and petroleum technicians, and nuclear technicians	7.9	$71,881	1.1	N/A	—
Medical scientists, and life scientists, all other	38.8	$91,464	26.4	$92,621	98.8

SOURCE: CPS's Annual Social and Economic Supplement (ASEC) (per the U.S. Census Bureau).
NOTE: The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Certain occupations are not classified in CPS in all years, thus we do not report income for all occupations. N/A indicates insufficient sample size to report income for the occupation.

Table C.12 presents results for physical science occupations. In this case, at the broad occupational group level, workers in the federal government earned substantially more than private-sector workers according to the descriptive data. Federal workers had higher average incomes in the largest detailed occupation—the "all other" category, with these workers earning about 10 percent more on average, as well as in the occupations of agricultural and food scientists (who had nearly 50-percent higher incomes on average in the federal sector) and atmospheric and space scientists (2.4-percent higher incomes). However, it was not universally the case that federal workers earned more within physical science occupations; earning more on average in the private sector were astronomers and physicists (16.0-percent higher incomes) and chemists and materials scientists (3.7-percent higher incomes).

Table C.13 presents results for social science occupations. We see that economists accounted for nearly 60 percent of social scientists in the federal government—but earned about two-thirds more on average in the private sector. Psychologists accounted for nearly 60 percent of private-sector social scientists—and earned about 4 percent more in the private sector than in the federal government. For those in the "all other" category, accounting for about one quarter of both sectors' social scientist workforces, federal workers earned about one-third more on average than their private-sector counterparts.

Table C.12. STEM Worker Income, by Sector and by Detailed Occupation within Physical Science, 2009 to 2018 Average

Occupation	Private: Share Physical Science (percent)	Private: Income	Federal: Share Physical Science (percent)	Federal: Income	Private Income Share of Federal Income (percent)
Physical Science (Broad Occupation)	100.0	$86,703	100.0	$103,366	83.9
Agricultural and food scientists	7.8	$72,438	8.5	$106,313	68.1
Astronomers and physicists	2.5	$141,243	11.0	$121,802	116.0
Atmospheric and space scientists	1.3	$76,052	8.2	$77,902	97.6
Chemical technicians	18.3	$52,635	0.9	N/A	—
Chemists and materials scientists	26.4	$88,886	13.9	$85,732	103.7
Natural science managers	3.8	$129,601	1.6	N/A	—
Physical scientists, all other	39.9	$97,017	55.8	$106,494	91.1

SOURCE: CPS's Annual Social and Economic Supplement (ASEC) (per the U.S. Census Bureau).
NOTE: The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Certain occupations are not classified in CPS in all years, thus we do not report income for all occupations. N/A indicates insufficient sample size to report income for the occupation.

Table C.13. STEM Worker Income, by Sector and by Detailed Occupation within Social Science, 2009 to 2018 Average

Occupation	Private: Share Social Science (percent)	Private: Income	Federal: Share Social Science (percent)	Federal: Income	Private Income Share of Federal Income (percent)
Social Science (Broad Occupation)	100.0	$97,116	100.0	$105,553	92.0
Economists and market researchers	16.6	$219,735	58.9	$132,151	166.3
Psychologists	57.3	$79,171	16.5	$76,042	104.1
Social scientists, all other	26.1	$67,707	24.7	$90,861	74.5

SOURCE: CPS's Annual Social and Economic Supplement (ASEC) (per the U.S. Census Bureau).
NOTE: The private sector excludes workers in federal, state, and local government. The public sector refers to federal workers. Certain occupations are not classified in CPS in all years; thus, we do not report income for all occupations.

Summary of Income for Federal and Private-Sector STEM Workers by Occupational Category

This section presents descriptive income comparisons for detailed CPS occupations that fall within the five broad groups. Table C.9 is included in the report as Table 4.11 and provides comparisons for detailed occupations within IT and computer science, the largest of the five broad groups. Tables C.10 through C.13 provide this same information for the remaining four broad groups. As the tables show, there is notable variation across the detailed occupations within each broad group according to the descriptive data, which do not control for any individual characteristics that may drive these differences. In engineering and life sciences, rough parity at the broad group level obscured differences across the detailed occupations, with private sector workers faring better on average in some fields and federal workers faring better in others. For physical scientists and social scientists, despite federal workers earning more on average overall, there are nonetheless detailed occupations in which private-sector workers earned higher average incomes.

Comparing Federal and Private-Sector STEM Incomes by Broad Occupational Category

In Chapter 4, we provided results of regression models comparing incomes of federal STEM workers to private-sector STEM workers, controlling for factors that may affect income differences such as education level, age, and geographic region. In those models, we also controlled for the five broad occupational categories used in the study. From that analysis, we find that private-sector STEM workers earn about $2,600 more in annual pay than federal STEM workers once observable differences are taken into account.

Based on feedback from DCPAS, we are providing additional regression analysis where we remove occupational category as a control variable and run the models by the occupational category, thus providing an estimate of the federal-private STEM income differences for each occupational category. Table C.14 is laid out like Table 4.14 in the report, but instead of reporting results by education level as done is in Table 4.14, we report results by occupational category. The first column lists the average income difference between federal STEM workers and private STEM workers within that occupational category. The second column includes controls for education level, age, gender, region, and urbanicity and thus takes account of compositional differences between federal and private STEM workers within each STEM category.

From Table C.14, we see that federal STEM workers in physical science, engineering, and social science occupations are paid more than their private-sector counterparts on average (first column estimates), indicating an overall average premium for federal STEM workers in those occupations. When controls for education level, age, gender, region, and urbanicity are included,

Table C.14. Regression Coefficients of Annual Income on Indicator for Being a Federal STEM Worker by Broad Occupational Category

	Federal Coefficient (GOV)— No Controls (Mean Difference between Federal and Private Sector STEM)	Federal Coefficient (GOV)— with Controls (Difference between Federal and Private Sector STEM Controlling for Composition)
Physical Science	$15,454***	–$1,971
	(3,317)	(3,089)
Life Science	$304	–$11,376***
	(2,898)	(3,103)
IT and Computer Science	$231	-$155
	(1,374)	(1,360)
Engineering	$6,948***	–$1,289
	(1,652)	(1,512)
Social Science	$23,465***	$14,597**
	(5,780)	(5,228)

SOURCE: 2009-2018 CPS ASEC.

NOTES: The table shows the coefficients on a GOV dummy for two regressions on each of the five enumerated subgroups of STEM occupation, which are listed in the first column. The first regression (left) includes no controls and only the GOV dummy; the second regression (right) includes controls for education, age, age squared, gender, region, urbanicity, and year. Standard errors are shown in parentheses beneath coefficient estimates. *** indicates significance at the 1-percent level; ** indicates significance at the 5-percent level.

the difference in average wages for STEM workers in physical science or engineering is no longer statistically different from zero, indicating that once differences in composition between federal and private-sector STEM employees in physical science or in engineering are accounted for, there is no wage premium for federal STEM workers. In social science occupations, the overall average premium of $23,465 falls to $14,597 after accounting for compositional differences but the $14,597 premium for federal employees is statistically significant. The average wages in the life science category are similar for federal versus private-sector STEM workers without any controls, but once the differences in composition are accounted for, federal STEM workers in life science occupations make $11,376 less, on average, than private-sector STEM workers in life science occupations. There is no statistically significant difference between wages of federal and private-sector STEM workers in IT and computer science occupations.

Summary of Comparing Federal and Private-Sector STEM Income

To supplement the finding of an approximately $2,600 private-sector premium for STEM workers, after controlling for a variety of demographic, occupational, and geographic factors, we conducted additional regressions where we instead break out the federal-private income comparisons by the five broad occupational categories. These supplemental regression models show that the premiums (both in terms of size and direction) vary by occupational category. After controlling for demographic, educational, and geographic factors, the largest private sector premium is in the life science occupational group where federal STEM workers make $11,376 less, on average, than private-sector STEM workers in life science occupations. The largest federal premium is in social sciences, where federal STEM workers earned an average of $14,597 more than private-sector STEM workers once observable differences between the two workforces are taken into account. The other three occupational categories have small private-sector premiums after controls are introduced into the models but the estimates were not statistically significant.

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