Gender Pay Gaps in U.S. Federal Science Agencies: An Organizational Approach[1]

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This study advances understanding of gender pay gaps by examining organizational variation. The gender pay gap literature supplies mechanisms but does not attend to organizational variation; the gender and science literature provides insights on the role of masculinist culture in disciplines but misses pay gap mechanisms. A data set of federal workers allows comparison of men and women in the same jobs and workplaces. Agencies associated with traditionally masculine (engineering, physical sciences) and gender-neutral (biological, interdisciplinary sciences) fields differ. Pay-gap mechanisms vary: human capital differences explain a larger share in gender-neutral agencies, while at male-typed agencies men are frequently paid more than women within the same job. Although beyond the federal workers' standardized pay scale, some interdisciplinary agencies more often pay men off grade, leading to higher earnings for men. Our theory of organizational variation helps explain local agency variation and how pay practices matter in specific organizational contexts.

The gender pay gap is one of the most common ways that both scholars and publics discuss gender inequality. Researchers and advocates have tended to focus on national pay gap dynamics, explained through individual human

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capital resources and gendered family contexts, or their confluence. However, the processes that generate pay gaps are local and play out in organizations; macrolevel change is produced in large part by mesolevel processes. In this article we examine pay gaps at the organization level in U.S. federal science agencies from 1994 to 2008. This approach allows us to examine and distinguish among the underlying processes generating gender pay gaps in these organizations and to theorize how gendered structures intersect with knowledge production in institutional fields.

Three literatures inform this study. The first is the standard gender pay gap literature that identifies human capital, occupational segregation, and direct discrimination mechanisms (Petersen and Saporta 2004; Goldin 2014; Misra and Murray-Close 2014). The second is the gender and science literature that, taken as a whole, describes disciplinary field differences in gender inequalities in science—such as between the physical sciences and the biological sciences. We focus in particular on gender frame theory (Ridgeway 2011), which contrasts scientific fields that are not strongly gender typed (gender neutral) like life sciences and those that are male typed (have masculine frames) like engineering.

Neither the gender pay gap nor gender and science literature systematically attends to organization-level processes. We expect that gender pay gaps vary organizationally in both their levels and mechanisms. Our third literature focuses on organizational variation in inequality-generating processes. The importance of organizational-level process has long been recognized (Baron and Bielby 1980; Reskin 1993; Reskin, McBrier, and Kmec 1999), but progress has been slow given the rarity of organizational-level data. Theoretical work has begun to advance a more specifically organizational perspective on inequality (Tilly 1999; Acker 2006; Tomaskovic-Devey and Avent-Holt 2019). The key insight we adopt from this literature is that organizations have internal logics that grow out of their formal and informal practices and environmental field-level influences. The key prediction from this literature is that we should expect organizational variation in inequality regimes—in the context of our study we should expect dynamic organizational variation in the levels and mechanisms producing the gender pay gap. We return to this literature in the conclusion, developing a theoretical proposal for future work that predicts that the magnitude and processes producing gender pay gaps will vary at the intersection of the degree of organizational hierarchy/collaboration and disciplinary coherence. For the more general gender pay gap literature, our results highlight the

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importance of organizational variation in inequality mechanisms, including specific organizational pay practices.

To examine the expectation in the gender and science literature that masculine sciences will generate more inequality, we focus on seven federal science agencies using high-quality personnel data. Some science agencies are connected closely with related disciplinary fields through their core missions, including funding and regulation of scientific activities, and through the identities of scientists who work in the agencies. Other science agencies are more inter- or multidisciplinary, both in their funding patterns and in the activities and commitments of the scientists and leadership of the agency. Our organizational approach is uncommon in the gender and science literature, and so this is the first study we know of both to conceptualize science organizations as disciplinary or interdisciplinary and to examine the gendered pay outcomes for these agencies.[2] The gender and science literature has uncovered the role of masculinist culture in disciplinary fields but, to date, has not paid close attention to the mechanisms driving inequalities.

In contrast, the gender pay gap literature does pay close attention to the mechanisms producing gaps; however, very little research attends to organizational variation in the pay gap levels and mechanisms. Following the literature, we observe three primary mechanisms that can be expected to produce gender pay gaps: (1) gender differences in human capital, (2) the allocation of people into gender segregated jobs, and (3) within-job pay disparities. A major gap in the previous literature is that there has been no systematic study of the variation in how much each of these three mechanisms accounts for gender pay gaps in different organizations. Previous studies have lacked the data on and the theory of variation in the gender gap in a population of comparable organizations. In line with our theoretical approach, we developed statistical models to identify these three mechanisms and their organizational dynamics across the 15-year study period in the population of U.S. federal science agencies.

We discover variation associated with the gender frames of science agencies. Masculine-discipline-associated agencies show a larger overall gap, especially in earlier years. We also discover agency-specific variation in mechanisms precipitating gender inequality, which does not conform neatly to a masculine or gender-neutral framing. We link this variation to the introduction of

[2] The time period we examine (1994–2008) experienced a sea change in science toward multiple investigator interdisciplinary projects (Wuchty, Jones, and Uzzi 2007; Lamont 2009; Porter and Rafols 2009; Leahey 2016; Hackett et al. 2017), and much research has tracked that trend toward interdisciplinarity. There has been much less research on the role of science agencies in the interdisciplinary trend (but see Rhoten, O'Connor, and Hackett 2009); however, it is generally acknowledged that increased grant funding has flowed into interdisciplinary calls for proposals.

more market-based logic that allowed some agencies to circumvent standardized pay practices designed to decrease inequality. Our theory of organizational variation helps explain both the presence of local agency variation and how pay practices matter in specific organizational contexts. We find that, particularly in some interdisciplinary focused agencies, federal pay grades actually create gender inequalities when men are systematically paid "off grade" at higher salaries than women in the same agencies. Thus, relative to the conventional gender pay gap literature, we argue that at the organizational level there is a need to theorize and observe dynamics of inequality-installing pay practices. Durable inequalities are maintained when the bar is always moving—as when pay grade no longer applies and men are more likely than women to have special off-grade salary considerations.[3]

The "case" for our study of organizational contextual effects on gender pay equity is population-level data for all of the nondefense agencies and federal workers in those agencies from 1994 to 2008. This population of organizations is perhaps the most conservative case in the United States for gender pay gaps, as federal agencies are subject to policies for gender equity enforced by the U.S. Equal Employment Opportunity Commission and are subject to a yearly market gap analyses (with models that include human capital among other variables) to establish salaries for pay grades across agencies. Science agencies, which are the focus of our analysis and theory of organizational variation here, come in for even further scrutiny on gender equity. A 2016 Government Accountability Office report, for example, compared seven agencies (overlapping with our focal agencies) on gender equity in the extramural grants made to scientists. Where we might expect to see little or no gender pay gap, we find that important gaps remain and vary in size across agencies. Our examination of organizational differences in gender pay gaps among science agencies—which represent different scientific fields—contributes to sociological understanding of how gender inequalities are built into organizational structures and how those structures intersect with specifically gendered knowledge production systems.

ORGANIZATION-LEVEL QUESTIONS ABOUT THE PAY GAP

To motivate our analysis, we draw on the concept of gendered organizations created by Acker (1990, 2006) and extended by others (Britton 2000; Martin

[3] Off-grade salaries conceal workers' rank, preventing direct comparison between men and women with similar education and job responsibilities. This hidden inequality, discussed further below, is typically justified with market logic.

2003), as well as Ridgeway's (2011) gender frames theory. Gendered organization theory focuses on processes at the organization level, while Ridgeway focuses on field-level cultural frames (e.g., the masculine typing of computer sciences). We bring together these two theoretical perspectives (organizational level and field level) in conceptualizing our unit of analysis—an organization that is imprinted with the gender of the scientific field to which it is linked. We bring Ridgeway and Acker together to ask a new question: Do masculine-typed agencies display a larger (or different kind of) gender gap in pay than gender-neutral science agencies?

Gendered organization theory as originally proposed by Acker (1990) is helpful in thinking about how workplaces are gendered, rather than assuming inequality should be examined only on an individual worker level. Organizations are not gender neutral; instead, they operate with "ideal worker" schemas that often assume a male worker. Britton (2000) additionally argued that the gendering process is altered by organizational context. In more recent conceptualizations, Acker (2006, 2012) agreed, suggesting that organizational gender inequality regimes can be expected to vary as a function of workplace level class and human resource practices, although this intersectional gendering is often hidden within bureaucratic discourses. Others have pointed out that gendered organizations are always nested in larger institutional contexts, including institutional, national, and even cross-national gender structures (Connell 2002; Martin and Collinson 2002; Walby 2004). In this analysis we hold the macrolevel context of nation and sector constant by examining U.S. federal agencies and focus closely on variation at the mesolevel of organizations and their scientific fields. We examine dynamic organizational variation in the levels and mechanisms producing the gender pay gap. From the career mobility literature, we expect that this variation should reflect both internal social relations and the influence of field-level processes (Borkenhagen and Martin 2018).

Variation at the mesolevel is conceptually important to gendered organization theory but has rarely been studied empirically. Only a handful of studies look at variation in gendered organization. Smith-Doerr (2004, 2010) has theorized variation based on organizational form, drawing from her research on both the life sciences and screen writing, which demonstrates that women do worse in hierarchical as compared to network-based forms of organization. A series of studies by Kalev, Dobbin, and colleagues looks at variation in access to managerial jobs associated with human resource practices (e.g., Kalev, Dobbin, and Kelly 2006). In another example specifically on pay gaps, Avent-Holt and Tomaskovic-Devey (2012) showed that the gender wage gap varied widely across Japanese and U.S. manufacturing plants, conditioned by national (equal opportunity policies) and organizational (segregation) level processes. An important case study by Salzinger (2003) compared gender relations in four Mexican maquiladora manufacturing plants: these organizations had strikingly

different gendered expectations despite sharing the same spatial context and a single cultural norm of the ideal worker as a docile, nimble-fingered, third world woman. In Germany (Abendroth et al. 2017), gender pay gaps appeared to vary by supervisor's gender as it interacted with specific human resource practices. These studies suggest that substantial local variation in gendered organization exists but also that further analyses are needed to understand how these inequality processes differ systematically across organizational contexts.

Our empirical focus on federal science agencies allows us to draw on previous studies of disciplinary differences in scientific fields in thinking about variation in gender inequality. We expect fields culturally framed as masculine (physics, engineering) would have more gender bias in hiring, segregation, pay, and promotion decisions and thus a larger average pay gap than fields that are gender neutral (biology, interdisciplinary fields). Within science contexts, disciplinary differences play a role in shaping the structure and culture of organizations (Knorr Cetina 1999). Disciplinary contrast intersects with the ways that scientific disciplines are gendered (Traweek 1999; Charles and Bradley 2009; Ecklund, Lincoln, and Tansey 2012; Cain and Leahey 2014).

Engineering and physical sciences are often reported as worse for women in terms of gender-biased culture and experiences of hostility. Masculinity is featured in the core engineering identities of "mastery" and "tool use" (Oldenziel 1999; Faulkner 2007). Physicists value masculine tales of independence and competition in which exposing the weaknesses of others is important to the "haughty" display valued in the field (Traweek 1999). In physics and computer science it is still common to hear that girls and women are "not good at math" (Margolis and Fisher 2002; Ecklund et al. 2012). Thinking like an engineer means disengaging social competencies from technical ones (Cech 2014), and this dualism is aligned with the masculinity of engineering as a field (Faulkner 2007).

Ecklund et al. (2012) found that scientists explained the difference between women's participation in biology compared to physics in terms of the gendered character of each field. The narrative about physics is clearly and directly masculine (that it requires abstract reason, math, and logic for which women do not possess talents), whereas the narrative about biology is slightly and indirectly feminine (that it requires interacting with living things and thus attracts women who nurture and care; Ecklund et al. 2012). Other studies that include interviews with scientists outside of academia have not found the same feminine slant in explanations about biological sciences but rather more gender-neutral narratives, such as the life sciences tending to value contributions to collaborative research by men and women alike (Smith-Doerr 2004).

In Ridgeway's (2011) gender frames argument, some scientific fields are framed as male typed or masculine (like engineering and computer science), and others are gender neutral and not as clearly labeled by gender (like life sciences). Ridgeway uses a cultural framing distinction to explain the fact

that women have made inroads in fields in which professions are not clearly labeled as male. She draws on Smith-Doerr's (2004) findings in the biotechnology industry in which women are more often in leadership roles in firms, noting the stark contrast to McIlwee and Robinson's (1992) findings of barriers to women's advancement in clearly masculine engineering and software firms. Thus, in the conceptualization of gender frames that we employ, scientific fields are often meaningfully masculine and gender neutral (rather than masculine and feminine). A culturally gender-neutral space like the life sciences field, or an interdisciplinary science agency, is not the same as a feminine field.[4] Just as an all-genders restroom is a distinctly different space from either a men's or women's public restroom, certain fields in this theory are framed meaningfully as gender neutral.

Ridgeway's discussion of the gender framing of scientific fields does not address the emerging trend toward interdisciplinarity. From 1975 to 2005 interdisciplinary collaboration and citation increased, especially in neighboring disciplines (Porter and Rafols 2009). Studies that look at the growth in interdisciplinary collaboration across scientific fields do not usually consider gender, although some studies describe trends for women and men scientists. A few studies find that women scientists report somewhat stronger preferences for interdisciplinary research (Rhoten and Pfirman 2007) or engage in it somewhat more than men scientists do (Mansilla 2006; van Rijnsoever and Hessels 2011). In contrast, Leahey's (2006) work shows that women scientists specialize in subfields less than men do and that women and men scientists engage in interdisciplinary collaboration at the same rate (Leahey, Beckman, and Stanko 2017). Some qualitative studies also show that there are few gender differences in narratives about interdisciplinary collaboration (Smith-Doerr, Vardi, and Croissant 2016; Misra et al. 2017). From what we can observe using studies of interdisciplinary research by individual scientists, there are few significant gender differences, suggesting that interdisciplinary-based science organizations should be framed as gender neutral. Although we treat both life sciences and interdisciplinary agencies as gender neutral, interdisciplinarity has not been researched in terms of gendered outcomes in the way that life science fields have. Rather than investigating at the level of individual women and men's research records, instead we conceptualize an organizational level of interdisciplinarity. The distinction between gender-neutral/interdisciplinary organizations and gender-neutral/life science field organizations may also be related to other ways that organizations vary—such as interdisciplinary agencies as more generalist and life sciences agencies as more specialist organizations.

[4] Other occupations (like nursing) may be feminine typed, but none of the science and engineering fields represented by federal agencies fall into that category.

What Kinds of Organizational Variation in Inequality Mechanisms Create Pay Gaps by Gender?

Focusing on allocative, segregation (valuative), and within-job processes, we examine how organizations vary in the degree to which these three mechanisms contribute to their pay gap.

Allocative mechanisms.—Allocative discrimination occurs when women and men are sorted into different jobs through hiring, promotion, and firing processes (Reskin 2003; Petersen and Saporta 2004; Castilla 2008). We treat the organizational practice of hiring men and women with different levels of experience and education as a potential source of "allocative" bias. These disparities are not considered discrimination in most legal frameworks, but if an organization disproportionately hired more educated men and less educated women, or senior men and early career women, we view this as a gendered practice in hiring decisions that may generate substantial gender pay gaps. Selection is usually considered a supply-side phenomenon; we are instead treating selection as an organizational practice. In most studies, allocative discrimination—the sorting related to individual human capital differences—is bundled into a series of individual control variables. One exception is research on the motherhood wage penalty, which reveals some tension between individual choice and employer discrimination (Misra and Murray-Close 2014). Another exception is Mun's (2010) work on gender and hiring in Japan, which shows that employers allocate training and wages on the basis of the simultaneous sex typing of jobs and applicant pools.

Segregation/valuative mechanisms.—A more commonly noted and robust finding in the gender pay-gap literature is that the gap is related to occupational segregation; men and women occupy different jobs, and men's work pays better even net of human capital (e.g., Reskin and Roos 1990; England 1992; in science, see Leahey 2007; Broyles 2009; Frehill, Abreu, and Zippel 2015). Valuative discrimination is a concept that includes the idea that a lower value is placed on jobs typically held by women (Petersen and Saporta 2004). Although which jobs are men's work and which jobs are women's work varies across time and place, overall the separation of workers into jobs by gender lingers on (Goldin 2014; Mandel 2016).

Within-job discrimination mechanisms.—Critics point out that measuring segregation at an aggregate occupational level compares apples to oranges in terms of men's and women's work. For example, within the same occupation such as restaurant service, men more often work in fine-dining establishments while women work in family-style diners (Hall 1993). This incomparability opens the way to criticism that, even when controlling for occupation, the jobs that men and women are doing may be quite different and could explain much of the gender gap in pay (Reskin and Roos 1990; Tomaskovic-Devey 1993; Petersen and Morgan 1995). Appropriate comparisons should observe

gender sorting into jobs within organizations; however, a key limitation in previous research is the lack of data at the organizational level (Kmec 2003).

"Direct" discrimination in statistical models predicting pay gaps is often defined as whatever is leftover in the models after controlling for occupational segregation and human capital (Broyles and Fenner 2010; Misra and Murray-Close 2014). A strong empirical critique of the residual approach came from Petersen and Morgan's (1995) analysis of gender pay gaps at the job level (occupations within workplaces). They found a much smaller gender pay gap within jobs than is found in occupational analyses of national samples that lack information on workplaces. In our analysis we follow Petersen and Morgan's lead and treat the within-job, human-capital-controlled gender pay gap as evidence of evaluating equally situated men and women differently (within-job discrimination). Within-job (or evaluative) discrimination means women are paid less than men coworkers in the same job in the same organization. Within-job discrimination need not be motivated by conscious bias. Castilla (2008) showed that even in an organization where there were no gender differences in performance evaluations, pay bias crept in when the same merit rating score was awarded lower pay increases for women than for men. This work also underlines the importance of specific pay practices in generating inequality.

Studies comparing within-job gaps across organizations.—Perhaps because of the difficulty in obtaining large-scale employer-employee matched data for U.S. organizations, we know of only four other U.S.-based studies that match employees and employers to examine within-job gender gaps in multiple workplaces.[5] The first two studies use organizational information primarily as a control in order to explain differences between individuals. In the first study, using 1980s data from the Bureau of Labor Statistics, Petersen and Morgan (1995) found a very small gender gap in pay remaining after controlling for job (occupation within organization). The second study by Bayard et al. (2003) matched individuals to workplaces by geography and industry using a census sample and the Standard Statistical Establishment List. Workplace information is again used as a statistical control to identify what part of the national gender pay gap can be attributed to differences between organizations. These studies show that differences between organizations do matter for gender income inequality, but they do not shed light on how those differences operate.[6] For us, organizations are an analytic lens, rather than a statistical control.

[5] The studies by Petersen and Saporta (2004) and Castilla (2008) mentioned above each look at only one organization and in effect control for organization by design.

[6] There is also a set of studies using data from the Czech Republic (Křížková, Penner, and Petersen 2010), Norway (Petersen, Penner, and Høgsnes 2014), Sweden (Meyersson Milgrom, Petersen, and Snartland 2001), Germany (Abendroth et al. 2017), Japan (Mun 2010), and Spain (De la Rica Goiricelaya 2002). With the exception of Mun (2010) and Abendroth et al. (2017), these studies use organizational-level information to increase precision in wage estimates but do not examine organizational variation in its own right.

The third study compares U.S. and Japanese manufacturing plants and found that field-level and organizational segregation mechanisms produced gender pay gap variation across workplaces (Avent-Holt and Tomaskovic-Devey 2012). The fourth set of studies used an administrative data set of California state employees from 1979 to 1985, and the authors were explicitly organizational in their conceptualization. Baron and Newman (1990) found that the devaluation of earnings in jobs held mostly by women varied with organizational context, pointing to jobs with ambiguous performance evaluation as generating larger gender inequalities. Baron, Mittman, and Newman (1991), using the same data, showed gender integration was responsive to external political pressures, internal constituency groups, and managerial leadership. These studies highlight the power of field-level processes and organizational practices on gendered outcomes and are closest to ours conceptually.

The Context: U.S. Public Sector, 1994–2008

Our analysis of gender inequality in the U.S. federal government attends to how change over time might unfold. Pay gaps can be expected to change with the web of institutional practices and politics occurring at organizational, national, and even cross-national levels (Walby 2004). The overall gender pay gap in the United States declined between 1970 and 1994 and stalled thereafter, leaving a significant national average gender pay gap (Blau and Kahn 2006; England 2010; Campbell and Pearlman 2013). A significant gender gap in pay remains even in the public sector (Government Accountability Office 2009).

For our study, there is reason to believe that there might not be much change over time, given the stalled improvement in U.S. pay equity right about the time when our sample begins (in 1994). At the same time, public sector workplaces have been singled out as more equitable than the private sector because of their combination of more formal personnel practices and affirmative action policies. Yet previous research on the public sector shows that government agencies are also gendered organizations. Masculine-gendered organization characterizes legislative work (Bolzendahl 2014) and state and local government agencies (Kelly and Newman 2001; Swanberg 2004; Healy, Bradley, and Forson 2011; Charles 2014). Connell's (2006) study of five Australian government agencies finds evidence of an "overall pattern of gender relations" in government agencies that favors masculinity and men.

Still, relative to private sector organizations, other research has found lower levels of gender job segregation and pay inequality among public sector employees. Equal opportunity policies diffused earlier and more widely in the public sector (Mandel and Semyonov 2014). Mandel and Semyonov show that most of the decline in the gender pay gap among public employers happened between 1980 and 2000, with little change since, and an increasing

influence of occupational segregation after 2000. Wilson, Roscigno, and Huffman (2013) argue that the public sector has shifted to look more like the private sector in terms of managers' discretion over employees' job stability, and the authors' find racial inequality was higher in the 2000s than in the 1980s. It may be that this same process led to the stalling of gender progress in public employment documented by Mandel and Semyonov (2014). Importantly, neither of these projects had access to organizational-level data, and so the public sector includes all local, state, and federal employees. It is possible that their findings of stalled or reversed progress may not apply specifically to gender gaps among federal employees.

In fact, a report on federal government employees finds a rapidly declining gender pay gap between 1988 and 2007, primarily because of the increasing similarity in women's and men's human capital (Government Accountability Office 2009). That report did not distinguish among federal agencies, nor did it account for job-level segregation. Taken together, the literature suggests that in recent decades the federal government may have been a more women-friendly context than the public sector in general. If this is the case, then we would expect gender pay gaps to decline over time in the federal science agencies we examine.

One assumption we carried into this analysis was that the U.S. federal government pay grade system would account for most (if not all) of the gender pay gap after controlling for human capital and occupational segregation.[7] Surprisingly, what we found (described in more detail below) is that agencies selectively use the pay grade system. Sometimes agencies do not pay workers on the pay grade system, and we find that the selective use of pay grade is gendered. Of the federal workers in our study who received salaries from positions exempted from the grade system, 74% were men. Agency pay grade assignment turns out to be a specific organizational mechanism generating gender inequality and a way that gender biases are hidden by routine organizational practices (Acker 1990). This particular gendered practice may be unique to the public sector but underlines a more general point that the organizational context is key for understanding inequalities. Because pay grade is used quite differently in different agencies, its unequal effects are invisible without analysis at the organizational level.

The literature in the corporate sector that examines how market-based wages affect the gender gap in pay helps us to understand how science agencies

[7] The assumption that pay grade removes gender pay gaps has been made in previous studies of gender inequality in the U.S. government. A couple of studies (DiPrete and Soule 1988; Yamagata et al. 1997) examined the gender distributions in the federal internal labor markets in the 1960s–1980s with samples of U.S. Federal Office of Personnel Management (OPM) data, by grouping together occupations by pay grade across the government. They do not report which agencies the sampled employees occupied, nor did these studies include pay data.

that remove men more often than women from the federal pay grade system can lead to a greater gender pay gap. Following the literature, we might assume that the organizational narrative is that workers are removed from the pay grade system in order to pay them "market wages." Because the gender pay gap is higher in the private sector, going outside of the pay grade system to pay market wages may reinforce private sector disparities within the public system. Paradoxically, markets are often assumed to have a more "merit-based" competition for wages, but in reality they show more gender-biased outcomes (Castilla and Benard 2010; Castagnetti and Rosti 2013). In the corporate sector, Roth (2006) notes that this type of ideology about meritocracy when pay is variable leads to significant gender inequality in salaries. In our analyses we examine directly how public-sector organizations' choices about pay grade/off grade affects gender equity.

DATA AND METHODS

Data were obtained from the OPM in the form of raw, deidentified data on the population of federal workers from 1994 to 2008.[8] The data set includes variables for pay, position, occupation, job type, and personal characteristics of all federal employees outside of the Department of Defense. Individuals whose characteristics are unique enough to allow them to be identified are also excluded. Job incumbents who were employed for multiple years have records for each year, but we cannot identify the same individual across years. Our population of employer-employee-matched data, however, allows us to examine the mechanisms that produce gender pay gaps in specific organizational contexts.

Our data set includes over 16 million records, 2.8 million of which are employees in the seven science agencies we examine here.[9] We include only full-time, nonseasonal employees. Our data set provides sufficient detail to locate individuals in jobs within federal agencies and examine how patterns of inequality vary across agency contexts and year. To our knowledge this is the first data set of this kind to be obtained from OPM. Because these are population data, tests of statistical significance are not appropriate. We rely instead on descriptions of the actual levels and trends in gender pay gaps for each agency and observe and quantify the impact of the underlying allocative, segregation, and within-job mechanisms.

[8] At the time the data were obtained (2012), the Obama administration was in office, so the request was made (based on key informant advice) for data from the previous two presidential administrations.

[9] We were not able to obtain a complete set of data for the National Science Foundation (NSF) in 2008; thus, NSF data are excluded for that one year.

Focal Science Agencies

Science agencies are significant for scientific fields and vice versa. U.S. government science agencies distribute funding resources and regulations for scientists and engineers. Science agencies are closely tied to disciplines in several ways: (1) the agencies fund a significant amount of academic research in the United States and establish funding priorities, (2) scientists rotate between federal science agencies and academic positions, (3) agencies employ scientists who conduct internal research projects, and (4) science agencies regulate science and technology fields.

We focus on seven U.S. science agencies that span physical, biological, and engineering disciplines, as well as interdisciplinary research: National Oceanic and Atmospheric Administration (NOAA), National Institutes of Health (NIH), Department of Agriculture (USDA), National Science Foundation (NSF), Centers for Disease Control and Prevention (CDC), Environmental Protection Agency (EPA), and Department of Energy (DOE). We selected agencies that include a range of internal and external science funding as well as regulatory functions. By examining and comparing organizations within the federal government, we have the benefit of consistency in reporting and human resource policies for gender equity across all agencies.

To characterize how the seven focal science agencies differ from other federal agencies, consider leadership. Science agencies are more likely to be led by scientists. Table 1 shows that about 38%–67% of the administrative and professional positions in these agencies are held by scientists, while in the federal government overall, on average only 28% of leadership positions are held by scientists. Science agencies differ in the disciplines to which they are most closely tied. The key disciplines at CDC and NIH are health and biological sciences, and at NOAA and DOE, physical sciences and engineering. The other agencies are less clearly dominated by either life or physical sciences. EPA degree holders often come from (environmental) engineering and biological sciences, and USDA, from agriculture and natural resource conservation. The largest share of NSF science leaders hold degrees in physical sciences; however, degree fields do not cluster neatly around a common core at NSF. The next largest group of NSF scientists hold degrees in biological sciences, followed by social sciences, engineering, and mathematics/statistics, reflecting the interdisciplinary mission of the agency. Our theoretical perspective considers gendered organizations as a whole; thus, we do not limit our sample to certain kinds of employees (e.g., only scientists or only administrators) in our analyses of pay gaps. Understanding pay gaps across the entire organization—from jobs at the lowest pay grade to the top—provides a holistic organizational perspective.

These agencies' links to scientific fields mean that they represent different gender frames in Ridgeway's (2011) categories: some are masculine (based

TABLE 1
DESCRIPTIVE STATISTICS FOR AGENCY ADMINISTRATORS AND PROFESSIONALS, 1994–2008 (%)

	Scientists	Top Five Degree Fields of Scientists
Masculine sciences:		
NOAA	67.08	Physical sciences (52.18), biological sciences (17.58), engineering (6.83), social sciences (4.35), math and statistics (2.69)
DOE	38.42	Engineering (58.32), physical sciences (13.78), business management (4.71), biological sciences (4.29), social sciences (3.72)
Gender neutral, life sciences:		
NIH	63.78	Biological sciences (40.82), health sciences (28.36), physical sciences (8.03), psychology (4.03), engineering (2.2)
CDC	44.63	Biological sciences (30.59), health sciences (22.74), physical sciences (8.34), engineering (7.24), social sciences (6.3)
Gender neutral, interdisciplinary:		
EPA	42.93	Engineering (33.51), physical sciences (23.44), biological sciences (22.65), natural resources (4.21), health sciences (2.36)
NSF	38.30	Physical sciences (34.29), biological sciences (15.98), social sciences (14.67), engineering (12.8), math and statistics (8.12)
USDA	54.20	Agriculture (28.24), natural resources (18.54), biological sciences (16.58), engineering (7.4), health sciences (6.43)
All other agencies	28.00	

on physical sciences and engineering), while others are gender neutral (based on life sciences or interdisciplinarity). We conceptualize some science agencies as being interdisciplinary because of their reliance on the convergence of knowledge between disciplines—both for regulating science and technology (like EPA and USDA) and in funding federal grants (like NSF). In extending gender framing as originally conceptualized by Ridgeway, we argue that interdisciplinary agencies also represent a gender-neutral field.[10] Table 2 presents the percentage of workers in the entire agency and among the agency leadership who are women. This empirical look at the agency echoes the theoretical categorization: the masculine science agencies employ fewer women across the entire agency and among leadership positions. In all agencies, however, women are underrepresented in leadership positions relative to women's overall employment in the agencies.

[10] To say that the field is gender neutral does not imply that either individuals or organizations are gender neutral. We expect that individuals remain gendered in their identities and interactions and that organizations develop local gendered practices (Acker 2006).

TABLE 2
AGENCY GENDER COMPOSITION, 1994–2008 (%)

	Females	Female Leadership
Masculine sciences:		
NOAA	29.76	26.41
DOE	37.27	35.38
Gender neutral, life sciences:		
NIH	58.89	54.94
CDC	59.27	55.65
Gender neutral, interdisciplinary:		
EPA	48.78	44.68
NSF	61.52	52.75
USDA	42.19	36.52

NOTE.—Because of data limitations, 2008 is excluded for NSF only.

Concepts and Measures

Pay.—Pay is the value of workers' 12-month yearly salary in constant 2008 dollars. It is the sum of their base salary and supplements, assuming a 40-hour workweek. This basic salary specifically excludes overtime pay. In the regression models, we take the natural log of annual salary. We examine organizational variation in the levels and mechanisms behind the gender pay gap by decomposing the gap at each agency yearly into component parts. These parts include (1) individual characteristics (to examine allocative discrimination) and (2) occupational segregation and pay grade. Pay grade is a variable specific to the federal workforce that combines both individual and occupational elements. We are also interested in (3) the within-job (residual) pay gap after accounting for individual and occupational characteristics. It is this last component of the pay gap that is often counted as legal discrimination (e.g., England 1992; Petersen and Saporta 2004).

Individual-level variables.—Our analysis controls for workers' experience, race/ethnicity, and education. OPM provided us with age data in three-year intervals to protect individual identity; we assign workers the midpoint of the three-year range. We use age as a proxy for experience and include age^2 in regression models. Race/ethnicity is a categorical variable identifying workers as non-Hispanic white, non-Hispanic black/African-American, Asian, Latino/Latina, or Native American. Education is a categorical variable identifying the highest degree earned.

Occupation.—The U.S. government has a standardized set of job titles and responsibilities that apply across agencies. In some cases, a title may apply to one job at one agency. The titles are narrow in their scope and describe specific jobs (e.g., park ranger, electrician, tax law specialist, museum curator).

Pay grade.—The U.S. government uses pay grades from the federal General Schedule (GS) pay scale to set wages for workers with similar jobs and

qualifications. The GS scale includes 16 well-defined grades with narrow pay bands and is designed to link pay to job responsibilities, educational credentials, and tenure. In a meritocratic world, pay grade should reduce the gender pay gap almost entirely. Even if men are systematically at the highest end of a given GS pay band and women are systematically at the lower end, any remaining gap should be quite small. If the gender pay gap among federal workers is mainly due to gender differences in human capital, tenure, and job responsibilities, the pay grade control is likely to explain much of the gap.

As mentioned previously, we found that pay grades are not universally followed. The GS covers more than 80% of the employees. But agencies are free to use alternative "pay plans" for specific classes of workers. Alternative pay plans are more often used for professional and scientific workers whose private sector salaries would be much larger than on the GS scale. The agencies vary markedly in the share of workers on the GS scale; 92% of USDA workers are on the GS pay plan, but only 61% of NSF workers are. Across the seven agencies, there are 58 pay plans in use including GS. Nearly half (26) of the plans are unique to one agency, and some are unique to a single office, facility, or commission within an agency. More than a few of the plans cover only one employee at an agency. For example, appeals judges on one DOE commission have a distinct pay plan, as do nurses working at one particular NIH hospital. Most plans have a ranked numerical scale, but not all scales are associated with pay bands. The range and diversity of pay plans suggests considerable agency discretion in wage setting, especially for professional workers. We include GS pay grade in our models, along with a dummy indicator for workers who are not on the GS plan. We mean impute GS grade by agency-year for the off-GS workers, so that we can include them in our analyses. This approach weights the mean and may introduce some bias to the variance; however, with such a large case count, this is unlikely to be a serious concern.

We do not have measures for hours worked or for job tenure. While it is a weakness of our analysis that we do not have a measure of tenure, the pay grade variable very likely captures most of the effects of tenure. Because the salary data we use specifically exclude overtime pay, we standardize our pay measure to full-time-equivalent employees. We also note that the federal government environment is designed to enforce a 40-hour workweek. Thus, the potential influence of overtime (or part-time) work on gender pay gaps is limited by design in our study.

Analysis Strategy

We begin with descriptive analysis to establish the existence of organizational variation in gender pay gaps. Next, nested regression models examine the processes underlying each agency's gender pay gap. Because we have population data, we do not consider the results of significance tests (*P*-values), which

allow for estimation of population parameters based on sample statistics. Technically, *P*-values indicate that a difference in sample statistics is likely to exist in the population as well—with population data we know that differences we see are population differences. Simply because we have population data does not mean that any differences we see in our parameters are meaningful differences. Instead, we consider how differences may matter for the lives of workers and how they compare to the magnitude and variability of the measures.

Our data are multilevel—individuals are nested in occupations, which are nested in agencies, which are nested in time—and our modeling strategy allows us to analyze data at these different levels. Because we are studying the population of employees, we have large case counts at each level that allow us to use fixed-effects regression and have confidence in the results. In most sociological research employing hierarchical linear modeling, researchers use fixed effects at the individual level but random effects at higher levels because of data limitations. Random-effects models produce efficient estimates for smaller samples by assuming that the effects of independent variables are uncorrelated; for example, the effect of education on pay is the same for workers across occupations. Because we have large population data, we have no such limitations and need not rely on this often-violated assumption.[11] We have average case counts of 110 people per occupation per agency-year. By running models separately for each agency and each year, we are effectively fixing effects at all levels, over time.

The baseline model (M1) estimates the total gender pay gap; the second (M2) adds controls for individual characteristics (education, age, and race), yielding a pay gap controlling for individual differences (allocative discrimination); the third model (M3) adds the fixed effects for occupation and pay grade, yielding estimates of segregation and wage setting effects (valuative discrimination) and a within-job pay gap.[12] The final model allows us to compare workers with same individual characteristics, working in the same job, in the same pay grade (or off the GS scale), at each agency. The models are specified below:

[11] Hausman tests indicated that fixed effects are more appropriate for almost every one of our models. In fewer than five of the 149 models, tests indicated that random effects would also be appropriate. As an additional robustness test, we ran the analysis using multilevel models and found that results for the gender gap coefficient are identical to at least two decimal places in 143 of 149 models and not substantially different in the other six models.

[12] Adding occupation and pay grade separately in our models could, theoretically, allow us to examine separately the effects of occupational segregation—if men and women with equivalent levels of human capital are sorted into jobs that pay different wages. In practice, pay grade is a function of worker characteristics and job responsibilities and set at the same time. Therefore, we model pay grade and occupation fixed effects simultaneously.

M1: Baseline Gender Inequality:

$$\ln(\widehat{\text{income}}_{\text{year,agency}}) = a + \underbrace{\beta\text{gender}_{\text{year,agency}}}_{\text{unexplained}}.$$

M2: Gender Inequality Net of Individual Characteristics:

$$\ln(\widehat{\text{income}}_{\text{year,agency}}) = a + \underbrace{\beta\text{gender}_{\text{year,agency}}}_{\text{unexplained}} + \underbrace{\sum \beta\text{individual characteristics}_{\text{year,agency}}}_{\text{explained}}.$$

M3: Gender Inequality Net of Individual Characteristics, Occupational Segregation, Pay Grade:

$$\ln(\widehat{\text{income}}_{\text{year,agency}} = a + \underbrace{\beta\text{gender}_{\text{year,agency}}}_{\text{unexplained}}$$
$$+\underbrace{\sum \beta\text{individual characteristics}_{\text{year,agency}} + \beta\text{occupation}_{\text{fixed effects}_{\text{year,agency}}} + \beta\text{pay grade}_{\text{year,agency}}}_{\text{explained}}.$$

Note that within-agency occupational fixed effects mean that any residual measurement error is not associated with stable traits of these jobs, including preferences related to gender.

Our approach to decomposing the pay gap is an adaptation of the Petersen and Saporta (2004) method (see also Petersen and Morgan 1995; Goldin 2014). We use sequential models to absorb gender income difference. Our first model estimates the agency-specific gender earnings gap. Our second model controls for individual demographic and human capital characteristics. The reduction in the gender gap is the net effect of gendered human capital selection. The third model adds an occupational fixed effect as well as pay grade. The difference between M2 and M3 is the effect of occupational and pay grade sorting processes. The gender pay gap in the third model is the within-job and within-pay-grade gender gap and is our best estimate of within-job gender discrimination.[13] Finally, for M3 we calculate the gender differences in mean pay grade and being off pay grade and multiply them by the estimated slope for pay grade and off pay grade to get a unique estimate of the gendered pay grade allocation on the pay gap. The occupational effect is calculated by subtraction of the M3 from the M2 gender coefficients.

[13] Because formal pay gap decompositions, such as those specified by Blinder (1973) and Oaxaca (1973), require identical models for men and women, they are not practical for the occupational sorting analysis here. Using Blinder-Oaxaca decomposition means that any occupation having fewer than two men and two women would be dropped mechanically. More troubling is that completely segregated—all male or all female—jobs would be excluded from the estimate of occupational sorting in Blinder-Oaxaca models, and these are important data in our analysis.

ORGANIZATIONAL VARIATION AND PAY GAP FINDINGS

How do science agencies vary in the amount and composition of the gender pay gap? Do masculine science agencies (based on physical sciences and engineering) have larger pay gaps than gender-neutral science agencies (based on life sciences and interdisciplinary agencies)? Table 3 presents these contrasts as well as pay gaps for each science agency. The overall gender pay gap is similar between masculine and gender-neutral agencies, with somewhat larger overall gaps in male-typed science agencies. By 2008 overall pay gaps narrowed across all agencies. The life science agencies ended with a notably larger gap than interdisciplinary science agencies and somewhat larger than masculine science agencies. Most strikingly, the overall pay gap varies substantially across individual agencies, ranging in 1994 from women earning $0.58 on the male dollar at NSF to $0.78 at NIH, and in 2007–8 from women earning $0.73 on the male dollar at NSF to $0.89 at USDA. All agencies saw substantial decreases in the overall gender pay gap over this period.

Figure 1 displays the 2008 pay gap for the gender-neutral (life sciences and interdisciplinary) agencies compared to the masculine science agencies.[14] The life science agencies have the largest overall gap (*dark bars*), while interdisciplinary agencies have the smallest, and masculine science agencies fall in the middle. The within-job residual gaps from the fully controlled models (*light bars*) are small across all agencies. Consistent with gender framing theory, the masculine science agencies have the largest within-job gap, suggesting that in those agencies biases may be more likely to arise from interactional (rather than allocative or segregation) mechanisms. Life science agencies show a gap that is only slightly smaller than masculine science agencies, while interdisciplinary agencies display near gender equity with a within-job gap of less than 1 cent on the dollar.

While the gender and science literature predicts that masculine science agencies would display more bias in wage setting and thus larger gender pay gaps in the fully controlled models, there are also striking overall gaps in gender-neutral life science agencies. In order to have large overall gaps but small within-job pay gaps, these agencies must systematically hire more women than men into lower-paying positions. At the individual job level, women approach parity with men; however, these agencies reproduce traditional gender stratification at the organization level (see fig. 2). The day-to-day experience of most women in these agencies will not reflect gender parity—the average woman working in a science agency is likely to interact with many more men than women who outrank her. This interactional context operates under precisely

[14] See online data appendix for a summary table of coefficients for gender only for models 1–3 in 1994 and 2008. Full sets of coefficients for all variables in each model and year are also available in the data appendix.

TABLE 3
WOMEN'S AND MEN'S EARNINGS BY AGENCY AND SCIENCE TYPE, 1994 AND 2008 ($)

	1994 Average Salary			2008 Average Salary		
	Men	Women	Women's Earnings per Men's Dollar	Men	Women	Women's Earnings per Men's Dollar
Masculine sciences	79,027	57,464	.73	98,330	85,452	.87
NOAA	68,894	51,461	.75	89,577	78,173	.87
DOE	87,264	60,635	.69	108,941	92,311	.85
Gender neutral, life sciences	77,194	59,488	.77	102,344	85,388	.83
NIH	77,224	60,289	.78	105,106	86,539	.82
CDC	77,116	57,462	.75	96,293	83,113	.86
Gender neutral, interdisciplinary	62,441	48,287	.77	75,906	68,084	.90
EPA	86,059	65,321	.76	109,759	96,772	.88
NSF	111,980	64,429	.58	130,634	95,841	.73
USDA	58,508	44,529	.76	70,252	62,232	.89

NOTE.—Because of data limitations, 2007 data replace 2008 data for NSF only.

the kind of gendered organizational logic that Acker (2006) invokes when she considers systematic inequalities that seem legitimate but nonetheless result in gender stratification.

Without controls, NSF has the largest gender pay gap by far. After adding human capital, occupation, and pay grade controls, NSF has a moderate within-job gap (and a wide standard error). The USDA has the smallest pay gap with and without controls; USDA also has the smallest share of workers who are

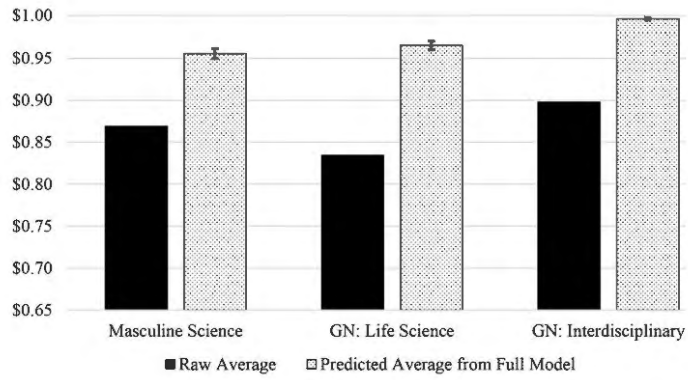

FIG. 1.—Women's 2008 earnings per men's dollar, by science type. Masculine science agencies based on physical and agricultural sciences are NOAA and DOE; gender-neutral science agencies based on life sciences and interdisciplinary focus are USDA, EPA, and NSF. Because of data limitations, 2007 data are substituted for NSF.

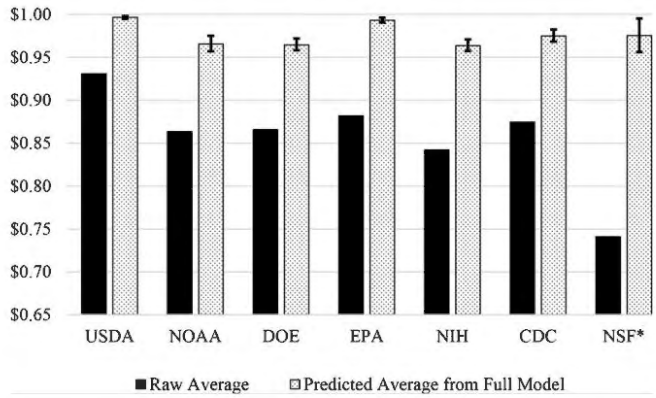

FIG. 2.—Women's 2008 earnings per men's dollar, by science agency. Because of data limitations, the 2007 pay gap is substituted for NSF.

paid off the GS pay grade system. After all controls, the two masculine science agencies—NOAA and DOE—have larger gender pay gaps than all other agencies (save NIH), supporting the idea that male-typed science agencies tend to be less equitable than gender-neutral science agencies. At the same time, there is considerable organizational variation in both the magnitude of and, as we will shortly report, the processes that lead to gender pay gaps across each of the individual agencies. Clearly the process is not as simple as the gender framing of discipline accounts suggest.

We now turn to an organizational analysis of the specific mechanisms that generate the gender gap in pay. Following the literature, we focus on three key processes: (1) pay differences controlling for the usual variables on individual characteristics (education, experience, and race) that frequently play a role in allocation processes; (2) job segregation and wage setting (including the decisions about who is paid on and off pay grade), which we view as part of valuative processes in which women's work is paid less; and (3) the remaining within-job pay gap, which is closest to the legal notion of discrimination. We display the results of these models in two series of figures. With attention to our second research question about how pay gaps may vary between organizations linked to male-typed science fields and to gender-neutral science fields, we present figures 3–5 (fig. 3 for masculine and figs. 4 and 5 for gender-neutral science agencies). We also present a series of figures (figs. 6–12) displaying individual agency results for each of the seven organizations we study.

All agencies show a decreasing overall gender pay gap from 1994 to 2008. This change is seen in the declining height of the top line across figures 3 and 4 and is part of a trend in which the gender pay gap decreased over time across all U.S. federal agencies. The decrease happened at a consistent rate and does

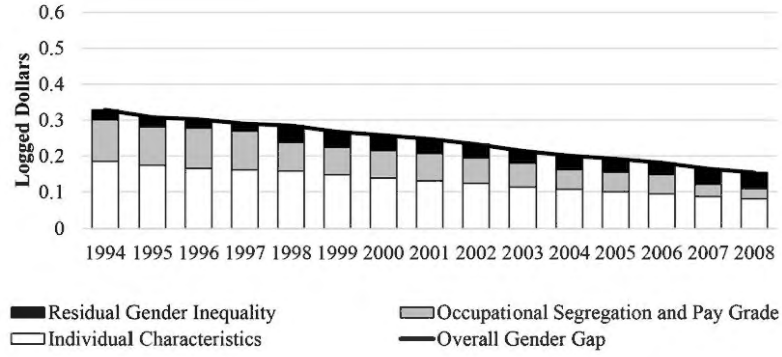

FIG. 3.—Gender pay gap elements: masculine science agencies

not appear to be related to changes in presidential administration. It also stands in contrast to the national trends of stable pay gaps across this period.

Differences in individual worker characteristics explain much of the gender pay gap across agencies and over time. However, as we can see in figures 4 and 5, the differences in individual characteristics (including human capital) explain more of the gap in the gender-neutral (life sciences and interdisciplinary) agencies than in masculine science agencies. It appears that gender-neutral science agencies enact a hiring pattern in which the organizations, on average, tend to hire women with less education and experience and to hire men with higher levels of human capital. Consequently, women receive lower pay on average. The legalistic logic of comparing men and women in the same job with the same education and experience would dismiss these large overall gaps, possibly as supply-side problems. Instead we consider this pattern to be the result of organizational action that generates inequality. The end result is

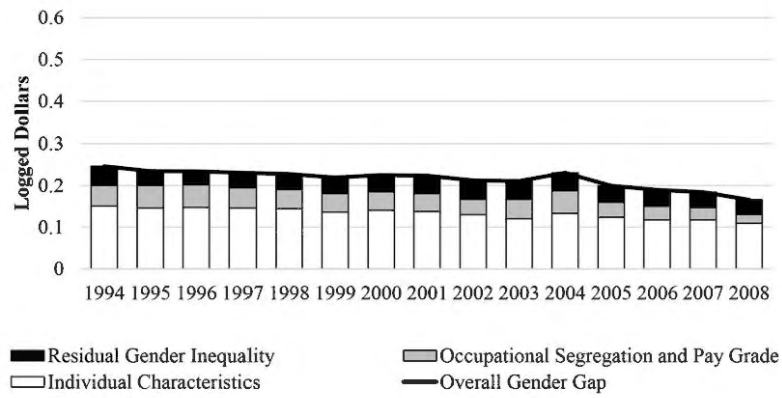

FIG. 4.—Gender pay gap elements: gender neutral, life sciences

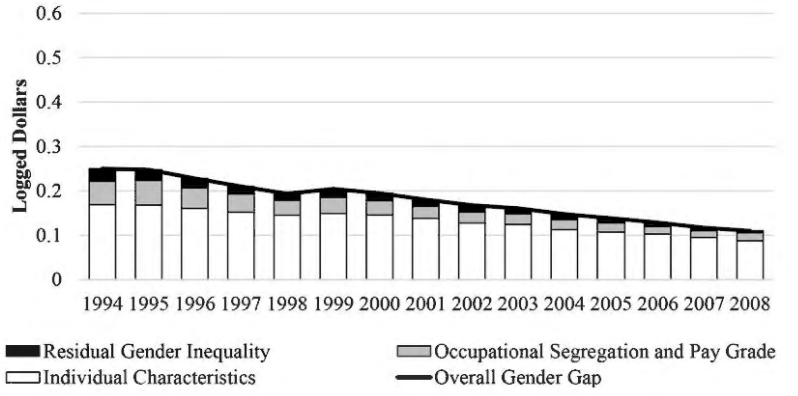

FIG. 5.—Gender pay gap elements: gender neutral, interdisciplinary. Because of data limitations, the 2007 pay gap is substituted for NSF.

persistent gender stratification in organizations that otherwise embrace practices intended to increase equity.

In the 1990s, occupational segregation and differences in pay grade explained a larger share of the gender pay gap in masculine agencies than in gender-neutral agencies. Figures 3–5 show these trends at the occupation level over time by agency type. The share of the gap explained by the occupational segregation mechanism decreased over time in male-typed and life science agencies, while there was little change in interdisciplinary agencies. By 2008, occupational segregation accounted for about the same proportion of the pay gap at masculine (physical sciences) and interdisciplinary agencies but comparatively less at life science agencies.

Overall, the most change in the gender gap mechanisms occurs in the male-typed agencies. The masculine science agencies had the smallest within-job pay gap in 1994, but by 2008 these agencies had the largest share of their gender pay gap within job—meaning they paid similar men and women working in the same jobs different salaries. In contrast, the within-job pay gap explained the smallest share of the overall gap at the interdisciplinary agencies by 2008.

We expected pay grade from the GS scale to be a major factor in setting pay for federal workers. It is, for those who are on it; however, the GS scale does not apply to workers in science agencies as universally as we had imagined. Nearly 40% of NSF employees and 30% of NIH employees are not paid on the GS scale. It appears that pay grade assignment is an organizational decision that varies by agency and has consequences for gender inequality. Organizational assignment of pay grade contributes to gender gaps because average pay is higher for workers paid off the GS pay grade, and men are more likely to be paid off the GS pay grade.

In the final analysis, we compare women and men with similar individual characteristics (human capital and race) in the same job at the same agency in the same pay grade (or off grade). Unsurprisingly, residuals at this level are quite small. The interesting differences between the masculine and gender-neutral science agencies come in when we consider what composes the gender pay gap. When we examine women and men with the same background characteristics, working in the same job at the same agency, we find that the within-job pay gap is a larger share of the gender gap at the male-typed science agencies. At the same time, masculine science agencies tend to have lower levels of gender pay inequality related to individual differences. The masculine science agencies (NOAA and DOE) are among those with the largest share of the within-job gender pay gap. The life sciences agencies (NIH and CDC) also have relatively large shares of the within-job gap after controlling for other factors, while the share of the within-job gender pay gap at the interdisciplinary agencies (USDA, NSF, and EPA) is quite small.

Looking in greater detail at science agencies individually in figures 6–12, we see that organizations vary in the share of the gap explained by each gender inequality process (allocative, valuative, and within job). Most agencies had a pattern of inequality that remained fairly constant across the years of observation. For example, at NSF in 1994 80% of the gender gap was explained by differences in individual characteristics (allocative processes), 12% from job segregation and pay grade (valuative processes), and 7.5% of the gender gap remained within job. In 2007 the gender pay gap at NSF was still explained by 84% individual characteristics, 9% job value characteristics, and 7% within-job gender gaps (see table 4). Of all the agencies, only NOAA underwent a significant transformation in its patterns of inequality, and the direction was toward an increasing within-job gap, so that the gender pay gap between similar men and women in the same jobs increased over the

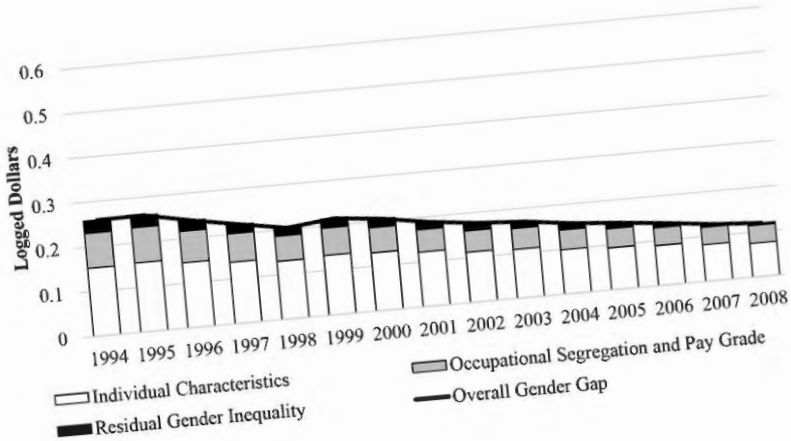

FIG. 6.—Gender pay gap elements: USDA

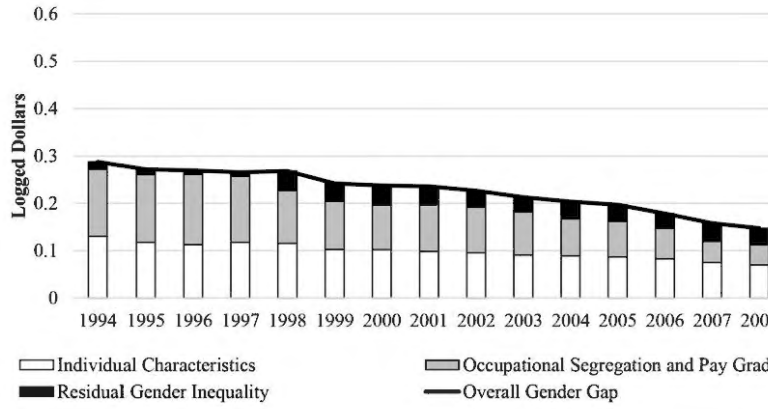

FIG. 7.—Gender pay gap elements: NOAA

observed time period. In 1994, 45% of the gap at NOAA was from individual characteristics, 49% from job segregation and pay grade, and 5.4% remained as a within-job gap. By 2008 the gender pay gap at NOAA was explained by 47% individual characteristics, 29% job value characteristics, and 24% within-job gender gaps. Over time, the gap at NOAA was explained much less by valuative processes (job segregation and pay grade) and much more by within-job disparities (despite being the only agency to have a larger proportion of women than men paid off pay grade). This particular agency is the only one that demonstrates increasing within-job gender gaps over time.

The decrease in the overall gap is a visible linear trend at all agencies and mirrors what we see for the federal government overall (analyses available on request). This uniform decrease in gender gaps in pay suggests that there

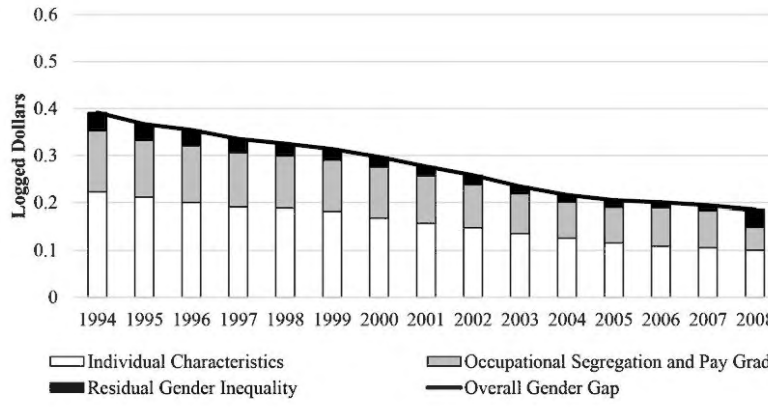

FIG. 8.—Gender pay gap elements: DOE

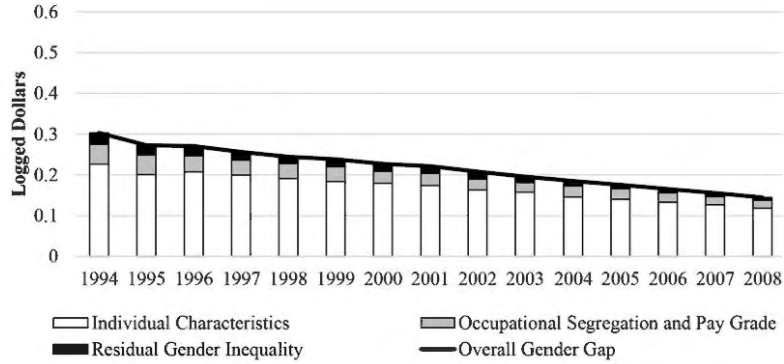

FIG. 9.—Gender pay gap elements: EPA

has been a strong field effect from federal sector employment practices during 1994–2008. These declining pay gaps are much more pronounced than what past research shows for the U.S. national economy or for the public sector overall. Our divergent finding strongly suggests that the relevant field effect is not due to a national gender regime or the distinction between private and public sectors but rather to specific employment practices of the U.S. federal government.

Table 4 summarizes the percentage of the pay gap explained by each of the processes—allocation by individual characteristics, valuative by occupational and pay grade, and within-job disparities—at the beginning and end of the observation period. Across all the agencies, differences in individual characteristics account for the largest share of the gender pay gap, ranging from 45% for NOAA in 1994 to 84% at NSF in 2007. From 1994 to 2008,

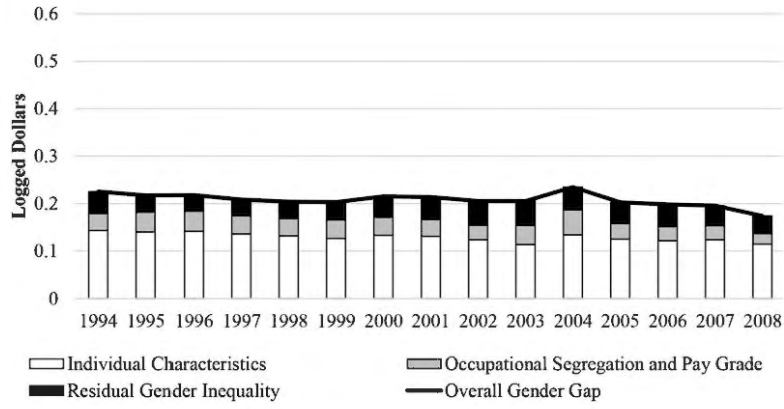

FIG. 10.—Gender pay gap elements: NIH

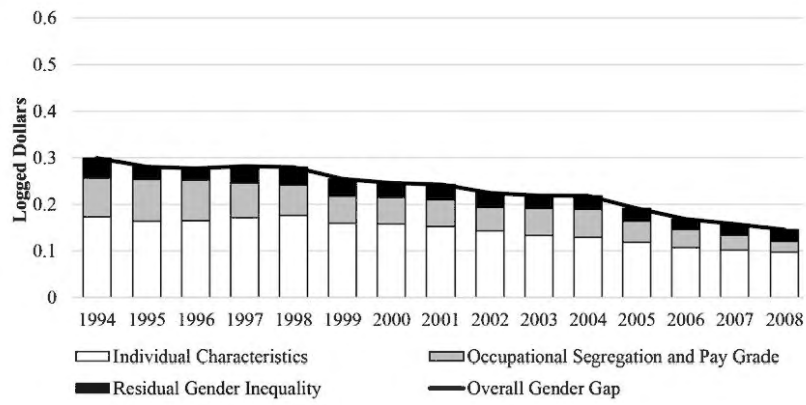

FIG. 11.—Gender pay gap elements: CDC

the share of inequality explained by allocation processes increased at all agencies except DOE. This change seems consistent with federal efforts to reduce the within-job gender pay gap by ranking employees on the basis of credentials, responsibilities, and tenure; these more merit-based criteria explain more of the gender pay inequality over time.

When comparing the male-typed and gender-neutral agencies, differences in the elements that constitute the pay gap become clear. USDA (a gender-neutral type agency) has a larger share of nonscientific workers and employs fewer workers who are not paid according to the grade system; thus, job and pay grade explain more than a third of the gender pay gap at USDA, and within-job inequality is very low. USDA's type of gendered organization seems to be more classically bureaucratic. On average, gender-neutral agencies like

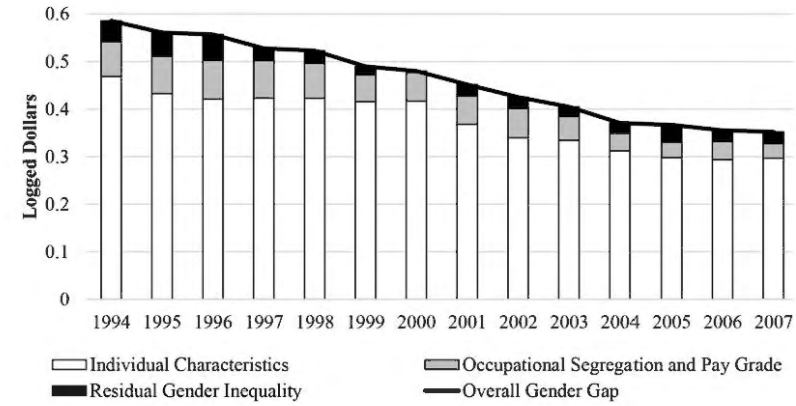

FIG. 12.—Gender pay gap elements: NSF

TABLE 4
SHARE OF PAY GAP EXPLAINED BY EACH PROCESS, BY AGENCY (%)

	1994			2008		
	Individual Characteristics	Occupation and Rank	Within Job	Individual Characteristics	Occupation and Rank	Within Job
Masculine sciences	56.26	35.18	8.56	52.33	18.73	28.94
NOAA	45.44	49.17	5.39	47.46	28.72	23.82
DOE	56.86	33.26	9.87	54.32	26.17	19.51
Gender neutral, life sciences	61.34	20.00	18.66	65.96	13.07	20.97
NIH	63.80	15.85	20.36	65.82	12.87	21.31
CDC	57.92	27.88	14.20	66.87	15.78	17.35
Gender neutral, interdisciplinary	62.40	23.00	14.60	67.67	20.85	11.48
EPA	74.81	15.97	9.22	81.95	13.41	4.64
NSF	80.10	12.41	7.49	84.26	8.68	7.06
USDA	59.25	29.94	10.80	63.45	33.65	2.90

NOTE.—The share of the gap from occupational segregation and rank and the within-job residual appear larger and smaller, respectively, than either of the two agencies that make up the masculine science agency grouping. This is a result of the difference in average pay between the agencies. Because of data limitations, 2007 data replace 2008 data for NSF only.

USDA and EPA have a larger gender pay gap related to education and experience differences, while the pay gaps in physical science agencies like DOE occur within jobs. Within-job gaps mean that for a woman and a man with the same background in the same job with the same pay grade, the man will be paid more. In other words, among U.S. science agencies, those based on physical sciences appear on average to display more direct discrimination within job and pay grade.

As seen in table 5, earnings set outside the GS pay grade scale were consistently associated with higher wages (even net of occupation title). Men were more likely to be paid off grade in every agency in every year, with only one exception.[15] The segregation of workers by gender into payment off grade means that it can become another mechanism producing gender pay inequality. The proportion of off-grade workers at most agencies decreased over time, as did the gender gap in being paid off grade, weakening the gendered effects of the off-grade mechanism overall by 2008. There was quite a bit of variation by agency, however. In 2008 off-grade assignment accounted for a considerable portion of the gender pay gap at NSF (about 48% of the overall gap) and NIH (about 34% of the gap), a moderate portion at USDA (about 21%) and DOE (about 14%), and smaller shares at CDC and EPA. (The exception is NOAA—which had a larger share of women than men off grade in 2008 only—and so women had a small pay advantage on average [.006 logged dollars] in that year.) These findings overall are consistent with a recent evaluation of a program in the Defense Department, in which off-grade employees had higher earnings and women were less likely to be hired off grade (Lewis et al. 2017).

The individual agencies clearly vary in ways not captured by the gender frame of the scientific field. Interdisciplinary and life science agencies do not exhibit equity but rather have a different kind of inequality than the masculine science agencies. Interdisciplinary science agencies like NSF hire women into jobs requiring less education and skill and hire men into more skilled occupations, and as a result of these allocation processes agencies like NSF pay women less on average. In sum, organizational context appears to matter both at the field level (sciences framed as masculine vs. gender neutral) and in the particular gendered organization practices of each agency.

DISCUSSION AND CONCLUSION

Summary of Findings

This article contributes to sociological understanding of the effects of organizational context on gender inequality by examining variation in the composition of the pay gap at seven U.S. science-based government agencies. In the

[15] In 2008 at NOAA, the agency with the smallest share of women (30.83%), more women were paid off grade.

TABLE 5
OFF GS AND ON GS PAY BY GENDER AND AGENCY

	1994					2008				
	Men Off GS (%)	Women Off GS (%)	Off GS Premium	Gender Pay Gap from Off GS Premium (Logged Dollars)	Off GS Share of Total Gap (%)	Men Off GS (%)	Women Off GS (%)	Off GS Premium	Gender Pay Gap from Off GS Premium (Logged Dollars)	Off GS Share of Total Gap (%)
Masculine sciences:										
NOAA	23.64	9.95	.576	.079	27.44	49.60	68.29	.034	−.006	−4.37
DOE	39.82	10.43	.454	.133	34.07	38.36	20.27	.142	.026	13.89
Gender neutral, life sciences:										
NIH	52.44	23.74	.334	.096	42.54	42.83	19.94	.260	.060	34.22
CDC	47.67	17.13	.460	.141	46.97	18.64	11.44	.107	.008	5.29
Gender neutral, interdisciplinary:										
EPA	25.21	12.08	.424	.056	18.36	4.40	2.04	.396	.009	6.45
NSF	63.62	19.59	.574	.253	43.14	61.14	30.23	.546	.169	47.87
USDA	19.49	6.80	.561	.071	27.55	5.74	1.28	.563	.025	21.06

NOTE.—Because of data limitations, 2007 data replace 2008 data for NSF only.

agencies based on the sciences culturally framed as more masculine (physical sciences and engineering) more of the pay gap can be attributed to inequalities within jobs, so that men are paid more than women in the exact same jobs—even women at the same pay grade and with the same individual characteristics. Following the literature, we refer to this pay gap as within-job discrimination. In the agencies based on more gender-neutral sciences—life sciences and interdisciplinary agencies—more of the pay gap can be attributed to differences in individual characteristics, so that men and women of different educational and racial backgrounds are hired into different jobs in the agency in a way that reinforces gender hierarchies but does not produce much within-job discrimination. In addition to the differences between the gender-neutral and masculine science agencies in what explains gender pay gaps, the range of variation at individual agencies is striking. Differences in individual characteristics account for about 84% of the gender pay gap at NSF compared to about 47% at NOAA, while occupational segregation and pay grade account for about 33% of the gender pay gap at USDA compared to less than 9% at NSF.

The very idea that government employment is controlled by neutral, formal structures can make invisible the gendering that results in different inequality mechanisms at the organizational level. Within the U.S. federal system, gaps and differential implementation in current standardization schemes create an opportunity for discrimination by allowing gendering and gender-based bias to infiltrate these systems designed to inhibit or correct for human cognitive error and ensure an objective merit-based system of employment rewards. Our analysis provides potential insights into the effectiveness of current federal employment standardization and transparency measures for reducing various contributors to pay inequality. We expected that federal pay grade would both be standardized across agencies and provide a transparent way that gender equity could be achieved in pay. In practice, however, the use of pay grades was a local option. People not on the pay grade system are able to negotiate much higher pay rates, and the majority of the workers with that flexibility outside of the federal pay grade system are men. What surprised us was the large role of off-grade assignments, which favored men in all agencies over the period, except NOAA after 2000. Off-grade pay practices, we find, are a mechanism for generating gender inequality in the U.S. federal government. In general, pay practices, even formally meritocratic practices, at the organizational level, can hide a hidden gender inequality regime (Acker 2006; Castilla 2008).

Limitations

We rely on the extensive literature on the gendered cultural frames of scientific disciplines (especially within the United States) to operationalize measures of

masculine and gender-neutral organizational contexts in our quantitative study. A more in-depth look at the institutionalization of gendering processes in the various science agencies would be valuable (such as how male leadership in DOE may be shaped by physics norms, while male leaders in USDA take an interdisciplinary approach to agriculture) but is beyond the scope of this article. We hope this initial look at variation encourages further research, including qualitative case studies of science agencies, perhaps using designs similar to Salzinger's (2003) study of four maquiladora plants in the same region of Mexico. Also, as with any study of organizational populations, patterns that we find here may not be replicated in other populations. Because organizations can and do develop their own local flavor of gendered inequality, it suggests that perhaps the goal should not be empirical replication but rather identification of both the general and local mechanisms at play in particular organizations and fields.

Our focus on the organizational level means that we may be missing some individual-level processes. Because we do not have individual person fixed effects, we cannot rule out the argument that women may self-select into low-paying jobs for reasons not related to occupation or observed human capital. The largest threat of this kind might be women's avoidance of long-hour jobs as identified in the work-family literature (Budig and England 2001; Cha and Weeden 2014). However, we limit our models to full-time workers, and because federal government workers have regular work hours (enforced by bureaucratic practices) this explanation is unlikely to be a large source of bias in our estimates. We also do not have a measure for job tenure, although we expect that including pay grade in our models captures it. To the extent that these omitted variables influence estimates, they would be contained in the residual within-job pay gap. These model limitations are problematic for the interpretation of within-job discrimination, yet note that these measurement issues are present for both masculine and gender-neutral agencies and thus less likely to influence between-organization comparisons.

Implications for Future Research: Disciplining Gendered Organization

Does gendered variation in this organizational population provide theoretical insights about inequalities in other organizational contexts? We think that there are clear and important extensions for both the gender and science and more general pay gap literatures. In addition, we propose a conceptual framework that might be extrapolated from the variation we observed in science agencies to predict possible patterns in other organizational settings.

The gender and science literature has a core focus around the gendered culture of disciplinary fields. This literature has not paid much attention to specific organizational practices (but see McIlwee and Robinson 1992; Smith-Doerr 2004), nor has it distinguished clearly between the specific mechanisms,

as opposed to the more general scientific cultures producing gender inequalities. While we find some support for the gender frame version of this type of cultural analysis in terms of residual pay gaps, we also show that gender-neutral science cultures can be highly unequal (e.g., NSF). A focus on mechanisms helps reveal that there are many routes to gender inequality, and some (e.g., differences in the human capital of people hired and paying men off pay grade) may seem formally meritocratic yet install inequalities in more subtle ways than disciplinary cultures imply.

The more general pay gap literature has a much stronger focus on mechanisms but can also be improved by attending to organizational processes. The first contribution in this regard is to expand the menu of plausible mechanisms to include workplace specific pay and other human resource practices. In our study, off-grade pay practices were particularly important, and we see this result as congruent with studies that emphasize organizations' interactional processes (e.g., Salzinger 2003; Smith-Doerr 2004) and human resource practices (Acker 2006; Kalev et al. 2006; Castilla 2008; Abendroth et al. 2017).

The focus on organizational processes and practices contributed by this article leads to a recognition that we should not confine our thinking to national-level pay gaps or trends but also see the potential for substantial organizational-level variation in the levels, trends, and mechanisms producing gender inequalities. A simple, but striking, finding that underlines this point is that the stalled national gender pay gap is fully consistent with a decreasing pay gap in some organizational contexts (here, the federal government). Occupational segregation and off-grade pay plans both weaken over time in these federal science agencies. Because the national trend in the United States shows stagnant pay gaps, it suggests to us that in other organizational contexts there are inequality-enhancing processes generating the stable levels of overall gender inequality. In the private sector, increased between-firm segregation (Ferguson and Koning 2018), the rise of gendered over work and high earnings pay practices (Cha and Weeden 2014), and the increased use of pay for performance (Hanley 2011) seem among the likely candidates for such inequality-enhancing organizational processes.

Looking more specifically at our case, it is clear that a simple field-level gender framing is insufficient to explain our findings. Perhaps a gendered cultural analysis of disciplines is simply too narrow. We think that our empirical findings might be interpreted to suggest two key dimensions of organizational-level variation for these science agencies that are related to different patterns in gender pay gaps. This interpretation is presented in table 6.

One dimension of organizational variation that we examined in this article is how knowledge-based organizations may have a relatively greater focus on a set of disciplinary fields, which in turn are culturally masculine or gender neutral. DOE and NOAA are based in the physical sciences and engineering; NIH and CDC are tied closely to the life sciences. Other organizations have

TABLE 6
Organizational Patterns and Gender Pay Gaps: Dimensions for Further Research

	Hierarchical Logic of Innate Inequalities	Collaborative Logic of Collective Efforts
Disciplinary field focus	Most durable gender gap—job segregation and within-job disparity (DOE, NOAA)	Stable gap within job and human capital, less due to job segregation (NIH, CDC)
Interdisciplinary commitment	Large human capital gap and new hidden inequalities (e.g., off-grade; NSF)	Smallest gap, nearly vanishing within-job gap (USDA, EPA)

a commitment to an interdisciplinary or more generalist approach to scientific fields. USDA and EPA span agricultural, environmental, social, and economic sciences. NSF has recently called for transcending even interdisciplinary approaches to science to a "convergence" approach to knowledge production.

The second key dimension that our data hint at is the tension between individual merit and collective effort. Research has shown that some of the scientific fields for these agencies are more closely tied to assumptions of individual genius or brilliance behind scientific advancement, while others are more associated with effort and teamwork (Leslie et al. 2015). That research found that "genius" assuming fields are more likely to exclude women scientists. At the organizational level, agencies that have a core assumption of individual genius from their field follow a logic of hierarchies—some are innately born to lead. But, agencies with a core assumption of collective rather than individual effort behind scientific advancement follow a relatively more collaborative logic. Physical sciences and engineering were found to focus on individual genius, so we might place DOE and NOAA in this category. NSF we might also place in this category, as it was founded by physicists, and despite its interdisciplinary commitment it still has a focus on genius investigators, with prominent displays at headquarters and on websites of the Nobel Prize winners funded by NSF. The life sciences are more oriented to teamwork, as are agencies with missions to promote health and environment, so we would place NIH, CDC, USDA, and EPA in the more collaborative logic side. If these two dimensions hold water (we are speculating here and fully admit that this proposed framework would need further development and testing in other organizational settings for confirmation), we could see some patterns for how inequalities play out across these two organizational dimensions.

Table 6 displays these patterns. The most durable gender pay gap—where both job segregation and within-job disparities remain—can be found in organizations that are both disciplinary focused and have a hierarchical logic of success (e.g., NOAA, DOE). The organizations that have a hierarchical logic of individual genius but are also committed to interdisciplinarity may develop hidden paths to inequality—recruiting men with more human capital

and making special arrangements to pay them (e.g., off the pay grade system, as at NSF). Job segregation plays less of a role in organizations with a collective effort logic, but organizations with a disciplinary focus may retain a stable gender gap in the within-job and human capital difference (e.g., NIH, CDC). The smallest gender gap—where the within-job disparities nearly disappear—may be found at organizations that are both collectively oriented and interdisciplinary (e.g., USDA, EPA).

The categories in table 6, suggested by our findings, are meant to provoke research and further discussion about organizational variation in gender gaps. A general lesson for organizations is to attend to the cross-classification of gendered cultures and competitive, winner-take-all pay, promotion, and layoff practices versus more collaborative labor processes. Smith-Doerr's (2004) finding that women in the gender-neutral life sciences had better career outcomes in collaborative biotech firms than more hierarchical pharmaceutical and academic workplaces is consistent with this multiple logic interpretation. Kalev's (2009) finding that adoption of team work labor processes reduced gender and racial workplace inequality does as well. More research is needed to expand Acker's (2006) insight that organizations are inequality regimes produced at the nexus of gender and class and potentially raced (see also Ray 2019).

Implications for Gender Theory Summarized

A long-standing debate in the gender stratification literature is whether occupations first increase in the percentage of workers who are female, which then brings down the average pay of those occupations, or whether the average pay of an occupation declines first, and then the occupation has an influx of women workers (Reskin and Roos 1990; England 2010). The "which comes first—feminization or low pay" question about occupations, however, misses the field-level gendered expectations that Ridgeway (2011) brings out in cultural framing theory. She argues that cultural framing theory does better to explain why Whittington and Smith-Doerr (2008) find positive outcomes for women in biotech while McIlwee and Robinson (1992) see negative outcomes for women in computing. A focus on numbers or percentages of women misses the status expectations and appropriate work aspects of fields as masculine or gender neutral. We notice that the focus on organizations and organizational-level processes, however, is not engaged in cultural framing theory. What is needed is a focus on gendered organization (Acker 1990) that attends to variation (Britton 2000; Salzinger 2003) and the framing of fields at the same time. Our theoretical approach in this article advances the cultural framing argument to engage with the organizational level and addresses the lack of variation designed into most studies of gendered organization. The significant contribution of this approach can be seen, for example,

in demonstrating the need for new research on how interdisciplinary organizations (more generalist organizations) differ from specializing disciplinary organizations and how these variations in organizations intersect with gendered organization and definitions of appropriate labor. We find that the most equitable kinds of organizations are interdisciplinary and also may be gender neutral in defining expertise by a greater focus on collective hard work than on innate genius. An important area for further research beyond the scope of this article (perhaps from an organizational ecology approach) is the relationship between gendered organization, field generalism/specialism, and equity.

Implications for Policy

Gender pay gaps are usually constructed as an individual-level problem, and solutions follow from that diagnosis. Most equal pay laws rely on individuals to identify discrepancies and seek redress. Our findings add to a body of research that suggests an individual-level approach can, at best, only partially eliminate inequities.

Implications for personnel management.—Our research suggests that the federal personnel system has been effective in reducing within-job pay gaps. The federal system is less effective, however, in dealing with gender disparities in who gets hired. It is important to understand how organizational gendering interacts with current employment systems to more or less effectively address inequalities due to (1) hiring patterns by human capital; (2) occupational segregation, pay, and other human resource practices; or (3) face-to-face discrimination. Our analysis suggests that organizations need to look carefully at all policies and processes and their implementation.

Gaps due to organizations sorting men and women with equal human capital into different jobs with different pay should be understood as related to the gendered nature of the organization, not just a function of individual choice. Hiring men and women with differences in average education defines a gendered "appropriate" worker for specific tasks. The significance of human capital factors in pay gaps at the organizational level (despite convergence in relative education, experience, and tenure for women and men) suggests that variation between organizations in who gets hired for what is an important but underexamined inequality-generating mechanism.

Another lesson is that policies that appear meritocratic may fail in practice. Castilla and Benard (2010) find a paradox in meritocracies that may help explain some of the ongoing within-job disparities we reveal in masculine-type federal science agencies. They find that when organizations are explicitly presented as meritocratic, individuals in managerial positions favor a man over an equally qualified woman with higher remuneration. The paradox is that meritocracy should mean that everyone has an equal chance to receive

rewards on the basis of his or her individual merits. Other studies on cognitive bias have similarly found that in contexts in which people feel they are unbiased or objective, they are actually more likely to behave in biased ways (Monin and Miller 2001; Crandall and Eshleman 2003). To the extent that managers believe the standardized federal personnel system prevents bias, the paradox of meritocracy may be contributing to the within-job disparities our analysis reveals.

Tournament theory also illuminates potential mechanisms at work within the science agencies. Castagnetti and Rosti (2013) find that environments where gender stereotypes are more prevalent are more likely to stage unfair "occupational tournaments." The pay grade system as currently constructed provides at least two opportunities to introduce an unfair tournament or competition for wages. As employees enter the system or are promoted, the assignment of pay grade may include gendered assessments of past productivity and experience. Hiring or promoting using a salary level off pay grade is another mechanism that introduces greater potential subjectivity and unfairness. Past research on merit-based review and diversity policies shows that they often lead to no change or even higher gender inequalities (Kalev et al. 2006; Castilla 2008; Abendroth et al. 2017). Our results for off-pay grade assignments underline prior observations that human resource formalization is not a mechanical equalizing process and can introduce new inequality mechanisms (Acker 2006; Tilly 2009). Our organizational approach, in which we find complex interactions between field-level cultures and local practices, suggests that gender inequities cannot be challenged simply with formal policies. The inherent complexity of organizations as inhabited institutions (Hallett and Ventresca 2006) requires monitoring of the policies meant to increase equity.

Implications for public policy.—Nationally, gender pay gaps stopped converging around 1994 (England 2010) and slowed down in the public sector after 2000 (Mandel and Semyonov 2014), and racial inequalities in the public sector have been rising since the 1980s (Wilson et al. 2013). All of these previous findings, however, are based on analyses with no information on specific organizational contexts. In addition to the organizational variation discussed in this article, we find a consistent decline in the gender pay gap across the federal science agencies. We also find the effects of segregation processes are much smaller than in the literature, suggesting that the sorting of people into jobs in science agencies is closely tied to human capital. Thus, as a group, science agencies display trends that may be different from nonfederal workplaces. We also expect there is more variation across agencies within the federal government still to be discovered. While our organizational research is restricted to federal science agencies, our findings support an argument for the value of similar analyses for other organizations interested in understanding and addressing inequities.

Previous research shows that formal personnel policies must be accompanied by transparency and managerial accountability to be effective (Dobbin 2009; Tetlock and Mitchell 2009; Castilla and Bernard 2010; Bergsteiner 2012; Castilla 2015). These studies and others suggest that periodic evaluation of pay gaps (transparency) and their causes at the organization level hold promise and should be adopted for routine use in private and public organizations.

Current accountability mechanisms do not deal adequately with the organizational level, although there are bright spots. Some states like Minnesota now require equal pay analysis at the organizational level for government and contractors. A federal executive order during the Obama administration proposed the same for private sector employers subject to federal Equal Employment Opportunity Commission reporting. These approaches recognize that organization-level analysis and legal accountability are necessary steps to realize equal pay. Lack of access to organization-level pay data has limited the analysis of pay for comparable men and women workers at and across organizations. The collection of private sector pay data to hold firms accountable for compliance with equal pay laws could help address this data deficiency.

Our results demonstrate the importance of expanding the notion of employment discrimination beyond the residual after human capital and segregation are statistically controlled. While courts may require residual disparity as evidence of pay discrimination, social scientists can bring an organizational focus to policy discussions. Some bias is the result of unequal treatment in the same context, some is the sorting of people into employment with higher and lower rewards, and some is the gendered patterns in the skill level of hired employees. All of these outcomes are decisions primarily controlled by employers. By studying how organizations as a whole are gendered, research can contribute to more effective solutions.

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