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Representative bureaucracy in challenging environments: Gender representation, education, and India

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ABSTRACT

A bureaucracy representative of disadvantaged groups in a society has been linked to better outcomes for those groups in a wide variety of policy areas. Most of the empirical work identifying this link has used United States data, a highly conducive case for representation. Would the same relationship be seen in more challenging organizational and environmental contexts? Using the K-12 education context in India as a proxy for a challenging environment, this article examines how and when gender representation in K-12 schools leads to enhanced outcomes. We find a modest relationship between the presence of female teachers in a school and the academic outcomes of female students. Contextual factors both within the organization (more class days, longer teacher hours, and a smaller student to teacher ratio) and related to the external environment (infrastructure, rural location) enhance this association between teacher gender and student performance.

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Years of empirical analysis on representative bureaucracy has established that bureaucratic institutions representative of minority groups can positively affect policy outcomes for those groups under certain conditions, especially in the policy areas of education, child protection, and law enforcement (Favero and Molina 2018; Grissom, Kern, and Rodriguez 2015; Hong 2017; Riccucci and Meyers 2004). Research has explored the various pathways through which bureaucratic representation generates positive outcomes and has probed the conditions required for representation to affect outcomes. Studies have also covered various salient demographic characteristics, bureaucratic levels, and governmental agencies (see Bishu and Kennedy 2020; Kennedy 2014). Recent work has, further, attempted to differentiate between and identify the relevance of both individual-level and organizational-level representation (see Meier and Nicholson-Crotty 2006; Nicholson-Crotty et al. 2016; Favero and Molina 2018; Vinopal 2018). Most studies have, however, focused on bureaucracies in the US or Western European contexts (but see Agyapong 2018; Song 2018; Zhang 2019) and on individual-level conditions affecting the representation-outcome relationship.

The inadequate understanding of how different national contexts and administrative regimes affect the representative bureaucracy theory severely limits its generalizability beyond the 'western' world. A narrow contextual focus also means that the full range of organizational and environmental conditions needed for representation to lead to more responsive policy outcomes has not been adequately explored. Theoretically important organizational variables for bureaucratic action

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could include access to basic infrastructure, physical resources, organizational training, time for bureaucrats to adequately perform critical aspects of their role, and how embedded those societal norms are that exacerbate disadvantages for minority groups in a particular society. Given these gaps in the literature, this article addresses the research question, *how does representation at the organizational level affect policy outcomes and what environmental factors moderate this relationship in a non-western context?*

Our investigation brings three innovations to the study of representative bureaucracy. First, we expand the study of representation effects at the organizational level by testing various direct and indirect organizational factors that can theoretically facilitate or limit representative bureaucracy. Specifically, by focusing on both factors that will directly affect the work of the bureaucrat (such as task demands) and more indirect environmental constraints, we seek to discern the internal and external conditions needed (beyond values, attitudes or beliefs) for representing bureaucrats to have a positive effect on the needs of their represented group. Second, by studying a context that features far more variation in task demands and resources than existing studies, we investigate representative bureaucracy in environments inhospitable to representation. Third, our study contributes to a nascent but growing body of research that tests representative bureaucracy theory in national contexts beyond the US or Western Europe and does so with the largest number of organizations ever studied (300,000 schools). We achieve this by conducting an analysis of gender representation in K-12 schools in India to identify how and when a female teacher in India might enhance the academic outcomes of female students.

The article begins with a review of representative bureaucracy theory and key gaps in the literature. We then outline our theoretical framework and hypotheses to test how extensive variation in organizational conditions and environmental factors moderate the relationship between passive representation and outcomes. This is followed by a summary of the Indian bureaucratic context, including the salience of gender as an identity and India's K-12 educational system. The contextual variation in Indian schools, in areas such as task difficulty and resources among others, extends representative bureaucracy theory into environments very different from those previously studied. After discussing the data and methodology, we review the findings and identify various factors that either enhance or dampen the policy effects of gender representation in Indian K-12 schools. We end with proposing future directions for research to adequately test the conditions under which representative bureaucracy theory will hold in practice.

Representative bureaucracy

Representative bureaucracy theory states that bureaucrats' origins and backgrounds shape their values and actions, which in turn influences their bureaucratic decision-making. The theory further differentiates between passive representation, or the degree to which individuals in a bureaucracy mirror the entire population they serve, and active representation, which is when individual bureaucrats advocate for the interests of the population they represent, potentially leading to improved outcomes for this represented group (Mosher 1982; Selden 1997; Meier 2019). After the initial descriptive analyses of passive representation in bureaucratic institutions, empirical work focused on exploring the link and various pathways between passive and active representation. This includes theorizing about and testing the presence of symbolic representation, identifying the conditions under which passive representation leads to positive policy outcomes, and studying representation under different policy contexts as well as for different salient identities.

Passive representation has been found to lead to active representation when the bureaucrat represents the interests of the client and takes actions that benefit the individual client (Nicholson-Crotty et al. 2016), when the bureaucrat advocates for changes in organization policies that benefit the represented group (Roch, Pitts and Navarro 2010), and through contagion effects where the presence of the minority bureaucrat changes the behavior of other bureaucrats, which benefits minority clientele (Atkins and Wilkins 2013). Subsequent literature separately identifies

symbolic representation to occur when passive representation changes the attitudes or behaviors of individuals who are represented, thereby enhancing outcomes independent of any bureaucrat's action (Riccucci, Van Ryzin, and Lavena 2014; Riccucci, Van Ryzin, and Jackson 2018; Theobald and Haider-Markel 2008). Symbolic representation may occur when a bureaucrat serves as an aspirational role model for the target group that identifies with them, and alters their behavior (Atkins and Wilkins 2013). It could also occur by providing a signal that the target group's interests will be given consideration (Vinopal 2018; Riccucci, Van Ryzin, and Jackson 2018; Theobald and Haider-Markel 2008).

In terms of the conditions under which passive representation leads to improved outcomes, a shared value set between the bureaucrat and represented group (Meier 1975), the amount of discretion possessed by bureaucrats (Keiser et al. 2002), the salience of the policy area to the shared demographic trait (Wilkins and Keiser 2004), and the ability of bureaucrats to influence the actions of their colleagues/organization (Atkins and Wilkins 2013) are identified as necessary aspects of the working environment (for comprehensive reviews see Bishu and Kennedy 2020; Kennedy 2014). The literature also distinguishes between individual-level representation and organizational-level representation; the latter is the effect of an aggregate level of representation on outcomes (Vinopal 2018). Studies find evidence of an organizational-level representation effect that is separate from the individual effects. This possibly captures contagion effects of minority bureuacracts influencing the actions of majority bureaucracts as well as the influence of overall organizational policies (Favero and Molina 2018; Vinopal 2018).

After an early focus on race and ethnicity, research on gender representation began gaining momentum in the 2000s (Keiser et al. 2002; Riccucci and Meyers 2004). Riccucci and Meyers (2004) identify the role of institutional bureaucratic contexts, and whether the policy area is gendered, for gender representation to take place. Their study (and others) find active representation for women in a variety of contexts from K-12 education (Keiser et al. 2002; Dee 2005; Stearns et al. 2016; Song 2018) to child welfare (Riccucci and Meyers 2004; Wilkins and Keiser 2004) to law enforcement (Andrews and Miller 2013; Riccucci, Van Ryzin, and Lavena 2014) and even job counseling (Guul 2018).

As for policy contexts, many representative bureaucracy studies focus on education because the interaction between teachers as street-level bureaucrats and students as beneficiaries is an apt setting to test the aforementioned conditions. First, various identities could be considered salient in the educational context, including gender, race/ethnicity, and religion. Second, discretionary authority is a key aspect of teaching, and rules or supervision can only dampen it to a limited extent. Third, teachers can have a powerful "role model" effect based on the lengthy interaction time they have with students. Finally, in certain contexts teachers can also influence curriculum and pedagogy changes as well as the actions of other teachers via formal and informal interactions (see Atkins and Wilkins 2013). Related research finds that passive representation leads to improved educational outcomes both when race and ethnicity are salient (Grissom, Nicholson-Crotty, and Nicholson-Crotty 2009; Morton 2015; Nicholson-Crotty et al. 2016; Pitts 2007; Roch and Edwards 2017), and when gender is salient (Dee 2005; Keiser et al. 2002; Stearns et al. 2016).

Despite the continued focus on studying the effects of representation, we have a limited understanding of representation in national contexts beyond the western world and of the moderating effect of organizational or environmental conditions. An emerging body of work investigates representation, especially gender representation in the educational context, of non-western countries. (Agyapong 2018; Song 2018; Zhang 2019). These three studies find that passive representation is associated with better test scores of female students, with the role model effect (Agyapong 2018) and the amount of teacher discretion (Song 2018) influencing the strength of this improvement. The country contexts of China, South Korea, and Ghana that the studies deal with, however, only cover some variations in bureaucratic influence, organizational structure, and political institution setup. Further studies on representation in other national contexts will, therefore, contribute to

the generalizability of representative bureaucracy theory. There is also a gap in our knowledge of how environmental or organizational conditions moderate representation effects. To date, conditions such as hierarchy (Keiser et al. 2002) and span of control (Meier and Bohte 2001) have been found to influence the link between passive representation and outcomes. Research has yet to explore the relevance of other variables, both directly linked to the work of the bureaucrat (task difficulty, for example) or indirectly affecting their working environment (like resource availability, training quality, and workplace location).

Theory and context

In this study, we test the moderating influence of organizational contexts on the relationship between passive gender representation and education outcomes in K-12 schools in India. Although substantial research has linked female teachers to better outcomes for female students, these studies have not been able to identify the organizational contexts that either directly or indirectly facilitate or restrict representation. Here, we refer to direct variables as those that deal with the actual process of teaching and indirect as those that concerns the environment surrounding the bureaucrat. Factors that could directly affect the work of a teacher and are relevant to the study of representation include the level of task difficulty experienced by the teacher, the training and socialization they undergo, and the amount of peer and supervisory support, among others. Factors that could affect the work environment in schools include basic infrastructure and other physical resources as well as the level of discrimination or inequality experienced by the minority group, among others. For the purposes of this study, we will focus on task difficulty as a key factor that may directly affect a teacher's work. Additionally, we focus on school infrastructure and geographic location to examine the influence of the work environment on representation.

Representative bureaucracy theory suggests that as direct organizational factors become more favorable or as the basic job burdens decline, the bureaucrat has more freedom and opportunities to act as a representative (Meier 2019). Lower levels of task difficulty would, therefore, allow teachers to actively represent by making additional efforts beyond their job to encourage the represented students or by better understanding their needs. This suggests that active representation is more likely, and thus the relationship between female teachers and female student performance will be enhanced, when teachers' task difficulty is low. For a teacher, a low level of task difficulty could mean a favorable student teacher ratio, an appropriate number of working hours to adequately perform the job, or an appropriate number of school days to give teachers enough time to make the additional efforts needed to enhance representative effects. In short, passive representation should show a larger association with outcomes when task difficulty is low.

Here, we intend to distinguish between a lack of time to adequately represent (as captured by measures of task difficulty such as number of working hours or school days) from a lack of teacher discretion to operate, which has been shown to restrict representation effects (Meier and Bohte 2001; Marvel and Resh 2015). We argue that motivation is a key differentiating factor between how lack of time and lack of discretion would relate to representation effects. Discretion can be thought of as a pre-condition to representation, whereas a lack of time acts as an enhancer/dampener. In our argument, therefore, we assume that teachers are able to approach their tasks with a certain level of discretion, given the nature of their job and the implausibility of around-the-clock supervision. Task difficulty, however, could influence any potential representation effects because it permits or constrains the free time and discretion that teachers have to actively represent.[1]

The infrastructure of the school and the area where it is located can be considered as factors external to the teacher–student relationship. While they may create a more conducive environment for when teachers want to act as a representative, they may not have any effect on

representation if teachers do not want to make an additional effort. On the flip side, unfavorable environmental conditions may make active representation difficult or impossible and will have an even stronger negative effect when teachers do not want to act as representatives. The geographic location of a school may also suggest other characteristics of the external environment such as serving a population that is impoverished and isolated from potential opportunities to change. Limited access to resources in such isolated communities may exacerbate the problem of income inequalities. In such situations, where there are few prospects for students and even fewer for female students, teachers may be discouraged from representation and may not even be able to serve as a role model. Representation, either active or symbolic, is likely to be limited.

The empirical case

The vast gender disparities and the organizational complexity of the K-12 education system in India make it an ideal case to test our theoretical expositions. India currently ranks 127 of 160 countries on UNDP's 2018 Gender Inequality Index, with the gender gap starting early in life as shown by the skewed sex ratio in the country (Das Gupta and Mari Bhat 1997; United Nations Development Programme 2018). The ratio of 933 females per thousand males in India (Office of the Registrar General & Census Commissioner 2011), as one example, contrasts with a ratio of 1034 females per thousand males in the US (Howden and Meyer 2011). Further, infant boys receive more time and better-quality childcare, including being breastfed for longer and being given more vitamin supplements (Barcellos, Carvalho, and Lleras-Muney 2014). The gap continues into adult-related outcomes with a 16 percentage point difference between the literacy rates of men and women (Office of the Registrar General & Census Commissioner 2011). Men are three times more likely than women to be part of the labor force, one of the largest disparities noted across countries. Biased attitudes are also common, with women enjoying little freedom of choice or control over their life and parents exhibiting a strong preference for male children (Jayachandran 2015).

The disparities are also apparent in educational outcomes with female students found to underperform male students in reading and math (White et al. 2016). Also, while the enrollment of girls in primary school has improved, they are less likely than boys to continue education post eighth grade (Ministry of Human Resource Development 2018). To combat the gender gap, the Indian Government has launched many policy initiatives including financial aid for female students, making education until 8th grade compulsory for all children, and making schools more accessible.[2] This highlights gender as a salient identity for education policymaking and representation in India.

The Indian education system is also organizationally complex. Around 1.5 million schools offer education services in one or more of the following grade-level groupings: pre-primary, primary (grades 1-5), upper primary (grades 6-8), secondary (grades 9-10), and higher secondary (grades 11-12). They also offer instruction in 31 different languages (Meghanathan 2011). Education policymaking and implementation is jointly shared by the central and state governments, with the central government in charge of policymaking at the macro level and each state modifying the policy to offer different curricula and board examinations, as well as different levels of quotas and reservations for minority groups.[3] Schools also experience teacher shortages with nearly one million posts lying vacant as of 2017 (Singh 2017).

In terms of management, despite a recent boom in privately run schools, 73% of schools are government-run and charge no fees. More importantly, private schools are skewed toward serving urban areas, where only 20% of the schools are located. They also mainly serve the primary grades and charge a wide range of annual fees (National University of Educational Planning and Administration 2016). After controlling for the background characteristics for children, studies also find no discernable difference in performance between private low-fee and government

schools (see Anderson and Lightfoot, 2019). School choice for most of the Indian population is limited, and this limitation is exacerbated by location (rural vs. urban areas) and by parental income (see Appendix A).

For teachers, the translation of representation to positive outcomes may be more limited for three reasons. First, teachers are assigned many non-education functions that limit their teaching time. A typical government-school teacher is expected to keep student records for all the government programs any student is enrolled in, staff election booths, conduct census surveys, make home truancy visits, and aid in the implementation of various child-related policies (Vernekar and Singhal 2018). Second, India is a highly heterogeneous country with various salient identity groups based on caste, religion, income, language, and region. Female students, therefore, face varying levels of disadvantage based on how they align with these different identities; and these differences may also affect teacher actions. Lastly, there is a gap between legislative policy and implementation at the local level. The Indian educational environment is resource poor and subject to massive variation across the country, providing little leverage for teachers seeking to improve the education of girls. We might, therefore, find limited organization-level representative effects in K-12 schools in India.

The variation in factors directly affecting the work and work environment of teachers, however, allows us to empirically test our theoretical framework. Unlike situations in the US where task difficulty varies but within modest limits, the task difficulty of Indian teachers can be extreme. The instructional year across schools ranges from 30 days a year to 250 days, and teacher working hours range from two to twelve per day. Similarly, while the mean student-teacher ratio is 28 (compared to approximately 12–15 in the US), it rises above 100 in many schools (see tables in Appendix B for summary statistics). Logically, a teacher has more opportunities for active representation in a school with a student teacher ratio of 28 or less and when a school has more instructional days/working hours, than when student teacher ratios are massive, and schools meet infrequently. The first operational hypothesis, therefore, is that *passive representation will have a stronger association with student outcomes when student to teacher ratios in a school are lower, when teacher working hours are higher, and when schools meet for more class days.*

The environmental context of Indian schools might also provide situations where active representation is difficult or impossible. Indian schools vary dramatically in resources particularly when infrastructure is considered. Some schools in India lack basics such as a library, electricity, running water, or even a school building. This lack of infrastructure may dampen the ability of teachers to adequately support students, further limiting any representative effects. The urban-rural divide in India is another important environmental context that can be held as a proxy for the environment beyond the school. Schools in rural areas, on average, have inferior physical infrastructure (see Appendix B) and the added barrier of serving a population that is poorer and has access to fewer resources beyond the school (see Ghosh 2017). Additionally, rural areas experience higher women's illiteracy rates, more child marriages, and more violence toward women (Brahmapurkar 2017). The rural location of schools can therefore be used as a proxy for a more difficult external environment for teachers to actively represent for students. The second operational hypothesis linked to representation, then, is that *passive representation will have a weaker association with educational outcomes when schools have poorer infrastructure, and when the schools are in rural areas.*

Data and method

To test our hypotheses, we created a school-level dataset using the Unified District Information System for Education (U-DISE) that was developed by the Ministry of Human Resource Development, Government of India. The U-DISE annually collects data from all recognized (and many unrecognized) schools in the country, covering infrastructure facilities, location, funding, management, number of students and teachers, demographic make-up, dropout rates, and end-of-year examination performance. The most comprehensive database available on K-12 education

in India that is periodically updated, it currently includes information on 1.5 million schools from 2005 to 2017. The data are submitted by school principals to specialized staff at the district level, and two levels of consistency checks are conducted before being uploaded to the information system (National University of Educational Planning and Administration 2019). Permission to access the data was sought via an online application to the National Institute of Education Planning and Administration that currently maintains the database. Given the incomplete nature of the dataset in the earlier years and systematic missingness of key variables in some of the later years, this study uses data from academic years 2014–15 to 2017–18.

Independent variables

To measure passive gender representation among the teaching staff, we computed the percentage of female teachers in the school. Post 4th grade, students interact with most teachers in their school through subject teaching, extra-curricular, and co-curricular activities. The variable will therefore measure the organization-wide representation of female teachers across the school (see Favero and Molina 2018 for organizational effects of representation) and is complemented by dependent variables that measure overall academic performance (as explained below). Despite the gender-skewed national labor pool in the country, on average 41% of teachers in the dataset are female.

To measure the potential for active representation, we use three task difficulty variables as proxies for internal context: the total number of class days, the number of hours teachers work in a day, and the ratio of students to teachers in the school. To assess the external contexts that might limit representation, we use two environmental factors as variables. First, we include a school-level infrastructure index which is a factor score (eigenvalue 1.6) that measures basic facilities available to students and teachers including computer labs, a library, playgrounds, and electricity[4]. Low scores indicate few resources. Second, we include a binary variable that denotes whether or not the school is located in a rural area of the country.

Dependent variable

To measure academic achievement, we used the percentage of female students scoring more than 60% in the eighth-grade end of year examination. In the Indian education system, the eighth grade is considered a gateway grade after which students either drop-out or decide to continue their education by entering secondary school. While the U-DISE dataset has information on both the number of students who pass and those that score 60%+, disaggregated by gender, we focus on the latter measure of academic success. We do so because the eighth-grade examinations are not standardized, and grading is at the discretion of the school's teachers. This may lead teachers to pass most students to the next grade unless there is a grave reason not to. The dataset confirms this, with a mean pass percentage of about 90% for the examinations. Scoring 60% or above, however, allows teachers to communicate academic progress and future academic success in the crucial secondary school examinations. This measure of academic success has more variation and hence it is the preferable dependent variable (the percentage of female students scoring 60%+ of the total number that appeared). The data show that, on average, 62% female students perform well in the grade 8 exams with considerable variation across schools and years All variable descriptions and summary statistics can be found in Appendix Table B1.

Control variables

We included three sets of controls – student, teachers, and school management/infrastructure characteristics – to test whether the gender representation relationship was spurious. First, we included a Herfindahl index measuring the caste-related diversity of the student population in

each school. Research has found that diversity in student population negatively affects academic achievement outcomes although studies have not yet covered the Indian context (Bankston and Caldas 1996). Moreover, the caste system in India has caused historical disadvantages for various groups of people in terms of educational attainment, income levels and other socio-economic indicators (Borooah 2005; Dunn 1993). Second, we controlled for the educational qualifications of teachers, as it could suggest having better teaching skills, which in turn could positively affect academic outcomes.

Lastly, we included whether the school is government run or privately run, whether the medium of instruction is English, a constructed school quality index, and the school sex ratio, calculated as the ratio of female students to male students. Government schools do not charge students any fees for attendance, providing an indication of the socio-economic status of students and their parents. English medium schools are used as a proxy for socio-economic status and better access to education services. The school quality index—calculated to provide for the existence of a school management committee, school development plan, textbook provision, and special student training—is included to capture the overall quality of the school's management/governance that could affect the academic scores of students[5]. The sex ratio is included to provide for any gender disparities in the student population that could have representation effects on the students.

Method

To test our hypotheses, we used pooled ordinary least squares (OLS) models with time fixed effects to control for any idiosyncratic events and robust standard to account for heteroskedasticity. First, we identified the linear relationship between female teacher composition in the school and the proportion of female students scoring well in their grade 8 examination. We also estimated the relationship with a quadratic term for female teacher composition and with a lagged measure of performance (Table 1). The quadratic term provides a nonlinear estimation to test for the diminishing influence of female teachers when they form a higher proportion of the school's teachers. The lagged dependent variable measure provides for time-invariant unobservable effects on the relationship and helps test for the path dependency of performance.

The moderating effects of task difficulty and work environment were tested by adding interaction terms for each of the contextual variables and calculating the marginal changes in the relationship (Tables 2 and 3). Given the dependent variable measure, only those schools with eighth grade classes in the 2014–18 time period were included as observations, leading to an n of approximately 1.3 million, that is, around 300,000 schools per year. We also encountered some unrealistic outliers when new variables were generated (e.g. percentage values higher than 100). The dataset was therefore cleaned to only include percentage values between 1 and 100 and variable values that fell within four standard deviations of the mean. For any given variable, this did not lead to a drop of more than 3% of the observations.

Results and discussion

Table 1 presents the results of the pooled OLS regression without any interaction terms. Model 1 in the table shows that a one percentage point increase in female teachers is associated with an increase of 0.08 percentage points in female students scoring 60% or better on the exam, a relatively small marginal effect. Model 2, with the lagged dependent variable, illustrates two additional findings of note regarding the autoregressive nature of female student performance. First, even controlling for the previous level of student performance, the relationship remains strongly significant. Second, the size of the relationship drops as is to be expected (0.048), but this should be interpreted as the first-year effect based on the lagged estimation. If one calculates the total

Table 1. Pooled OLS regression analysis with time fixed effects.Dependent Variable: % female students scoring 60%+ in eighth grade exam

Variables	(1) Linear	(2) Lagged DV	(3) Quadratic
Female teachers (%)	0.08	0.05	0.18
	(0.001)***	(0.001)***	(0.003)***
Lag DV: female students scoring 60%+ (%)		0.40	
		(0.001)***	
Squared % female teacher			−0.001
			(0.00003)***
Student teacher ratio	−0.13	−0.09	−0.13
	(0.002)***	(0.002)***	(0.001)***
Teacher work hours (per day)	5.98	3.79	5.96
	(0.037)***	(0.045)***	(0.037)***
Instructional days (per year)	0.10	0.09	0.09
	(0.002)***	(0.003)***	(0.002)***
English medium school	0.42	1.04	0.56
	(0.099)***	(0.127)***	(0.099)***
Caste Herfindahl Index	5.71	3.55	5.89
	(0.141)***	(0.170)***	(0.141)***
Infrastructure index	4.60	3.05	4.48
	(0.033)***	(0.039)***	(0.033)***
School quality index	−1.42	−0.40	−1.39
	(0.045)***	(0.056)***	(0.045)***
Rural school	0.15	0.37	−0.03
	(0.085)**	(0.102)***	(0.083)
Government school	−14.97	−9.38	−15.12
	(0.095)***	(0.118)***	(0.095)***
Teachers with graduate degrees (%)	−0.13	−0.08	−0.13
	(0.001)***	(0.001)***	(0.001)***
Teachers with teaching qualification (%)	0.16	0.10	0.17
	(0.001)***	(0.002)***	(0.001)***
School sex ratio	−0.02	−0.02	−0.02
	(0.002)***	(0.002)***	(0.002)***
Academic year 2015–16	−2.05		−2.08
	(0.079)***		(0.079)***
Academic year 2016–17	−0.82	1.84	−0.83
	(0.079)***	(0.082)***	(0.079)***
Academic year 2017–18	−0.49	2.46	−0.55
	(0.082)***	(0.088)***	(0.083)***
Constant	1.06	−9.53	0.32
	(0.627)***	(0.775)***	(0.627)
Observations	1,338,391	759,248	1,338,391
R-squared	0.138	0.283	0.139

Robust standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

effect using the Koyck lag approximation (0.048/(1–0.4)), the total impact over time is 0.08 or virtually the same as the linear estimation.

Model 3 provides a nonlinear estimation of female teacher influence, and the squared term is significant and negative indicating a nonlinear relationship. Taking the first derivative of this equation and setting it equal to zero, however, indicates that the relationship between female teachers and female test scores reaches its maximum when 87.5% of teachers are female. While the data contain schools with more than 87.5% female teachers, the number of schools is relatively few and might simply reflect diminishing returns. Graphing this relationship suggests that the tapering off of the influence is very gradual and female teachers almost always contribute positively to female students' academic scores (refer to appendix C for graphs of the linear and non-linear relationships).

The effect of female teachers, however, is not the only or even the strongest determinant of female student test scores, which also reflect the quantity of instruction, school infrastructure, the school type, and economic conditions. Since the modeling effort focused on trying to account for

Table 2. Results of interactions with measures of task difficulty.Dependent Variable: % female students scoring 60%+ in eighth grade exam

Variables	(1) Instructional days	(2) Teacher work hours	(3) Student teacher ratio	(4) Additive index
Female teachers (%)	−0.06	0.07	0.09	−0.21
	(0.016)***	(0.008)***	(0.002)***	(0.013)***
Female teachers × Instructional days	0.0006			
	(0.00007)***			
Female teachers × Teacher work hrs		0.001		
		(0.001)		
Female teachers × Student teacher ratio			−0.0003	
			(0.00004)***	
Female teachers × additive index				0.13
				(0.006)***
Student teacher ratio	−0.13	−0.13	−0.12	
	(0.002)***	(0.002)***	(0.002)***	
Teacher work hours (per day)	5.99	5.93	5.97	
	(0.037)***	(0.068)***	(0.037)***	
Instructional days (per year)	0.08	0.10	0.10	
	(0.004)***	(0.002)***	(0.002)***	
English medium school	0.43	0.42	0.43	0.72
	(0.099)***	(0.099)***	(0.099)***	(0.098)***
Caste Herfindahl Index	5.74	5.71	5.72	5.57
	(0.141)***	(0.141)***	(0.141)***	(0.141)***
Infrastructure index	4.61	4.60	4.59	4.57
	(0.033)***	(0.033)***	(0.033)***	(0.033)***
School quality index	−1.39	−1.42	−1.41	−0.92
	(0.045)***	(0.045)***	(0.045)***	(0.045)***
Rural school	0.15	0.15	0.14	0.13
	(0.183)*	(0.083)*	(0.083)*	(0.083)
Government school	−15.01	−14.97	−14.98	−15.48
	(0.095)***	(0.095)***	(0.095)***	(0.095)***
Teachers with graduate degrees (%)	−0.13	−0.13	−0.13	−0.13
	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Teachers with teaching qualification (%)	0.17	0.17	0.17	0.18
	(0.001)***	(0.001)***	(0.001)***	(0.001)***
School sex ratio	−0.02	−0.02	−0.02	−0.03
	(0.002)***	(0.002)***	(0.002)***	(0.002)***
Additive index				23.23
				(0.291)***
Academic year 2015-16	−2.06	−2.05	−2.05	−1.72
	(0.079)***	(0.079)***	(0.079)***	(0.079)***
Academic year 2016-17	−0.83	−0.82	−0.81	−0.61
	(0.079)***	(0.079)***	(0.079)***	(0.079)***
Academic year 2017-18	−0.49	−0.49	−0.49	−0.72
	(0.083)***	(0.083)***	(0.083)***	(0.083)***
Constant	6.39	1.39	0.63	7.00
	(0.912)***	(0.713)*	(0.629)	(0.657)***
Observations	1,338,391	1,338,391	1,338,391	1,338,391
R-squared	0.138	0.138	0.138	0.132

Robust standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

as many factors as possible to ensure the gender relationship was not spurious, we will not spend time in interpreting the coefficients for the control variables but rather focus on the representation relationships.

As noted above, the theoretical advantage of the Indian case for studying representative bureaucracy is the extensive contextual variation. This allows for greater precision in specifying situations and variables that can facilitate or hinder representation. Our first hypothesis concerns the task demands on the teacher and cases where the internal organizational context (i.e., task demands or resources) are such that teachers might perceive that active representation

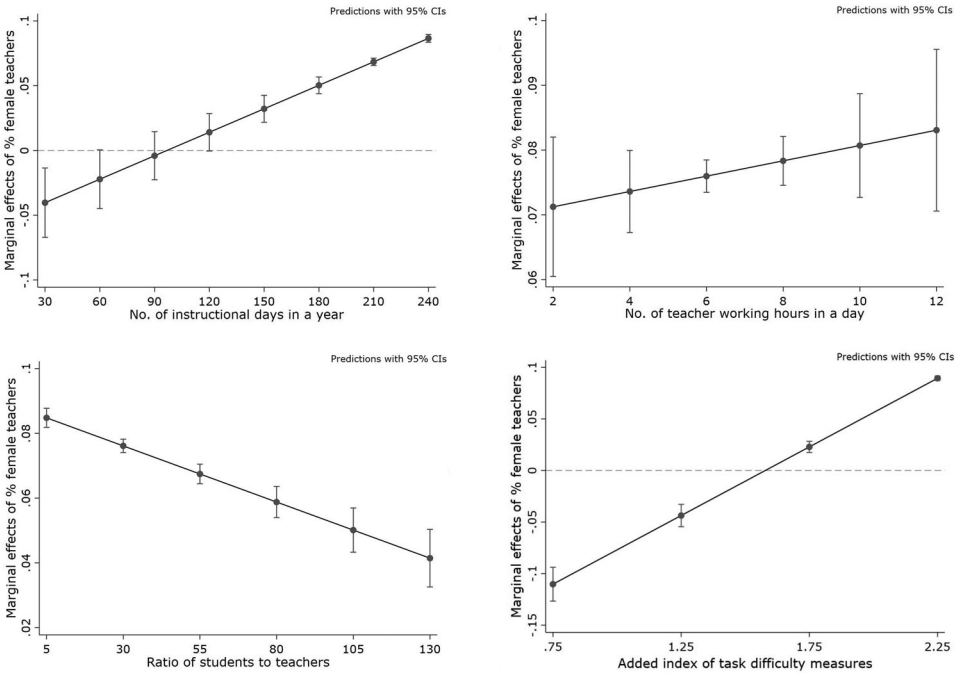

Figure 1. Moderating effect of task difficulty measures on female teacher representation.

will potentially be effective. Three such moderating variables are considered: number of instructional days, teacher working hours, and the student teacher ratios. Our hypotheses are that passive representation is more likely to translate into active representation and influence female test scores when the teacher has more instructional days and working hours to spend with the student and when the student-teacher ratio is lower. The interactions to test these three models are presented in Table 2. All three interactions generate relationships in the predicted direction, that is, female teachers are associated with better female student test scores when there are more instructional days, when they have longer working hours in a day, and when the student-teacher ratio is smaller. Because interactions are at times difficult to interpret, we present a series of graphs in Figure 1 that illustrate the marginal effect of female teachers at various levels of the interactive relationships.

The top left graph in Figure 1 illustrates that the marginal effect of female teachers on female academic performance drastically improves, from approximately .01 when students have 120 days of instruction in a year to approximately .09 when they have 240 days of instruction (essentially year-round schooling). The representation effect of female teachers, therefore, increases as working conditions get more favorable to active representation. Similarly, in the top right graph we see an increase of the marginal effect from when teachers work two hours (0.07) to when they work eight (0.08), albeit at a very modest level. Lastly, the bottom left graph shows the marginal effect of female teachers at various ratios of students to teachers. In line with the findings above, as the student teacher ratio drops from very high (140) to levels more akin to those found in the US (∼20), the marginal effect increases from 0.04 to 0.08.

The conditional effects of each of the task demands are associated with increases in the relationship between female teachers and female academic outcomes. One obvious question is whether these changes might be cumulative and result in even larger substantive impacts. Ideally, we would like to know the relative influence of female teachers when class sizes are small, teachers have more time to teach, and schools meet more often. To provide some insight in terms of how these influences might be cumulative, we created an index of task demands by first

Table 3. Results of interactions with measures of work environment.Dependent Variable: % female students scoring 60%+ in eighth grade exam

Variables	(1) Rural vs urban schools	(2) Infrastructure Index	(3) Infrastructure & rural schools	(4) Infrastructure & urban schools
Female teachers (%)	−0.02	0.08	0.08	0.03
	(0.002)***	(0.001)***	(0.001)***	(0.004)***
Female teachers × rural school	0.11			
	(0.002)***			
Female teachers × infrastructure index		−0.01	0.01	−0.02
		(0.001)***	(0.001)***	(0.003)***
Student teacher ratio	−0.13	−0.13	−0.14	−0.06
	(0.001)***	(0.002)***	(0.002)***	(0.003)***
Teacher work hours (per day)	5.97	5.99	6.38	4.45
	(0.037)***	(0.037)***	(0.042)***	(0.076)***
Instructional days (per year)	0.10	0.10	0.11	0.07
	(0.002)***	(0.002)***	(0.003)***	(0.005)***
English medium school	0.69	0.50	0.69	1.97
	(0.099)***	(0.099)***	(0.129)***	(0.156)***
Caste Herfindahl Index	5.94	5.79	6.19	5.45
	(0.141) ***	(0.141)***	(0.158)***	(0.305)***
Infrastructure index	4.55	5.02	4.41	2.68
	(0.033)***	(0.053)***	(0.056)***	(0.232)***
School quality index	−1.43	−1.43	−1.17	−2.04
	(0.045)***	(0.045)***	(0.053)***	(0.085)***
Rural school	−6.41	0.12		
	(0.182)***	(0.083)		
Government school	−14.89	−14.99	−15.93	−10.66
	(0.095)***	(0.095)***	(0.108)***	(0.204)***
Teachers with graduate degrees (%)	−0.13	−0.13	−0.13	−0.09
	(0.001)***	(0.001)***	(0.001)***	(0.002)***
Teachers with teaching qualification (%)	0.17	0.17	0.18	0.10
	(0.001)***	(0.001)***	(0.001)***	(0.002)***
School sex ratio	−0.02	−0.02	−0.03	−0.02
	(0.002)***	(0.002)***	(0.003)***	(0.003)***
Academic year 2015-16	−2.04	−2.05	−1.76	−3.17
	(0.079)***	(0.079)***	(0.088)***	(0.179)***
Academic year 2016-17	−0.81	−0.83	−0.74	−1.28
	(0.079)***	(0.079)***	(0.088)***	(0.175)***
Academic year 2017-18	−0.53	−0.52	−0.51	−0.69
	(0.083)***	(0.083)***	(0.092)***	(0.185)***
Constant	6.36	0.86	−5.22	23.53
	(0.640)***	(0.627)	(0.706)***	(1.379)***
Observations	1,338,391	1,338,391	1,099,695	238,696
R-squared	0.139	0.138	0.139	0.068

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

standardizing the variables and then rescaling them to range between zero and one (with class size reverse coded so that larger numbers were smaller classes). We summed these indicators into an index that ranged from 0.75 to 2.8 with higher numbers representing task situations where active representation might be more feasible. Model 4 in Table 3 and the bottom right graph in Figure 1 shows this interaction and illustrates that the association between female teachers and female student test scores is strongly contingent on task demands. In the more restrictive situations (0.75–1.25 on the index), female teachers are associated with lower female academic performance, whereas in the least restrictive situations, the marginal effect of female teachers (0.1) is higher than when we study their impact on female students without examining any contingencies.

It is important to point out here that our dataset and analysis does not allow us to pinpoint the specific mechanism through which a more favorable task environment leads to a stronger association between female teacher percentages and female student test scores. It may be active

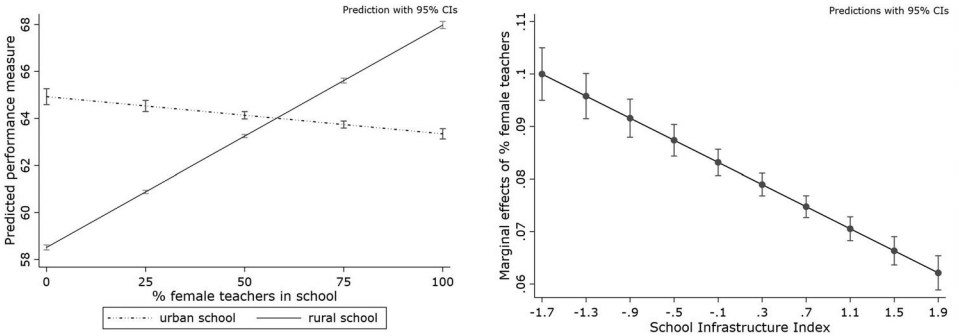

Figure 2. Moderating effect of work environment measures on female teacher representation.

representation, or more appropriate teaching techniques or even just those female students have more time to interact with female teachers and, therefore, more opportunities to observe them as a role model. This opportunity for symbolic representation could then lead to improved outcomes. Further theoretical and qualitative empirical research on this topic could help clarify which of the paths are more likely to lead to representative effects and when. Additionally, it is possible that female teacher percentages in a school are endogenous to the task demand variables. To control for this possible endogeneity, we estimated an instrumental variable model, using task demands as the instruments (see Appendix table D1 for results). The results are very similar to those from our original model, providing no evidence that schools with higher percentages of female teachers tend to have lower levels of task difficulty.

We test our second hypothesis in Table 3, examining cases where the working environment is extremely difficult and the teacher's influence (either as active representatives or as role models) might be limited. These include cases with little educational infrastructure and schools located in rural areas. The first graph in Figure 2 shows that female teachers in rural areas can increase the percentage of female students scoring 60%+ by nearly ten percentage points. Interestingly, in urban schools an increase in female teacher percentage has a slight negative association with the academic performance of female students. One possible reason for this finding is that we are capturing some differences in teacher values, by location. Unfortunately, the dataset does not allow us to further explore this line of enquiry, but future research can focus on distinguishing between resource or location, and teacher values, to better understand the when and how of representation.

Another surprising finding, as shown in second graph in Figure 2, is that the marginal influence of female teachers is nearly 1.5 times more for schools with the lowest score on the infrastructure index (0.1), in comparison to schools with the highest score (0.06). Further analysis of the data, however, shows that these preliminary findings on urban versus rural and infrastructure do not reveal the entire story. Models 3 and 4 in Table 3 split the data into rural and urban schools and demonstrate the contextual differences. An increase in the infrastructure index in rural schools is associated with a *positive* increase in the marginal effect of female teachers, increasing from approximately 0.06 to 0.105. The same marginal plot for urban schools, however, shows a marginal effect that gets smaller and eventually turns negative as can be seen in Figure 3.

One likely explanation for this anomaly of urban schools with better infrastructure is reverse causality. Government programs logically allocate their scarce resources to visible cases with the greatest need. Poorly resourced urban schools are likely to be highly visible and offer the government an opportunity to demonstrate that it is taking action (and adding infrastructure is perhaps the most visible policy action). To determine if that might be the case, we ran Granger (1988) causality models on the relationship between infrastructure and school performance (see Appendix Table D2 for results). The results showed that positive changes in school infrastructure took place in better performing schools in rural areas but no relationship in urban areas. Because

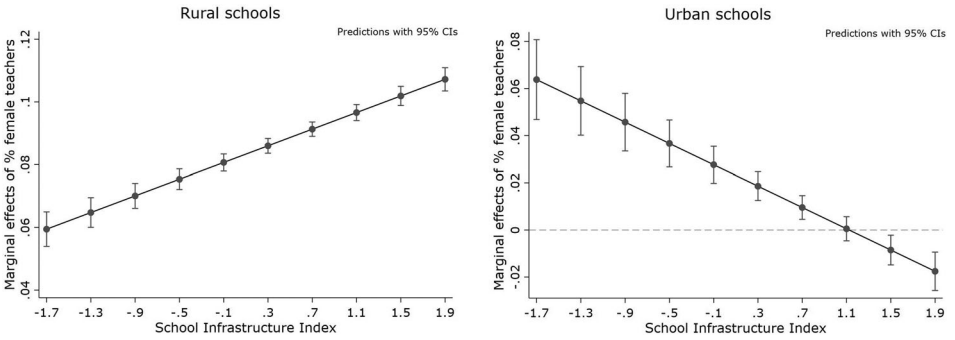

Figure 3. Moderating effect school infrastructure and location on female teacher representation.

it takes some time for improvements in infrastructure to influence academics, these allocation decisions might be why we see no relationship in urban schools. This analysis is exploratory and further research is required to fully ascertain the cause for urban schools with greater infrastructure negatively influencing representation effects.[6]

In summary, these interactive findings show, with one anomaly (urban schools with greater infrastructure), that passive representative of female teachers is positively associated with the educational performance of female students in situations where either factors directly affecting the teacher's work are favorable or where the surrounding environment facilitates representation. The results are consistent with the theoretical notion that representation in a context with extreme variation in resources and task difficulty will only occur when the situations are somewhat more favorable. They suggest that representation, even in a policy area that is highly conducive to it such as K-12 education, is not as commonplace as the more western-oriented research would suggest. Despite the unfavorable context in India, we still find positive relationships which lend overall support to the theory of representative bureaucracy.

Conclusion

This article seeks to advance the theory of representative bureaucracy and substantively contribute to the literature in several ways. First, by situating the study in India, a non-western national context characterized by high gender inequality and significant resource constraints, we are able to expand the theoretical applications of representative bureaucracy beyond the U.S and thereby contribute to its generalizability (Bishu and Kennedy 2020). We find positive correlates of representative bureaucracy influence even under conditions that make representation difficult. The results are modest, but girls perform better in schools that have more female teachers.

Second, the Indian context allows us to explore the organizational and environmental influences that are required for representation to lead to improved minority outcomes. By taking advantage of greater variation in task demands and resources faced by Indian schools compared to schools in developed nations (the locus for most other education studies of representative bureaucracy), the study was able to specify how organizational context influences this process of representation. In cases where task demands of teaching become extreme (huge class sizes, few hours of instruction, and few days for schooling), the association between female teachers and female student academic performance drops by half or more. This provides some evidence to support recent micro-theory that highlights the role of time and slack resources in the likelihood of representation by bureaucrats (Meier 2019). In addition, the complexities of how context conditions potential representation effects were demonstrated by examining the role of infrastructure and urbanization. Although simple interactions showed greater impact in rural

areas, and with poor infrastructure, subsequent analysis revealed that infrastructure mattered positively, but only in rural areas.

Third, since this study incorporated far more schools than any previous examination of representative bureaucracy, it had the statistical power to examine new theoretical relationships. The large number of cases permitted us to include contexts not previously studied in terms of extremely high task demands and low resources, and in those cases the influence of representation dropped. Although the current study shows the same relationship between gender representation and educational outcomes as found in other countries, the interactions between task demands and representation suggests that there are limits to representative bureaucracy even in highly conducive policy areas such as education. This suggests that positive associations between gender representation and the performance of female students are not universal and further theoretical understanding of representative bureaucracy will be enhanced by studying new and different contexts.

As with all papers, there are limitations to this study. A preliminary analysis of the data at the state-level shows considerable variation in representation, which points to a need to unpack the dataset and explore the heterogeneous effects in the different Indian states. The context of these states differs dramatically in terms of political and economic stability, wealth, religious divisions, and gender attitudes. Disaggregation may also help understand our anomalous negative representation finding in the case of urban schools with good infrastructure or find other situations where representation is associated with negative results. Additionally, the quantitative nature of our study means that we cannot say with utmost certainty why passive representation leads to enhanced outcomes in India and what the causal path is through which task difficulties and external environmental factors impede or facilitate the representation relationship. Finally, we were only able to test a few measures of factors affecting the work of the teacher and the environment in which their operate based on the data available to us.

Our analysis engenders several avenues for future research. It highlights the need for more representative bureaucracy studies to be conducted in national contexts beyond the western world and for a better understanding of the organizational and environmental influences that moderate the effects of representation. Studies in contexts that can be considered unwelcome to representation, based on certain identities or by considering rural-urban divides, can help clarify organizational and environmental factors that need to exist for passive representation to affect outcomes. Additionally, qualitative research, involving both clients and bureaucrats, can shed light on the causal mechanisms through which factors such as task difficulty and resource scarcity affect representation outcomes. A practically important area of inquiry here would be the role that teacher values and motivations play in overcoming environmental barriers to improve minority outcomes. Theoretical and empirical work on environmental influences will, therefore, help identify the limits of representative bureaucracy theory and the most useful practical applications to promote equitable outcome in different contexts.

Notes

1. Other processes that might generate a positive correlation between teacher gender and girls' performance include a better understanding of how gender affects learning on the part of women teachers, lower levels of gender bias by female teachers, or additional effort by female students as the result of symbolic representation. These pathways between descriptive representation and outcomes are less likely to be affected by contextual factors given that they are not as restricted by time and resource constraints.
2. The central government passed the Right to Free and Compulsory Education (RTE) Act in 2009 which grants every child the fundamental right to free, compulsory, and full-time education between the ages 6-14. It also lays down norms for basic school infrastructure, student teacher ratios, teacher training requirements, and prohibitions of corporal punishment among others (*Ministry of Human Resource Development* 2019). A national campaign called "*Beti Bachao, Beti Padhao*" (save the girl child, educate the girl child) was also launched in 2014 to improve the sex ratio and ensure survival and education of the girl

child (*Ministry of Women and Child Development* 2018). Implementation, however, is plagued by issues like poor fund allocation management, inadequate monitoring and evaluation systems, and unfocused expenditures (*The Hindu BusinessLine* 2017; Nikore 2019).

3. Further complicating matters is the management of education policy in the country. Administration of education policy is in the hands of education secretaries/district officers at the local level but many of these are Indian Administrative Service officers (or report to them) who are trained at the central government level. The administrators are ultimately accountable to the Education Minister of the state. In terms of financing, the center covers a large percentage of education spending across states.
4. The school infrastructure index was constructed using principal component factor analysis from four variables: the presence of a computer lab, library, playground, and the availability of electricity in the school. These measures were chosen to indicate basic school facilities that would aid the teaching-learning process. The measures are also listed as basic amenities that each school should provide students, under the RTE Act guidelines (Ministry of Human Resource Development 2019). The variables loaded onto a single factor with an eigenvalue of 1.6, accounting for 40% of variance in the items.
5. Similar to the school infrastructure index, the school quality index was constructed using principal component factor analysis of four variables: whether the school has a school management committee, a school development plan, specialized training for school dropouts to bring them to the same level as students of their age, and whether the school has access to textbooks based on the curriculum they follow. These measures are meant to capture softer aspects of the school infrastructure that would aid the teaching-learning process. The measures are also highlighted as a key management structures that schools should use to improve their education provision, under the RTE Act guidelines (Ministry of Human Resource Development 2019). The analysis produced a single factor with an eigenvalue of 2.73, that measured 68% of the variance in the included items.
6. Determining the reasons for funding (mis)allocation for school infrastructure improvements is beyond the scope of this paper. Urban schools will be more visible politically and that might motivate funding deteriorating urban schools, with the less visible rural funding used for political objectives. Regardless of the reasons for distributing infrastructure funding, those decisions do influence school performance and the bureaucratic representation process.

Disclosure statement

The authors declare no conflicts of interest.

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Data availability statement

The data that support the findings of this study are openly available in Harvard Dataverse at https://doi.org/10.7910/DVN/CP5X7S.

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Supplementary appendices

Appendix A. Do female students select into schools with more female teachers?

The positive relationship that we find between female students and female teachers could be due to well-performing female students selecting into schools with more female teachers. While there are not a lot of theoretical reasons to support this (school choice in India is limited based on location and parental income), we explored this possibility by analyzing the correlation between female student and female teacher percentages in the schools. The results show that the correlation between female teachers and female student percentages is very weak, even when the female teacher variable is lagged. This further supports our assumption that female students are not selecting into schools that have more female teachers and that this is not the cause for any association that we identify in our study.

Table A1. Correlations between percentage female teachers and students in school.

	% female teachers	Lagged % female teachers	% total female students	% female students in Gr.8
% female teachers	1			
Lagged % female teachers	0.94	1		
% total female students	0.14	0.14	1	
% female students in Gr.8	0.10	0.11	0.77	1

Appendix B. Description of variables used in the dataset

Table B1. Description of variables and summary statistics for all schools.

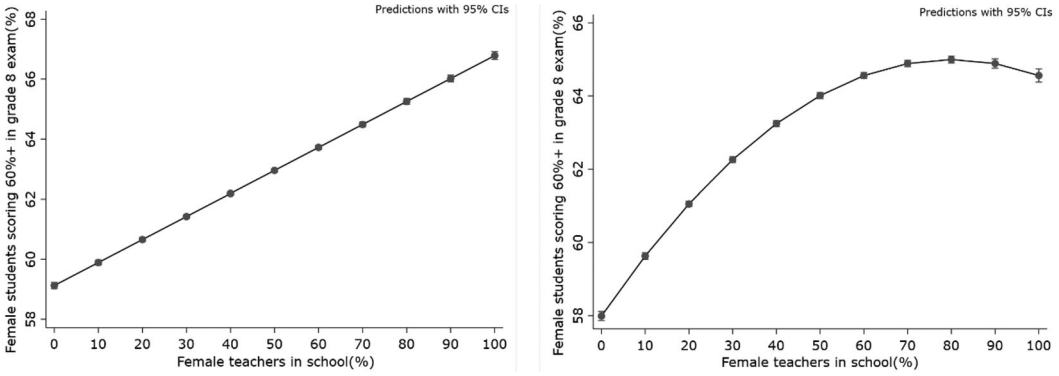
All Schools N = 1,338,391

Variable	Description	Mean	SD	Min	Max
Female teachers (%)	Percent of total teachers in the school that are female	40.51	31.12	0	100
Female students scoring 60%+ in gr.8 (%)	Percent of girls that scored more than 60% in eighth grade exam	62.23	35.33	0	100
Instructional days	Number of instructional days for students in the year	224.22	13.39	30	250
Teacher working hours	No. of hours the teachers work in a day	6.54	0.75	2	12
Student teacher ratio	Ratio of students to teachers in school	28.33	20.06	0.17	150
Rural school	Dummy: 1 means the school is in a rural area	0.82	0.38	0	1
Infrastructure index	Factor: Measures availability of computers, library, playground and electricity	0.58	0.95	−1.68	2.03
Teachers with graduate degrees	Percent of total teachers in school that have graduate degrees or above	76.05	29.87	0	100
Teachers with professional qualification	Percent of total teachers in school that have a professional teacher qualification	86.97	26.99	0	100
Government school	Dummy: 1 means the school is managed by a govt body (0 is a private body)	0.67	0.47	0	1
English medium school	Dummy: 1 means the medium of instruction in the school is English	0.13	0.33	0	1
School sex ratio	Ratio of the total girls in the school to total boys	1.36	12.69	0.05	2087
School quality index	Factor: measures presence of a management committee, development plan, student special training, & textbooks	0.04	1.00	−1.92	0.81
Caste Herfindahl index	Index: Measures the size of each caste group in the school as an indicator of diversity	0.59	0.21	0.25	1

Table B2. Summary statistics for rural vs. urban schools.

	Rural schools N = 1,099,695				**Urban schools** N = 238,696			
Variable	Mean	SD	Min	Max	Mean	SD	Min	Max
Female teachers (%)	35.38	29.37	0	100	64.15	27.86	0	100
Female students scoring 60%+ in gr.8 (%)	60.16	35.65	0	100	71.74	32.19	0	100
Instructional days	224.51	13.38	30	250	222.87	13.39	33	250
Teacher working hours	6.55	0.73	2	12	6.52	0.84	2	10.3
Student teacher ratio	28.22	20.10	0.25	150	28.83	19.87	0.17	150
Infrastructure index	0.49	0.96	−1.68	2.03	0.93	0.77	−1.68	2.03
Teachers with graduate degrees (%)	74.62	29.97	0	100	77.09	30.13	0	100
Teachers with professional qualification (%)	86.71	26.96	0	100	85.26	28.67	0	100
Government school	0.76	0.43	0	1	0.27	0.45	0	1
English medium school	0.09	0.28	0	1	0.30	0.46	0	1
School sex ratio	1.26	9.19	0.05	1726	1.84	22.67	0.05	2087
School quality index	0.21	0.91	−1.92	0.81	−0.69	1.09	−1.92	0.81
Caste Herfindahl index	0.61	0.21	0.25	1	0.58	0.22	0.25	1

Appendix C. The relationship between female teachers and female student academic performance



Appendix D. Robustness checks on the moderating effects of task difficulty and work environment

Table D1. Instrumental variable estimation for task difficulty on female teachers (%).

Variables	(1) DV: female student performance
Instrumented female teachers	0.089
	(0.001)***
English medium school	1.635
	(0.137)***
Caste Herfindahl Index	7.278
	(0.189)***
Infrastructure index	5.305
	(0.044)***
School quality index	−0.256
	(0.061)***
Rural school	0.809
	(0.113)***
Government school	−15.59
	(0.128)***
Teachers with graduate degrees (%)	−0.148
	(0.001)***
Teachers with teaching qualification (%)	0.194
	(0.002)***
School sex ratio	−0.026
	(0.002)***
Academic year 2016-17	1.363
	(0.092)***
Academic year 2017-18	2.361
	(0.097)***
Constant	−57.837
	(0.248)***
Observations	751,064
R-squared	0.119

Robust standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table D2. Granger model results on the infrastructure- performance relationship.

	Rural area schools		Urban area schools	
Variables	(1) DV: female student performance	(2) DV: Infrastructure index	(3) DV: female student performance	(4) DV: Infrastructure index
Lagged female student performance	0.40	0.00003	0.38	−9.97e-06
	(0.001)***	(0.00001)**	(0.003)***	(0.00003)
Lagged infrastructure index	3.30	0.92	0.98	0.90
	(0.042)***	(0.001)***	(0.109)***	(0.001)***
Female teachers (%)	0.05	0.0002	0.01	0.0002
	(0.001)***	(0.00002)***	(0.003)***	(0.00003)***
Student teacher ratio	−0.11	0.0004	−0.04	0.001
	(0.002)***	(0.00002)***	(0.004)***	(0.0001)***
Teacher work hours (per day)	4.10	−0.003	2.89	−0.01
	(0.052)***	(0.001)***	(0.959)***	(0.001)***
Instructional days (per year)	0.10	0.001	0.06	0.0003
	(0.003)***	(0.00003)***	(0.006)***	(0.0001)***
English medium school	1.62	0.04	1.65	0.02
	(0.169)***	(0.002)***	(0.196)***	(0.002)***
Caste Herfindahl Index	3.80	−0.01	3.65	−0.01
	(0.190)***	(0.002)***	(0.389)***	(0.004)
School quality index	−0.23	0.01	−0.84	0.004
	(0.067)***	(0.001)***	(0.108)***	(0.001)***
Government school	−9.93	−0.02	−7.15	−0.01
	(0.135)***	(0.001)***	(0.252)***	(0.003)**
Teachers with graduate degrees (%)	−0.08	−0.00001	−0.07	0.0001
	(0.001)***	(0.00001)	(0.003)***	(0.00003)*
Teachers with teaching qualification (%)	0.11	0.0002	0.06	−0.0001
	(0.002)***	(0.00002)***	(0.003)***	(0.00003)***
School sex ratio	−0.02	0.0001	−0.01	0.00002
	(0.002)***	(0.00003)***	(0.003)***	(0.00002)
Academic year 2016-17	1.67	0.005	2.60	0.02
	(0.091)***	(0.001)***	(0.196)***	(0.002)***
Academic year 2017-18	2.07	−0.03	3.46	−0.01
	(0.097)***	(0.001)***	(0.208)***	(0.002)***
Constant	−14.17	−0.11	9.86	0.07
	(0.868)***	(0.009)***	(1.734)***	(0.018)***
Observations	630,525	630,525	126,030	126,030
R-squared	0.285	0.881	0.204	0.836

Robust standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$