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Supporting Online Material

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Materials and Methods

SOM Text
Fig. S1
Tables S1 to S3

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Female Leadership Raises Aspirations and Educational Attainment for Girls: A Policy Experiment in India

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Exploiting a randomized natural experiment in India, we show that female leadership influences adolescent girls' career aspirations and educational attainment. A 1993 law reserved leadership positions for women in randomly selected village councils. Using 8453 surveys of adolescents aged 11 to 15 and their parents in 495 villages, we found that, relative to villages in which such positions were never reserved, the gender gap in aspirations closed by 20% in parents and 32% in adolescents in villages assigned a female leader for two election cycles. The gender gap in adolescent educational attainment was erased, and girls spent less time on household chores. We found no evidence of changes in young women's labor market opportunities, which suggests that the impact of women leaders primarily reflects a role model effect.

Quotas are an increasingly common response to the enduring underrepresentation of women in various domains, from science and politics to the corporate boardroom. Around 100 countries have adopted gender quotas in politics—mostly since the United Nations' Fourth World Conference on Women in 1995 (1)—and in 2004 Norway became the first country to mandate the presence of women on corporate boards, with a 40% quota. Policy-makers hope that quotas will have long-term effects on women's labor market outcomes over and above the immediate impact on leaders' gender balance, because the first women who become leaders may shape both parents' and children's beliefs about what women can achieve, through their policies and/or through a direct role model effect. In turn, this may raise their aspirations and shape educational and career choices. We present experimental evidence from a field setting in India that supports this view.

The idea that gender identity is at least partially a social construction is widely acknowledged in sociology (2) and social cognitive theory (3). These literatures identify belief in one's own ability (self-efficacy) as a key mechanism for personal agency and show that this belief is highly correlated with educational aspirations and subsequent occupational choices (4). Interventions affecting these beliefs have been shown to influence long-term behavior—for example, effort and perform-

ance in schools (5). Gender disparities in efficacy beliefs, in turn, are cited as an important factor behind the difference in male and female aspirations (6), especially in leadership (7, 8). Role incongruity is often emphasized as the source of the gap in beliefs (9, 10), raising the possibility that role models can challenge prevalent stereotypes and help to reduce this gap. Studies show that girls may be less likely to aspire to become scientists because there are few female scientists (11–14). Exposure to own-gender experts can provide such role models, break stereotypes regarding gender roles (15), and improve individual women's aspirations and propensity to enter traditionally male-dominated areas (15–17).

Several open questions remain. These include whether role model effects can counteract potential backlash (18) and whether other social and economic constraints prevent aspirational improvements from enabling achievement gains. Further, much of the existing evidence comes from observational studies, where beliefs or actions of individuals exposed to different role models are compared (19–22), or from laboratory or short-term school-based experiments, where individuals are exposed to different role models either in person or on paper (11, 16, 23). In observational studies, people exposed to alternative role models may themselves have different preferences or opportunities. In the laboratory or school setting, data on beliefs and aspirations are often gathered after a brief exposure to a role model (24); this may not reflect real life, where exposure is more enduring. Similarly, the consequences of psychological processes on behavior are generally followed over a brief period [see (5) for an exception].

In this study, we took advantage of a large-scale randomized natural experiment in India, which quickly increased the number of women

in leadership positions at the village level. Exploiting a rule that requires the random selection of villages where only women could compete for this position, we compared the aspirations of parents for their sons and daughters aged 11 to 15, as well as the aspirations of adolescents for themselves across villages with female and male leaders. We next examined whether changes in girls' aspirations were accompanied by changes in educational outcomes and time spent on domestic chores. Finally, we investigated the potential channels for this effect.

Since 1993, when India adopted gender quotas for elected positions on village councils, the gender balance of village leadership has markedly altered: Across India, the fraction of elected local leaders who are female has risen from less than 5% in 1992 to more than 40% by 2000 (25). In West Bengal, our area of study, as in most Indian states, one-third of village councils are randomly selected to be reserved for a woman chief councilor (or “pradhan”) in every election. Random selection of reserved councils enables us to identify the causal relationship between the election of female leaders and villagers' aspirations: There should be no other difference between villagers living in councils reserved once or twice versus unreserved councils. Moreover, because of concurrent reservations for historically disadvantaged groups (scheduled caste and scheduled tribes), seats are not set aside to women by pure rotation: Between 1998 when the system was implemented in West Bengal and 2007 when we collected our data, a village council could have been reserved for a female pradhan once (in 1998 or 2003), twice (in 1998 and 2003), or never (26), giving us the opportunity to study the “dose response” in exposure to a female leader. Previous research has shown that women leaders invest in goods preferred by women, such as drinking water (27), and improve men's perception of women's leadership abilities (28).

Our survey team collected data in 2006 and 2007 in one West Bengal district, Birbhum, a rural and poor district located about 200 km from Kolkata. Our survey covered a random sample of 495 villages in Birbhum's 165 village councils. Tables S1 and S2 compare 1991 census data (before reservation) and household survey data according to reservation status of the council. Because of the randomization, councils have very similar characteristics. We interviewed 15 randomly selected households per village, administering separate questionnaires to the youngest married couple in each household and to all adolescents (aged 11 to 15) residing in the household. The final sample of respondents with adolescent children consisted of 2335 male and 2438 female respon-

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dents, which covered 3257 adolescents. Among adolescents our sample was slightly bigger, consisting of 1852 girls and 1828 boys (29).

The household roster had information on educational attainment, from which we constructed three variables: 1 if ever attended school, 1 if can read and write, and last grade completed. We report results using the normalized average across these three outcomes as the dependent variable [as in (30, 31)]. A time-use module asked adults and adolescents about time spent on 16 agricultural or household activities during the past 24 hours. We constructed time spent on domestic chores as minutes spent getting water, cooking, cleaning, providing child care, collecting fuel, and doing laundry.

The adult questionnaire covered parents' aspirations for adolescents with four questions concerning desired educational attainment, desired age of marriage, preferred occupation at the age of 25, and whether the parent wished for the child to become pradhan. We constructed five indicator variables to capture aspirations: 1 if the parent would like the child to at least graduate from secondary school (grade 12); 1 if the parent wishes the child to marry at an age above 18; 1 if the preferred

occupation is different from housewife or what the in-laws prefer; 1 if the answer is doctor, engineer, scientist, teacher, or a legal career; and 1 if the parent desires the child to become pradhan. For adolescents, we administered the same aspiration questions and coded them in an identical manner.

These five variables are good measures of aspirations, because they are future-oriented and predictive of current behavior (4). However, they cover separate spheres of aspirations, and therefore, they could be differently affected by any intervention. Validation tests show that the first four have a fairly high degree of correlation (Cronbach's $\alpha = 0.66$ for parents, 0.55 for teenagers), whereas the wish to be pradhan is less correlated with any of the others. Thus, in addition to the individual variables, we report the effect of the standardized average across the first four outcomes.

To investigate whether changed opportunities for young women underlie aspirational changes, we examined educational and occupational outcomes of young adults (aged 16 to 30). Using the household roster, we constructed educational variables identical to those for adolescents, along with two indicator variables for occupation (1 if

the respondent is not a housewife, 1 if the respondent has a high-education job) and the standardized average of the two variables. Finally, to gauge whether female leadership affected schooling quality, we examined scores on a math and reading test administered to 9-year-old school-enrolled children (26).

Tables 1 and 2 present findings on how the election of female leaders shapes parent and adolescent aspirations, and Fig. 1 provides a graphic representation. Both tables show, for each variable, the mean of parents' aspirations for boys and girls in never-reserved villages, as well as regression-adjusted difference in means by reservation status (26). The fifth column shows the effect across the standardized measure of the four previous outcomes, and the rightmost column shows aspirations about becoming pradhan.

Parents have higher aspirations for boys than for girls: On average, in villages that have never been reserved for a woman pradhan, parents' aspirations for girls are 0.68 standard deviation lower than for boys ($P < 0.001$, t test). For example, parents are 14 percentage points (45%) less likely to state that they would like their girl

Table 1. Parents' aspirations for their children. The first set of values consists of means and standard deviations (in brackets) of the variable in the column heading in never-reserved village councils. The coefficients in the remainder of the table are ordinary least-squares results for the dependent variable in the column heading and measure the difference in aspirations for boys and girls relative to the never-reserved sample. The row denoted "Gap" for never-reserved village councils shows the gap in aspirations between boys and girls. The subsequent "Difference in gap" rows show the gap in aspirations for boys and girls relative to the gap in the never-reserved sample. For example, the last

number in column 5 says that the gap in overall aspirations for girls versus boys has shrunk by 0.136 standard deviation (more than 20%) in twice-reserved village councils relative to never-reserved ones. Standard errors corrected for heteroskedasticity and clustering at the village council level are shown below the coefficients in parentheses. The sample size is 6140. The normalized average is computed across the four outcomes (columns 1 to 4), which are first normalized by subtracting the mean for never-reserved village councils and dividing by the standard deviation in the never-reserved sample. All estimates control for village characteristics described in table S1 and for respondent gender.

	Does not wish child to be housewife or whatever in-laws prefer	Wishes child to have a high-education job	Wishes child to marry after age 18	Wishes child to graduate or get higher education	Normalized average	Wishes child to be pradhan
Means and SDs in never-reserved village councils						
Boys	0.991 [0.092]	0.068 [0.252]	0.992 [0.089]	0.318 [0.466]	0.329 [0.446]	0.688 [0.463]
Girls	0.242 [0.429]	0.039 [0.193]	0.756 [0.430]	0.176 [0.381]	-0.357 [0.654]	0.588 [0.492]
Coefficients						
Never reserved						
Gap	-0.747 (0.018)	-0.028 (0.009)	-0.238 (0.012)	-0.140 (0.019)	-0.684 (0.025)	-0.093 (0.020)
Reserved once						
Boys	-0.005 (0.009)	0.016 (0.014)	-0.004 (0.006)	0.003 (0.025)	0.013 (0.027)	-0.041 (0.025)
Girls	-0.015 (0.023)	0.020 (0.009)	-0.021 (0.014)	-0.015 (0.020)	-0.011 (0.031)	0.000 (0.029)
Difference in gap	-0.010 (0.025)	0.003 (0.015)	-0.017 (0.016)	-0.018 (0.026)	-0.024 (0.035)	0.041 (0.029)
Reserved twice						
Boys	-0.033 (0.018)	-0.012 (0.016)	-0.018 (0.010)	0.003 (0.044)	-0.042 (0.039)	0.008 (0.043)
Girls	0.064 (0.028)	0.012 (0.014)	0.021 (0.025)	0.051 (0.036)	0.093 (0.050)	0.101 (0.044)
Difference in gap	0.097 (0.036)	0.025 (0.020)	0.038 (0.026)	0.048 (0.048)	0.136 (0.059)	0.092 (0.049)

to graduate or study beyond the secondary school level ($P < 0.001$, t test).

The gender gap in aspirations in villages with a female leader for two election cycles drops by 0.14 standard deviation ($P < 0.03$, t test) relative to places that never had one. As parental aspirations for boys are unchanged, the entire decline in the gap is accounted for by improvements for girls. Moreover, the largest changes occur for occupation-related aspirations. For example, the fraction of parents who believe that a daughter's, but not a son's, occupation should be determined by her in-laws declines from 76 to 65%. Previous research suggests that women have more subjective identification with women role models than men (17), implying that the effect may be larger for mothers than fathers. Indeed, mothers' aspirations over education and occupation are altered more broadly, whereas fathers primarily increase their desire for their daughters to become pradhan (26). This last result is consistent with previous research showing that men's (but not women's) perception of women's ability to lead improved in reserved village councils (28).

Similarly, the aspirations of adolescents themselves were affected by the presence of a female leader in the second cycle (Fig. 1, center panel, and Table 2). Although boys are more ambitious than girls, the gender gap among adolescents residing in unreserved village councils is smaller than among the parents. In never-reserved villages, the gender gap in adolescent aspirations is 0.51 standard deviation ($P < 0.001$, t test). The gender gap in the desire to graduate or more is 10 percent-

age points (32%; $P < 0.001$, t test). The decline in the gap in twice-reserved councils (average effect: 0.17 standard deviation, $P < 0.01$, t test) is very similar in magnitude for parents and adolescents, so girls' and boys' own aspirations remain more similar to one another than parents' aspirations for their daughters versus sons. Here again, the decline in the gap is entirely driven by an increase in girls' aspirations, not by a decrease in boys'. Adolescents girls are more likely to not want to be a housewife or have their occupation determined by their in-laws (8.3 percentage points; $P = 0.053$, t test), to want to marry after 18 (8.8 percentage points; $P = 0.034$, t test), and to want a job that requires an education (8.6 percentage points; $P = 0.02$, t test). In the last case, the gender gap reverses.

Paralleling the changes in aspirations, the presence of female leaders also alters educational attainment and time use (Fig. 1, right panel, and Table 3). Relative to girls, adolescent boys in never-reserved councils are 6% more likely to attend school ($P < 0.01$, t test) and have a 4% higher likelihood of being able to read and write ($P < 0.01$, t test). Like elsewhere in the developing world, adolescent girls spend more time on domestic chores than their male counterparts (79 min more per day in never-reserved villages; $P < 0.001$, t test). The presence of female leaders did not affect educational and time-use outcomes for adolescent boys, but it improved the outcomes for girls. By the second cycle of female leadership, the gender gap in educational outcomes is completely erased (and even reversed), and girls spend less time on household activities (the gender

gap in time spent on household activities declines by 18 min relative to never-reserved councils; $P = 0.05$, t test).

In all cases, the gender gap starts shrinking only during the second electoral mandate held by a woman. Results in table S6 confirm that this is a "dose response" rather than a "length since first exposure" effect (26).

Women in leadership positions can change aspirations of girls through two main channels: first, by undertaking policies that make it easier for women to succeed, thus changing beliefs on what is possible for girls; and second, by providing a role model of a successful woman. In any setting where actual female leadership is affected [as opposed to situations where female role models are briefly introduced (14, 32)], the two effects may coexist. No experiment can completely distinguish between the two. The trade-off is that only experiments in these settings can shed light on the impact of real-world changes in leadership.

For India, previous research has found that women leaders invest in public goods that are more in line with female preferences, in particular water infrastructure (27, 33). This may explain the reduction in time spent on domestic chores by adolescent girls. Furthermore, if female leaders invested differentially in schooling for girls, this may also underlie the change in educational outcomes we observe. We now provide several pieces of evidence suggesting that in this context, the role model effect of female leaders is an important channel (perhaps the most important) in changing parents' and girls' aspirations.

Table 2. Adolescents' aspirations. Data are presented as in Table 1. The sample size is 3680. All estimates control for village characteristics described in table S1.

	Does not wish to be housewife or whatever in-laws prefer	Wishes to have a high-education job	Wishes to marry after age 18	Wishes to graduate or get higher education	Normalized average	Wishes to be pradhan
Means and SDs in never-reserved village councils						
Boys	0.998 [0.048]	0.157 [0.364]	0.980 [0.141]	0.296 [0.457]	0.248 [0.447]	0.499 [0.500]
Girls	0.600 [0.490]	0.166 [0.373]	0.660 [0.474]	0.195 [0.396]	-0.260 [0.758]	0.485 [0.500]
Coefficients						
Never reserved						
Gap	-0.398 (0.026)	0.008 (0.020)	-0.319 (0.025)	-0.099 (0.018)	-0.507 (0.034)	-0.017 (0.026)
Reserved once						
Boys	-0.008 (0.011)	0.053 (0.022)	-0.004 (0.013)	0.038 (0.026)	0.050 (0.029)	-0.013 (0.035)
Girls	-0.031 (0.034)	0.062 (0.021)	0.010 (0.031)	0.035 (0.022)	0.045 (0.045)	-0.010 (0.039)
Difference in gap	-0.023 (0.036)	0.009 (0.028)	0.014 (0.034)	-0.003 (0.028)	-0.005 (0.052)	0.003 (0.039)
Reserved twice						
Boys	0.008 (0.017)	-0.014 (0.034)	0.003 (0.021)	0.034 (0.047)	0.017 (0.048)	0.057 (0.056)
Girls	0.083 (0.043)	0.086 (0.036)	0.088 (0.041)	0.035 (0.035)	0.182 (0.056)	0.049 (0.055)
Difference in gap	0.075 (0.042)	0.099 (0.051)	0.085 (0.049)	0.001 (0.045)	0.166 (0.057)	-0.008 (0.053)

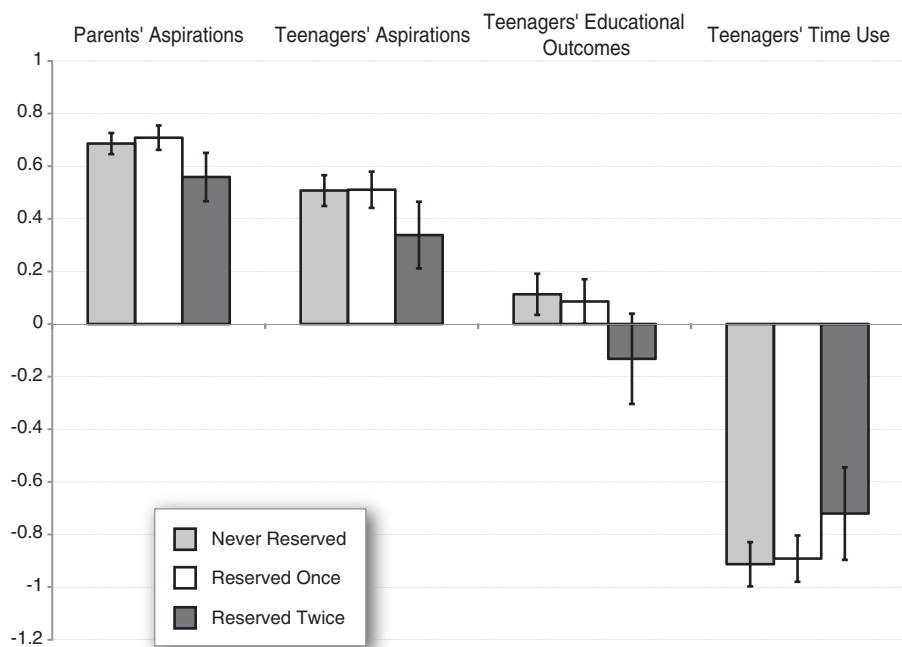


Fig. 1. Gap in aspirations, educational outcomes, and time use. The gray, white, and black bars represent difference in the normalized average of aspirations of parents for their adolescent boys and girls (left-most panel) and the difference in normalized average of aspirations, educational outcomes, and time spent on domestic chores between adolescent boys and girls themselves in village councils that have never been reserved, have been reserved only once, and have been reserved twice for a female leader, respectively. The error bars represent the 95% confidence interval.

In Fig. 2, table S5, and (26), we find no evidence that female reservation influenced the careers, education, or labor market outcomes of young adults (aged 16 to 30), a group that adolescent girls and their parents are likely to look to when forming expectations about their future (34). The gender gap in the educational outcomes of young adults is not smaller in twice-reserved villages ($P > 0.6$, t test). There is no impact on the probability that young women in villages reserved twice are housewives ($P > 0.8$, t test), have jobs requiring high education ($P > 0.2$, t test), or have access to employment-generating schemes ($P > 0.5$, t test). Finally, neither these young women ($P > 0.5$, t test) nor other women in the household ($P > 0.4$, t test) spend less time on domestic chores in villages.

Moreover, there is no evidence that female leaders made improvements in educational infrastructure that could have benefited girls more than boys. Young girls are as likely as young boys to be in school, and there is no difference in test scores (26). The reduction in the gender gap in education of adolescents is thus not due to a change in the environment. It is also probably not due to an 18-min reduction in time spent on domestic chores. It is most likely a consequence of the change in aspirations. In turn, the reduction in time spent on chores may reflect parents giving girls time to study.

Finally, the timing of the effect (starting in the second cycle) suggests that female leaders' image underlies the change in aspiration and

Table 3. Adolescents' educational outcomes and time use. Data are presented as in Table 1. The sample size is 3680. All estimates control for village characteristics described in table S1.

	1 if attends school	1 if can read and write	Grade completed	Normalized average	Total time on domestic chores (minutes per day)
Means and SDs in never-reserved village councils					
Boys	0.744 [0.436]	0.947 [0.225]	5.538 [2.166]	0.055 [0.760]	29.298 [50.841]
Girls	0.684 [0.465]	0.908 [0.289]	5.409 [2.386]	-0.058 [0.898]	108.231 [96.884]
Coefficients					
Never reserved					
Gap	-0.060 (0.019)	-0.038 (0.014)	-0.132 (0.113)	-0.112 (0.041)	78.954 (4.845)
Reserved once					
Boys	0.005 (0.022)	-0.020 (0.013)	0.019 (0.117)	-0.020 (0.042)	-5.095 (3.719)
Girls	0.010 (0.026)	-0.002 (0.015)	-0.002 (0.138)	0.004 (0.051)	-6.844 (7.178)
Difference in gap	0.005 (0.029)	0.018 (0.021)	-0.021 (0.153)	0.024 (0.058)	-1.748 (6.475)
Reserved twice					
Boys	0.005 (0.044)	-0.012 (0.031)	-0.094 (0.247)	-0.025 (0.100)	2.869 (6.881)
Girls	0.098 (0.049)	0.050 (0.029)	0.587 (0.237)	0.223 (0.102)	-14.772 (10.153)
Difference in gap	0.093 (0.051)	0.062 (0.033)	0.681 (0.243)	0.248 (0.102)	-17.641 (8.971)

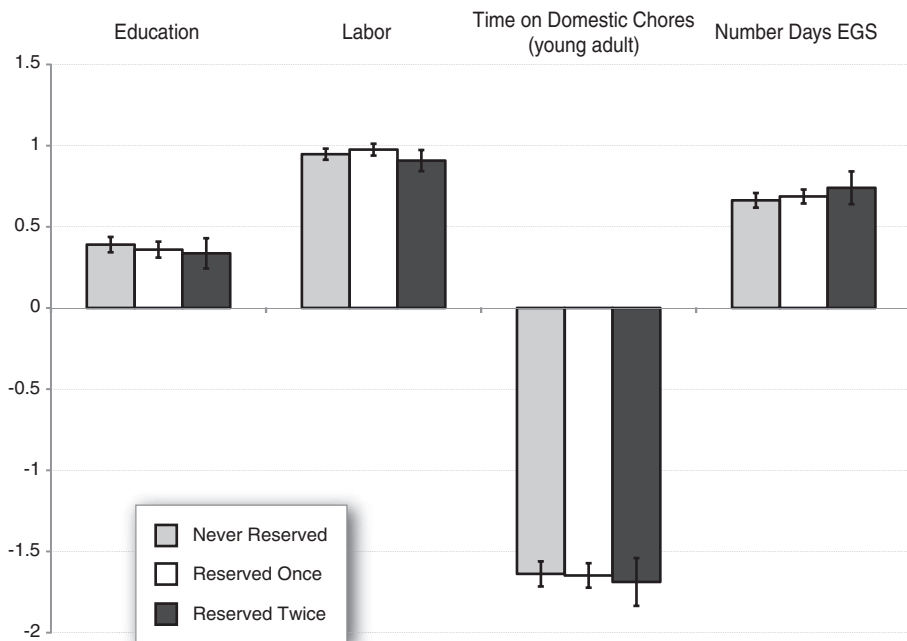


Fig. 2. Potential channels: gap in young adult educational outcomes, young adult labor market outcomes, young adult time use, and access to public services. The gray, white, and black bars represent the gender gap in normalized average of young adults' educational and labor market outcomes, adult time use, and access to employment generation schemes in village councils that have never been reserved, have been reserved only once, and have been reserved twice for a female leader, respectively. The error bars represent the 95% confidence interval.

educational outcomes for two reasons: (i) The changes in infrastructure provision, especially greater investment in water-related facilities, occur in the first electoral cycle after reservation. In the second cycle, there is no discernible difference in infrastructure provision across once- and twice-reserved villages (27, 28). (ii) Previous work (28) has shown that in the first cycle, voters have a comparatively low opinion of their female leaders. However, with exposure, their beliefs change progressively: first, their opinion about the ability of women to lead in general (as captured by responses to vignettes in which the gender of the politician is experimentally altered) and then, by the second cycle, their opinion about their own leader's abilities. Voters in twice-reserved villages have as positive a view of their female leader as villagers in never-reserved areas (almost all of whom have male leaders). Voters are also more likely to elect women for unreserved seats in councils that have been reserved twice for a female leader. The timing of the effect on aspirations and education is consistent with the time it takes for female leaders to be seen in a positive light.

Women in leadership positions have long been thought to have the potential to pave the way for long-term changes by influencing aspirations; our study demonstrates their impact in a nationwide policy experiment in India. We present evidence suggesting that this impact exceeds their (relatively limited) ability to change the concrete situation of women and girls in the short run through direct policy actions. It is their presence

as positive role models for the younger generation that seems to underlie observed changes in aspirations and educational outcomes of adolescent girls.

These results show that laws can help to create role models by opening opportunities that were previously unavailable to a group, and that this increased opportunity does not diminish the aspirations of those outside the group. The ability of affirmative action to create role models has been subject to debate: Although the policy allows members of disadvantaged groups to access positions of prestige and power, it may also cause a backlash if it creates the perception that the achievement was not due to merit. Our study shows that in the Indian context, the positive effect of exposure to a female leader dominated any possible backlash, probably because it gave women a chance to demonstrate that they are capable leaders. And, perhaps most important, our study establishes that the role model effect reaches beyond the realm of aspirations into the concrete, with real educational and time-use impacts.

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24. For example, in one of the studies in (17), women's perceptions of their role in mathematics and their actual performance on a math test are analyzed after exposure to a brief interaction with a same-sex expert in the laboratory, while another study had laboratory participants read biographies of engineers that were randomly varied to represent women or men, and (23) examines the change in college students' self-perceptions relative to a control group after reading an article about hypothetical female or male role models.
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Supporting Online Material

www.sciencemag.org/cgi/content/full/science.1212382/DC1
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