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Identity and Learning: a study on the effect of student-teacher gender interaction on student's learning

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Abstract

In this paper we examine whether students' and teachers' social identity play any role in the learning outcome of the students. More importantly, we ask if a student benefits by learning from a teacher of the same gender. Unlike the existing literature which explains such interaction in terms of role model based effect, we explain such interaction in terms of gender based sorting across private and public schools. Our results are driven by two critical difference between male and female members. For male and female teachers, the difference comes from their differential opportunity costs of teaching in schools at remote locations. For students, the difference between male and female members comes from the differential return to their human capital investment by parents –where for girls, a lower fraction of the return comes to their parental families after they are married following patriarchal norm. These factors create a sorting pattern which leads to an impact of gender matching. We then test our theoretical results using survey data collected from Andhra Pradesh.

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1 Introduction

The effect of teacher student identity matching on students' performance is well discussed in the literature. The positive role of identity matching (gender, race etc) is attributed either to Pygmalion effect or to role model effect. In one of the most influential studies on Pygmalion effect Rosenthal and Jacobson (1968) showed that teacher's higher expectation of some students' performance make them perform better, thereby making it a self-fulfilling prophecy. After this study was published a series of studies were done to re-examine the Pygmalion effect for students from different age and social strata and the results were ambiguous (Braun, 1976). The other possible channel through which identity matching affects students performance is the role model effect where a student of certain race or sex idolizes a teacher from the same identity and gets inspired to perform better. The role model effect is not limited to school performance and works for other decisions such as career choices as well (Almquist and Angrist, 1971; Basow and Howe, 1980). The literature on the effect of teacher-student gender matching, however, does not nail down the specific channel, neither does it assert that the above two channels are exhaustive. The papers in this literature rather test whether such matching indeed affects students' performance. In the backdrop of this literature the contribution of our paper is to provide a theory of such gender matching effect and test the implication of the model using a survey data from India. Unlike the pygmalion or role model effect which portray psycho-social behaviour, our theory is based on sorting mechanism based on economic incentives. Before outlining our results let us have a look at the literature on gender matching.

The major empirical challenge in this literature is to solve the selection problem as students and teachers are not always randomly assigned to a class. Many researchers have tried to exploit the longitudinal data structure to solve this problem. In one of the studies done in this line Dee (2007) looks at the performance of students enrolled in the eighth grade in different schools in the United States for different subjects (English, History and Mathematics) and the fact that different subjects are taught by teachers from different sexes allowed to control of the student fixed effect. Using this identification strategy the study found a positive effect of gender matching.

Nevertheless, there is hardly any consensus regarding the existence of any effect of student-teacher gender matching. In a subsequent study, Carrington et al. (2008) found little support for role model effect with eleven year old children enrolled in British schools. In a study conducted from a multilevel perspective, Marsh et al. (2008) also did not find any positive effect of male teachers on male students in Australian schools. While these studies are mostly based on single country, Cho

(2012) conducted a cross country study using data from OECD countries and did not find any effect of teacher-student gender matching. Similar results suggesting little or no support for gender interaction are reiterated in studies based in Ohio, United States (Price, 2010), Stockholm, Sweden (Holmlund and Sund, 2008) and Florida, United States (Egalite et al., 2015). In their study, Egalite et al. (2015) have used panel data and found no effect of gender matching for the elementary school students. However, they have found some effect for middle and high schools even though the magnitude is small. In a qualitative study based on classroom observations and individual interviews of 7-8 year old children enrolled in British schools and their teachers, Francis et al. (2008) did not find any support for gender matching effect.

While the above mentioned studies have hardly found any evidence in favour of gender matching, an important section of the literature has found support for positive effect of gender matching. For example, Rawal and Kingdon (2010) looked into the role of identity matching on the lines of gender, caste and religion using a data set from India. They found positive significant effect of matching along all the dimensions of identity including gender. In another study conducted in the similar line, Paredes (2014) has found a positive effect on female students if they are matched with female teachers. The study was based on a sample of 8th graders in Chile. She, however, did not find any negative effect on male students who are matched with female teachers. A similar positive result of gender matching has also been found by Muralidharan and Sheth (2016) in the context of India. Using a panel data, they found that female students perform better when they are matched with female teachers compared to when they are matched with male teachers. In a more recent study Lim and Meer (2017) have found positive gender matching effect for the girl students in Korean schools.

The literature in this area is largely empirical which tests the existence of gender matching effect. The main challenge in the literature is to solve the endogeneity problem. Theoretically, the literature is grounded in psychology focused on Pygmalion effect and role model effect. In this backdrop we provide a theory of gender matching effect resulting from a sorting mechanism. The sorting mechanism is driven by constraints faced by women students and teachers which are different from those faced by their male counterpart. Our theory shows that the gender matching effect is specific to the type (public/private) of schools and their location. We provide an empirical support for our theoretical results using a survey data from Andhra Pradesh. Our theoretical results are driven by specifications which are particularly true for less developed countries. This is consistent with the fact that in the literature most of the studies done in developed nations did not find support for gender matching while most of those done in less developed countries do.

Besides the specific literature of gender matching effect, the paper is also related to the literature of the effect of teachers' characteristics on students performance (Rockoff, 2004; Clotfelter et al., 2006; Kane et al., 2008; Metzler and Woessmann, 2012). This is also related to the papers on matching effect of other identity dimension such as race (Rezai-Rashti and Martino, 2010; Diamond et al., 2004; Egalite et al., 2015; Eddy and Easton-Brooks, 2011). The paper is organized as follows – in section 2 we present the theory and in section 3, empirical evidence followed by the conclusion.

2 Theory

2.1 Model Preliminaries

We consider a model of school choice by teachers as well as students and examine the effect of the resulting matching on the students' performances. Schools are distributed over different geographical locations. Each school employs one teacher. All teachers have a preferred location (presumably the urban centre) and the cost of going to a non-urban school is higher than that of joining an urban school for the teachers[1] This is true for all teachers. The students of a specific location must attend a school located in that area. In other words, the cost of travel is infinitely high for the students. Given this structure, we want to study the teacher-student matching and the effect of this matching on students' performances.

2.1.1 Schools

We consider two types of schools - private and government schools. The schools are uniformly distributed over the interval $[0,1]$ location-wise. At each point over the interval $[0,1]$, there is a government school. Thus, the number of government schools is of measure 1. However, whether there would be a private school at a particular location is determined from the model. The existence of a private school at a particular location requires two conditions to be met – first, there must be a teacher who is willing to teach in the private school at that location at the current private

[1] This doesn't necessarily imply that all teachers primarily belong to urban areas and therefore prefer urban schools. We assume that all teachers, even when they originally belong to rural areas, prefer to locate themselves at the urban areas because of other facilities like better healthcare opportunities for the family or better schooling opportunities for their children. The latter actually comes out as an outcome of our model and in that sense it is self-fulfilling.

school wage, and second, there must be students in that particular location who are willing to get enrolled in a private school. We denote a school's location by $x \in [0, 1]$. We assume that the teachers in government schools are better paid than teachers in private schools. In other words, $w_g > w_p$ where w_g and w_p are teachers' wages in government and private schools respectively. Barring few elite schools private school teachers in India are often under-paid with less job security. They can be fired any time and typically work without social security benefit (Muralidharan and Sundararaman, 2013). Our data, even though it does not contain the details about teachers' salary, shows that majority of the private school teachers have temporary jobs.

We also assume that the schools do not face any capacity constraint. Any student who is willing to go to a particular school in her locality gets that opportunity. However, the private schools charge a school fee of t from each student while the government schools are free. All schools try to recruit better quality teachers.

2.1.2 Teachers

Teachers are of two broad categories - Male and Female. However, within each category, there are teachers of different qualities. Within each category $i \in \{F, M\}$, teacher quality, q_i is uniformly distributed over the interval $[0, 1]$ with higher q_i indicating higher quality. For each quality, there is exactly one Male and one Female teachers. Thus, the total number of teachers is of measure 2 with measure 1 for female teachers and measure 1 for male teachers. The most preferred location for all teachers irrespective of their categories and qualities is $x = 1$. However, the cost of traveling to a distant school is different for Male and Female teachers. We assume that for a teacher of category $i \in \{F, M\}$, the pay-off from accepting a job with wage w in a school located at x is

$$u_i (w, x) = w - \theta_i (1 - x) \tag{1}$$

where $\theta_F = 1$ and $\theta_M = \theta < 1$. The cost of traveling to a distant school is higher for Female teachers than the Male ones. This can be justified using the notion that the cost of time away from home is higher for females because their contributions in home output is relatively higher than their male counterpart. Such cost differential can also be rationalized in terms of patriarchal norms that discourages women to work outside home. We also assume that all teachers' reservation pay-off is 0.

2.1.3 Students

At each location x, there are students of two categories - Girls (f) and Boys (m). Within each category, there are students of different abilities. We assume that at each location x and for each student category j, student ability a_j is uniformly distributed over the interval $[0, 1]$. Hence at each location, there are one boy and one girl students with ability a and this is true for all $a \in [0, 1]$. Thus, the measure of students at each location is 2 with 1 for boys and 1 for girls.

The students' school choice decisions are taken by the households. We assume a student must select a school in her/his location, i.e. traveling to a distant school is prohibitively costly. So the choice is limited between the local government school and the private school if one is available in the locality. We assume that the future productivity of a student depends on the knowledge acquired at school (k) as well as her own ability (a). The knowledge is verifiable and hence the potential employers can make the payment to a student contingent on the knowledge. However, the ability of a student is private information and the quality of teacher the student interacted with is non-verifiable. The employers only know the type of school a student attended at the time of making the job offer and hence can make the wage payment contingent on the average ability of the students attending that particular type of school. Given this formulation, the relative earning of a student going to a private school vis-a-vis that of one going to a government school with the same level of knowledge is the ratio of average abilities of students attending these two types of schools, i.e. $\frac{\bar{a}_p}{\bar{a}_g}$, where $\bar{a}_l$ is the average ability of students attending a type l school.

Suppose that at the time of making the school choice decisions for their children, the households' perceived relative premium from private schooling of their kids is $\beta \geq 1$. We will later show that in equilibrium there exists $\beta > 1$ such that $\beta = \frac{\bar{a}_p}{\bar{a}_g}$. Thus, the expected net return for a child with knowledge k from private schooling is

$$y_p(k) = \beta A k - t \tag{2}$$

and from government school is

$$y_g(k) = A k \tag{3}$$

where A is the marginal return to knowledge acquired from school and t is the cost of private schooling and

The families choose their children's school based on their future income that accrues to the family. In this respect, there is a critical difference between boys and girls. Given the culture of patriarchy prevailing in India, women move to her husband's ancestral home after marriage while men often stay with their parents. Hence, the expected share of future income of a student that comes back to his/her parental family is higher for boys than for girls. We model this by assuming that for boys the entire future income is expected to come back to the family while for the girls this amount is only a fraction of expected future income[2]. This distinction, in our model becomes critical when parents choose schools for their children. Hence, the net return from schooling in a private school for a boy child is given by

$$y_p^m = \beta A k - t \tag{4}$$

For a girl child the future return to private school for the family becomes

$$y_p^f = \alpha\beta A k - t \tag{5}$$

where α is the fraction of future return from schooling that comes back to the family for girls. Similarly, the return to education in government schools for boy and girl children are given respectively in the following equations:

$$y_g^m = A k \tag{6}$$

For a girl child the future return to government school for the family becomes

$$y_g^f = \alpha A k \tag{7}$$

2.1.4 Knowledge production

We assume that students are matched with their teacher in schools and as a result knowledge is produced. The knowledge production function has two inputs - the student's ability, a, and the teacher's quality, q, and takes the following form:

$$k = aq \tag{8}$$

The marginal effect of teacher's quality on student's knowledge depends on the student's ability.

2.2 Teacher-school matching

We first analyze the school choice decision of the teachers. We assume that if a teacher accepts a job in government schools, he/she is randomly allocated to any government school in the interval $[0, 1]$ over which the government schools are spread.

[2]Our results go through as long as we assume that the share of future income coming back to the parental family is higher for the boys than the girl.

Therefore, ex-ante the expected location of the government school for any teacher is $\frac{1}{2}$ given the uniform distribution of the government schools. Hence, the expected pay-off from a government job is

$$\Pi_g^i = w_g - \frac{\theta_i}{2}$$

for $i = F, M$. On the other hand, if a teacher gets a job in a private school located at x, her pay-off is

$$\Pi_p^i = w_p - \theta_i (1 - x)$$

A female teacher accepts a government job over an offer from a private school at location x, if and only if

$$w_g - \frac{1}{2} \geq w_p - (1 - x)$$

This leads to the following threshold condition for accepting government jobs for female teachers

$$x \leq w_g - w_p + \frac{1}{2} = x_0 \tag{9}$$

A male teacher does the same if and only if

$$w_g - \frac{\theta}{2} \geq w_p - \theta (1 - x)$$

This leads to the location threshold for male teachers

$$x \leq \frac{w_g - w_p}{\theta} + \frac{1}{2} = x_0' \tag{10}$$

Notice that since the private schools and government school board always try to recruit better quality teachers, the teachers of higher quality get to make their choices earlier than their low quality counterpart. In case of government school jobs however, the teachers cannot choose their exact school locations.

We now impose restrictions on the parameters to ensure that both male and female teachers are distributed over both types of school.

A1 $w_g > \frac{1}{2}$, $\theta < w_p < 1$

A2 $w_g - w_p < \frac{1}{2}$

A3 $w_g - w_p > \frac{\theta}{2}$

The restriction on w_g in A1 makes sure that the female teachers find it remunerative to accept government jobs. We will shortly see that the bounds on w_p generate voluntary unemployment for female teachers while full-employment for male teachers. In other words, these restrictions make sure that the participation constraint for the female teachers becomes binding at some point, while the same for the male teachers never binds. The implication of this assumption will become clearer later on.

A2 ensures that a female teacher prefers a job in a private school of her most preferred location ($x = 1$) over a government job and hence $x_0 < 1$. A3, on the other hand, makes sure that as long as government jobs are available, male teachers prefer government jobs over teaching in a private school.

We have already shown that female teachers prefer private schools at location $x \in (x_0, 1]$ to government school jobs. In absence of any gender bias from the employers, teachers get job offers sequentially according to their qualities. As a result, the female teachers at the top of the quality ladder ($q_F \in (x_0, 1]$) will accept offers from private schools located at $x \in (x_0, 1]$. All male teachers, on the other hand, prefer government jobs over private ones irrespective of their locations. But all male teachers do not get government jobs when female teachers compete for government jobs. As the top quality female teachers opt out of government jobs and choose private jobs at the locations $x \in (x_0, 1]$, male teachers with $q_M \in (x_0, 1]$ accept government job offers. However, these male teachers have no choice of their job locations.

Male teachers start facing competition from their female counterpart for government jobs, after the private jobs at locations $x \in (x_0, 1]$ are filled up by female teachers. Both male and female teachers prefer government jobs to private jobs at the locations $x \leq x_0$. Note that of all the government jobs – which are of measure 1 – jobs of measure $(1 - x_0)$ are already filled in by the top quality male teachers. Hence, government jobs of measure x_0 remains to be filled in and both male and female teachers compete for them. These jobs will be shared equally between male and female teachers moving downwards in the quality ladder from x_0. Thus, female teachers of quality $q_F \in [\frac{x_0}{2}, x_0]$ will now get government jobs. Note that male teachers of quality $q_M \in [x_0, 1)$ are already in government jobs and now male teachers of quality $q_M \in [\frac{x_0}{2}, x_0)$ take up government jobs. This results in male teachers of quality $q_M \in [\frac{x_0}{2}, 1)$ accepting government jobs.

In the previous paragraph, we looked at the teachers' choice between private jobs and government jobs. Once government jobs are filled-up, the rest can either choose private jobs or remain unemployed .

For female teachers, joining a private school at location x is better than remaining unemployed if and only if

$$w_p - (1 - x) \geq 0$$

This leads to

$$x \geq 1 - w_p = x_1 \tag{11}$$

Given A1, $1 - w_p > 0$, implying that $x_1 > 0$. This means that there exists some location x_1 for which female teachers prefer to remain unemployed rather than working in a private school located beyond x_1 .

For the male teachers, the condition for joining a private school at location x rather than remaining unemployed is

$$w_p - \theta(1 - x) \geq 0$$

This would imply

$$x \geq 1 - \frac{w_p}{\theta} = x_1' \tag{12}$$

Once again, A1 ensures that the above holds for every $x \geq 0$, i.e. the male teachers are willing to join a private school even at location 0 and no male teacher remain voluntarily unemployed.

Notice that since $w_g > \frac{1}{2}$, $x_1 < x_0$. Remember that female teachers prefer government schools to private schools in locations $x < x_0$. On the other hand, they rather remain unemployed than joining private schools in locations $x < x_1$. Hence, in the interval $x_1 \geq x < x_0$, their first preference is government jobs. But if they don't get one they are ready to join private schools rather than remain unemployment.

Let us now summarize our findings from above. We show that male teachers of quality $q_M \in (x_0, 1]$ get absorbed in the government schools in the first round when they face no competition from their female counterpart. In the next round of the quality ladder, both male and female teachers of quality $q \in [\frac{x_0}{2}, x_0]$ accepts government jobs. Hence, the total number of male teachers in government jobs become $(1 - \frac{x_0}{2})$ and total female teachers in government jobs become $\frac{x_0}{2}$. This exhausts the government jobs.

Now for private schools at locations $x \in [x_1, x_0]$, we are left with both male and female teachers with quality less than $\frac{x_0}{2}$ and they will be filling up the private jobs in these locations. Evidently, half of these private jobs will be filled up by people from each category. Hence, female teachers with $q_F \in [\frac{x_1}{2}, \frac{x_0}{2})$ will be employed in these private schools. This implies that for private schools, the top quality $(1 - x_0)$ female teachers accept private jobs, and then $(\frac{x_0}{2} - \frac{x_1}{2})$ of lower quality female teachers also accept private jobs. Among the male teachers $\frac{x_0}{2}$ accept private jobs. This makes the total measure of teacher willing to get employed in private jobs equal to $(1 - \frac{x_1}{2})$.

Hence, $\frac{x_1}{2}$ jobs remain vacant. But all the male teachers are willing to employed, and because these jobs are beyond x_1, female teachers prefer to remain unemployed to joining these remote location private schools. We assume that the only input needed to run a school is a teacher. We have shown that the private schools located at $x \in [0, \frac{x_1}{2})$ run into a supply bottleneck in the sense that these cannot get a teacher to run the school and thus cannot survive.

We summarize the above observations in the following figures. The first two figures show the quality-wise distribution of female and male teachers among government and private schools, while the last one shows the teacher profile of the private schools in different locations.

male.png

Figure 1: Quality-wise distribution of male teachers among government and private schools

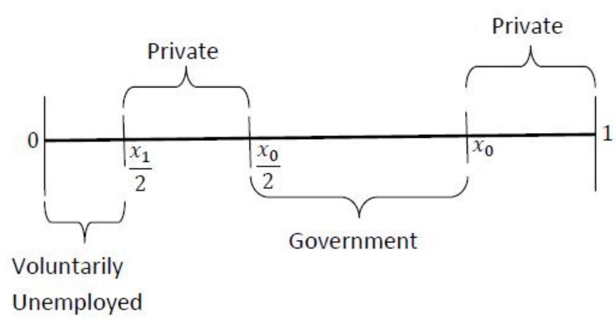

Figure 2: Quality-wise distribution of female teachers among government and private schools

In the next section, we model the students' schools choice. For that, we need the average teacher quality in government schools as student calculate their pay-offs from attaining government schools from that. For private schools they know the exact teacher quality in a location.

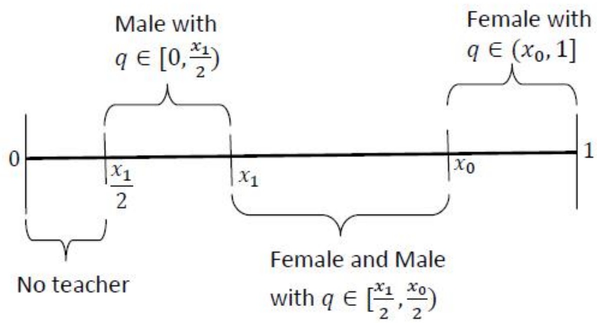

Figure 3: Teacher quality in private schools at different locations

2.3 Students' school choice decisions

Each household decides the type of school for its ward considering the net future return from education. The household, while making the choice, distinguish between boys and girls because it believes that while the whole future earning of a boy accrues to the family, only a fraction, α, of that the family can retain for a girl.

Since all male teachers with quality $q_M \in \left[\frac{x_0}{2}, 1\right]$ and all female teachers with quality $q_F \in \left[\frac{x_0}{2}, x_0\right]$ work in government schools, the average quality of all teachers in government schools can be easily determined as[3]

$$\bar{q}^g = \frac{2 + x_0^2}{4}.$$

If a student with ability a is sent to the government school in the locality, the expected acquired knowledge would be

$$k_g(a) = a\bar{q}^g$$

[3]It is easy to see that

$$\begin{aligned} \bar{q}^g &= \left(1 - \frac{x_0}{2}\right)\bar{q}_M^g + \left(x_0 - \frac{x_0}{2}\right)\bar{q}_F^g \qquad (13) \\ &= \left(1 - \frac{x_0}{2}\right)\left(\frac{x_0 + 2}{4}\right) + \frac{x_0}{2}\frac{3x_0}{4} \\ &= \frac{4 - x_0^2 + 3x_0^2}{8} \\ &= \frac{2 + x_0^2}{4} \end{aligned}$$

If the same student is sent to the private school, acquired knowledge depends on the student's location which is the same as the school's location. If the student's location is x, then

$$k_p(a,x) = \begin{cases} ax & \forall x \in (x_0, 1] \\ a.\frac{x}{2} & \forall x \in (x_1, x_0] \\ a.\left(x - \frac{x_1}{2}\right) & \forall x \in [\frac{x_1}{2}, x_1] \end{cases}$$

For locations $x < \frac{x_1}{2}$, the private schools cannot sustain because of teacher unavailability.

Now consider the households' school choice decision about a boy student of ability a located at $x \in (x_0, 1]$. If this boy is sent to a government school, his expected future earning would be

$$y_g^m(a,x) = Aa\bar{q}^g$$

If he is sent to a private school, his net expected earning is

$$y_p^m(a,x) = \beta Aax - t$$

The boy is sent to the private school if and only if

$$y_p^m(a,x) \geq y_g^m(a,x)$$

$$\Leftrightarrow \beta Aax - t \geq Aa\bar{q}^g$$

$$\Leftrightarrow a \geq \frac{\frac{t}{A}}{\beta x - \bar{q}^g} = a_1^m(x,\beta) \tag{14}$$

A girl at the same location will be sent to a private school if and only if

$$y_p^f(a,x) \geq y_g^f(a,x)$$

$$\Leftrightarrow \alpha\beta Aax - t \geq \alpha Aa\bar{q}^g$$

$$\Leftrightarrow a \geq \frac{\frac{t}{\alpha A}}{\beta x - \bar{q}^g} = a_1^f(x,\beta) \tag{15}$$

Similarly, for every location $x \in (x_1, x_0]$ and $x \in (\frac{x_1}{2}, x_1]$, we can find the critical ability levels for boys and girls above which they are sent to private schools. We denote these $a_2^i(x,\beta)$ and $a_3^i(x,\beta), i = f, m$ respectively and these can be derived as

$$a_2^m(x,\beta) = \frac{\frac{t}{A}}{\beta\frac{x}{2} - \bar{q}^g} \tag{16}$$

$$a_2^f(x,\beta) = \frac{\frac{t}{\alpha A}}{\beta\frac{x}{2} - \bar{q}^g} \tag{17}$$

and

$$a_3^m(x,\beta) = \frac{\frac{t}{A}}{\beta\left(x - \frac{x_1}{2}\right) - \bar{q}^g} \tag{18}$$

$$a_3^f(x,\beta) = \frac{\frac{t}{\alpha A}}{\beta\left(x - \frac{x_1}{2}\right) - \bar{q}^g} \tag{19}$$

Notice that for all x, β, $a_1^m(x,\beta) < a_1^f(x,\beta)$.

$a_j^i(x,\beta)$ falls with x as well as β for all i and j. Thus, higher the perceived return from private schooling relative to government schooling, higher is the number of students put to private school in every location where a private school exists. Similarly, given β, the more remote the private school is, the lower is the quality of teacher and hence lower is the return to private schooling. Thus, remote private schools would have lower number of students relative to government schools.

For locations $x \in (x_1, x_0]$ and for $\beta \geq 1$ the general conditions for sending boys and girls to private schools are detailed in the next two equations:

$$a_2^m(x,\beta) \leq 1 \Leftrightarrow x \geq \frac{\frac{t}{A} + \bar{q}^g}{\frac{\beta}{2}} = x^{2m}(\beta) \tag{20}$$

and

$$a_2^f(x,\beta) \leq 1 \Leftrightarrow x \geq \frac{\frac{t}{\alpha A} + \bar{q}^g}{\frac{\beta}{2}} = x^{2f}(\beta) \tag{21}$$

For locations $x \in (\frac{x_1}{2}, x_1]$, these conditions are

$$a_3^m(x,\beta) \leq 1 \Leftrightarrow x \geq \frac{\frac{t}{A} + \bar{q}^g}{\beta} + \frac{x_1}{2} = x^{3m}(\beta) \tag{22}$$

and

$$a_3^f(x,\beta) \leq 1 \Leftrightarrow x \geq \frac{\frac{t}{\alpha A} + \bar{q}^g}{\beta} + \frac{x_1}{2} = x^{3f}(\beta) \tag{23}$$

For any given x, $a_j^i(x,\beta)$ for all $i \in \{m, f\}$, $j \in \{1,2,3\}$ falls with β. Thus, in any given location, more students are sent to private school as the perceived return rises. Moreover, $x^{ji}(\beta)$ for all $i \in \{m, f\}$, $j \in \{2,3\}$ also falls with β implying that students in more locations are sent to private schools as β rises.

2.4 Finding equilibrium

We find the equilibrium in terms of β. For every β, the set of students going to private and government schools at every location is uniquely determined. This in turn determines the average abilities of students over all locations going to private and government schools, $\vec{a}^p$ and $\vec{a}^g$, as functions of β.

We assume that $a_1^m(x_0, 1) \leq 1$ i.e. even if there is no perceived private school premium, some students at $x = x_0$ are sent to the private school. The private school at $x = x_0$ has a teacher of quality x_0 while the government school at the same location has a randomly allocated teacher. Therefore, students would be sent to the private school at x_0 only if the quality of the private school teacher at x_0 exceeds that of the average government school teacher by an amount that justifies the private school fee[4]. This is assumed in A4.

A4 $\frac{t}{\alpha A} \leq x_0 - \bar{q}^g$

Given A4, at $\beta = 1$,

$$a_1^m(x_0, 1) \leq a_1^f(x_0, 1) < 1$$

Hence, some boys are girls[5] are sent to private schools at $x = x_0$.

Given A1-A4, it is fairly easy to verify that there exists $\beta^* > 1$ such that

$$\beta^* = \frac{\bar{a}^p(\beta^*)}{\bar{a}^g(\beta^*)} \tag{24}$$

We have kept out the formal proof of existence of such an equilibrium β^*. Intuitively, evan at $\beta = 1$, some students are sent to private school. Since at every location where a private school exists, ability-wise top students are sent to private schools from each gender category, the average ability of private schools students is higher than government school students. As β becomes very large, almost all students at every location where a private school exists are sent to private schools. However, private schools cannot exist at every location because of teacher shortage. Hence, as $\beta \to \infty$, in locations where private schhols exist go to private schools, while in all other locations all students go to government schools. Thus, as $\beta \to \infty$, avarage ability of private school students as well as government school students become $\frac{1}{2}$.

[4]A necessary condition for this assumption to hold is $x_0 > \bar{q}_g = \frac{2+x_0^2}{4}$ which requires x_0 to be high enough. For this, the difference between the teacher salaries in government and private schools needs to be high

[5]We can relax this assumption and our results will remain qualitatively unaffected as long as $\frac{t}{A} < 1 - \bar{q}^g$. Given this condition, we will always find an equilibrium in which private schools exist and the best students are always sent to private schools generating a positive labour market premium for private school goers. However, A4 makes the exposition clearer without compromising on basic message that we attempt to convey here.

Given the continuity of both $\bar{a}^p(\beta)$ and $\bar{a}^g(\beta)$ in β, there must be[6] $\beta^* > 1$ such that $\beta^* = \frac{\bar{a}^p(\beta^*)}{\bar{a}^g(\beta^*)}$.

2.5 Main results

We are now in a position to discuss the main results of the paper. The locations at which the private schools would have students depend on β^*. Notice that if a private school gets students at location y, then all private schools at location $x \in (y, 1]$ would also have students. Suppose $\underline{x}(\beta^*)$ is the remotest location at which a private school can get students. If $\beta^* \leq \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}$, then only private schools at locations $x \in [x_0, 1]$ would have students since for every $x < x_0$, $a_2^m(x, \beta) > 1$. Thus for this range of β^*, $\underline{x}(\beta^*) = x_0$. Similarly, for other values of β^*, we can identify $\underline{x}(\beta^*)$ in the following manner:

$$\underline{x}(\beta^*) = \begin{cases} x_0 & \forall \beta^* \in \left(1, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}\right] \\ x^{2m}(\beta^*) & \forall \beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}\right] \\ x^{3m}(\beta^*) & \forall \beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}, \infty\right) \end{cases} \tag{25}$$

Since for any finite β^*, $\underline{x}(\beta^*) > \frac{x_1}{2}$, even though there are some teachers willing to accept jobs in private schools at all locations $x \geq \frac{x_1}{2}$, these schools cannot survive because of lack of students. This leads to involuntary unemployment among teachers. The female teachers do not accept employment in private schools located at $x < x_1$. The male teachers however are willing to work at private schools located at $x \geq \frac{x_1}{2}$. Thus, the involuntary unemployment among male teachers are higher than the female teachers. These are stated in the following proposition.

Proposition 1 *In equilibrium, there is involuntary unemployment among teachers. The extent of involuntary unemployment is higher among male teachers than among female teachers at equilibrium.*

Interestingly, the standard remedy of involuntary unemployment - wage cut - may aggravate the problem instead of curing it. If w_p goes down, x_0 will increase leading to an increase in $\bar{q}_g$. This makes the government schools more attractive to students at all locations and as a result in some locations where the private school were getting students may not get them any more. This would tend to aggravate the problem of unemployment.

[6]The formal proof of the existence of equilibrium is available from the authors on request.

We next discuss gender-wise ability distribution of students in different types of school. First, notice that at every location at which a private school exists, ability wise top students from both male and female categories go to private schools while the rest goes to government school. Thus, at every location the average ability of students from each category going to private school exceeds the average ability of their counterparts going to the government school. At every $x > \underline{x}(\beta^*)$, the male students with ability $a \in [a^m(x, \beta^*), 1]$ attend private school while those with ability $a \in [0, a^m(x, \beta^*))$ go to government school. Thus, at every $x > \underline{x}(\beta^*)$, the average ability of male students going to private school is $\frac{a^m(x,\beta^*)+1}{2}$, while that of male students going to government school is $\frac{a^m(x,\beta^*)}{2}$. For the female students, these are $\frac{a^f(x,\beta^*)+1}{2}$ and $\frac{a^f(x,\beta^*)}{2}$ for private and government schools respectively. These observations lead to our next proposition.

Proposition 2 *The average abilities of both female and male students going to private schools exceed the average qualities of the same category students going to government schools at every location.*

We can now discuss our main results regarding gender-wise student performance in private schools. The number of female students going to private schools as well as their abilities depend among other things the equilibrium private school premium. We derive our results for the case $\beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}\right]$, for which $\underline{x}(\beta^*) = x^{2m}(\beta^*) \in [x_1, x_0)$. However, the results are robust across different equilibrium values of β^* for which cut-off locations are specified in equations (25). Given this β^*, at each location $x \in [x^{2m}(\beta^*), x_0)$, the abilities of male private school goers are $a \in [a_2^m(x, \beta^*), 1]$. At the locations $x \in [x_0, 1]$, the male students with abilities $a \in [a_1^m(x, \beta^*), 1]$ go to private schools.

Since at each school all students are being taught by the same teacher, the average performance of the male students going to a particular school is determined by the average ability of the male students in that particular school and the quality of the teacher. Thus for any private school at location x, the average performance of male students is given by

$$P^m(x,\beta^*) = \begin{cases} \frac{1+a_2^m(x,\beta^*)}{2}.\frac{x}{2} & \forall\ x \in [x^{2m}(\beta^*), x_0) \\ \frac{1+a_1^m(x,\beta^*)}{2}.x & \forall\ x \in [x_0, 1] \end{cases} \tag{26}$$

since the teacher quality in $x \in [x^{2m}(\beta^*), x_0)$ is $\frac{x}{2}$ while the teacher quality in $x \in [x_0, 1]$ is x. Similarly, the average performance of female students at location x

is given by

$$P^f(x,\beta^*) = \begin{cases} \frac{1+a_2^f(x,\beta^*)}{2}.\frac{x}{2} & \forall\, x \in [x^{2f}(\beta^*), x_0) \\ \frac{1+a_1^f(x,\beta^*)}{2}.x & \forall\, x \in [x_0, 1] \end{cases} \tag{27}$$

The number of male and femalestudents going to private schools at location x are given by

$$n^m(x,\beta^*) = \begin{cases} 1 - a_2^m(x,\beta^*) & \forall\, x \in [x^{2m}(\beta^*), x_0) \\ 1 - a_1^m(x,\beta^*) & \forall\, x \in [x_0, 1] \end{cases} \tag{28}$$

and

$$n^f(x,\beta^*) = \begin{cases} 1 - a_2^f(x,\beta^*) & \forall\, x \in [x^{2f}(\beta^*), x_0) \\ 1 - a_1^f(x,\beta^*) & \forall\, x \in [x_0, 1] \end{cases} \tag{29}$$

respectively.

We next discuss the performances of the boys and girls in private schools when they are matched with teachers of different genders. First, consider the private schools at locations $x \in [x_0, 1]$. The students in these schools are being taught by only female teachers. In the private schools at locations $x \in [x^{2m}(\beta^*), x_0)$, half the teachers are male and the rest are female. Hence any student going to a private school at these locations, will be taught by a female teacher with probability $\frac{1}{2}$ and by a male teacher by probability $\frac{1}{2}$.

Let us now consider the performance of the boys. The average performance of the boys in private schools when matched with female teachers can be derived as

$$\bar{k}_{pF}^m = \frac{\int_{x^{2m}(\beta^*)}^{x_0} \frac{n^m(x,\beta^*)}{2} P^m(x,\beta^*)\,dx + \int_{x_0}^1 n^m(x,\beta^*)\,P^m(x,\beta^*)\,dx}{\int_{x^{2m}(\beta^*)}^{x_0} \frac{n^m(x,\beta^*)}{2} dx + \int_{x_0}^1 n^m(x,\beta^*)\,dx}$$

For schools located at $x \in [x^{2m}(\beta^*), x_0)$, we have to use $\frac{n^m(x,\beta^*)}{2}$ instead of $n^m(x,\beta^*)$ since each private school at these locations would have a female teacher with probability $\frac{1}{2}$. For the private schools at location $x \in [x_0, 1]$, each school would have a female teacher. Thus, the average performance of the boys in private schools when matched with female teachers can be written as

$$\bar{k}_{pF}^m = \frac{\int_{x^{2m}(\beta^*)}^{x_0} \frac{\left(1-a_2^m(x,\beta^*)\right)}{2}.\frac{1+a_2^m(x,\beta^*)}{2}.\frac{x}{2}dx + \int_{x_0}^1 at\left(1 - a_1^m(x,\beta^*)\right)\frac{1+a_1^m(x,\beta^*)}{2}.xdx}{\int_{x^{2m}(\beta^*)}^{x_0} \frac{\left(1-a_2^m(x,\beta^*)\right)}{2} dx + \int_{x_0}^1 \left(1 - a_1^m(x,\beta^*)\right) dx}$$

For notational convenience we write

$$\bar{k}_{pF}^m = \frac{\frac{I_2^m}{2} + I_1^m}{\frac{N_2^m}{2} + N_1^m}$$

where I_j^t and N_j^i, $j = 1, 2, i = m.f$ are defined as

$$I_1^i = \int_{x_0}^{1} \left(1 - a^i\left(x, \beta^*\right)\right) . \frac{1 + a_1^i\left(x, \beta^*\right)}{2} . x dx \tag{30}$$

$$I_2^i = \int_{x^{2i}(\beta^*)}^{x_0} \left(1 - a_2^i\left(x, \beta^*\right)\right) . \frac{1 + a_2^i\left(x, \beta^*\right)}{2} . \frac{x}{2} dx \tag{31}$$

$$N_1^i = \int_{x_0}^{1} \left(1 - a_1^i\left(x, \beta^*\right)\right) dx \tag{32}$$

$$N_2^i = \int_{x^{2i}(\beta^*)}^{x_0} \left(1 - a_2^i\left(x, \beta^*\right)\right) dx$$

The average performance of boys when matched with male teachers can be written as

$$\bar{k}_{pM}^m = \frac{\int_{x^{2m}(\beta^*)}^{x_0} \frac{\left(1 - a_2^m(x,\beta^*)\right)}{2} . \frac{1 + a_2^m(x,\beta^*)}{2} . \frac{x}{2} dx}{\int_{x^{2m}(\beta^*)}^{x_0} \frac{\left(1 - a_2^m(x,\beta^*)\right)}{2} dx} = \frac{\frac{I_2^m}{2}}{\frac{N_2^m}{2}}$$

It is easy to verify that

$$\frac{I_1^m}{N_1^m} > \frac{1 + a_1^m\left(1, \beta^*\right)}{2} . x_0$$

while

$$\frac{I_2^m}{N_2^m} < \frac{x_0}{2}$$

since both $a_1^m\left(x, \beta^*\right)$ and $a_2^m\left(x, \beta^*\right)$ are falling in x and $a_2^m\left(x^{2m}\left(\beta^*\right), \beta^*\right) = 1$ by definition. Because $a_1^m\left(1, \beta^*\right) > 0$,

$$\frac{1 + a_1^m\left(1, \beta^*\right)}{2} . x_0 > \frac{x_0}{2}$$

and hence

$$\frac{I_1^m}{N_1^m} > \frac{I_2^m}{N_2^m}$$

Therefore,

$$\frac{\frac{I_2^m}{2} + I_1^m}{\frac{N_2^m}{2} + N_1^m} > \frac{\frac{I_2^m}{2}}{\frac{N_2^m}{2}}$$

holds. A similar result can be obtained for girls as well. This is stated in our next proposition.

Proposition 3 *Suppose A1-A4 hold. Both boys and girls in private schools perform better on average when matched with a female teacher than when matched with a male teacher.*

Since the average quality of female teachers is higher than that of male teachers in private schools, the intuition behind the result is straightforward.

We next explore whether there is any difference in performance of the boys and girls of same ability in private schools. Consider a boy with ability a. If $a < a_1^m(1,\beta^*)$, this boy is never sent to a private school wherever he is located. If $a \in [a_1^m(1,\beta^*), a_1^m(x_0,\beta^*))$, he is sent to a private school only if he is located at x such that $a_1^m(x,\beta^*) \leq a$. Similarly, if $a \in [a_1^m(x_0,\beta^*), a_2^m(x_0,\beta^*))$, the same boy would be sent to private school only if he is located at $x \in [x_0, 1]$. If $a \geq a_2^m(x_0,\beta^*)$, he would be sent to private schools at locations x such that $a_2^m(x,\beta^*) \leq a$. Similarly, we can trace out the cut-off locations for girls for every ability. However, for the boys and girls of same ability, the cut-off location for the girls are generally above that of the boys since $a_i^m(x,\beta^*) < a_i^f(x,\beta^*)$. However, if[7] $a \in [a_1^f(x_0,\beta^*), a_2^m(x_0,\beta^*))$, the cut-off location for both boys and girls is x_0.

Suppose for ability a, we denote the cut-off location for boys by $x_m(a)$ and girls by $x_f(a)$. Then,

$$x_m(a) = \begin{cases} \frac{\frac{t}{aA}+\bar{q}_g}{\beta} & \forall\ a \in [a_1^m(1,\beta^*), a_1^m(x_0,\beta^*)) \\ x_0 & \forall\ a \in [a_1^m(x_0,\beta^*), a_2^m(x_0,\beta^*)) \\ \frac{\frac{t}{aA}+\bar{q}_g}{\frac{\beta}{2}} & \forall\ a \in [a_2^m(x_0,\beta^*)), 1] \end{cases}$$

and

$$x_f(a) = \begin{cases} \frac{\frac{t}{\alpha aA}+\bar{q}_g}{\beta} & \forall\ a \in [a_1^f(1,\beta^*), a_1^f(x_0,\beta^*)) \\ x_0 & \forall\ a \in [a_1^f(x_0,\beta^*)), a_2^f(x_0,\beta^*)) \\ \frac{\frac{t}{\alpha aA}+\bar{q}_g}{\frac{\beta}{2}} & \forall\ a \in [a_2^f(x_0,\beta^*)), 1] \end{cases}$$

If α is not very low, the critical ability levels of the boys and girls can be easily ranked. We assume that α is such that the following holds:

$$a_1^m(1,\beta^*) < a_1^f(1,\beta^*) < a_1^m(x_0,\beta^*) < a_1^f(x_0,\beta^*) < a_2^m(x_0,\beta^*) < a_2^f(x_0,\beta^*) < 1$$

For ability levels $a \in [a_1^m(1,\beta^*), a_1^f(1,\beta^*))$, only boys are sent to private schools and these boys are exclusively taught by female teachers. For any other a, both boys and girls are sent to private schools.

[7] We are assuming $a_1^f(x_0,\beta^*) < a_2^m(x_0,\beta^*)$ which will hold if α is not very small.

Notice that except for $a \in [a_1^f(x_0, \beta^*), a_2^m(x_0, \beta^*))$, $x_m(a) < x_f(a)$. Consider $a \in [a_1^f(1, \beta^*), a_1^f(x_0, \beta^*))$. The expected performance of a boy with ability a is

$$\frac{1}{1 - x_m(a)} \int_{x_m(a)}^{1} ax dx = \frac{a(1 + x_m(a))}{2}$$

while that of a girl with same ability is

$$\frac{1}{1 - x_f(a)} \int_{x_f(a)}^{1} ax dx = \frac{a(1 + x_f(a))}{2}$$

Since $x_f(a) > x_m(a)$ at these levels of a, the expected performance of a girls with ability a will be better than a boy with same ability. If $a \in [a_1^f(x_0, \beta^*)), a_2^m(x_0, \beta^*))$, $x_m(a) = x_f(a) = x_0$ and hence the boys and girls would perform similarly. If $a \in [a_2^m(x_0, \beta^*), a_2^f(x_0, \beta^*))$, $x_m(a) < x_0$ while $x_f(a) = x_0$. In this case, the expected performance of a boy is

$$\begin{aligned} & \frac{1}{1 - x_m(a)} \left[\int_{x_m(a)}^{x_0} a.\frac{x}{2} dx + \int_{x_0}^{1} ax dx \right] \\ = \quad & \frac{a}{1 - x_m(a)} \left[\frac{1}{2} - \frac{x_0^2}{4} - \frac{(x_m(a))^2}{4} \right] \end{aligned}$$

while that of a girl is

$$\frac{1}{1 - x_0} \int_{x_0}^{1} ax dx = \frac{a}{1 - x_0} \left[\frac{1}{2} - \frac{x_0^2}{2} \right] = \frac{a(1 + x_0)}{2}$$

It is easy to verify that

$$\frac{(1 + x_0)}{2} > \frac{1}{1 - x_m(a)} \left[\frac{1}{2} - \frac{x_0^2}{4} - \frac{(x_m(a))^2}{4} \right]$$

for all $x_m(a) < x_0$. Finally, for $a \geq a_2^f(x_0, \beta^*)$, we can show that

$$\frac{a}{1 - x_m(a)} \left[\frac{1}{2} - \frac{x_0^2}{4} - \frac{(x_m(a))^2}{4} \right] < \frac{a}{1 - x_f(a)} \left[\frac{1}{2} - \frac{x_0^2}{4} - \frac{(x_f(a))^2}{4} \right]$$

for $x_f(a) > x_m(a)$. These are reported in our next proposition.

Proposition 4 *Suppose A1-A4 hold. Among the girls and boys who are sent to private school a girl is expected to perform generally better than a boy with the same ability.*

Our final result compares how students of different genders but same ability fare when matched with teachers of different gender. First consider a student of ability a. Notice that the girls in private schools $a < a_2^f(x_0, \beta^*)$ are not taught by by male teachers at all, we cannot judge the relative performance of male and female teachers in teaching girls with ability lower than $a_2^f(x_0, \beta^*)$. We thus consider $a \geq a_2^f(x_0, \beta^*)$. The girls of ability a are taught by female teachers at locations $[x_0, 1]$, while at locations $[x_f(a), x_0)$ they are taught by a female teacher with probability half and by a male teacher with probability $\frac{1}{2}$. Thus, the expected performance of a girl conditional on being matched with a male teacher is

$$k_f^M(a) = \frac{1}{\frac{1}{2}(x_0 - x_f(a))} \int_{x_m(a)}^{x_0} \frac{1}{2} a . \frac{x}{2} dx = \frac{a}{2} \frac{x_f(a) + x_0}{2}$$

Similarly, the the expected performance of a girl with same a conditional on being matched with a female teacher is

$$\begin{aligned} k_f^F(a) &= \frac{1}{\frac{1}{2}(x_0 - x_f(a)) + 1 - x_0} \left[\int_{x_m(a)}^{x_0} \frac{1}{2} a . \frac{x}{2} dx + \int_{x_0}^{1} a . x dx \right] \\ &= \frac{a}{2} . \frac{1 - \frac{3x_0^2}{4} - \frac{\left(x_f(a)\right)^2}{4}}{1 - \frac{x_0}{2} - \frac{x_f(a)}{2}} \end{aligned}$$

For a boy with ability $a \geq a_2^f(x_0, \beta^*)$, the expected performances are

$$k_m^M(a) = \frac{a}{2} \frac{x_m(a) + x_0}{2}$$

and

$$k_m^F(a) = \frac{a}{2} . \frac{1 - \frac{3x_0^2}{4} - \frac{(x_m(a))^2}{4}}{1 - \frac{x_0}{2} - \frac{x_m(a)}{2}}$$

One can easily verify that $k_f^F(a) > k_f^M(a)$ and $k_m^F(a) > k_m^M(a)$. So both boys and girls perform better under female teachers than under male teachers. However, it is interesting to note that the extent of loss in performance for a boy from being matched with a male teacher rather than a female teacher is less than that of a girl of same ability. This is stated in our next proposition.

Proposition 5 *The expected performances of boys and girls of any given ability is lower under male teachers than under female teachers. However, the extent of loss is lower for the boys than for the girls.*

The result is driven by the fact that girls of any given ability get better quality teachers than the boys of the same ability on an average. This along with the fact that the average quality of female teachers is higher than the male teachers would mean that the girls lose more from being matched with a female teacher. We relegate the formal proof of the second part to appendix.

3 Empirical result

3.1 Data

The data used in this study comes from the Young Lives study which was collected between 2002 and 2011 in the state of Andhra Pradesh. The sites were selected from three different agro-climatic areas and had a pro-poor bias with districts and sites being ranked according to a number of development indicators (Kumra, 2008). The administrative sub-districts (mandals) are the primary sampling units in our sample. We use data of the younger cohort of children born between January 2001 and June 2002. We make use of the rich demographic array of indicators of their socio-economic conditions and family compositions from the household survey. Additionally we use the separate schooling data collected through visits to the schools of a randomly selected sub-sample of the Younger Cohort in 2011. Attrition rate in the data is very low. 1930 children (96 per cent) in the Younger Cohort sample could be followed in 2009. Overall attrition by the third round was 2.2% (with attrition rate of 2.3 per cent for the younger cohort) over the eight-year period. In 2011, the Young Lives study randomly sampled 247 schools which were being attended by children in the Younger Cohort. The sampling frame consisted of all the Younger Cohort (YC) children who were still enrolled in school in Round 3 (2009-10) and were going to school within Andhra Pradesh. The sample included 952 children across 247 schools. The school-level survey was conducted between December 2010 and March 2011, i.e. in the school year immediately following the third wave of household-level data collection. The survey captured detailed school- level differences in infrastructure and funding, teacher qualifications and characteristics, classroom characteristics, teaching procedures and children's subjective experiences of schooling. It administered questionnaires to all school principals, teachers and detailed information on the mathematics teachers of the sample children from the younger cohort.

(Andhra Pradesh is divided into 23 administrative districts that are further subdivided into mandals. Generally, there are between 20 and 40 villages in a mandal. In total, there are 1,125 mandals and 27,000 villages in Andhra Pradesh(Kumra, 2008))

3.2 Empirical specification

The theoretical section outlined above suggests that better quality female students and female teachers end up in private school following a sorting mechanism. The mechanism is driven by two constraints that women teachers and parents of girl students face. Female teachers face higher costs of traveling and given the uncertainty regarding the location of government jobs, the best quality of them prefer private schools in urban areas. For the girl students, given the patriarchal norm of Indian society, a fraction of their future income comes back to their parental families. Therefore, only the best of the girl students are sent to private schools which are costly. In our empirical section we test our main hypothesis that female teachers have positive effect on the students' performance but the girl students benefit more from being matched with the female teachers than boys. Besides the mains results, we provide evidence in support of better quality female students and teachers being sorted to private schools. Our main empirical specification is given below:

$$Y_i = \alpha_0 + \alpha_1 D_i^{MS} + \alpha_2 D_i^{MT} + \alpha_3 D_i^{MT} * D_i^{MS} + \beta X_i^S + \gamma X_i^T + \epsilon_i \tag{33}$$

Where Y_i = Standardized z score in math test of the student i.

$D_i^{MS} = 1$ if student i is male

$D_i^{MT} = 1$ if student i's mathematics teacher is male

X_i^S = Set of control variables that captures background information of the student including household size, past test scores(cognitive and PPVT) to control for their innate ability, wealth index of household, education of the caregiver, religion, whether the household faced any recent shock, whether there is any household support for the student, region.

X_i^T = Set of control variables that captures background information of the teacher like highest qualification, received any teacher training, years of experience. We also

control for medium of instruction.
Our main aim is to look at the level and interaction effects of gender identity of the students and teachers on students' performance. In order to bring out this interaction in a more detailed manner, we create an interaction term between the gender identity of a student with that of his/her mathematics teacher. Hence, our main parameters of interest is α_3 that measures the interaction of gender dummies.

3.3 Results

We report the coefficient of our baseline regression in the table 1. We find that in rural public schools the coefficient of the interaction term between female student and female teacher is negative and significant. This is consistent with our predictions. The coefficients show the same sign as most of the rural schools are run by government. For the private schools the effect of female-female gender matching is positive and significant. For urban however, the sign is positive but not significant. Our model suggests that the result is being driven by urban private schools as teachers are ready to give up better paid government jobs for more convenient location. In table 2 we report the same regression for rural,government schools and urban, private schools. We see that the result is consistent with our theoretical predictions – negative significant effect of gender matching in rural government schools and positive significant effect of gender matching in urban private schools. However, in these tables we don't find any level effect of female students or female teachers. One possibility is that whatever be the level effect of female teachers or students get captured by the interaction effect. To capture any level effect we run the regression only with sex dummy of female teachers and students (and leave out the interaction term) in table 3. We see that in urban schools female students do better than their male counterpart. For teachers, the sign of the coefficient is positive as well but it is not significant. For rural schools the opposite picture arises. Female teacher has a negative significant effect on students' performance. In rural schools the coefficient for female students is negative but it is not significant.

3.4 Gender and teacher's qualification

We showed in our theoretical model that female teachers mostly accept private school jobs as female teachers often find it difficult to relocate themselves in remote places and private schools are often located in urban centers. We see this pattern from table (4) and (5). There are 135 male teachers in private schools as opposed to 232 female teachers. On the other hand, in government schools there are 402 male teachers as opposed to 183 female teachers.

In terms of the academic degree and professional degree, we see the pattern that our model predicted even though in some cases the results are more ambiguous than we liked. In case of degrees, able (4) and (5) reveal in private schools there are more female teachers (in terms of both absolute number and percentage) in the categories Higher Secondary and Bachelors. However, in Masters degree, male teachers dominate. In public schools female teachers dominate only in lower educational categories such as matriculation and Higher Secondary. But in both bachelor and masters, male teachers dominate both in absolute number and percentage.

Tables (6) and (7) reveal the gender wise distribution of qualifications across private and public schools. In private schools, majority teachers are female. Unlike, academic degree we have a clear result – in all professional qualification categories female teachers dominate their male counterpart in terms of absolute number. However, in terms of percentage male teachers outnumber female teachers in B.Ed category – 63.7% of male teachers have B.Ed degree compared to 42.24% of female teachers. However, in terms of absolute number even in this category female teachers (98) out number male teachers (86). In public school however, the exact opposite picture emerges – in all categories of qualification male teachers outnumber female teachers in terms of both percentage and absolute number.

3.5 Gender and job status

One of the critical assumption in our model asserts that salary in government schools is higher than that in private schools and women prefer jobs in private schools because of locational advantage. We do not have wage data to support our assumption. Instead, we look at the job status – temporary and permanent. We identify temporary jobs as jobs associated with lower salary. It is possible that per hour wage rate in temporary jobs is higher than that in permanent jobs. But given the uncertainty of getting assignments regularly it is not unreasonable to say that the life time salary of a permanent employee is higher than that of a temporary employee. We show in tables 8 and 9 that the number of temporary employees in private schools is way higher than their permanent employee size. More importantly, among the female teachers of private schools majority are temporary workers – 96 permanent vs 291 temporary. In government schools majority of the teachers are permanent workers – 392 permanent vs 192 temporary. But even within government schools, female teachers are more likely to be temporary workers. This lends somewhat support to our assumption that female teachers give preference to locations to higher salary. However, we do not have more detailed data on the exact location of the teachers to substantiate our assumption any further.

4 Conclusion

In this paper we have looked at the effect of student and teacher's gender on student's learning. More importantly, we have examined the interaction effect – how do students perform when they are matched with teachers of same gender. Even though we found evidence of interaction effect the explanation we provide for such effect critically differs from the existing literature which explains such interaction effect in terms of role model effect. We instead, explain such effect in terms of gender based quality sorting of both students and teachers across public and private schools. Our explanation is driven by two sets of parameters that creates the difference between the incentive structure for both male and female. For male and female teachers the crucial difference lies in different opportunity costs faced by men and women teachers while attending distantly located schools. For students, the difference comes from the differences in their families' claim on their return from human capital investment. For boy students, the return will come to the family while girls' family can only claim a fraction of it after they are married off following patrilocality norms. Our theory predicts that the interaction effect will be different for public and private schools which is confirmed by our empirical result. Such differential interaction effect across public and private schools also suggests that the result could not have been driven by any role model based explanation.

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Appendix

Proof of Proposition 5

The extent of loss for a boy of ability a from being matched with a male teacher instead of a female teacher is $k_m^F(a) - k_m^M(a)$ and for a girl of same ability is $k_f^F(a) - k_f^M(a)$. We show that

$$k_m^F(a) - k_m^M(a) < k_f^F(a) - k_f^M(a)$$

for $a \geq a_2^f(x_0, \beta^*)$, i.e when both boys and girls are taught by teachers of both genders.

Notice that

$$\begin{aligned} k_m^F(a) - k_m^M(a) &= \frac{a}{2}\left[\frac{1 - \frac{3x_0^2}{4} - \frac{(x_m(a))^2}{4}}{1 - \frac{x_0}{2} - \frac{x_m(a)}{2}} - \frac{x_m(a) + x_0}{2}\right] \\ &= \frac{a}{2}.\frac{2 - x_0^2 - x_0 - x_m(a)(1 - x_0)}{1 - \frac{x_0}{2} - \frac{x_m(a)}{2}} \\ &= \frac{a}{2}.\frac{[2 + x_0 - x_m(a)](1 - x_0)}{1 - \frac{x_0}{2} - \frac{x_m(a)}{2}} \end{aligned}$$

and similarly

$$k_f^F(a) - k_f^M(a) = \frac{a}{2}.\frac{[2 + x_0 - x_f(a)](1 - x_0)}{1 - \frac{x_0}{2} - \frac{x_f(a)}{2}}$$

Now,

$$k_m^F(a) - k_m^M(a) < k_f^F(a) - k_f^M(a)$$

if and only if

$$\frac{2 + x_0 - x_m(a)}{1 - \frac{x_0}{2} - \frac{x_m(a)}{2}} < \frac{2 + x_0 - x_f(a)}{1 - \frac{x_0}{2} - \frac{x_f(a)}{2}}$$

Cross-multiplication and canceling terms from both sides will reduce the inequality to

$$x_m(a) < x_f(a)$$

which holds for the range of a we consider here.

5 Tables

Table 1: Effect of gender matching on students' score: Baseline

	All	Govt	Pvt	Rural	Urban
	(1)	(2)	(3)	(4)	(5)
VARIABLES	z_math	z_math	z_math	z_math	z_math
female	0.0305	0.137	-0.270*	0.0405	0.0195
	(0.0798)	(0.0965)	(0.156)	(0.0829)	(0.300)
Math_Teacher_Female	-0.160*	-0.115	-0.168	-0.106	0.0189
	(0.0903)	(0.130)	(0.127)	(0.101)	(0.249)
Female teacher Female student interaction	-0.0334	-0.293*	0.463**	-0.253*	0.359
	(0.121)	(0.175)	(0.190)	(0.142)	(0.332)
Household size	-0.00730	6.65e-05	-0.0130	-0.0110	-0.00198
	(0.0155)	(0.0205)	(0.0233)	(0.0170)	(0.0395)
Wealth index	0.613***	0.825***	0.150	0.906***	1.018
	(0.200)	(0.293)	(0.309)	(0.242)	(0.712)
Caregiver's education	0.0386***	0.0311*	0.0416***	0.0334***	0.0472***
	(0.00963)	(0.0159)	(0.0120)	(0.0118)	(0.0175)
bad event	-0.0487	-0.127	0.156	-0.0682	0.129
	(0.0682)	(0.0924)	(0.102)	(0.0767)	(0.190)
Household support	-0.0311	-0.0483	-0.00780	-0.0354	-0.0215
	(0.0247)	(0.0325)	(0.0374)	(0.0264)	(0.0731)
region	-0.249***	-0.275***	-0.223***	-0.285***	-0.212**
	(0.0426)	(0.0576)	(0.0630)	(0.0489)	(0.0953)
normal_score_ppvt2	0.177	0.0282	0.332	0.177	0.0528
	(0.212)	(0.335)	(0.263)	(0.254)	(0.392)
normal_score_cog2	1.248***	1.277***	1.209***	1.358***	0.974**
	(0.185)	(0.244)	(0.289)	(0.208)	(0.424)
Teacher's religion	0.135*	0.112	0.117	-0.0365	0.335***
	(0.0732)	(0.158)	(0.0784)	(0.0994)	(0.119)
Teacher's highest edu	0.0983**	0.0536	0.178**	0.0848	0.159
	(0.0493)	(0.0703)	(0.0810)	(0.0557)	(0.128)
Teacher's highest qualification	0.102**	0.126*	0.0665	0.0852*	0.159**
	(0.0399)	(0.0724)	(0.0459)	(0.0492)	(0.0733)
Teacher's experience	-0.00507	-0.00268	-0.0117	-0.00571	-0.00529
	(0.00470)	(0.00575)	(0.00913)	(0.00530)	(0.0109)
english_medium	-0.160*	-0.224	-0.280***	-0.0584	-0.124
	(0.0883)	(0.948)	(0.0940)	(0.120)	(0.140)
Constant	3.964***	4.580***	3.472**	4.920***	2.044
	(0.921)	(1.245)	(1.411)	(1.069)	(2.105)
Observations	870	537	333	700	170
R-squared	0.246	0.218	0.294	0.252	0.330

Standard errors in parentheses

$***p < 0.01, **p < 0.05, *p < 0.1$

Table 2: Location wise gender interaction effect

	Govt-rural	Urban-private
	(1)	(2)
VARIABLES	z_math	z_math
Female student	0.111	-0.286
	(0.0967)	(0.315)
Math_Teacher_Female	-0.159	-0.121
	(0.134)	(0.269)
Female teacher Female student interaction	-0.317*	0.651*
	(0.178)	(0.341)
Household size	0.00879	0.0153
	(0.0205)	(0.0383)
Wealth index	0.635**	1.360*
	(0.305)	(0.705)
Caregiver's education	0.0287*	0.0531***
	(0.0164)	(0.0169)
bad event	-0.106	0.128
	(0.0940)	(0.185)
Household support	-0.0494	-0.0624
	(0.0325)	(0.0709)
region	-0.294***	-0.237***
	(0.0588)	(0.0886)
normal_score_ppvt2	-0.0368	-0.00938
	(0.336)	(0.370)
normal_score_cog2	1.298***	1.184***
	(0.245)	(0.410)
Teacher's religion	0.0475	0.344***
	(0.168)	(0.113)
Teacher's highest edu	0.0513	0.215*
	(0.0702)	(0.120)
Teacher's highest qualification	0.113	0.103
	(0.0724)	(0.0699)
Teacher's experience	-0.00256	-0.0149
	(0.00596)	(0.0125)
Constant	5.090***	2.121
	(1.275)	(1.957)
Observations	517	150
R-squared	0.215	0.414

Standard errors in parentheses

$***p < 0.01, **p < 0.05, *p < 0.1$

Table 3: Gender level effect

	Urban level only	Rural level only
VARIABLES	z_math	z_math
female student	0.311**	-0.0444
	(0.133)	(0.0679)
Math_Teacher_Female	0.200	-0.220***
	(0.184)	(0.0786)
Household size	0.00212	-0.0122
	(0.0394)	(0.0170)
Wealth index	0.921	0.915***
	(0.707)	(0.242)
Caregiver's education	0.0489***	0.0339***
	(0.0175)	(0.0118)
bad event	0.112	-0.0699
	(0.189)	(0.0768)
Household support	-0.0232	-0.0348
	(0.0731)	(0.0265)
region	-0.222**	-0.281***
	(0.0948)	(0.0489)
normal_score_ppvt2	0.0278	0.177
	(0.392)	(0.254)
normal_score_cog2	0.999**	1.364***
	(0.424)	(0.208)
Teacher's religion	0.346***	-0.0265
	(0.119)	(0.0994)
Teacher's highest edu	0.152	0.0837
	(0.127)	(0.0557)
Teacher's highest qualification	0.159**	0.0838*
	(0.0733)	(0.0492)
Teacher's experience	-0.00346	-0.00601
	(0.0107)	(0.00531)
english_medium	-0.116	-0.0600
	(0.140)	(0.120)
Constant	2.150	4.872***
	(2.104)	(1.070)
Observations	170	700
R-squared	0.325	0.249

Standard errors in parentheses
$***p < 0.01, **p < 0.05, *p < 0.1$

Table 4: Academic degree of teachers across gender in private schools

	Matriculation	HS	Bachelor	Masters	Other	Total
Male	0(0)	12(8.89)	83(61.48)	40 (29.63)	0	135(100)
Female	1(.43)	44(18.97)	165(71.12)	21(9.05)	1(0.43)	232 (100)
Total	1 (0.27)	56(15.26)	248(67.57)	61(16.62)	1(0.27)	367(100)

Table 5: Academic degree of teachers across gender in public schools

	Matriculation	HS	Bachelor	Masters	Other	Total
Male	9(2.24)	68(16.92)	239(59.45)	86(21.39)	0(0)	402(100)
Female	19(10.38)	62(33.88)	73(39.89)	29(15.85)	0(0)	183(100)
Total	28(4.79)	130(22.22)	312(53.33)	115(19.66)	0(0)	585(100)

Table 6: Professional degree of teachers across gender in private schools

	None	Diploma	B.Ed./TPT/HPT	M.Ed.	Other	Total
Male	34(25.19)	10(7.41)	86(63.7)	0	5(3.7)	135(100)
Female	102(43.97)	26(11.21)	98(42.24)	0	6(2.59)	232(100)
Total	136(37.06)	36(9.81)	184(50.14)	0	11(3.0)	367(100)

Table 7: Professional degree of teachers across gender in public schools

	None	Diploma	B.Ed./TPT/HPT	M.Ed.	Other	Total
Male	40(9.95)	116(28.86)	241(59.95)	5(1.24)	0	402(100)
Female	61(33.33)	47(25.68)	74(40.44)	0(0)	1(0.55)	183
Total	101(17.26)	163(27.86)	315(53.85)	5(.85)	1(.17)	585(100)

Table 8: Job status of teachers in private schools

	Permanent	Temporary	Total
Female	52(54.17)	180(66.42)	232 (63.22)
Male	44(45.83)	91(33.58)	135(36.78)
Total	96(100)	271(100)	367(100)

Table 9: Job status of teachers in public schools

	Permanent	Temporary	Total
Female	79(20.1)	104(54.17)	183(31.28)
Male	314(79.90)	88(45.83)	402(68.72)
Total	393(100)	192(100)	585(100)

Table 10: Gender Effect on Student's performance 2

Dep var: Math Z Score	RURAL-GOVT	RURAL-PVT	Urban-Govt	Urban-Pvt
Male	0.207	0.0116	-0.781	-0.365**
Math Teacher Male	(1.38)	(0.06)	(-0.90)	(-2.62)
	0.476***	-0.0494	-1.804	-0.519*
Interaction	(3.60)	(-0.22)	(-1.10)	(-2.14)
	-0.317	0.0713	2.620	0.639
Household Size	(-1.78)	(0.28)	(0.67)	(1.86)
	0.00879	-0.0589*	-1.287	0.0149
Wealth Index	(0.43)	(-2.03)	(-1.39)	(0.39)
	0.635*	0.663	8.309	1.346
Household Education	(2.08)	(1.60)	(1.57)	(1.90)
	0.0287	0.0187	0.366	0.0526**
Bad Shocks	(1.75)	(1.14)	(1.80)	(3.09)
	-0.106	0.164	2.007	0.130
Household Support	(-1.13)	(1.29)	(1.18)	(0.70)
	-0.0494	-0.00350	1.524	-0.0621
Region	(-1.52)	(-0.08)	(1.17)	(-0.87)
	-0.294***	-0.311***	1.645	-0.247**
Normalised past PPVT score	(-5.00)	(-3.60)	(0.69)	(-2.67)
	-0.0368	0.310	13.55	-0.0159
Normalised past Cognitive score	(-0.11)	(0.86)	(1.39)	(-0.04)
	1.298***	1.706***	-11.23	1.197**
Math Teacher Religion	(5.31)	(4.33)	(-1.30)	(2.90)
	0.0475	-0.0481	-1.909	0.351**
Math Teacher Education	(0.28)	(-0.43)	(-1.22)	(3.05)
	0.0513	0.127	-0.772	0.217
Math Teacher Qualification	(0.73)	(1.17)	(-0.75)	(1.80)
	0.113	0.0661	1.009	0.105
Math Teacher Experience	(1.56)	(1.04)	(0.89)	(1.49)
	-0.00256	-0.00938	0.0351	-0.0150
English Medium	(-0.43)	(-0.72)	(0.72)	(-1.20)
	0	-0.384**	-2.109	0.0532
Sector	(.)	(-2.93)	(-0.81)	(0.39)
Constant				
	4.724***	5.606**	-30.19	2.534
Observations	(3.69)	(2.86)	(-0.59)	(1.22)
	517	183	20	150
t statistics in parentheses				
$p < 0.05$	$**p < 0.01$	*** $p < 0.001$		