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 benefit by learning from a teacher of the same gender of his/her own 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 come from their difference in the return to human capital – for girls, a lower fraction of their return come to their parental families after they are married off. These factors create a sorting pattern which give rise 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 asymmetry in the educational achievement across different races, gender and other demographic characteristics has remained a major cause for concern in the modern egalitarian societies in their clamour for equality of opportunities for the citizens. In the current paper we examine how the gender gap in student learning is affected by the gender identity of the teacher.

Learning gap across students from different identity dimensions (race, gender, ethnicity etc) are well discussed in the literature. The issue of persistent learning gap between the black and the white in the USA is analyzed by various authors (Fairlie et al., 2014). In the Indian context there is a small but powerful literature on the lack of educational access by the scheduled castes and tribes (Sedwal and Kamat, 2008). Such persistence of educational achievement gap between different communities has been provoking the social scientists to explore the relationship between different affirmative action programmes and learning gaps in grater details.

In this context, the issue of pairing teachers and students from the same community has occupied the attention of the analysts. In this paper we are advancing our examination in the same line. On the basis of National Educational Longitudinal Survey (NELS) data Ehrenberg et al. (1995) have found that the match between teachers' race, gender and ethnicity and those of their students had little association with how much the students learned, but in several instances it seems to have been a significant determinant of teachers' subjective evaluations of their students. However, other authors have found that the performance gap in terms of class dropout rates, pass rates, and grade performance between whites and underrepresented minority students falls by roughly half when taught by an underrepresented minority instructor (Fairlie et al., 2014). The positive effect on the learning outcome of paring students and teachers from the same racial background has also been supported by Dee (2004).

In the literature there has been concern for the effects of racial dynamics between teacher and students on the educational outcome (Ferguson, 2003)(Ferguson, 1998). However, the magnitude and the exact nature of such dynamics are yet to be ascertained. Generally there are two broad categories of explanations regarding the effects of racial pairing of teacher and students on the students learning outcome one is categorized as active teacher effects and the other is known as passive teacher effects (Dee, 2004).

The former generally includes the specific favouritism exhibited by the teacher in terms of class allocation, coverage of material, interaction with students when the said teacher is paired with the students from her own racial background and apathy shown by the teachers when pairing from the same race is not done. The passive teacher effects, on the other hand, are triggered by a teachers racial presence and not by explicit teacher behaviors. The passive effects are further classified under two categories – *role model effect* and *stereotype threats* (Dee, 2005). The widely discussed phenomenon of *role model effect* arises when the presence of a demographically similar teacher raises a students academic motivation and expectation. When the students from some backward community find that the teacher is also from his own community it is supposed to instill a greater amount of confidence and enthusiasm in the students. This would then induce a kind of we can do also spirit amongst the students and they may upgrade their prior beliefs about educational possibilities. They may be more focused in studies and appreciative of the value of education under own-race teacher irrespective of the teachers actual behavior. The *stereotype threats* presupposes the importance of academic identification in the form of valuing self-worth in academic achievement for sustaining educational development. Generally, in situations, where the racial identity of students and teachers differs there may arise the possibility of students perceiving stereotypes attached in the interaction between the two which is not conducive for academic identification and subsequent achievement of the students (Dee, 2005). There is evidence of race-based stereotype threat. In an experiment based on verbal Graduate Records Examination (GRE) black students performed below the expectation compared to the white students when they were told beforehand that the test was diagnostic of ability (Steele, 1997).

In this backdrop, our contribution is two fold. First, we extend the question of teacher-student identity interaction on student's performance to gender identity while the literature is mostly dominated by the question of race. Second – and this is more important – rather than grounding our explanation on exogenous cultural traits such as role model or stereotype we explain this in terms of an endogenous sorting mechanism in terms of school type (private/public) and teacher's and student's quality. As a result of the sorting mechanism explained in the next section, we argue that there is quality sorting into private and public schools along the gender lines for both the teachers and students. Our model predicts that good female teachers join urban private schools while male teachers are evenly distributed across public schools. Also, only good quality female students attend private schools. Given this quality distribution of students and teachers along gender and school type, we find that in private schools female teachers have positive significant effect on female students.

2 Theory

2.1 Model Preliminaries

We consider a model of school choice by teachers as well as students and 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 more distant school from the most preferred location is higher 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. (1) There must be a teacher who is willing to teach in the private school at that location at the current private school wage. (2) 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.

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 get 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 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 high. 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 - Female (f) and Male (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 male and one female 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 male and 1 for female students.

The students' school choice decisions are taken by the households. We assume a student must select a school in her 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 as well as her own ability. 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 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

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

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:

$$k = aq \tag{4}$$

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, she is randomly allocated to any government school in the interval $[0, 1]$ over which the government schools are spread. 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

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

A male teacher does the same if and only if

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

Notice that since the schools always try to recruit better quality teachers, the teachers make their school choices sequentially according to their qualities. We now impose some 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. 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. This 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. A2, 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.

Since teachers get job offers sequentially according to their qualities, in absence of any gender bias from the employers, the female teachers in the top of the quality ladder will accept offers from private schools located at $x \in (w_g - w_p + \frac{1}{2}, 1]$. For notational convenience, we denote $x_0 = w_g - w_p + \frac{1}{2}$. Hence, the female teachers with $q_F \in (x_0, 1]$ are employed at private schools located at $x \in (x_0, 1]$. All male teachers, on the other hand, prefer government jobs over private ones and thus male teachers with $q_M \in (x_0, 1]$ will accept government job offers.

Notice that all teachers - both male and female - prefer government jobs over jobs in private schools located at $x \leq x_0$. However, since the total number of government schools is of measure 1 and $1 - x_0$ of these jobs are already filled up by top quality male teachers, the rest will be shared equally between male and female teachers moving downwards in the quality ladder from x_0. Thus, $q_F \in [\frac{x_0}{2}, x_0]$ female teachers and $q_M \in [\frac{x_0}{2}, 1]$ male teachers will accept government jobs.

Once government jobs are filled-up, the rest would accept employment in private schools if the net pay-off exceeds the reservation utility. For female teachers, joining a private school at location x is better than remaining unemployed if and only if

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

If $w_p \geq 1$, the above condition holds for all $x \geq 0$. So every female teacher accepts a job offer from even the location-wise worst private school rather than remaining unemployed. Given A1, $1 - w_p > 0$, i.e. some teachers prefer to remain unemployed rather than working in a far-off private school.

For the male teachers, the condition for joining a private school at location x is

$$w_p - \theta (1 - x) \geq 0 \Leftrightarrow x \geq 1 - \frac{w_p}{\theta}$$

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 0and no male teachers remain unemployed.

The female teachers accept employment in the private school located at $x \geq x_1 = 1 - w_p$. Notice that since $w_g > \frac{1}{2}$, $x_1 < x_0$. The jobs in private schools located at $x \in [x_1, x_0]$ will be accepted by both male and female teachers with quality less than $\frac{x_0}{2}$. Thus, half of these 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. For the male teachers, since everybody who doesn't get absorbed in government schools, will accept employment in private schools. However since the female teachers with $q_F \in [0, \frac{x_1}{2})$ choose to remain unemployed, the private schools located at $x < \frac{x_1}{2}$, won't find any teacher willing to accept employment and thus cannot. 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.

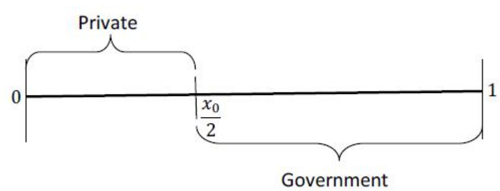

Figure 1: Quality-wise distribution of male teachers among government and private schools

We can now make some observations about the teacher quality in the two types of schools. Our first proposition discusses the gender specific quality of teachers in different types of school.

Proposition 1 *Suppose A1-A3 hold. Then, the average quality of male teachers in government schools exceeds the average quality of male teachers in private schools.*

This is pretty clear from Figure 1. The male teachers first opt for government schools. Only after the government school jobs are filled up, they

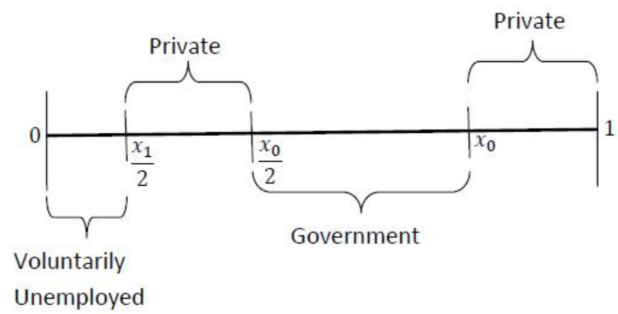

Figure 2: Quality-wise distribution of male teachers among government and private schools

opt for private schools. Given uniform distribution of teacher quality among males, the average quality of male teachers in government schools is

$$\bar{q}_M^g = \frac{\frac{x_0}{2} + 1}{2} = \frac{x_0 + 2}{4} \tag{5}$$

while that in private schools is

$$\bar{q}_M^p = \frac{\frac{x_0}{2}}{2} = \frac{x_0}{4}$$

and $\bar{q}_M^g > \bar{q}_M^p$.

In case of female teachers, the issue is more complicated. The top quality female teachers opt for private schools. The next rung prefers government schools over private ones. Then, once the government jobs are filled up, they opt for private schools as long as the net pay-off exceeds the reservation payoff. Thus, the average quality of female teachers in private schools depend on the farthest location in which a private school can survive in equilibrium. This in turn depends on the demand for private schooling among households in different locations. We will come back to this after we discuss the demand side.

In our next proposition we make a comparison across genders between the teachers in government schools.

Proposition 2 *Suppose A1-A3 hold. Then, the average quality of male teachers exceeds the average quality of female teachers in government schools.*

The average quality of female teachers in government schools is

$$\bar{q}_F^g = \frac{\frac{x_0}{2} + x_0}{2} = \frac{3x_0}{4} < \frac{x_0+2}{4} = \bar{q}_M^g$$

Thus, the average quality of male teachers in government schools exceeds the Suppose $\underline{x}$ is the location of the most distant private school in equilibrium. If $\underline{x} \in \left(\frac{x_1}{2}, x_1\right)$, then the average quality of female teachers in private schools is

$$\begin{aligned}
\bar{q}_F^p &= \frac{\left(\frac{x_0-x_1}{2}\right)}{\left(1-x_0+\frac{x_0-x_1}{2}\right)} \cdot \left(\frac{\frac{x_1}{2}+\frac{x_0}{2}}{2}\right) + \frac{(1-x_0)}{\left(1-x_0+\frac{x_0-x_1}{2}\right)} \cdot \left(\frac{x_0+1}{2}\right) \\
&= \frac{1}{2\left(1-\frac{x_0}{2}-\frac{x_1}{2}\right)}\left(\frac{x_0^2-x_1^2}{4}+1-x_0^2\right) \\
&= \frac{1}{4}\left(\frac{4-3x_0^2-x_1^2}{2-x_0-x_1}\right)
\end{aligned}$$

On the other hand if $\underline{x} \in [x_1, x_0]$, there are not enough private school jobs for all female teachers who are willing to join a private school. In this case, the average quality of female teachers in private schools is

$$\begin{aligned}
\bar{q}_F^p &= \frac{\left(\frac{x_0-\underline{x}}{2}\right)}{\left(1-x_0+\frac{x_0-\underline{x}}{2}\right)} \cdot \left(\frac{\frac{\underline{x}}{2}+\frac{x_0}{2}}{2}\right) + \frac{(1-x_0)}{\left(1-x_0+\frac{x_0-x_1}{2}\right)} \cdot \left(\frac{x_0+1}{2}\right) \\
&= \frac{1}{4}\left(\frac{4-3x_0^2-\underline{x}^2}{2-x_0-\underline{x}}\right)
\end{aligned}$$

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 show in the next section that the distant private schools may run into demand bottlenecks as well because no students may be willing to enroll at a high fee in a private school located in a remote region where they expect the teacher quality to be low. The demand constraint may also limit the sustainability of the private schools in distant locations and when the demand constraint becomes binding, the average quality of teachers (both male and female) in private schools would improve than the levels discussed above.

The average quality of all teachers in a government school can be easily determined. Notice that all male teachers with quality $q_M \in \left[\frac{x_0}{2}, 1\right]$ and all

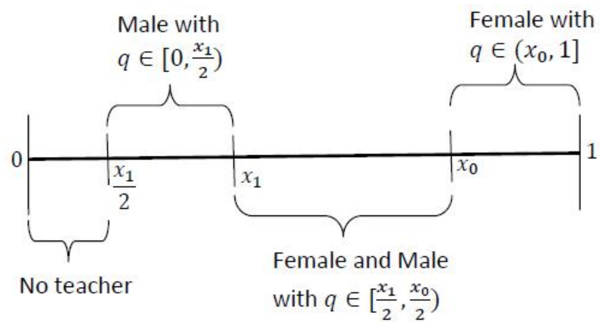

Figure 3: Teacher quality in private schools at different locations

female teachers with quality $q_F \in \left[\frac{x_0}{2}, x_0\right]$ work in government schools. Thus the average quality of all teachers in government schools is

$$\begin{aligned}\bar{q}^g &= \left(1 - \frac{x_0}{2}\right)\bar{q}^g_M + \left(x_0 - \frac{x_0}{2}\right)\bar{q}^g_F \qquad (6)\\ &= \left(1 - \frac{x_0}{2}\right)\left(\frac{x_0+2}{4}\right) + \frac{x_0}{2}\frac{3x_0}{4}\\ &= \frac{4 - x_0^2 + 3x_0^2}{8}\\ &= \frac{2 + x_0^2}{4}\end{aligned}$$

The average quality of teachers in private schools depends once again on the location of the most distant private school in equilibrium. If $\underline{x} \in [\frac{x_1}{2}, x_1]$

$$\begin{aligned}\bar{q}^p &= \frac{x_1 - \underline{x}}{1 - \underline{x}}.\frac{y - \frac{x_1}{2} + \frac{x_1}{2}}{2} + \frac{x_0 - x_1}{1 - \underline{x}}.\frac{x_1 + x_0}{4} + \frac{1 - x_0}{1 - \underline{x}}.\frac{x_0 + 1}{2}\\ &= \frac{1}{1 - \underline{x}}\left(\frac{(x_1 - \underline{x})\,\underline{x}}{2} + \frac{x_0^2 - x_1^2}{4} + \frac{1 - x_0^2}{2}\right)\end{aligned}$$

If on the other hand, if $\underline{x} \in (x_1, x_0)$,

$$\begin{aligned}\bar{q}^p &= \frac{x_0 - \underline{x}}{1 - \underline{x}}.\frac{\underline{x} + x_0}{4} + \frac{1 - x_0}{1 - \underline{x}}.\frac{x_0 + 1}{2}\\ &= \frac{1}{1 - \underline{x}}\left(\frac{x_0^2 - \underline{x}^2}{4} + \frac{1 - x_0^2}{2}\right)\end{aligned}$$

The average quality of teachers in private school once again depends on the location of the remotest private school.

2.3 Students' school choice decisions

Each household decides the type of school for its ward considering the net future return from education. The households, 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.

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

$$k_g(a) = a\left(\frac{2+x_0^2}{4}\right)$$

since the teachers in government schools are randomly distributed and $\bar{q}^g = \left(\frac{2+x_0^2}{4}\right)$. If the same student is sent to the private school, acquired knowledge depends on the location. If the student's location is x, then

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

For locations $x \leq \frac{x_1}{2}$, 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

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

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

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

$$\Leftrightarrow \beta A a x - t \geq A a \bar{q}^g$$

$$\Leftrightarrow a \geq \frac{\frac{t}{A}}{\beta x - \bar{q}^g} = a_1^m(x, \beta) \tag{7}$$

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

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

$$\Leftrightarrow \alpha\beta A a x - t \geq \alpha A a \bar{q}^g$$

$$\Leftrightarrow a \geq \frac{\frac{t}{\alpha A}}{\beta x - \bar{q}^g} = a_1^f(x, \beta) \tag{8}$$

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

$$a_2^m(x, \beta) = \frac{\frac{t}{A}}{\beta\frac{x}{2} - \bar{q}^g} \tag{9}$$

$$a_2^f(x, \beta) = \frac{\frac{t}{\alpha A}}{\beta\frac{x}{2} - \bar{q}^g} \tag{10}$$

and

$$a_3^m(x, \beta) = \frac{\frac{t}{A}}{\beta\left(x - \frac{x_1}{2}\right) - \bar{q}^g} \tag{11}$$

$$a_3^f(x, \beta) = \frac{\frac{t}{\alpha A}}{\beta\left(x - \frac{x_1}{2}\right) - \bar{q}^g} \tag{12}$$

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.

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 look for $\beta^* > 1$ such that

$$\beta^* = \frac{\bar{a}^p(\beta^*)}{\bar{a}^g(\beta^*)} \tag{13}$$

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 at the private school[1]. This is specified in A4.

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

Given A4, at $\beta = 1$ some boys go to private school at $x = x_0$. If $a_1^f(x_0, 1) \leq 1$, then some girls at the location $x = x_0$ are sent to private school as well. If not, then we can find some $x_1^f \in (x_0, 1]$ such that at each location $x \in \left[x_1^f, 1\right]$ girls with ability $a \in \left[a_1^f(x, 1), 1\right]$ are sent to private schools.

First consider the case $a_1^f(x_0, 1) \leq 1$. Then, for every $x \in [x_0, 1]$ the boys with ability $a \in [a_1^m(x, 1), 1]$ and girls with ability $a \in \left[a_1^f(x, 1), 1\right]$ are sent to private school for $\beta = 1$. Since $\frac{x_0}{2} < \frac{2+x_0^2}{4} = \bar{q}^g$, at every location $x \leq x_0$, the private school teacher quality is below the quality of average government school teachers, children are not sent to private schools in absence of any private school premium. In case $a_1^f(x_0, 1) > 1$, we have a similar situation except that the girls are not being sent to private schools even at locations $x \in [x_0, x_1^f)$.

[1]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.

Notice that for locations $x \in (x_1, x_0]$, the conditions for sending boys and girls to private schools are

$$a_2^m(x,\beta) \le 1 \Leftrightarrow x \ge \frac{\frac{t}{A} + \bar{q}^g}{\frac{\beta}{2}} = x^{2m}(\beta) \tag{14}$$

and

$$a_2^f(x,\beta) \le 1 \Leftrightarrow x \ge \frac{\frac{t}{\alpha A} + \bar{q}^g}{\frac{\beta}{2}} = x^{2f}(\beta) \tag{15}$$

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

$$a_3^m(x,\beta) \le 1 \Leftrightarrow x \ge \frac{\frac{t}{A} + \bar{q}^g}{\beta} + \frac{x_1}{2} = x^{3m}(\beta) \tag{16}$$

and

$$a_3^f(x,\beta) \le 1 \Leftrightarrow x \ge \frac{\frac{t}{\alpha A} + \bar{q}^g}{\beta} + \frac{x_1}{2} = x^{3f}(\beta) \tag{17}$$

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.

Now suppose β increases from 1. We consider the case when $a_1^f(x_0,1) \le 1$. The other case can be treated similarly. If β rises above $\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}$ so that $x^{2m}(\beta) \le x_0$, households start sending boys to private schools in the locations $x \in [x^{2m}(\beta), x_0]$. Once $\beta \ge \frac{\frac{t}{\alpha A}+\bar{q}^g}{\frac{x_0}{2}}$, the girls in the locations $x \in \left[x^{2f}(\beta), x_0\right]$ will be sent to private schools. As β rises above $\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}$, boys and then eventually girls at locations in the range $(\frac{x_1}{2}, x_1)$ are sent to private schools.

We can now characterize the distribution of students of each gender at all locations among private and government schools and hence average ability of students going to private and government schools for different values of β. It is fairly straightforward to verify that there exists at least one[2] finite $\beta^* > 1$ at which the perceived private school premium is exactly equal to the relative average ability of the private school students, i.e.

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

[2]There may be more than one equilibrium.

We have relegated the proof of existence of the equilibrium to appendix. The equilibrium private school premium, β^*, depends on the parameters of the model.

2.5 Main results

We are now in a position to 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 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 gets 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:

$$\underline{x}(\beta^*) = \begin{cases} x_0 & \forall \beta^* \in \left(1, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}\right] \\ x^{2m}(\beta^*) & \forall \beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}\right] \\ x^{3m}(\beta^*) & \forall \beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}, \infty\right) \end{cases} \tag{18}$$

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. This is stated in the following proposition.

Proposition 3 *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.

We examine the quality of female teachers in private vis-a-vis government schools. The average quality of female teachers in government schools is

$\bar{q}_F^g = \frac{3x_0}{4}$ while that in private school is

$$\bar{q}_F^p = \begin{cases} \frac{1+x_0}{2} & \forall \beta^* \in \left(1, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}\right] \\ \frac{1}{4}\left(\frac{4-3x_0^2-\underline{x}(\beta^*)^2}{2-x_0-\underline{x}}\right) & \forall \beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}\right] \\ \frac{1}{4}\left(\frac{4-3x_0^2-x_1^2}{2-x_0-x_1}\right) & \forall \beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}, \infty\right) \end{cases}$$

In the first case, $\underline{x}(\beta^*) = x_0$ and thus only the top quality female teachers go to the private school. If β^* is high, $\underline{x}(\beta^*) \in \left(\frac{x_1}{2}, x_1\right]$, but the female teachers do not accept private school jobs for $x \leq x_1$. If β^* is in the middle, $\underline{x}(\beta^*) \in (x_1, x_0]$, and in this case the average quality of female private school teachers depends on $\underline{x}(\beta^*)$.

If $\beta^* \in \left(1, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}\right]$, one can readily see that $\bar{q}_F^p > \bar{q}_F^g$. However, if $\beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}\right]$, $\bar{q}_F^p > \bar{q}_F^g$ if and only if

$$\frac{1}{4}\left(\frac{4-3x_0^2-\underline{x}(\beta^*)^2}{2-x_0-\underline{x}}\right) > \frac{3x_0}{4}$$

$$\Leftrightarrow (2-\underline{x}(\beta^*))(2+\underline{x}(\beta^*)-3x_0) > 0$$

$$\Leftrightarrow \underline{x}(\beta^*) > 3x_0 - 2$$

Since in this range $\underline{x}(\beta^*) \geq x_1$, a sufficient condition for this to hold is $x_1 > 3x_0 - 2$. If $\beta \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}, \infty\right)$, $\bar{q}_F^p > \bar{q}_F^g$ if and only if $x_1 > 3x_0 - 2$. However, this cannot be guaranteed by our assumptions. If this condition fails, $\bar{q}_F^p > \bar{q}_F^g$ when the equilibrium β^* is relatively low and $\underline{x}(\beta^*)$ is high enough. These are summarized in the following proposition.

Proposition 4 *Suppose A1-A4 hold. In equilibrium, the average quality of female teachers in private schools exceeds that in government schools if, either private school wage is high enough or the equilibrium private school premium is low enough such that private schools can not be sustained in remote locations.*

Notice that the condition $x_1 > 3x_0 - 2$ simplifies to

$$w_g - \frac{2}{3}w_p < \frac{1}{2}$$

This cannot be ensured by A2 and w_p needs to be higher for this to hold. However, even if this condition is violated, the average quality of female teachers may be better than their counterparts in government schools if low equilibrium private school premium restricts establishment of private schools in remote locations.

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 two propositions.

Proposition 5 *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.*

Proposition 6 *Among the private school goers at any location in which a private school exists in equilibrium, boys outnumber girls. However, in private schools where both boys and girls are sent, the average ability of girls exceeds that of the boys.*

The first part of the last proposition follows directly from the fact that at any x, $a^m(x, \beta^*) < a^f(x, \beta^*)$. The second part follows from the comparison of the average abilities of the two categories in private schools.

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. Suppose $\beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}\right]$. We derive our results for this case. However, the results are robust across different equilibrium values of β^*. If $\beta^* \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}\right]$, $\underline{x}(\beta^*) = x^{2m}(\beta^*) \in [x_1, x_0)$. 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

$$P^m(x,\beta^*) = \begin{cases} \frac{1+a_2^m(x,\beta^*)}{2}.\frac{x}{2} & \forall\, x \in [x^{2m}(\beta^*), x_0) \\ \frac{1+a_1^m(x,\beta^*)}{2}.x & \forall\, x \in [x_0, 1] \end{cases} \tag{19}$$

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.

The number of male students going to private schools at location x is given by

$$n^m(x, \beta^*) = \begin{cases} 1 - a_2^m(x, \beta^*) & \forall\, x \in [x^{2m}(\beta^*), x_0) \\ 1 - a_1^m(x, \beta^*) & \forall\, x \in [x_0, 1] \end{cases} \tag{20}$$

The average performance of all male students in private schools can thus be computed as

$$\bar{k}_p^m = \frac{1}{N_m(\beta^*)} \int_{x^{2m}(\beta^*)}^{1} n^m(x,\beta^*)\, P^m(x,\beta^*)\, dx \tag{21}$$

where

$$N_m(\beta^*) = \int_{x^{2m}(\beta^*)}^{1} n^m(x, \beta^*)\, dx$$

The average performance of all female students in private schools is

$$\bar{k}_p^f = \frac{1}{N_f(\beta^*)} \int_{x^{2f}(\beta^*)}^{1} n^f(x,\beta^*)\, P^f(x,\beta^*)\, dx \tag{22}$$

where $n^f(x,\beta^*)$, $P^f(x,\beta^*)$, N_f and $x^{2f}(\beta^*)$ defined accordingly.

The comparative performance of girls vis-a-vis the boys in private schools is stated in our next proposition.

Proposition 7 *Suppose A1-A4 hold. The average performance of girls exceeds that of boys in private schools.*

The proof of the proposition is technical and relegated to appendix.

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 $\frac{1}{2}$.

First consider the boys. The average performance of the boys in private schools when matched with female teachers can be derived exactly as in Eq. (21) except that for schools located at $x \in [x^{2m}(\beta^*), x_0)$, we have to use $\frac{1-a_2^m(x,\beta^*)}{2}$ instead of $1 - a_2^m(x, \beta^*)$ since each school would have a female teacher with probability $\frac{1}{2}$. Thus, the average performance of the boys in private schools when matched with female teachers can be written as

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

For notational convenience we write

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

where

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

$$I_1^m = \int_{x_0}^{1} \left(1 - a_1^m(x, \beta^*)\right) . \frac{1 + a_1^m(x, \beta^*)}{2} . xd$$

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

and

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

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

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

It is easy to verify that

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

while

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

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

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

and hence

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

Therefore,

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

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

Proposition 8 *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, this is intuitive.

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[3] $a \in [a_1^f(x_0,\beta^*), a_2^m(x_0,\beta^*))$, 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.

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

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

while that of a girl with same ability is

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

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

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

would perform similarly. If $a \in \left[a_2^m(x_0,\beta^*), a_2^f(x_0,\beta^*)\right)$, $x_m(a) < x_0$ while $x_f(a) = x_0$. In this case, the expected performance of a boy is

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

while that of a girl is

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

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 9 *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 10 *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 accord-ing to a number of development indicators (Kumra, 2008).The admin- istrative 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 from the household survey for ex- ample parental/caregiver education, wealth index of the household, caste, religion, household heads gender, number of siblings, sibling composition, child anthropometry, a host of school level outcomes (cognitive outcomes and test scores in mathematics, Telugu and En- glish, sector(rural/urban),region/community type, whether member of any social group, number of household members giving financial sup- port to the child, the number of school going kids present in the house- hold, birth order of the child, whether household suffered from any major bad event in the last four years etc. 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 (Singh, 2013). The survey captured detailed school- level differences in infrastructure and funding, teacher qualifications and characteristics, classroom characteristics, teaching procedures and childrens 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

In this paper we offer the first systematic empirical study of ethnic interactions between students and instructors at the primary school level. We test whether female students experience significant achievement gains from being taught by a female teacher. These questions are examined using a novel and unique dataset with detailed demographic information on teacher as well as students from a large and ethnically diverse sample of 952 children across 247 schools in Andhra Pradesh. Our data contain comprehensive background information on instructors including their education level, teacher specific qualification, years of experience. We have background information of the principal, class teacher and math teacher of the student. We also have information on ability of students approximated by past scores on cognitive and ppvt tests that tries to account of selective sorting of individuals by ability into school types that can differ systematically.

Our basic empirical approach uses a regression model in which the parameter of interest is the differential effect between the differential effect of males and female students of being assigned to a 'male' teacher. While our empirical model addresses many of the potential threats to internal validity, we cannot directly control for differential sorting across ethnic categories student groups that may arise if, for example, motivated general caste students systematically sort into or have access to schools having teacher of a general caste while highly motivated 'lower' caste students do not or vice versa. We do not have the information on what choices, if any, the students had in terms of selecting their schools and whether a priori the caste identities of the school teachers are known. However, with a rich set of observable variables that is highly correlated with unobserved student abilities including a students past performance on test scores, we try to control for these potential unobserved heterogeneities.

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

(23)

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

$D_i^M S$ ='male' dummy of student i

$D_i^M T$='male' dummy of student is mathematics teacher T

$X_i^{S=}$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 parameters of interest are α_3 and α_5 that measures the interaction of ethnic and gender dummies.

We estimate this regression and report the results by splitting the sample across type (public/private) of school and sector(rural/urban) to examine differential pattern across government versus private school and urban/rural sector. In this paper we offer the first systematic empirical study of gender interactions between students and instructors at the primary school level. We test whether any significant gain is present in learning outcomes if the teacher is of the same gender as that of the student. These questions are examined using a novel and unique dataset with detailed demographic information on teacher as well as students from a large and ethnically diverse sample of 952 children across 247 schools in Andhra Pradesh. Our data contain comprehensive background information on instructors including their education level, teacher specific qualification, years of experience. We have background information of the principal, class teacher and math teacher of the student. We also have information on ability of students approximated by past scores on cognitive and ppvt tests that tries to account of selective sorting of individuals by ability into school types that can differ systematically.

Our basic empirical approach uses a regression model in which the parameter of interest is the differential effect between males and female students of being assigned to a 'male' teacher. While our empirical model addresses many of the potential threats to internal validity, we cannot directly control for differential sorting across gender categories student groups that may arise if, for example, motivated male students systematically sort into or have access to schools having male teacher. However, our theory explains the result in terms of endogenous sorting mechanism. Hence, in a sense our empirical results validates our theory and theory makes up for any weakness in our identification strategy. We estimate this regression and report the results by splitting the sample across type (public/private) of school and sector(rural/urban) to examine differential pattern across government versus private school and urban/rural sector.

3.3 Results

From our theory we have three major predictions which are summarized below:
Hypothesis 1: The average quality of female teachers is higher than that of their male counterpart in private schools.
Hypothesis 2: The average performance of female students is higher than the male students in private schools.
emphHypothesis 2: The interaction effect of female (male) student female (male) teachers would be negative (positive).

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. We wanted to see that whether students learn better from some one from his/her own gender. Unlike the existing literature that explains such results with role model effect, we provide an explanation why the quality distribution of male and female teachers (and students) are different across private and public schools.

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 (1) and (2). 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 (1) and (2) 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 (3) and (4) 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 term 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 5 and 6 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.

3.6 Effect of gender matching

We now examine our main hypotheses in the tables 7 and 8. We have already listed the main hypothesis that we are going to test above. We find the results are fairly consistent with our predictions. We find that male students in private schools do worse than the female students. We find same pattern for the teachers as well – male teachers have a lower impact than their female counterpart on students in private schools. In government schools the result gets reversed as the male teachers have a positive impact on the student's scores compared to their female counterpart.

We find the sign of the coefficient on the interaction term of male teacher male student to have a positive effect on student's performance. This means that male teachers are bad for everyone in private schools. But the marginal negative effect of a bad male teacher is partly mitigated when he is matched with a male student. Looking at the result confirms that this effect is driven by the private schools. In case of government schools, such interaction effects show opposite sign even though that is not significant. In our theory our result holds for same ability students. To replicate the theoretical result we have put a control of pre-school cognitive ability which controls for student's ability. The theoretical result is mainly driven by differential quality for teachers. One may ask why we are getting the result even after controlling for teacher's qualification (both academic and professional). In response, we argue that the data does not reveal the teacher's grades in those professional and academic degrees. Hence, one who earned bachelor's degree with a C grade are put together in the same degree with some one with an A grade making the data on degree qualification as an imperfect indicator of one's professional and academic knowledge. We claim that the result is driven by the quality differential of teachers within the same category academic and professional qualification.

3.7 Examining alternative explanations

One of the major contribution of our work is to show that the interaction effect of gender matching of the students and teachers is coming out of the quality sorting of teachers across public and private schools along the gender line. This explanation is different from the existing literature which claims that such interaction comes from role model effect. If it really comes from the role model effect we could not have got different interaction effect in private and government schools.

Another possible explanation for female teachers doing well in private schools may come from the incentive structure. One may argue that female teachers are teaching well in private schools as they are mostly temporary staff and they have higher incentive to teach better than their male colleagues for saving their jobs. This explanation also does not hold ground when we look at the government schools where male teachers teach significantly better even majority of them are permanent staff.

Next we control for the medium of instruction and find English medium is negatively associated with math score for private schools but not for government schools. Next we filter the results by rural/urban sector. Both male students and male teachers are associated with worse outcomes as compared to females. For private schools in rural sector we do not find any significance of caste of either student or teacher. Interestingly for rural private schools, we find that English medium schools are associated with worse off score for math score on average. For government rural schools we find here that having a male teacher for this type of schools is associated with better outcomes. Again, the gender interaction term is negative and significant.

Across specifications we find that variables like wealth index, caregiver's qualification, past cognitive score are all positive and significant. In terms of gender, in rural schools we find male teacher coefficient is positive and significant, however the gender interaction variable is negative and significant.

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 different opportunity costs faced 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 for girls' their parental family can only claim a fraction of it after they are married of. 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.

Appendix

4.1 Existence of Equilibrium

First notice that both $\bar{a}_p$ and $\bar{a}_g$ are continuous functions of β. By A4 some boys are sent to private school at location x_0 even when $\beta = 1$. Now suppose the number of boys and girls sent to private school at some β are $N_m(\beta)$ and $N_f(\beta)$ respectively. The farthest location at which boys and girls are sent to private schools are

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

and

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

respectively. Hence,

$$N_m(\beta) = \begin{cases} \int_{x_0}^{1}\left(1-a_1^m(x,\beta)\right)dx & \forall\ \beta \in \left(1, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}\right] \\ \left[\begin{array}{c} \int_{x^{2m}(\beta)}^{x_0}\left(1-a_2^m(x,\beta)\right)dx \\ +\int_{x_0}^{1}\left(1-a_1^m(x,\beta)\right)dx \end{array}\right] & \forall\ \beta \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}\right] \\ \left[\begin{array}{c} \int_{x^{3m}(\beta)}^{x_1}\left(1-a_3^m(x,\beta)\right)dx \\ +\int_{x_1}^{x_0}\left(1-a_2^m(x,\beta)\right)dx \\ +\int_{x_0}^{1}\left(1-a_1^m(x,\beta)\right)dx \end{array}\right] & \forall\ \beta \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}, \infty\right) \end{cases}$$

Notice that as $\beta \to \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}$, $x^{2m}(\beta) \to x_0$ and $a_2^m(x_0,\beta) \to 1$ and as $\beta \to \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}$, $x^{3m}(\beta) \to x_1$ and $a_3^m(x_1,\beta) \to 1$. Thus, $N_m(\beta)$ is continuous in β. Similarly, we can argue that $N_f(\beta)$ is also continuous in β.

The average ability of boys going to private schools can thus derived by

$$\bar{a}_m^p(\beta) = \begin{cases} \frac{1}{N_m(\beta)} \left[\int_{x_0}^{1} \left(1 - a_1^m(x,\beta)\right) \left(\frac{1+a_1^m(x,\beta)}{2} \right) dx \right] & \forall\, \beta \in \left(1, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}\right] \\ \frac{1}{N_m(\beta)} \left[\begin{array}{c} \int_{x^{2m}(\beta)}^{x_0} \left(1 - a_2^m(x,\beta)\right) \left(\frac{1+a_2^m(x,\beta)}{2} \right) dx \\ + \int_{x_0}^{1} \left(1 - a_1^m(x,\beta)\right) \left(\frac{1+a_1^m(x,\beta)}{2} \right) dx \end{array} \right] & \forall\, \beta \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_0}{2}}, \frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}} \right] \\ \frac{1}{N_m(\beta)} \left[\begin{array}{c} \int_{x^{3m}(\beta)}^{x_1} \left(1 - a_3^m(x,\beta)\right) \left(\frac{1+a_3^m(x,\beta)}{2} \right) dx \\ + \int_{x_1}^{x0} \left(1 - a_2^m(x,\beta)\right) \left(\frac{1+a_2^m(x,\beta)}{2} \right) dx \\ + \int_{x_0}^{1} \left(1 - a_1^m(x,\beta)\right) \left(\frac{1+a_1^m(x,\beta)}{2} \right) dx \end{array} \right] & \forall\, \beta \in \left(\frac{\frac{t}{A}+\bar{q}^g}{\frac{x_1}{2}}, \infty \right) \end{cases}$$

By the same argument, we made above $\bar{a}_m^p(\beta)$ is continuous in β and so is $\bar{a}_f^p(\beta)$. Now, the average productivity of all students going to private schools at all locations,

$$\bar{a}^p(\beta) = \frac{N_m(\beta)}{N_m(\beta) + N_f(\beta)} \bar{a}_m^p(\beta) + \frac{N_f(\beta)}{N_m(\beta) + N_f(\beta)} \bar{a}_f^p(\beta)$$

also continuous in β.

Remember that average ability of all students in all locations is $\frac{1}{2}$ and the total measure of students is 2. Out of these, $N_m(\beta) + N_f(\beta)$ go to private schools and the rest go to private schools. Since the overall average ability is the weighted average of the abilities of students in private and government schools with the weights being the shares of students in two types of schools, we can write

$$\frac{2 - (N_m(\beta) + N_f(\beta))}{2} \bar{a}^g(\beta) + \frac{N_m(\beta) + N_f(\beta)}{2} \bar{a}^p(\beta) = \frac{1}{2}$$

Thus,

$$\bar{a}^g(\beta) = \frac{1 - (N_m(\beta) + N_f(\beta))\, \bar{a}^p(\beta)}{2 - (N_m(\beta) + N_f(\beta))}$$

is also continuous in β.

Since only students from the top end of the ability profile at any location go to private schools at any β, generally $\bar{a}^p(\beta) > \bar{a}^g(\beta)$. Since some students go to private schools even at $\beta = 1$,

$$\frac{\bar{a}^p(1)}{\bar{a}^g(1)} > 1$$

However, as $\beta \to \infty$, $\underline{x}_m(\beta) = x^{3m}(\beta) \to \frac{x_1}{2}$ and $\underline{x}_f(\beta) = x^{3f}(\beta) \to \frac{x_1}{2}$. Moreover, at every x, $a_i^m(x,\beta)$ and $a_i^f(x,\beta)$ converge to 0. Thus, as as $\beta \to \infty$, all students at all locations where private schools exist (private schools cannot exist at locations below $\frac{x_1}{2}$ because of lack of supply of teachers) go to private schools. Thus as $\beta \to \infty$, $\bar{a}^p(\beta) \to \frac{1}{2}$. Hence, $\bar{a}^g(\beta) \to \frac{1}{2}$ as well. Hence,

$$\lim_{\beta \to \infty} \frac{\bar{a}^p(\beta)}{\bar{a}^g(\beta)} = 1$$

Since $\frac{\bar{a}^p(\beta)}{\bar{a}^g(\beta)}$ is continuous in β, $\frac{\bar{a}^p(\beta)}{\bar{a}^g(\beta)} > 1$ at $\beta = 1$ while $\frac{\bar{a}^p(\beta)}{\bar{a}^g(\beta)} \to 1$ as $\beta \to \infty$, there must exist a $\beta^* > 1$ such that at $\beta = \beta^*$

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

This proves the existence of an equilibrium β^*.

4.2 Proof of Proposition 6

The difference in the performances of the boys and girls originates from the difference in the relative private school fees they have to bear - $\frac{t}{A}$ for boys and $\frac{t}{\alpha A}$ for the girls with $\alpha < 1$. We show that as the effective school fee rises for any particular group, average performance for that group rises at any given β^*. Suppose the effective fee for the boys is $\tau = \frac{t}{a}$. We show that $\frac{\delta \bar{k}_p^m}{\delta \tau} > 0$.

Notice that

$$\begin{aligned}\frac{\delta \bar{k}_p^m}{\delta \tau} &= \int_{x^{2m}(\beta^*)}^{1} \left[P^m(x,\beta^*) \frac{\delta}{\delta \tau} \left(\frac{n^m(x,\beta^*)}{N_m(\beta^*)} \right) + \frac{n^m(x,\beta^*)}{N_m(\beta^*)} \frac{\delta}{\delta \tau} \left(P^m(x,\beta^*) \right) \right] dx \\ &\quad - P^m\left(x^{2m}(\beta^*),\beta^*\right) \frac{n^m\left(x^{2m}(\beta^*),\beta^*\right)}{N_m(\beta^*)} . \frac{\delta}{\delta \tau} \left(x^{2m}(\beta^*) \right)\end{aligned}$$

Since $n^m\left(x^{2m}(\beta^*),\beta^*\right) = 1 - a_2^m\left(x^{2m}(\beta^*),\beta^*\right) = 0$ by definition of $x^{2m}(\beta^*)$,

$$\frac{\delta \bar{k}_p^m}{\delta \tau} = \int_{x^{2m}(\beta^*)}^{1} \left[P^m(x,\beta^*) \frac{\delta}{\delta \tau} \left(\frac{n^m(x,\beta^*)}{N_m(\beta^*)} \right) + \frac{n^m(x,\beta^*)}{N_m(\beta^*)} \frac{\delta}{\delta \tau} \left(P^m(x,\beta^*) \right) \right] dx$$

Since $P^m(x,\beta^*)$ and $n^m(x,\beta^*)$ are only piecewise continuous, we have to integrate them separately over the two mutually exclusive intervals $[x^{2m}(\beta^*), x_0)$ and $[x_0, 1]$.

Notice that

$$\frac{1}{\frac{n^m(x,\beta^*)}{N_m(\beta^*)}}.\frac{\delta}{\delta\tau}\left(\frac{n^m(x,\beta^*)}{N_m(\beta^*)}\right)=\frac{1}{n^m(x,\beta^*)}.\frac{\delta}{\delta\tau}\left(n^m(x,\beta^*)\right)-\frac{1}{N_m(\beta^*)}\frac{\delta}{\delta\tau}\left(N_m(\beta^*)\right)$$

First consider the interval $[x^{2m}(\beta^*), x_0)$. In this interval, $n^m(x,\beta^*)=1-a_2^m(x,\beta^*)$ and by Eq. (9) $a_2^m(x,\beta^*)=\frac{\tau}{\beta^*\frac{x}{w}-\bar{q}^g}$. Thus,

$$\frac{\delta}{\delta\tau}\left(n^m(x,\beta^*)\right)=-\frac{\delta}{\delta\tau}\left(a_2^m(x,\beta^*)\right)=-\frac{1}{\tau}a_2^m(x,\beta^*)$$

Similarly, for the interval $[x_0,1]$,

$$\frac{\delta}{\delta\tau}\left(n^m(x,\beta^*)\right)=-\frac{\delta}{\delta\tau}\left(a_1^m(x,\beta^*)\right)=-\frac{1}{\tau}a_1^m(x,\beta^*)$$

Since

$$N_m(\beta^*)=\int_{x^{2m}(\beta^*)}^{x_0}\left[1-a_2^m(x,\beta^*)\right]dx+\int_{x_0}^{1}\left[1-a_1^m(x,\beta^*)\right]dx$$

we can write

$$\begin{aligned}\frac{\delta}{\delta\tau}\left(N_m(\beta^*)\right) &= -\frac{1}{\tau}\int_{x^{2m}(\beta^*)}^{x_0}a_2^m(x,\beta^*)\,dx-\frac{1}{\tau}\int_{x_0}^{1}a_1^m(x,\beta^*)\,dx\\ &\quad -\left[1-a_2^m\left(x^{2m}(\beta^*),\beta^*\right)\right]\frac{\delta}{\delta\tau}\left(x^{2m}(\beta^*)\right)\\ &= -\frac{1}{\tau}\left[\int_{x^{2m}(\beta^*)}^{x_0}a_2^m(x,\beta^*)\,dx+\int_{x_0}^{1}a_1^m(x,\beta^*)\,dx\right]\end{aligned}$$

where the last term vanishes because $a_2^m(x^{2m}(\beta^*),\beta^*)=1$. However,

$$N_m(\beta^*)=1-x^{2m}(\beta^*)-\left[\int_{x^{2m}(\beta^*)}^{x_0}a_2^m(x,\beta^*)\,dx+\int_{x_0}^{1}a_1^m(x,\beta^*)\,dx\right]$$

and hence,

$$\frac{\delta}{\delta\tau}\left(N_m(\beta^*)\right)=-\frac{1}{\tau}\left[1-x^{2m}(\beta^*)-N_m(\beta^*)\right]$$

Therefore, using the expressions for $n^m(x,\beta^*)$ at different intervals and some manipulations we can write

$$\frac{\delta}{\delta\tau}\left(\frac{n^m(x,\beta^*)}{N_m(\beta^*)}\right)=\begin{cases}\frac{1}{\tau}\frac{1-a_2^m(x,\beta^*)}{N_m(\beta^*)}\left[-\frac{a_2^m(x,\beta^*)}{1-a_2^m(x,\beta^*)}+\frac{1-x^{2m}(\beta^*)-N_m(\beta^*)}{N_m(\beta^*)}\right] & \text{if } x\in[x^{2m}(\beta^*),x_0)\\ \frac{1}{\tau}\frac{1-a_1^m(x,\beta^*)}{N_m(\beta^*)}\left[-\frac{a_1^m(x,\beta^*)}{1-a_1^m(x,\beta^*)}+\frac{1-x^{2m}(\beta^*)-N_m(\beta^*)}{N_m(\beta^*)}\right] & \text{if } x\in[x_0,1]\end{cases}$$

From Eq. (19), we know that

$$\frac{\delta}{\delta\tau}\left(P^{m}\left(x,\beta^{*}\right)\right)=\begin{cases}\frac{1}{\tau}\frac{a_{2}^{m}(x,\beta^{*})}{2}.\frac{x}{2} & \text{if } x\in\left[x^{2m}\left(\beta^{*}\right),x_{0}\right)\\ \frac{1}{\tau}\frac{a_{1}^{m}(x,\beta^{*})}{2}.\frac{x}{2} & \text{if } x\in\left[x_{0},1\right]\end{cases}$$

Thus,

$$\begin{aligned}\frac{\delta\bar{k}_{p}^{m}}{\delta\tau} &= \frac{1}{\tau}\int_{x^{2m}(\beta^{*})}^{x_{0}}\left(\begin{array}{c}\frac{1-a_{2}^{m}(x,\beta^{*})}{N_{m}(\beta^{*})}\left[-\frac{a_{2}^{m}(x,\beta^{*})}{1-a_{2}^{m}(x,\beta^{*})}+\frac{1-x^{2m}(\beta^{*})-N_{m}(\beta^{*})}{N_{m}(\beta^{*})}\right]\frac{1+a_{2}^{m}(x,\beta^{*})}{2}.\frac{x}{2}\\ +\frac{1-a_{2}^{m}(x,\beta^{*})}{N_{m}(\beta^{*})}\frac{a_{2}^{m}(x,\beta^{*})}{2}.\frac{x}{2}\end{array}\right)dx\\
&+\frac{1}{\tau}\int_{x_{0}}^{1}\left(\begin{array}{c}\frac{1-a_{1}^{m}(x,\beta^{*})}{N_{m}(\beta^{*})}\left[-\frac{a_{1}^{m}(x,\beta^{*})}{1-a_{1}^{m}(x,\beta^{*})}+\frac{1-x^{2m}(\beta^{*})-N_{m}(\beta^{*})}{N_{m}(\beta^{*})}\right]\frac{1+a_{1}^{m}(x,\beta^{*})}{2}.x\\ +\frac{1-a_{1}^{m}(x,\beta^{*})}{N_{m}(\beta^{*})}\frac{a_{1}^{m}(x,\beta^{*})}{2}.x\end{array}\right)dx\\
&= \frac{1}{2\tau N_{m}\left(\beta^{*}\right)}\int_{x^{2m}(\beta^{*})}^{x_{0}}\left[\begin{array}{c}-a_{2}^{m}\left(x,\beta^{*}\right)\left(1+a_{2}^{m}\left(x,\beta^{*}\right)\right)\\ +\frac{1-x^{2m}(\beta^{*})-N_{m}(\beta^{*})}{N_{m}(\beta^{*})}\left(1-\left(a_{2}^{m}\left(x,\beta^{*}\right)\right)^{2}\right)\\ +\left(1-a_{2}^{m}\left(x,\beta^{*}\right)\right)a_{2}^{m}\left(x,\beta^{*}\right)\end{array}\right]\frac{x}{2}dx\\
&+\frac{1}{2\tau N_{m}\left(\beta^{*}\right)}\int_{x_{0}}^{1}\left[\begin{array}{c}-a_{1}^{m}\left(x,\beta^{*}\right)\left(1+a_{1}^{m}\left(x,\beta^{*}\right)\right)\\ +\frac{1-x^{2m}(\beta^{*})-N_{m}(\beta^{*})}{N_{m}(\beta^{*})}\left(1-\left(a_{1}^{m}\left(x,\beta^{*}\right)\right)^{2}\right)\\ +\left(1-a_{1}^{m}\left(x,\beta^{*}\right)\right)a_{1}^{m}\left(x,\beta^{*}\right)\end{array}\right]xdx\\
&= \frac{1}{2\tau N_{m}\left(\beta^{*}\right)}\int_{x^{2m}(\beta^{*})}^{x_{0}}\left[\begin{array}{c}\frac{1-x^{2m}(\beta^{*})-N_{m}(\beta^{*})}{N_{m}(\beta^{*})}\\ -\frac{1-x^{2m}(\beta^{*})+N_{m}(\beta^{*})}{N_{m}(\beta^{*})}\left(a_{2}^{m}\left(x,\beta^{*}\right)\right)^{2}\end{array}\right]\frac{x}{2}dx\\
&+\frac{1}{2\tau N_{m}\left(\beta^{*}\right)}\int_{x^{2m}(\beta^{*})}^{x_{0}}\left[\begin{array}{c}\frac{1-x^{2m}(\beta^{*})-N_{m}(\beta^{*})}{N_{m}(\beta^{*})}\\ -\frac{1-x^{2m}(\beta^{*})+N_{m}(\beta^{*})}{N_{m}(\beta^{*})}\left(a_{1}^{m}\left(x,\beta^{*}\right)\right)^{2}\end{array}\right]xdx\end{aligned}$$

Hence, $\frac{\delta\bar{k}_{p}^{m}}{\delta\tau}>0$ if and only if

$$\begin{aligned}&\left(1-x^{2m}\left(\beta^{*}\right)-N_{m}\left(\beta^{*}\right)\right)\left[\int_{x^{2m}(\beta^{*})}^{x_{0}}\frac{x}{2}dx+\int_{x^{2m}(\beta^{*})}^{x_{0}}xdx\right]\\
> \;&\left(1-x^{2m}\left(\beta^{*}\right)+N_{m}\left(\beta^{*}\right)\right)\left[\int_{x^{2m}(\beta^{*})}^{x_{0}}\left(a_{2}^{m}\left(x,\beta^{*}\right)\right)^{2}\frac{x}{2}dx+\int_{x^{2m}(\beta^{*})}^{x_{0}}\left(a_{1}^{m}\left(x,\beta^{*}\right)\right)^{2}xdx\right]\end{aligned}$$

Notice that

$$\int_{x^{2m}(\beta^{*})}^{x_{0}}\frac{x}{2}dx+\int_{x^{2m}(\beta^{*})}^{x_{0}}xdx=\frac{1}{2}-\frac{x_{0}^{2}}{4}-\frac{\left(x^{2m}\left(\beta^{*}\right)\right)^{2}}{4}$$

while

$$\begin{aligned}
N_m(\beta^*) &= 1 - x^{2m}(\beta^*) - \left[\int_{x^{2m}(\beta^*)}^{x_0} a_2^m(x,\beta^*)\,dx + \int_{x_0}^{1} a_1^m(x,\beta^*)\,dx\right] \\
&= 1 - x^{2m}(\beta^*) - \Gamma
\end{aligned}$$

where

$$\begin{aligned}
\Gamma &= \int_{x^{2m}(\beta^*)}^{x_0} a_2^m(x,\beta^*)\,dx + \int_{x_0}^{1} a_1^m(x,\beta^*)\,dx \\
&= \frac{2\tau}{\beta}\log\left(\frac{\beta^*\frac{x_0}{2} - \bar{q}^g}{\beta^*\frac{x^{2m}}{2} - \bar{q}^g}\right) + \frac{\tau}{\beta}\log\left(\frac{\beta^* - \bar{q}^g}{\beta^* x_0 - \bar{q}^g}\right)
\end{aligned}$$

The last expression is obtained by using $a_2^m(x,\beta^*)$ and $a_1^m(x,\beta^*)$ from Eqs. (9) and (7) respectively and integrating. Notice that $1 - x^{2m} > \Gamma > 0$, since $x^{2m} < x_0 < 1$ and $a_2^m(x,\beta^*) \le 1$ and $a_1^m(x,\beta^*) < 1$. Thus,

$$1 - x^{2m}(\beta^*) - N_m(\beta^*) = \Gamma$$

and

$$1 - x^{2m}(\beta^*) + N_m(\beta^*) = 2\left(1 - x^{2m}(\beta^*)\right) - \Gamma$$

Now integrating

$$\int_{x^{2m}(\beta^*)}^{x_0} \left(a_2^m(x,\beta^*)\right)^2 \frac{x}{2}dx + \int_{x_0}^{1} \left(a_1^m(x,\beta^*)\right)^2 x dx$$

and after manipulating some expressions we get

$$\begin{aligned}
&\int_{x^{2m}(\beta^*)}^{x_0} \left(a_2^m(x,\beta^*)\right)^2 \frac{x}{2}dx + \int_{x_0}^{1} \left(a_1^m(x,\beta^*)\right)^2 x dx \\
= &\ \frac{\tau}{\beta}.\left[\frac{2\tau}{\beta}\log\left(\frac{\beta^*\frac{x_0}{2} - \bar{q}^g}{\beta^*\frac{x^{2m}}{2} - \bar{q}^g}\right) + \frac{\tau}{\beta}\log\left(\frac{\beta^* - \bar{q}^g}{\beta^* x_0 - \bar{q}^g}\right)\right] \\
&+ \frac{2\tau^2}{\beta^2}.\bar{q}^g\left[\frac{1}{\beta^*\frac{x^{2m}}{2} - \bar{q}^g} - \frac{1}{\beta^*\frac{x_0}{2} - \bar{q}^g}\right] + \frac{\tau^2}{\beta^2}.\bar{q}^g\left[\frac{1}{\beta^* x_0 - \bar{q}^g} - \frac{1}{\beta^* - \bar{q}^g}\right] \\
= &\ \frac{\tau}{\beta}\Gamma + \frac{\tau}{\beta}\Delta
\end{aligned}$$

where

$$\Delta = \frac{2\tau}{\beta}.\bar{q}^g \left[\frac{1}{\beta^* \frac{x^{2m}}{2} - \bar{q}^g} - \frac{1}{\beta^* \frac{x_0}{2} - \bar{q}^g} \right] + \frac{\tau}{\beta}.\bar{q}^g \left[\frac{1}{\beta^* x_0 - \bar{q}^g} - \frac{1}{\beta^* - \bar{q}^g} \right]$$

Hence, using the expressions we derived

$$\frac{\delta \bar{k}_p^m}{\delta \tau} > 0$$

if and only if

$$\frac{\Gamma}{2\left(1 - x^{2m}\left(\beta^*\right)\right) - \Gamma} \left(\frac{1}{2} - \frac{x_0^2}{4} - \frac{\left(x^{2m}\left(\beta^*\right)\right)^2}{4} \right) > \frac{\tau}{\beta}\Gamma + \frac{\tau}{\beta}\Delta$$

Since $x^{2m}\left(\beta^*\right) = \frac{\tau + \bar{q}^g}{\frac{\beta}{2}}$, $\frac{\tau}{\beta} = \frac{x^{2m}(\beta^*)}{2} - \frac{\bar{q}^g}{\beta}$. Therefore, we can rewrite the above inequality as

$$\Gamma \left(\frac{\frac{1}{2} - \frac{x_0^2}{4} - \frac{\left(x^{2m}(\beta^*)\right)^2}{4}}{2\left(1 - x^{2m}\left(\beta^*\right)\right) - \Gamma} - \frac{x^{2m}\left(\beta^*\right)}{2} \right) > \frac{\tau}{\beta}\Delta - \frac{\bar{q}^g}{\beta}\Gamma \qquad (24)$$

Since $\Gamma > 0$, the LHS of above is positive if and only if

$$\frac{\frac{1}{2} - \frac{x_0^2}{4} - \frac{\left(x^{2m}(\beta^*)\right)^2}{4}}{2\left(1 - x^{2m}\left(\beta^*\right)\right) - \Gamma} > \frac{x^{2m}\left(\beta^*\right)}{2}$$

$$\Leftrightarrow 1 - \frac{x_0^2}{2} - \frac{\left(x^{2m}\left(\beta^*\right)\right)^2}{2} - 2\left(1 - x^{2m}\left(\beta^*\right)\right) x^{2m}\left(\beta^*\right) + \Gamma x^{2m}\left(\beta^*\right) > 0$$

$$\Leftrightarrow \left(1 - x^{2m}\left(\beta^*\right)\right)^2 + \frac{\left(x^{2m}\left(\beta^*\right)\right)^2}{2} + \Gamma x^{2m}\left(\beta^*\right) - \frac{x_0^2}{2} > 0$$

We write the LHS of the last inequality as $L\left(x^{2m}\right)$. Notice that $\lim_{x^{2m} \to x_0} L\left(x^{2m}\right) > 0$. Also notice that

$$\begin{aligned} L'\left(x^{2m}\right) &= -2\left(1 - x^{2m}\right) + x^{2m} + x^{2m}\frac{\delta \Gamma}{\delta x^{2m}} + \Gamma \\ &= -2\left(1 - x^{2m}\right) + x^{2m} - x^{2m} + \Gamma \\ &= -2\left(1 - x^{2m}\right) + \Gamma \\ &< 0 \end{aligned}$$

since $\frac{\delta\Gamma}{\delta x^{2m}} = -1$ and $\Gamma < (1 - x^{2m})$. Hence, $L\left(x^{2m}\right) > 0$ for all $x^{2m} \leq x_0$.

The RHS of Eq. (24) can be written as

$$
\begin{aligned}
& \frac{\tau}{\beta}\Delta - \frac{\bar{q}^g}{\beta}\Gamma \\
= \; & \frac{\tau}{\beta}\left(\frac{2\tau}{\beta}.\bar{q}^g\left[\frac{1}{\beta^*\frac{x^{2m}}{2} - \bar{q}^g} - \frac{1}{\beta^*\frac{x_0}{2} - \bar{q}^g}\right] + \frac{\tau}{\beta}.\bar{q}^g\left[\frac{1}{\beta^* x_0 - \bar{q}^g} - \frac{1}{\beta^* - \bar{q}^g}\right]\right) \\
& -\frac{\bar{q}^g}{\beta}\left(\frac{2\tau}{\beta}\log\left(\frac{\beta^*\frac{x_0}{2} - \bar{q}^g}{\beta^*\frac{x^{2m}}{2} - \bar{q}^g}\right) + \frac{\tau}{\beta}\log\left(\frac{\beta^* - \bar{q}^g}{\beta^* x_0 - \bar{q}^g}\right)\right) \\
= \; & \frac{\tau\bar{q}^g}{\beta^2}.2\left[\left(\frac{\tau}{\beta^*\frac{x^{2m}}{2} - \bar{q}^g} + \log\frac{\beta^*\frac{x^{2m}}{2} - \bar{q}^g}{\tau}\right) - \left(\frac{\tau}{\beta^*\frac{x_0}{2} - \bar{q}^g} + \log\frac{\beta^*\frac{x_0}{2} - \bar{q}^g}{\tau}\right)\right] \\
& +\frac{\tau\bar{q}^g}{\beta^2}.\left[\left(\frac{\tau}{\beta^* x_0 - \bar{q}^g} + \log\frac{\beta^* x_0 - \bar{q}^g}{\tau}\right) - \left(\frac{\tau}{\beta^* - \bar{q}^g} + \log\frac{\beta^* - \bar{q}^g}{\tau}\right)\right] \\
= \; & \frac{\tau\bar{q}^g}{\beta^2}.2\left[\left(a_2^m\left(x^{2m}, \beta^*\right) + \log\frac{1}{a_2^m\left(x^{2m}, \beta^*\right)}\right) - \left(a_2^m\left(x_0, \beta^*\right) + \log\frac{1}{a_2^m\left(x_0, \beta^*\right)}\right)\right] \\
& +\frac{\tau\bar{q}^g}{\beta^2}.\left[\left(a_1^m\left(x_0, \beta^*\right) + \log\frac{1}{a_1^m\left(x_0, \beta^*\right)}\right) - \left(a_1^m\left(1, \beta^*\right) + \log\frac{1}{a_1^m\left(1, \beta^*\right)}\right)\right]
\end{aligned}
$$

Since the function $\frac{1}{y} + \log y$ is rising in y for $y > 1$, $\frac{x^{2m}}{2} < \frac{x_0}{2} < x_0 < 1$ and both $a_2^m\left(x, \beta^*\right)$ and $a_1^m\left(x, \beta^*\right)$ are falling in x, both bracketed terms in the last line of the above are negative. Thus,

$$\frac{\tau}{\beta}\Delta - \frac{\bar{q}^g}{\beta}\Gamma < 0$$

This shows that

$$\frac{\delta\bar{k}_p^m}{\delta\tau} > 0$$

Since girls face a higher τ than boys,

$$\bar{k}_p^f > \bar{k}_p^m$$

This completes the proof.

4.3 Proof of Proposition 10

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.

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Tables

Table 1: 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 2: 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 3: 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 4: 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 5: 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 6: 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 7: Gender Effect on Student's performance 1

Dep var: Math Z Score	ALL	GOVT	PVT	RURAL	URBAN
Male	-0.0125	0.154	-0.240*	0.213	-0.379*
	(-0.14)	(1.05)	(-2.19)	(1.83)	(-2.58)
Math Teacher Male	0.160	0.435***	-0.364*	0.359**	-0.378
	(1.66)	(3.34)	(-2.36)	(3.24)	(-1.53)
Interaction	-0.0174	-0.303	0.496**	-0.253	0.359
	(-0.14)	(-1.74)	(2.68)	(-1.78)	(1.08)
Household Size	-0.0100	0.000590	-0.0233	-0.0110	-0.00198
	(-0.65)	(0.03)	(-1.02)	(-0.65)	(-0.05)
Wealth Index	0.887***	0.671*	0.929**	0.906***	1.018
	(3.92)	(2.20)	(2.63)	(3.75)	(1.43)
Household Education	0.0408***	0.0281	0.0413***	0.0334**	0.0472**
	(4.24)	(1.76)	(3.53)	(2.83)	(2.69)
Bad Shocks	-0.0864	-0.0946	0.0568	-0.0682	0.129
	(-1.24)	(-1.01)	(0.56)	(-0.89)	(0.68)
Household Support	-0.0366	-0.0454	-0.0258	-0.0354	-0.0215
	(-1.48)	(-1.40)	(-0.70)	(-1.34)	(-0.29)
Region	-0.240***	-0.291***	-0.215***	-0.285***	-0.212*
	(-5.63)	(-5.00)	(-3.51)	(-5.83)	(-2.22)
Normalised past PPVT score	0.196	0.00492	0.301	0.177	0.0528
	(0.93)	(0.01)	(1.17)	(0.70)	(0.13)
Normalised past Cognitive score	1.246***	1.281***	1.247***	1.358***	0.974*
	(6.75)	(5.27)	(4.42)	(6.53)	(2.29)
Math Teacher Religion	0.151*	0.0852	0.161*	-0.0365	0.335**
	(2.07)	(0.54)	(2.08)	(-0.37)	(2.81)
Math Teacher Education	0.107*	0.0537	0.176*	0.0848	0.159
	(2.17)	(0.77)	(2.23)	(1.52)	(1.25)
Math Teacher Qualification	0.0879*	0.114	0.0300	0.0852	0.159*
	(2.19)	(1.57)	(0.66)	(1.73)	(2.18)
Math Teacher Experience	-0.00425	-0.00362	-0.0100	-0.00571	-0.00529
	(-0.90)	(-0.63)	(-1.13)	(-1.08)	(-0.49)
English Medium	-0.131	-0.510	-0.248**	-0.0584	-0.124
	(-1.48)	(-0.53)	(-2.70)	(-0.49)	(-0.89)
Sector	0.286*	-0.431	0.541***		
	(2.56)	(-1.76)	(4.23)		
Constant	3.005**	5.567***	2.200	4.601***	2.442
	(3.07)	(3.86)	(1.55)	(4.29)	(1.12)
Observations	870	537	333	700	170
t statistics in parentheses					
$*p < 0.05$	$** \; p < 0.01$	$***p < 0.001$			

Table 8: 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 * $p < 0.05$	$**\, p < 0.01$	*** $p < 0.001$		