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Students today, teachers tomorrow: Identifying constraints on the provision of education[☆]

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ABSTRACT

With an estimated one hundred fifteen million children not attending primary school in the developing world, increasing access to education is critical. This paper highlights a supply-side factor – the availability of low-cost teachers – and the resulting ability of the market to offer affordable education. We first show that private schools are three times more likely to emerge in villages with government girls' secondary schools (GSSs). Identification is obtained by using official school construction guidelines as an instrument for the presence of GSSs. In contrast, private school presence shows little or no relationship with girls' primary or boys' primary and secondary government schools. In support of a supply-channel, we then show that, villages which received a GSS have over twice as many educated women, and private school teachers' wages are 27% *lower* in these villages. In an environment with low female education and mobility, GSSs substantially increase the local supply of skilled women lowering wages locally and allowing the market to offer affordable education. These findings highlight the prominent role of women as teachers in facilitating educational access and resonate with similar historical evidence from developed economies. The students of today are the teachers of tomorrow.

1. Introduction

Despite the powerful global consensus created through the Millennium Development Goals, over a third of developing countries are unlikely to achieve universal primary enrollment by 2015. While low demand for education is one likely explanation for this poor performance, a key supply-side constraint is the availability of affordable teachers. The potential pool of teachers is limited in many parts of the developing world—less than 12% of the population in Sub-Saharan Africa complete secondary education and even less so in rural areas. Educationists increasingly argue that there are severe teacher "shortages," a concern that resonates with the challenges faced in designing incentives for teachers to move to rural areas and to exert greater effort (UNESCO, 2004; Urquiola and Vegas, 2005; Chaudhury et al., 2006). Given this stress on teacher supply in low-income countries, it is therefore surprising that there is little micro-economic evidence relating a higher supply of potential teachers to better educational provision.

In this paper, we provide the first evidence that public investments in secondary education facilitate future educational provision by increasing the local pool of potential teachers and therefore decreasing the cost of providing education. In other words, the students of today become the teachers of tomorrow.

There are two steps to our argument. First, we show that the construction of government girls' secondary schools (henceforth GSS) in Pakistan had a large impact on the education market: Instrumental variable estimates suggest that villages where such schools were constructed are 27 percentage points or three times more likely to see *private* primary schools emerge in the following years.[1] The instrument, an indicator for whether a village has the largest

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[1] The vast majority of private schools operate in a free and relatively unregulated market as for-profit, co-educational, English-medium schools that offer secular education (contrary to popular views, non-profit and religious schools play a small role in Pakistan, with at most a 3% enrollment share (Andrabi et al., 2006)) and hire teachers from the local market. This is in contrast to the government sector where teacher hiring is governed by teachers' unions, state-wide hiring regulations, and non-transparent processes.

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population among all its neighbors ("local top-rank"), is based on official population based guidelines for GSS construction from a Social Action Program in the 1980s. Since two villages with equal populations may differ in whether they are locally top-ranked or not, the instrument provides substantial variation even after controlling for polynomials in village population. A series of robustness tests, in the spirit of Altonji et al. (2005), provides additional support for the exclusion restriction.

In the second step, we argue that GSS construction impacts private primary school location because it augments local teacher supply in an environment with low female geographical and occupational mobility. In support of a "women as teachers" supply channel, we document that: (a) private provision is affected *only* by GSS construction (girls' primary or boys' primary/secondary schools have little effect); (b) having a GSS more than doubles the number of women in the (median) village with secondary or higher education; and (c) the fraction of secondary educated females in a village has a large impact on private educational provision, while the fraction of similarly educated men does not. These facts could be reconciled with solely demand-side explanations if the demand for education is primarily driven by mothers with secondary education (as opposed to mothers with primary education or fathers with any level of education). A more conclusive test is based on observing the effect of GSS construction on private school teachers' wages: Whereas demand-side explanations suggest that teacher wages should increase in villages with a GSS, supply-side explanations suggest the opposite. In support of the latter, we show that private school teachers' wages are 27% *lower* in villages with a GSS. With teacher wages accounting for close to 90% of the operational costs of private schools, this lower wage in GSS villages offers a substantial cost advantage. Moreover, consistent with the hypothesized mechanism, we find that this wage drop is higher in villages with more restricted female labor markets as proxied by village development indicators and sex-ratios.

Our results illustrate how investments that increase the supply of teachers in rural areas of low-income countries can boost educational provision. As in the United States (Rivkin et al., 2005), a finding from observational and experimental studies in low-income countries is that augmenting teacher resources leads to better outcomes, whether through reducing class-sizes (Case and Deaton, 1999; Urquiola, 2006), reducing teacher absenteeism (Duflo et al., 2012), or providing additional teachers for poorly performing students (Banerjee et al., 2007). This naturally raises the question of where the additional teachers are going to come from, and therefore the structure of the broader labor market for teachers. For instance, work on the decline in teaching quality in the United States highlights the link between teacher supply and female labor force participation (Corcoran et al., 2004; Hoxby and Leigh, 2004). The only randomized intervention, to our knowledge, that tried to increase the supply of schools through the private educational market failed precisely because teachers could not be found (Alderman et al., 2003). In this paper we provide the first evidence of the tight link between the teacher labor market and educational markets in a low-income setting, thus highlighting the initial role of the public sector in bolstering the supply of teachers.

The remainder of the paper is structured as follows: Section 2 is a brief guide to the institutional context and data, Sections 3 and 4 present the empirical methodology, and the results, respectively, and Section 5 concludes.

2. Institutional background and data

2.1. The context

Pakistan, as other South Asian and African countries, has seen an explosion in the private sector share of primary education. Private school numbers have increased over ten-fold, from 3800 in 1983 to 47,000 by 2005, and currently, over a third of primary enrollment is in the private sector with the fastest growth in rural areas (Andrabi et al., 2008).[2]

While this private school growth is impressive, it has generated more cross-sectional than time-series variation with growth mostly bunched in the 1990s. Hence, our paper exploits the cross-sectional variation in private school location to identify constraints to education provision. One of the key observations for the purposes of this paper is that since these private schools represent for-profit enterprises operating in a largely unrestricted market (there are no public subsidies and little regulation), their locational decisions are informative about supply and demand factors in the educational market rather than public priorities or ideology (which may influence the location of public, NGO, or religious schools). Central to this argument is the importance of human capital, and specifically women as teachers in the provision of private education, together with the limited availability of secondary-educated women in a restricted geographical labor market and the resulting impact on skilled female wages.

In fact, the majority of private schools are driven by a low-cost, low-price business model. Andrabi et al. (2008) show that the median annual fee in a Pakistani rural private school in 2000 was Rs. 600, so that a month's fee was somewhat less than the daily unskilled wage.[3] The data show that there are few fixed costs in running a private school in Pakistan (private schools are often setup initially in the owner's house) with teachers' wages forming the bulk, 90%, of the overall operational costs. Typical schools employ four teachers, mostly locally-resident women with at least a secondary education, and enroll around 100 children.

These low fees are sustained through the reliance on female teachers.[4] In the context of a patriarchal society, limited geographical and occupational mobility for women implies that locally-resident women offer a cheaper ("captured") supply of teachers. Female wages are indeed 30% lower than male wages after controlling for educational qualifications and experience (World Bank, 2005). More than 70% of all women live in the village where they were born; less than 3% are engaged in off-farm work; and among those with secondary education and a wage-earning job, 87% are teachers or health workers. Safety concerns and a patriarchal society restrict the ability of women to find wage work outside the village where they live or in occupations other than teaching and publicly-provided health care (World Bank, 2005). Consequently, public investments in human capital for women likely boost the local supply for teachers.

However, the supply of potential female teachers is low and varies across villages based on the availability of nearby schooling options. In 1981, there were 4 literate adult women (out of 242) in the median village in Punjab, the largest and most dynamic province in the country. Over sixty percent of villages in the province had *three* or fewer secondary-school educated women, and 41% had no such women. This was driven in part by a shortage of local secondary schooling options for rural women. In our sample, the presence of a GSS is associated with an increase of over 50% (compared to the median village without a GSS) in the percentage of women with a secondary education (from 3 to 4.6%).

These two features of the market for female skilled labor—low wages and limited supply—combined with the unrestricted and

[2] Contrary to popular belief and media reporting, these changes have little to do with religious education. Andrabi et al. (2006) show that enrollment in religious schools, or madrassas is low (roughly 1%) and has remained constant since the mid-80s.

[3] In contrast, private schools (elementary and secondary) in the United States charged $3524 in 1991. At 14% of GDP per capita, the relative cost of private schooling is 3.5 times higher in the US.

[4] In comparison, wages for *public* sector teachers are five times higher for both men and women. As a result, per-child spending in rural private schools (Rs. 1012 annually) is half of that in rural public schools (Rs. 2039 annually), although available facilities are comparable across the two.

unsubsidized market for private schooling inform our empirical strategy. The presence of a GSS should generate cross-sectional variation in the availability of locally resident women with secondary education. If the availability of human capital constrains private education provision and there is limited mobility, this in turn should affect the likelihood of a private school existing in a village.

2.2. Data

We employ three data sources: (a) a complete census of private schools carried out by the Federal Bureau of Statistics in 2000; (b) administrative data on the location and date of construction of public schools in the Punjab province available from the province's Educational Management and Information Systems (EMIS, 2001) augmented with the National Educational Census (NEC, 2005); and (c) data on village-level demographics and educational profiles from the 1981 and the 1998 population censuses of Punjab, which provide both baseline and contemporaneous information on village-level characteristics.

We restrict our analysis to rural areas in the province of Punjab, the largest province in the country which hosts 60% of the population, two-thirds of whom live in rural areas.[5] Since the EMIS and the other datasets do not employ a common village coding scheme, we had to match villages in the different databases on the basis of their names. Using a combination of a phonetic algorithm and manual post-match, we were able to match over 90% of the villages across databases (23,064 of the 25,266 unique Punjabi villages in the 1981 census).

In our final estimation sample, we restrict attention to villages that did not receive a girls' or boys' secondary school prior to 1981 and did not have such secondary schools in their neighboring villages. This reduces our sample to 9333 villages, but affords two advantages. First, it allows for cleaner econometric identification and interpretation of the results as our instrument utilizes public school construction guidelines that were applied for GSSs constructed *after* the 1980s. This also alleviates exclusion restriction concerns that arise if our instrument were to predict other public goods. Second, focusing on the shorter exposure (to GSS) periods is likely to better isolate supply-side effects since GSS construction probably impacts a range of demand factors over a longer time span. It is nevertheless reassuring to note that all of our main results hold in the full sample of villages, both in terms of statistical and economic significance, and several of these results are in fact stronger (Appendix Table II).[6]

Table 1 presents the summary statistics for the final sample. Two and a half percent, or 232 villages, in this sample received a GSS between 1981 and 2001.[7] Conditional on existence, the median age of a GSS is fourteen years; therefore, most were constructed early on in the twenty-year period. There is a private school in one out of every eight villages, and the majority of these villages already had or received a primary public school. Finally, the number of women reporting secondary or higher education, eight or more years of schooling, increased from one in the median village in 1981 to nine by 1998.

Table 1
Summary statistics (village level).

Variable	Mean	50th percentile	S.D.	N
1981 number of women with middle + education	4.28	1	17.94	9333
1998 number of women with middle + education	26.74	9	92.80	9333
1981 percent women with middle + education	0.01	0	0.03	8882
1998 percent women with middle + education	0.06	0.03	0.07	8915
Households per capita with radio access (1998)	0.03	0.02	0.03	8952
Ratio of females to males, under age 14 (1998)	0.94	0.93	0.24	8892
Area (acres, 1998)	1550.34	1042	2520.51	9091
Percent of houses permanent (1998)	0.06	0.06	0.05	8935
Households with water access (1998)	0.01	0.001	0.02	8935
Households with electricity access (1998)	0.07	0.07	0.06	8935
1981 total population	1020.36	667.00	1247.91	9333
1998 total population	1537.70	961.00	2053.87	9333
1981 population of largest village in PC	1670.04	1375.00	1310.46	9333
Number of villages in PC (1998)	4.57	4	2.28	9333
Girls' secondary school exists	0.02	0	0.16	9333
Girls' primary school exists	0.56	1	0.50	9330
Boys' secondary school exists	0.01	0	0.12	9333
Boys' primary school exists	0.70	1	0.46	9330
Girls' secondary school exposure (if one exists)	13.15	14	5.47	232
Girls' primary school exposure (if one exists)	21.43	18	11.80	4967
Boys' secondary school exposure (if one exists)	12.62	13.50	5.16	138
Boys' primary school exposure (if one exists)	35.21	31	19.66	6475
Private school exists	0.13	0	0.33	9258
Number of private schools	0.22	0	0.87	9258
Average teaching wage (annual-log Rs)	9.04	9.10	0.70	1131
Private school enrollment rate (if one exists)	0.12	0.06	0.37	1165

This table presents the summary statistics for various variables of interest. The years for which the above data are given by source: All 1981/1998 variables are from the 1981/1998 Population Censuses while all schooling data is from the EMIS, NEC, or private school census.

3. Methodology and empirical framework

There are two broad empirical challenges. The first is to identify the causal impact of GSSs on subsequent private school existence. The second is to argue that the driving force is a teacher supply channel rather than an increase in the demand for education from secondary-educated women.

A simple framework outlines the entrepreneur's problem, highlighting the role of the public sector and the econometric and interpretational issues in identifying the impact of a GSS. An entrepreneur opens a school in village i if the net return is positive.[8] Given that school fees

[5] Not all data sets (e.g., EMIS, 1981 Census) were readily accessible for other provinces, and urban areas could not be matched at the granular level necessary to exploit the cross-sectional variation in private school location and GSS presence that we utilize in the paper.

[6] Interestingly, while our restricted sample result shows that GSS presence leads to a lower wage (Table 5), in the full sample although initial exposure to GSS is indeed associated with lower wages, prolonged exposure (more than 26 years) is associated with higher wages. This is consistent with a net supply impact within a shorter timeframe (20 years) but suggests that, in the longer term, the demand effect may dominate: As more and more educated girls become mothers and grand-mothers, they impact educational demand. It therefore offers another important consideration for why restricting our analysis to the reduced sample is appropriate in identifying the (initially dominant) supply channel.

[7] This number is quite low relative to what the school construction guidelines would have suggested. While this is not surprising given that these guidelines were constrained by budgetary limitations, it may lead to concerns about the power of the instrument and the external validity of our results. We therefore address these in detail later in the paper.

[8] This assumes that there is no shortage of entrepreneurs (otherwise, not every positive NPV project will be undertaken). Incorporating such shortages does not change the qualitative results. The qualitative results also extend to a dynamic framework provided that the fixed costs of setting up schools are small.

and teachers' salaries account for 98.4% and 89% of total revenues and costs, respectively (Andrabi et al., 2008), $NetReturn_i = Fee_i * N_i - Wage_i * T_i$, where Fee_i is the average private school fee for a single student in village i, $Wage_i$ is the average private school teacher's salary, and N_i and T_i are the number of students enrolled and teachers employed. Since the schooling market may be geographically segregated, wages and fees may differ across villages. GSS construction both increases the supply of teachers in the village, thus affecting $Wage_i$, and may increase schooling demand, reflected in Fee_i. A reduced form expression for net return can then be written as:

$$NetReturn_i = \alpha + (\beta_1 + \gamma_1)GSS_i + \beta' X_i^D + \gamma' X_i^S \quad (1)$$

where X_i^D and X_i^S are village demographics and characteristics that respectively affect the demand for private schooling and the costs of running such schools. The demand and supply impacts of GSS construction are captured by β_1 and γ_1 respectively. We are interested both in the joint estimation of $(\beta_1 + \gamma_1)$ and in arguing that the there is a supply channel (i.e., γ_1 is positive and significant).

Since the net return a private school earns is not observed, we treat net return in Eq. (1) as a latent variable in a probability model such that $\text{Prob}(\text{PrivateSchoolExists}) = \text{Prob}(\text{NetReturn}_i > 0)$, and estimate:

$$Private_{it} = \alpha + (\beta_1 + \gamma_1)GSS_{it} + \beta' X_{it} + \sum_r \gamma'_r S_{irt} + (v_i + \varepsilon_{it}) \quad (2)$$

where $Private_{it}$ is a binary variable that takes the value 1 if a private school exists in village i at time t and GSS_{it} is a binary variable that takes the value 1 if a GSS exists in village i at time t. X_{it} is the observed village characteristics at time t and S_{irt} is the other government schooling options (primary boys'/girls' schools and boys' secondary school) at time t, where each option is indexed by r. The error term, $(v_i + \varepsilon_{it})$, consists of a time-invariant unobserved component, v_i, and a random component, ε_{it}. The main identification challenge is that the presence of a GSS in village i in time period t is likely a function of (unobserved) village/region attributes and hence the OLS estimate of $(\beta_1 + \gamma_1)$ in Eq. (2) is biased and inconsistent. While first differencing Eq. (2) helps, the estimated $(\beta_1 + \gamma_1)$ in such a specification would still be biased due to time-varying covariates that determine receiving a GSS and affect private school presence. Therefore, we instrument for GSS construction using program guidelines for a school expansion program undertaken in the 1980s.

3.1. Identification strategy

Our instrumental variable strategy exploits the fact that the regressor of interest, the construction of a GSS, is partly based on whether the village has the largest population locally. To the extent that this local top-rank generates a relationship with village population that is highly discontinuous/nonsmooth (two villages with arbitrarily close/similar populations may differ in whether they are top-ranked), it can be used as an instrument while directly controlling for linear and polynomial functions of the underlying covariate itself (Campbell, 1969; Angrist and Lavy, 1999).

GSS construction after 1981 was a consequence of the 1980 Pakistan Social Action Program (SAP). Specific guidelines affected where these schools could be built. In particular, the recommended guidelines for opening a new GSS specified a preference for higher village (student) populations and stipulated that there be no other GSS within a ten-kilometer radius. We capture this guideline through a "local top-rank" indicator variable, $Rule_i$, that takes the value 1 if village i is the largest village (in terms of population[9]) among nearby villages (the set PC_i) and 0 otherwise:

$$\text{Rule}_i = \begin{cases} 1 \; \textit{if} \;\; \text{Population}_i = \max\limits_{j \in PC_i} \left(\text{Population}_j\right) \\ 0 \; \textit{if} \;\; \text{Population}_i < \max\limits_{j \in PC_i} \left(\text{Population}_j\right) \end{cases}$$

In the absence of precise village location data, we use the next highest administrative classification, the "Patwar-Circle" (PC), which typically covers four villages, to approximate the radius rule. In terms of actual land area, this is a reasonable approximation; dividing the size of the province by the number of PCs shows that one school in every PC would satisfy the radius requirements of the rule. We should note though that this is a proxy measure for the 10 km distance radius guideline and it likely results in us obtaining a weaker first stage. Since there are no village-level GIS databases available, this is the only feasible strategy and we deal with a potentially weaker first stage by using bivariate probit estimation to obtain more plausible second stage estimates. Fig. 1 shows that this local top-rank indicator indeed displays a relationship with village population that is highly discontinuous and nonsmooth (i.e. not only do similar/equal-sized village differ in the indicator value but also larger-sized villages may have a lower indicator value).

Our final empirical specification is:

$$\begin{aligned} Private_i = {} & \alpha_{PC_i} + (\beta_1 + \gamma_1)GSS_{it} + \beta'_1 Pop_{i81} + \beta'_2 Pop^2_{i81} + \beta'_3 Pop_{i98} \\ & + \beta'_4 Pop^2_{i98} + \beta' X_{it} + \sum \gamma'_r S_{irt} + (v_i + \varepsilon_{it}) \end{aligned} \quad (3)$$

where the X_{it} controls also include indicators of village wealth and area. We estimate Eq. (3) using $Rule_i$ as an instrument for GSS_{it}. By including a full set of PC fixed effects, α_{PC_i}, and polynomials in village population, the remaining variation that the $Rule_i$ exploits is likely uncorrelated with the demand for private schooling. Nevertheless, in Section 4, we present several robustness tests to check for the validity of the exclusion restriction. Specifically, we show: (a) our instrument does not predict the construction of other public goods, and (b) it is the local (within-PC) population rank that matters rather than the population rank of a village in the next larger administrative unit above a PC, where the radius rule would less likely apply.

3.2. Isolating the supply-side

To identify the existence of a supply-side effect, we employ two strategies. First, on the quantity margin, a supply-side channel suggests several patterns. In particular, we expect: (a) since 98% of teachers in private schools report at least secondary education, *secondary* schools should have a larger impact on private school existence than primary schools; (b) the effect of GSS should be larger than that of boys' secondary schools; (c) villages with a GSS should report a larger stock of educated women[10]; and (d) private school existence should respond more to the stock of women with higher education than men.

[9] Since GSSs could have been built in any year between 1981 and 1998, we assign a value of one to $Rule_i$ if it was the largest village in its PC based either on its 1981 or 1998 population. In addition, for the 4.5% of villages in our sample that are alone in their PC, we assign a value of 0 to the instrument. Our results are robust to using either 1981 or 1998 population exclusively or assigning the value 1 to $Rule_i$ for single-village PCs.

[10] This test relies on there being limited migration. To the extent that educated women migrate out (in), the estimates could be attenuated (overestimated). With female migration rates around 15% (Hamid, 2010), we don't perceive this as a substantial concern.

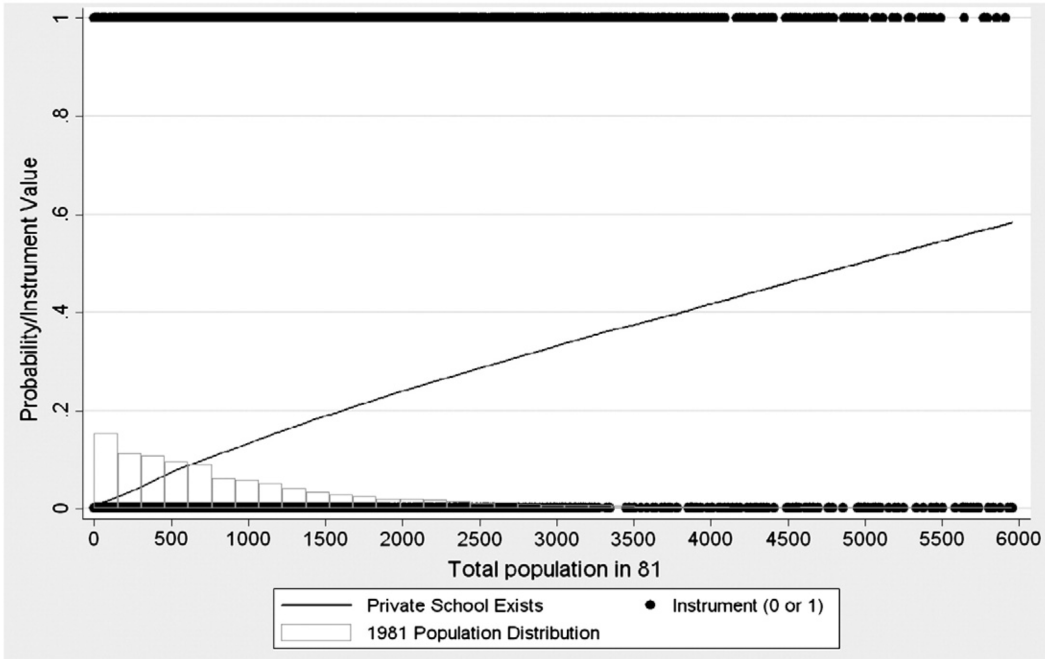

Fig. 1. Private school existence/rule-based instrument and 1981 population. The figure illustrates how the existence of private schools and the binary instrument covary with 1981 village population (the relationship with 1998 population is very similar). Here, we plot the binary instrument, $Rule_i$, for all villages in our sample and the non-parametric relationship between private school location and village population. We note that there are both "eligible" and "ineligible" villages at all population levels. The bar graphs illustrate the population distribution.

Second, and more conclusive evidence for the presence of the supply-side channel comes from the price margin. If private schools locate in villages with a GSS due to increases in demand, we should see higher teachers' wages in such villages. Conversely, if the GSS effect works in part through the supply channel, we should observe lower wages. Therefore, one should test for differences in skilled women's wages in villages with and without a GSS. Since the only available village-level data that captures skilled women's wages is the private school census which records average teacher wages in all private schools, a simple correlation of wages and GSS may be biased, with the bias depending both on how GSS were placed and on the truncation of the wage distribution due to missing wages in villages without private schools. We address this selection problem using both a Heckman selection model and the "control-function" approach (Angrist, 1995). Details of both approaches are in Appendix I.

4. Results

4.1. IV strategy: first stage and specification checks

To clarify the identifying assumptions needed for our instrumental variable strategy, Fig. 1 plots both the relationship between the instrument, $Rule_i$, and village population and the *non-parametric* relationship between private school existence and village population. For the former, it is noteworthy that there are both "eligible" ($Rule_i = 1$) and "ineligible" ($Rule_i = 0$) villages *at all population levels*. We can thus compare two villages with the same population but different eligibility status, allowing us to exclude the direct effect of population on private school existence. Further, given that the non-parametric relationship between private school existence and village population is approximately linear, linear and quadratic population terms in the regression specification likely sufficiently control for the underlying relationship between village population and private school existence.

Table 2 presents the first stage results. Column (1) runs a probit specification with linear and quadratic controls for population, and shows that an eligible village was 1.24 percentage points more likely to receive a GSS. Column (2) augments the first stage with other village-level public goods and PC fixed effects (there are 2875 separate PCs in the sample), resulting in similar point estimates that are significant at the 1% level of confidence: Villages with $Rule_i = 1$ were 1.6 percentage points more likely to receive a GSS. Although the point estimate seems small, this is because few GSSs were constructed. In fact, this estimate represents an almost 100% increase over the fraction of ineligible (instrument = 0) villages that had received a GSS by 2001. Both the basic and more demanding first stage are at or above the proposed critical thresholds for detecting weak instruments (Stock et al., 2002).

4.1.1. IV strategy: exclusion restriction

We first confirm that there are neither statistically significant baseline differences in educational levels for women or men nor in their age distribution between eligible (instrument = 1) and ineligible (instrument = 0) villages (Appendix Table I). The only differences are in the initial population and area, which arise directly from the construction of the instrument and are controlled for in the IV specifications. Moreover, there are no differences in other village socio-economic attributes, such as the extent of permanent housing, media access (TV and radio), men/women with national identification cards, or sex-ratios.

The exclusion restriction could also fail if the government used the same village population-rank criteria for allocating *other* investments. The PC classification was used in the colonial times as a land revenue assessment and recording unit and continues to be used as such and is an explicit classification used in the population census. However, it is not used as a jurisdiction for policy making purposes such as the delivery of public services or political representation. The smallest administrative political unit is instead the Union Council (UC),

Table 2
First stage and falsification tests.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variable	First stage—probit and OLS		OLS falsification tests—other public goods						Falsification test—probit with QH top rank	
	Girls' secondary school	Girls' secondary school	Girls' primary school	Boys' primary school	Boys' secondary school	Water	Electricity	Permanent houses	Girls' secondary school	Girls' secondary school
Instrument	0.0124***	0.016***	0.011	0.011	0.0008	−0.0002	0.002	0.002		0.012***
	(0.004)	(0.005)	(0.015)	(0.014)	(0.0037)	(0.0008)	(0.001)	(0.001)		(0.004)
Has highest population in QH, 1981									−0.005	−0.003
									(−0.008)	(0.008)
Girls' primary school exists		−0.052***								
		(0.004)								
Boys' secondary school exists		0.232***								
		(0.017)								
Boys' primary school exists		0.003								
		(0.005)								
Area (000s of acres)		0.001								
		(0.002)								
% houses permanent		0.076								
		(0.053)								
1981 population (000s)	0.0059*	0.014	0.293***	0.374***	−0.002	0.002	0.018***	−0.002	0.0087**	0.006*
	(0.004)	(0.010)	(0.027)	(0.025)	(0.007)	(0.001)	(0.002)	(0.002)	(0.0035)	(0.004)
1981 population $(000s)^2$	−0.0003	(0.001)	−0.033***	−0.041***	0.002*	−0.0003*	−0.002***	0.0001	−0.0005**	−0.0003
	(0.0002)	(0.001)	(0.003)	(0.003)	(0.001)	(0.0002)	(0.0003)	(0.0003)	(0.0002)	(0.0002)
1998 population (000s)	0.003	0.003	−0.019	−0.054***	0.008**	0.0001	−0.002	0.001	0.0029	0.003
	(0.002)	(0.005)	(0.014)	(0.013)	(0.003)	(0.0007)	(0.001)	(0.001)	(0.0020)	(0.002)
1998 population $(000s)^2$	-2×10^{-5}	0.0002	0.002***	0.003***	3×10^{-5}	2×10^{-5}	1×10^{-4}***	-1×10^{-5}	-2×10^{-5}	-2×10^{-5}
	5×10^{-5}	(0.0001)	(0.0004)	(0.0004)	(10×10^{-5})	2×10^{-5}	(0.1×10^{-4})	(3×10^{-5})	(5×10^{-5})	$(5\times1^{-}0^{5})$
PC fixed effects		Y	Y	Y	Y	Y	Y	Y		
R-squared			0.48	0.46	0.48	0.42	0.70	0.69		
Adjusted R-squared		0.17								
Pseudo R-squared	0.05								0.05	0.05
Chi-square stat (instrument =	13.04									
F-stat (instrument = 0)		8.9								
Observations	9333	8705	9330	9330	9333	8935	8935	8935	9333	9333

Standard errors in parentheses with * indicating significance at 10%, ** at 5%, and *** at 1%. Columns (1)–(2) present first stage regressions using the eligibility rule as a predictor for the location of GSS. Column (1) gives the increased probability of finding a GSS in an eligible village (with basic population controls). Column (2) presents a linear first stage that includes controls for the village's population in 1981 and 1998, other village level public goods, and PC fixed effects. Columns (3)–(8) check that the instrument does not predict other public goods. Columns (9)–(10) show that a village having the highest population within a QH does not predict GSS construction.

with little overlap between the two (Government of Pakistan, 1967, 1979; Ali and Nasir, 2010). Columns (3) through (8) in Table 2 directly assess this by demonstrating that our instrument does not predict any other government investments, ranging from other types of schooling to other public goods such as potable water and electrification. While the point estimates for primary schools appear similar to that of the GSS, they represent less than a 2% increase relative to the comparison group as compared to the 100% increase for GSSs between eligible and ineligible villages.

A third possible concern is that being a top-ranked village in a region is important in itself and that our instrument does not reflect the ten-kilometer-radius rule but a more general rank effect. If local rank is important in general, one would still expect that being the top-ranked village in the next largest administrative unit after the PC, a Qannongoh Halqa (QH), would also predict having a GSS. Columns (9) and (10) run this "placebo test" and demonstrate that it is local rank in PC and not local rank in QH that matters. This lends further support that our instrument predicts GSS placement because of the ten-kilometer-radius rule rather than some inherent characteristic about top-ranked villages within administrative units. Moreover, as we detail in the next section, PC-rank only matters in regions where we would expect it to (i.e., where a GSS was provided).[11]

4.1.2. GSS impact on private schools

Table 3 first presents the OLS results based on Eq. (3).[12] The construction of a GSS increases the probability of a private school in the village by 9.5 percentage points [Column (1)]. Note that the specification includes a full set of village-level controls, including exposure to

[11] An additional placebo experiment groups villages into "fake" PCs and estimates the reduced form relationship, $cov(Private_{it}, GSS_{it}|Pop)$, five thousand times. Our actual reduced form coefficient lies within the top 1 percentile of the distribution of reduced form coefficients generated by the fake PC simulations, demonstrating that it is extremely unlikely that the coefficient we obtain is an artifact of a village being large; what matters is the specific assignment of villages to PCs.

[12] We focus on the existence of private schools rather than their enrollment share. Most variations in the number of children enrolled in private schools are driven by the extensive (whether or not there is a private school in the village) rather than the intensive (variation in private school enrollment conditional on existence) margin. Our results are similar if we look at private school enrollment. We prefer the extensive margin since the data on enrollment is noisier.

Table 3
GSS impact on private school existence.

	(1) OLS	(2) First difference	(3) Linear, second stage	(4) Bivariate probit-ATE	(5) Bivariate probit-average ToT effect	(6) Reduced form-program QHs	(7) Reduced form-non-program QHs
Instrument						0.038***	−0.0017
						(0.014)	(0.016)
Girls' secondary school exists	0.095***	0.097***	1.505*	0.266*	0.246***		
(= received GSS after 1981)	(0.025)	(0.025)	(0.802)	(0.151)	(0.092)		
Girls' primary school exists	0.016*		0.089**	xx	xx	0.007	0.017
	(0.0080)		(0.043)			(0.011)	(0.014)
Boys' secondary school exists	−0.005		−0.333*	xx	xx	−0.030	0.112*
	(0.034)		(0.191)			(0.040)	(0.063)
Boys' primary school exists	−0.005		−0.009	xx	xx	−0.009	0.001
	(0.009)		(0.012)			(0.012)	(0.014)
Received girls' primary school		0.0190					
after 1981		(0.035)					
Received boys' secondary school		−0.011					
after 1981		(0.008)					
Received boys' primary school		−0.026***					
after 1981		(0.010)					
Area (000s of acres)	−0.008**		−0.009**	xx	xx	−0.029***	−0.002
	(0.003)		(0.004)			(0.007)	(0.004)
% houses permanent	0.194*		0.083	xx	xx	0.184	0.208
	(0.103)		(0.142)			(0.133)	(0.163)
1981 population (000s)	0.046***		0.013	xx	xx	0.035	0.054*
	(0.017)		(0.028)			(0.027)	(0.028)
1981 population $(000s)^2$	−0.0030		−0.0002	xx	xx	0.004	−0.007**
	(0.002)		(0.003)			(0.004)	(0.003)
1998 population (000s)	0.064***		0.059***	xx	xx	0.060***	0.067***
	(0.009)		(0.012)			(0.012)	(0.014)
1998 population $(000s)^2$	−0.001***		−0.001***	xx	xx	−0.002***	−0.002***
	(0.0003)		(0.0004)			(0.0005)	(0.0004)
Δ population (000s)		0.075***					
		(0.005)					
PC fixed effects	Y	Y	Y			Y	Y
R-squared						0.51	0.57
Adjusted R-squared	0.31	0.28					
Prob > F						37.81	24.71
Prob > Chi-square			0.00				
Observations	8705	8900	8705	8705	8705	5191	3514
Number of PCs (1998)			2784				

Standard errors in parentheses with * indicating significance at 10%, ** at 5%, and *** at 1%. This table presents the regression results for which the dependent variable is a dummy indicating the presence of at least one private school in a village (or the change in this variable for the first difference specification). Column (1) gives OLS results for the impact of GSS on private school existence. Column (2) shows a first-differenced specification. (First-differencing girls' secondary school exists does not change the variable because our sample contains no villages which had a GSS prior to 1981. That is, having a GSS in our sample is equivalent to receiving one after 1981.) Columns (3)–(5) present the IV specifications. Column (3) gives the second stage results from a linear specification. Columns (4)–(5) implement the bivariate probit specification and report, respectively, the average treatment effect and the treatment on the treated effect of a GSS on the existence of a private school with analytical standard-errors computed using the delta method. Controls are present in these two regressions where marked with an "xx", but coefficients and standard errors are not given. These regressions also include (in the absence of PC fixed effects) linear and quadratic controls for the population of the largest village in the PC as well as a control for the number of villages in the PC. Columns (6)–(7) present an additional check of the instrument by showing that the reduced form only holds in broad areas where at least one GSS was provided. Villages are divided into two sub-groups: "program regions," where at least one village in the QH received a GSS [Column(6)]; and "non-program regions," where no village in the QH received a GSS [Column (7)].

other types of public schools and PC fixed effects. Column (2) addresses any selection concerns arising from time-invariant village effects by first-differencing (1998 less 1981 values) the data at the village level. The effect of receiving a GSS on change in private school existence increases slightly to 9.7 percentage points.

Fig. 2 provides a simple illustration of our instrumental variable estimates by dividing villages into four population quartiles (averaged over 1981 and 1998 populations). The top panel compares the percentage of villages with a GSS in the "eligible" ($Rule_i = 1$) group compared to "ineligible" ($Rule_i = 0$) group. This difference represents the first-stage of the instrumental variables (IV) estimate, $cov(GSS_{it}, Rule_i)$. The bottom panel illustrates the reduced form regression by comparing, over the same population quartiles, the percentage of villages with a private school in the "eligible" and "ineligible" groups. Given that the instrument varies in every population quartile, our results are not driven by variation in a single population group. For all population quartiles, the first-stage indicates that eligible villages were more likely to receive a GSS. In addition, the reduced form suggests that, controlling for population, villages that were eligible to receive a GSS were also more likely to see private schools arise at a later date.

Columns (3) to (5) of Table 3 present the IV regression coefficients. Column (3), the linear IV specification, shows that the estimated coefficient of GSS on private school existence increases from the OLS and first difference specifications to 1.50 in the linear IV specification. Given that both the existence of a GSS and the presence of a private school are binary variables, Columns (4) and (5) present estimates of the average treatment effect (ATE) and treatment on treated (ATT) using a bivariate probit specification; the marginal effects are reported only for variable of interest ("xx" indicates other variables included in the specification) and we report analytical standard-errors computed using the delta method. The point-estimate from the bivariate probit is still large but less than a fifth that of the linear IV and significant at the 10% level of confidence for the ATE and the 1% level for the ATT. The biprobit estimates suggest

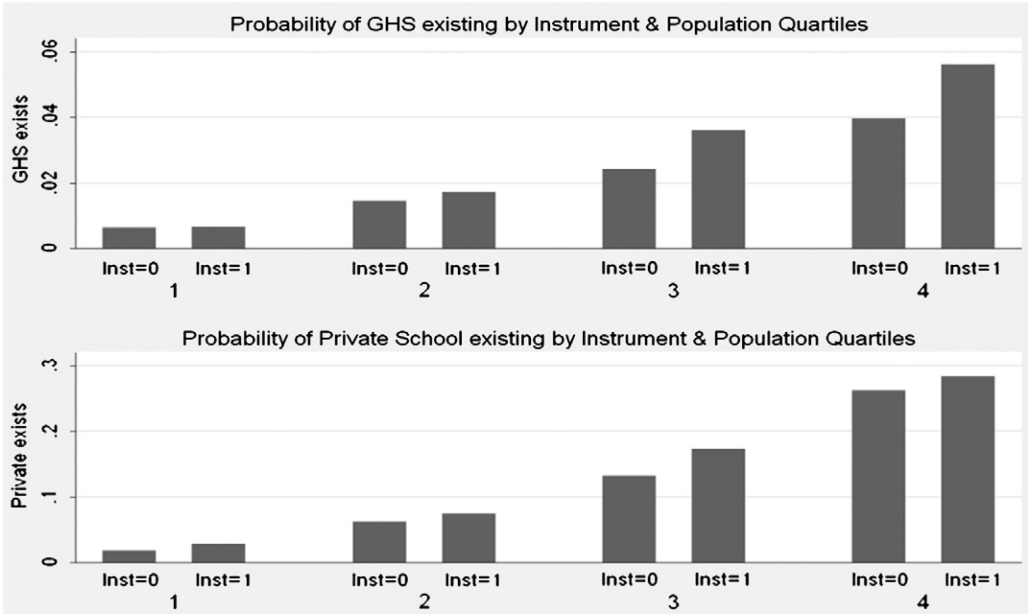

Fig. 2. Probabilities of schools existing by instrument and population quartiles. This figure provides a simple illustration of the our instrumental variable estimates by dividing villages into four population quartiles, averaged over 1981 and 1998 populations. The top panel illustrates the first stage by comparing the percentage of villages with a GSS in the "eligible" group compared to the "ineligible" group. The bottom panel illustrates the reduced form, by comparing, over the same population quartiles, the percentage of villages with a private school in the "eligible" and "ineligible" groups.

that private schools are 25 to 27 percentage points more likely to locate in villages with a GSS—more than a 200% increase over the comparison group (villages without a GSS) probability of 12.3%. Given confidence intervals obtained from linear IV estimates are particularly large when treatment probabilities are low and the model includes additional covariates (see Chiburis et al. (2012) and Appendix II), our preferred estimates are from the bivariate probit specification.

The larger IV estimates suggest that time-varying omitted variables that increase the likelihood of private schools are in fact negatively correlated with GSS construction. There are several reasons why one may expect this. Governments may act altruistically, trying to equalize differences between villages by allocating GSSs to villages with lower educational demand. However, less altruistically, schools are often also provided in villages with powerful/feudal local landlords and officials as political rents. These villages in turn likely have lower development/educational demand levels. Moreover, given the requirement to give land for free for school construction, these schools were constructed in areas where land prices were also low. To the extent that low land prices are associated with poor educational returns, we would expect similar results to those documented here.

4.1.3. A further check of the exclusion restriction

Columns (6) and (7) present an additional check by showing that the reduced form only holds where one would expect (i.e., regions where at least a GSS was provided). We divide villages into two sub-groups, "program regions," where at least one village in a broadly defined area (we use QH, the unit larger than a PC) received a GSS and "non-program regions," where no village in the QH received a GSS. Note, in particular, that even if we do not know how *regions* were selected, comparisons across program and non-program areas are instructive. In particular, if population rank within the PC has no independent effect on the probability of setting up a private school, we should find a strong relationship between private school existence and eligibility for villages in program regions but *not* in non-program regions. A contrary result in non-program areas would suggest a violation of the exclusion restriction. Our results confirm that population rank with the PC has an effect on private school location only in program areas, providing further support for the instrument. Column (6) shows that for program regions, eligibility increases the probability of a private school by 3.8 percentage points; conversely, in non-program regions, eligibility has no impact on private school existence [Column (7)].[13]

4.2. Potential channels: evidence for supply-side effects

As described in Section 3, we now examine whether the impact of GSS on private schools operates through a supply-side channel by looking at the quantity and price margins.

4.2.1. Quantity margin

We first examine whether, consistent with a women-as-teachers channel, GSSs have a larger impact on private school existence relative to other types of public schooling (Table 4). Column (1) shows that the coefficient for years of exposure to a GSS is almost four times as large as that of the next most important public school type. Column (2), the first-difference specification, shows that by better addressing time-invariant village selection factors, the importance of GSS is further magnified: no other (than GSS) public schooling type affects the likelihood of a private school setting up in the village.

Columns (3) to (6) show that, as expected, GSSs are indeed associated with more educated women in the village. In both the OLS and first-difference specifications, a GSS increases the number of adult women with higher levels of education (equal to eight or more years of schooling) to 10.8 more women, a more than doubling of the *stock* of educated women in the village. Column (5) utilizes a similar IV strategy and, as before, shows that while the IV estimate is significant, it is substantially larger than the OLS estimate. This is due to the relatively small first stage coefficient (see Table 2). Column (6) makes this clear by presenting the reduced form estimate. While

[13] Replicating the first-stage, linear IV, and biprobit estimates for program regions also produces similar results and with more statistical significance given a stronger first-stage (not surprising, since identification is achieved only off the variation in program regions).

Table 4
Private school existence: the female teacher channel.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Private school exists		Number of women with middle + education				Private school exists	
	OLS	First difference	OLS	First difference	Second stage	Reduced Form	OLS	First difference
Instrument						3.46***		
						(1.19)		
Years exposure to girls' secondary school	0.006***							
	(0.002)							
Years exposure to girls' primary school	0.0015***							
	(0.000)							
Years exposure to boys' secondary school	0.001							
	(0.003)							
Years exposure to boys' primary school	0.0004**							
	(0.0002)							
Girls' secondary school exists		0.097***	10.81***	9.52***	219.32**			
		(0.025)	(2.93)	(3.55)	(103.06)			
Girls' primary school exists			2.37**		13.08**	1.79*		
			(0.99)		(5.46)	(0.98)		
Boys' secondary school exists			7.51*		−40.96*	9.98**		
			(3.98)		(24.55)	(3.93)		
Boys' primary school exists			1.28		0.59	1.27		
			(1.06)		(1.49)	(1.06)		
Received girls' primary school after 1981		−0.011		−4.32***				
		(0.008)		(1.17)				
Received boys' secondary school after 1981		0.019		14.25***				
		(0.035)		(4.91)				
Received boys' primary school after 1981		−0.026***		−0.65				
		(0.010)		(1.36)				
% women with middle + education							0.376***	
							(0.084)	
% men with middle + education							0.033	
							(0.049)	
Δ % women w/ middle + education								0.414***
								(0.086)
Δ % men w/ middle + education								−0.047
								(0.050)
Area (000s of acres)	−0.008**		−2.03***		−2.15***	−2.03***	−0.008**	
	(0.003)		(0.39)		(0.53)	(0.39)	(0.003)	
% houses permanent	0.187*		44.83***		28.43	45.14***	0.276**	
	(0.104)		(12.05)		(18.30)	(12.06)	(0.128)	
1981 population (000s)	0.028		−1.61		−6.36*	−3.35	0.046***	
	(0.018)		(2.04)		(3.63)	(2.15)	(0.017)	
1981 population (000s)^2	−0.001		−0.32		0.07	−0.16	−0.003	
	(0.002)		(0.24)		(0.38)	(0.25)	(0.002)	
1998 population (000s)	0.065***		9.71***		8.91***	9.45***	0.064***	
	(0.009)		(1.05)		(1.49)	(1.06)	(0.009)	
1998 population (000s)^2	−0.0012***		1.79***		1.76***	1.79***	−0.0012***	
	(0.0003)		(0.03)		(0.05)	(0.03)	(0.0003)	
Δ population (000s)		0.075***		60.39***				0.072***
		(0.005)		(0.71)				(0.005)
PC fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R-squared	0.32	0.28	0.88	0.77		0.88	0.32	0.27
Prob > F					4.08			
Observations	8355	8900	8705	8975	8705	8705	8685	8711

Standard errors in parentheses with * indicating significance at 10%, ** at 5%, and *** at 1%. Columns (1)–(2) present estimates for the effects of school exposure on private school existence from a linear probability model and a first difference specification. (First-differencing girls' secondary school exists does not change the variable because our sample contains no villages which had a GSS prior to 1981. That is, having a GSS in our sample is equivalent to receiving one after 1981.) Using the same approach, Columns (3)–(4) assess the correlation between educated women and the presence of a GSS. Columns (5)–(6) examine this relationship through an instrumental variable specification and present the second stage and reduced form. Finally, Columns (7)–(8) show the extent to which the extent of secondary-school-educated women in the village are associated with private school existence.

the large magnitude of the IV estimate is difficult to take literally and we believe the OLS/first difference estimates are more realistic, the point is that GSS existence substantially increases the number of educated women in the village even when potential selection concerns are taken into account.[14]

[14] We should note that the OLS/first-difference are large enough to generate (the few) teachers one would need for the supply channel, but not enough to produce sufficient educated mothers that one would expect if the demand channel were the primary driver. While the IV estimates could generate such a demand channel, they are implausibly large: The median village in our sample has only 9 women with higher education in 1998, with a mean of 26 and, with a typical GSS only graduating around 5 or so girls per year. Even by 2005, an increase of 220 women is therefore quite implausible.

Finally, Columns (7) and (8) examine the importance of secondary school educated women directly on the existence of a private school. In both the OLS and first-difference specifications, the impact of women with eight or more years of schooling is large and very significant, while the percentage of similarly educated males has *no* impact on the existence of a private school.

Another potential approach to isolating the supply-side is to use variation in the timing of the public school construction since supply-side channels suggest that private schools will emerge five to eight years after the construction of a GSS (or three years if there was a preexisting primary school). Although there is suggestive evidence that this is indeed the case as the impact of GSSs on private schools is primarily driven by 5 or more years of exposure to GSSs, the data are too limited to further exploit this source of variation.

4.2.1. Price margin

Table 5 provides further evidence for the existence of a supply channel. Recall, that a *fall* in private school teacher (i.e. skilled women) wages would suggest the existence of a supply-side channel, since demand-side factors should lead to increases in such wages. We compare the average (log) teacher salary in private schools in villages with and without a GSS using data from the private school census. Column (1) presents the OLS results in the sample of villages for which we have teacher wage data. We include PC FEs in all specifications. The results are large and significant: Private schools in villages with a GSS report a 27% lower average teaching wage.

Since we only observe wage data where a private school exists, Columns (2) through (5) correct for selection into the sample. Columns (2) and (3) present results using Heckman's selection model, and Columns (4) and (5) use the "control function" approach (see Appendix I). In both approaches, identification is based on the non-linearity of the selection equation (see Duflo, 2001) as an example). Augmenting the instrument set with potential candidates that are correlated to the probability of having a private school but uncorrelated to the wage-bill can further help with the identification and the efficiency of the estimator. Following Downes and Greenstein (1996), we propose using the *number of public boys' primary schools* as an additional instrument in the selection equation. In the presence of competitive schooling effects, private schools should be less likely to set up in villages where there are public boys' primary schools. Additionally, such schools are unlikely to affect the wage-bill of the entrepreneur directly since public school teachers are rarely, if ever, hired locally and because their wages are fixed and centrally determined. While we remain cautious in using this instrument since primary schools for boys may be endogenously placed, it does serve as a robustness check on the identification based on non-linearities in the selection equation. Columns (2) and (4) use the functional form of the selection equation to achieve identification, and Columns (3) and (5) introduce the additional instrument. The results are similar to the OLS estimates, with estimates of 27 to 28% suggesting that selection into the non-zero wage sample is of limited importance.

Columns (6) and (7) present tentative evidence that wage declines due to a GSS are larger in villages where labor markets for women are more restricted and localized. In both cases, we have standardized the interaction variable so as to allow for the GSS coefficient

Table 5
Supply side impact: average teaching wage in private schools.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	Heckman	Heckman (expanded first stage)	Control function	Control function (expanded first stage)	OLS	OLS
Girls' secondary school exists	−0.318*	−0.321***	−0.321***	−0.324*	−0.325*	−0.356*	−0.365**
	(0.186)	(0.091)	(0.092)	(0.191)	(0.187)	(0.187)	(0.188)
Girls' primary school exists	0.075	0.061	0.061	0.069	0.068	0.057	0.074
	(0.087)	(0.042)	(0.043)	(0.099)	(0.088)	(0.087)	(0.087)
Boys' secondary school exists	0.295	0.282**	0.285**	0.269	0.269	0.333	0.299
	(0.220)	(0.111)	(0.112)	(0.226)	(0.225)	(0.221)	(0.220)
Boys' primary school exists	0.019	0.015	0.0001	0.013	0.010	0.036	0.011
	(0.087)	(0.042)	(0.044)	(0.096)	(0.091)	(0.087)	(0.087)
Std. ratio of females to males, under age 14						0.028	
						(0.085)	
Std. ratio of females to males, under age 14×girls' secondary school exists						1.567*	
						(0.854)	
Std. households per capita with radio access							0.051
							(0.467)
Std. households per capita with radio access×girls' secondary school exists							0.305
							(0.266)
Area (000s of acres)	−0.058	−0.056***	−0.058***	−0.058	−0.058	−0.061	−0.061
	(0.039)	(0.021)	(0.021)	(0.040)	(0.039)	(0.039)	(0.039)
% houses permanent	0.006	0.055	0.046	0.016	0.003	−0.058	−0.238
	(1.320)	(0.635)	(0.644)	(1.329)	(1.327)	(1.318)	(1.333)
1981 population (000s)	0.122	0.274**	0.253**	0.198	0.186	0.138	0.136
	(0.104)	(0.110)	(0.105)	(0.185)	(0.182)	(0.105)	(0.105)
1981 population (000s)^2	−0.021*	−0.039***	−0.037***	(0.031)	(0.030)	−0.021*	−0.022*
	(0.012)	(0.014)	(0.013)	(0.021)	(0.021)	(0.012)	(0.012)
1998 population (000s)	0.028	0.097*	0.088*	0.033	0.027	0.016	0.027
	(0.053)	(0.052)	(0.049)	(0.093)	(0.092)	(0.053)	(0.053)
1998 population (000s)^2	0.001	−0.001	−0.001	0.0002	0.0003	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
PC fixed effects	Y	Y	Y	Y	Y	Y	Y
Adjusted R-squared	0.46			0.45	0.46	0.46	0.46
Observations	1090	9292	9292	1090	1090	1090	1090

Standard errors in parentheses with * indicating significance at 10%, ** at 5%, and *** at 1%. This table examines the impact of GSS on skilled women wages. The dependent variable is the (logarithm of the) average salary of a private school teacher in the village. Since private school teachers are almost entirely women and educated women are mostly employed as teachers, this measure is a reasonable proxy for skilled women wages. Column (1) presents the OLS results. The sample is slightly smaller than the number of villages where there is a private school since, in a few cases in the PEIP data, private schools did not report wages. Columns (2)–(5) correct for selection into the wage sample. Columns (2)–(3) present results using Heckman's selection model. Columns (4)–(5) use the "control function" approach. Columns (3) and (5) include the presence of a government boys' primary school in the village as an additional instrument in the selection stage. Finally, Columns (6)–(7) present tentative evidence that wage declines are larger in villages where labor markets for women are more restricted. In both cases we have standardized the interaction variable so as to allow for the GSS coefficient itself to be interpretable/comparable to the previous specifications. Column (6) examines the differential effect of GSS construction on wages for more and less progressive villages using the (standardized) female/male ratio for children under the age of 14 as an indicator of gender bias. Column (7) presents similar results using (standardized) households per capita with access to radios as an indicator of village-level development.

itself to be interpretable/comparable to the previous specifications. Column (6) considers the differential effect of GSS construction on wages for villages that vary in progressivity as proxied by the (standardized) female/male ratio for children under the age of 14. Villages at the 25th percentile of the distribution (actual female/male ratio of 0.86) see a wage decline of 58% due to GSS construction, compared to essentially no decline for villages at the 75th percentile of the distribution (actual female/male ratio of almost 1). Column (7) uses (standardized) household's per capita access to radios as an indicator of village-level development. While the results for the interaction term are only significant at the 26% level in this case, the signs are in the expected direction. Wages decline by 46% in villages where no houses have access to radios (6% of the sample), compared to a 26% decline in villages which are at the 75th percentile of the radio access distribution. While encouraging, these results are, at best, tentative. Endogenous variation (these variables are only available in the 1998 and not baseline, i.e. 1981, census), as well as the suitability of these two indicators as proxies for the restrictiveness of the female labor market, requires that they be viewed with some caution.

Interestingly, the wage estimates obtained are broadly consistent with arbitrage conditions that should hold in equilibrium under a supply-side explanation. First, assuming that men have fewer or no occupational and geographic mobility restrictions, (equivalent) men must command at least 27% higher wages than women since otherwise private schools could setup in villages without a GSS by hiring (local/non-local) men rather than women. Andrabi et al. (2008) show that men, with the same observed characteristics, earn 33% more than women. Second, neither larger class-sizes nor higher fees are feasible in order to off-set the higher male teacher cost. Our estimates suggest that the required class-size increase would lead to an educational quality drop that would no longer make the private school competitive relative to the (free) public sector.[15] Similarly, given the relatively high price-elasticity estimated from data in Pakistan, Carneiro et al. (2010) find that a 1% increase in prices reduces the market share per private school by 1.2%), fee increases are also not feasible.

5. Conclusion

This paper highlights a potential virtuous cycle of human capital accumulation. In an environment with low educational levels, teacher shortages can pose severe and persistent constraints by raising the cost of educational provision. When credit markets are imperfect or long-term commitments are not credible, this can lead to poverty traps (Ljungqvist, 1993; Banerjee, 2004). In such cases, public funds may address the inter-temporal externalities generated through the link between consuming schooling today and providing schooling tomorrow. This speaks to a broader public finance literature that concerns itself with crowd-out (Cutler and Gruber, 1996). If public capital reduces the cost of production for private capital, it is possible that *over time* public investments crowd-*in* subsequent private capital (Aschauer, 1989a,b). This likely holds for public infrastructure investments such as transportation and basic research. Whether this is the case in education is particularly important to know given the historically large public investments that countries make in human capital. Our paper provides evidence for such crowd-in.

The evidence of crowd-in and supply-side constraints cautions against over-optimism regarding market educational provision and, in doing so, provides a clearer rationale for the public sector's role. This is particularly important given a new round of pessimism about public sector provision. In South Asia for instance, the public sector is widely regarded as broken. With teacher absenteeism exceeding 40% in some areas (Chaudhury et al., 2006) and political imperatives making reform difficult (Grindle, 2004), the private sector is increasingly viewed as a viable alternative (Tooley, 2005; Tooley and Dixon, 2005).

This paper shows that private sector schools do not arise in a vacuum. Previous public investments crowd-in the private sector so that government schools are not only contemporaneous substitutes but also temporal complements with private sector provision (Tilak and Sudarshan (2001) confirm a similar complementary relation in India). Moreover, analogous supply-side constraints likely exist at higher education levels. The fact that the private sector hasn't made as much in-roads in secondary schooling suggests that teaching supply constraints have yet to be alleviated at that level.

To the extent that the public sector can alleviate binding supply constraints, the longer-term impacts likely represent more than a sectoral realignment of children from public to private schools. There are several reasons to think that the emergence of private schools has had a positive impact on educational outcomes in terms of enrollment and learning outcomes. A randomly allocated subsidy for the creation of private schools in rural Pakistan led to increases of 14.6 and 22.1 percentage points in female enrollment for two of three program districts, likely by reducing average distance to schools (Kim et al., 1999). In our sample, overall enrollment rates in villages with private schools are 13 percentage points higher even after controlling for other schooling options and village/regional characteristics. In addition, test scores of children in rural private schools are almost a standard deviation higher than those of their government counterparts even after accounting for possible child selection through IV and dynamic panel data methods (Andrabi et al., 2011a,b). Evidence from other countries also suggests that private sector growth represents an improvement in overall education (West and Woessmann, 2010). Moreover, private schools appear to offer higher-quality education at far lower costs. The unionization and pay-grade of public teachers implies that per-child costs of private schools are half that of public schools (Jimenez et al., 1991; Kim et al., 1999; Alderman et al., 2003; Hoxby and Leigh, 2004).

The public sector is then left with a tricky task in these environments. If the private sector is to play a role in educational provision, initial investments from the public sector help build up the necessary supply of teachers. However, once the private sector enters the local market, the public sector becomes a direct competitor for students and, to an extent, teachers. This direct competition coupled with poor accountability in the government sector now hurts educational provision. If, as we suggest, private schools represent an increase in the quality of education and raise overall enrollment levels, the public sector has to do enough, but not too much.

Appendix I

I.1. Selection issues in the wage bill

Since we only observe the wage bill in villages where there is a private school, a concern described in the main text is that simple OLS estimates may be biased if such selection is not accounted for. Here, we provide details on two approaches that we use in the paper to address such concerns. Following Angrist (1995), the problem can be formally stated as follows. The wage-bill is determined

[15] Andrabi et al. (2011a) show that the yearly value-added of private schooling is around 0.25 standard-deviations. Although the estimates from the experimental literature on class-size reductions vary somewhat, a number of studies suggest gains of 0.2 to 0.3 standard deviations due to a reduction of four to ten students (Angrist and Lavy, 1999; Krueger, 1999; Muralidharan and Sundararaman, 2011). Given median wages and school fees in Punjab, this translates into seven more children per class to generate enough revenue to cover the 33% higher wages of a male teacher. Such an increase would however almost entirely offset the private school quality advantage.

through a linear equation conditional on the existence of a private school

$$WB_i = \alpha + \beta GSS_i + \varepsilon_i \tag{4}$$

and a censoring equation (denoting $WB_i = I$ as the indicator for whether WB_i is non-missing)

$$\mathrm{WB}_i = I\{\delta \mathrm{GSS}_i - \nu_i > 0\}. \tag{5}$$

The instrument, Z_i, determines a first stage

$$GSS_i = \gamma + \mu Z_i + \tau_i. \tag{6}$$

Given the validity of the instrument, Z_i, we assume that $cov(\tau_i, Z_i) = 0$. Then,

$$E(\varepsilon_i | Z_i, WB_i = 1) = E(\varepsilon_i | Z_i, (\delta\gamma + \delta\mu Z_i > \nu_i - \delta\tau_i)$$

so that $cov(\varepsilon_i, Z_i) \neq 0$ in Eq. (4) above. Thus, although Z_i is a valid instrument for the decision to setup a private school, it is not a valid instrument in Eq. (4). There are two potential solutions.

Following Heckman (1979), if we assume that $(\varepsilon_i, \nu_i, \tau_i)$ are jointly normally distributed, homoskedastic, and independent of Z_i, we obtain the familiar "Mills ratio" as the relevant expectation function conditional on participation. That is,

$$E(\varepsilon_i | Z_i, (\delta\gamma + \delta\mu Z_i > \nu_i - \delta\tau_i) = \lambda(\delta\gamma + \delta\mu Z_i)$$

where $\lambda(\delta\gamma + \delta\mu Z_i) = \frac{-\phi(\lambda(\delta\gamma + \delta\mu Z_i))}{\Phi(\lambda(\delta\gamma + \delta\mu Z_i))}$ and $\phi(.)$ and $\Phi(.)$ are the density and distribution functions of the normal distribution for $\nu_i - \delta\tau_i$. This Mills ratio can then be directly included in Eq. (4) as the appropriate selection–correction.

An alternative approach, proposed by Heckman and Robb (1986) and developed by Ahn and Powell (1993), uses the "control-function" approach, where we condition on the predicted probability of $WB_i = 1$ in Eq. (4). In essence, this method proposes to estimate β by using pair-wise differences in WB_i for two villages (in our case) for which the non-parametric probability of participation is very close. The approach is implemented by first estimating Eq. (5) directly, and then including the predicted probability of participation (and its polynomials) as additional controls in Eq. (4).

Appendix Table I
Differences in means.

Variable	Instrument = 1	Instrument = 0	Difference	P-value
Area in acres (1998)	2084.61	1326.88	757.73	0.00
	44.58	32.12	57.43	
Total population (1981)	1644.75	759.79	884.96	0.00
	22.78	14.48	26.82	
Total population (1998)	2516.91	1129.06	1387.85	0.00
	43.42	22.22	44.38	
% Δ population (1981 to 1998)	0.62	0.69	−0.07	0.24
	0.030	0.037	0.059	
Ratio of females to males (1981)	0.904	0.904	0.000	0.99
	0.006	0.004	0.007	
Ratio of females to males (1998)	0.938	0.946	−0.007	0.16
	0.005	0.003	0.005	
% women aged 4 and below (1981)	0.158	0.154	0.004	0.63
	0.007	0.005	0.008	
% women aged 5–14 (1981)	0.285	0.284	0.001	0.92
	0.009	0.006	0.010	
% women with ID card (1998)	0.490	0.478	0.012	0.30
	0.010	0.006	0.012	
% literate women, aged 15+ (1981)	0.016	0.017	−0.001	0.74
	0.002	0.002	0.003	
% women with middle + education, aged 15+	0.014	0.014	0.000	0.91
	0.002	0.001	0.003	
% men aged 4 and below (1981)	0.144	0.141	0.004	0.65
	0.007	0.004	0.008	
% men aged 5–14 (1981)	0.293	0.291	0.003	0.81
	0.009	0.006	0.010	
% men with ID card (1998)	0.691	0.684	0.007	0.50
	0.009	0.006	0.011	
% literate men, aged 15+ (1981)	0.169	0.166	0.003	0.73
	0.007	0.005	0.009	
% men with middle + education, aged 15+ (1981)	0.120	0.119	0.001	0.95
	0.006	0.004	0.007	
% houses permanent (1998)	0.063	0.065	−0.002	0.76
	0.005	0.003	0.006	
% households with water (1998)	0.011	0.010	0.001	0.61
	0.002	0.001	0.002	
% households with electricity (1998)	0.075	0.068	0.006	0.27
	0.005	0.003	0.006	
% households with TV (1998)	0.029	0.028	0.001	0.82
	0.003	0.002	0.004	
% household with radio (1998)	0.025	0.028	−0.003	0.38
	0.003	0.002	0.004	

Standard errors in parentheses. This tables gives evidence that there are no unexpected baseline differences in observables between eligible (Instrument = 1) and ineligible (Instrument = 0) villages. The only significant differences are in population and area, which arise directly from the construction of the instrument. Several 1998 variables of interest are included when 1981 numbers are not available, though these are not, strictly speaking, baseline measurements.

Appendix II

II.1. Comparing linear IV and biprobit estimates

Chiburis et al. (2012) show that in the model given by

$$\begin{aligned} T^* &= \alpha z + c_1 + \varepsilon_1 \\ T &= 1[T \geq 0] \\ Y^* &= \gamma T + c_2 + \varepsilon_2 \\ Y &= 1[Y^* \geq 0] \end{aligned}$$

with $(\varepsilon_1, \varepsilon_2)$ jointly distributed as standard bivariate normal with correlation ρ, $p_T = (T = 1)$ and $p_Y = (Y = 1)$, the local average treatment effect (LATE), estimated by the linear IV, is approximated by

$$\Delta_{LATE} \approx \frac{\gamma}{\sqrt{1-\rho^2}} \phi\left(\frac{\Phi^{-1}(p_Y) - \rho\Phi^{-1}(p_T)}{\sqrt{1-\rho^2}}\right)$$

and the asymptotic variance is approximated by

$$N\,Var\left[\hat{\Delta}_{IV}\right] \approx \frac{p_Y(1-p_Y)}{\alpha^2 \left[\phi(\Phi^{-1}(p_T))\right]^2 Var[z]}.$$

Asymptotic variance of the IV estimator increases as p_Y gets closer to 1/2 and as p_T gets closer to 0, both of which characterize the case discussed here.

Appendix Table II
Full sample regressions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	First stage/falsification test (OLS)		Impact on private school existence			Channels (OLS)			Wages
	Girls' secondary school	Boys' secondary school	OLS	Linear, second stage	Bivariate probit—ATE	Private school existence	Number of women with middle + education	Private school existence	Heckman
Instrument	0.037***	0.058***							
	(0.006)	(0.007)							
Girls' secondary school exists			0.100***	1.082***	0.309***		31.82***		
			(0.009)	(0.257)	(0.033)		(1.41)		
Girls' primary school exists	−0.227***		−0.007	0.217***	xx		−3.19***		
	(0.005)		(0.006)	(0.059)			(0.94)		
Boys' secondary school exists	0.254***		0.093***	−0.158**	xx		8.36***		
	(0.007)		(0.008)	(0.067)			(1.35)		
Boys' primary school exists	0.043***		−0.003	−0.045***	xx		0.35		
	(0.006)		(0.006)	(0.014)			(1.00)		
Years exposure to girls' secondary school						0.003***			−0.003*
						(0.0002)			(0.001)
Years exposure to girls' secondary school^2									0.0001**
									(0.000)
Years exposure to girls' primary school						0.001***			−0.006***
						(0.0002)			(0.002)
Years exposure to girls' primary school^2									0.0001***
									(0.000)
Years exposure to boys' secondary school						0.0016***			−0.0001
						(0.0001)			(0.001)
Years exposure to boys' secondary school^2									-1×10^{-9}
									(1×10^{-9})
Years exposure to boys' primary school						0.0004***			−0.0006
						(0.0001)			(0.001)
Years exposure to boys' primary school^2									1×10^{-9}
									(1×10^{-9})
% women with middle + education								0.589***	
								(0.055)	
% men with middle + education								0.090**	
								(0.035)	
Area (000s of acres)	−0.005***		−0.009***	−0.004*	xx	−0.009***	−3.85***	−0.008***	−0.000***
	(0.002)		(0.002)	(0.003)		(0.002)	(0.28)	(0.002)	(0.000)
% houses permanent	0.123**		0.331***	0.209**	xx	0.332***	38.82***	0.349***	0.425
	(0.059)		(0.067)	(0.094)		(0.067)	(10.78)	(0.088)	(0.325)
1981 population (000s)	0.037***	0.054***	0.059***	−0.004	xx	0.053***	−0.37	0.068***	0.040
	(0.004)	(0.004)	(0.007)	(0.019)		(0.008)	(1.16)	(0.007)	(0.029)
1981 population (000s)^2	−0.0006***	−0.001***	−0.004***	(0.001)	xx	−0.005***	0.85***	−0.005***	−0.005*
	(0.0001)	(0.0001)	(0.001)	(0.001)		(0.001)	(0.13)	(0.001)	(0.003)
1998 population (000s)	0.053***	0.081***	0.086***	0.044***	xx	0.082***	21.34***	0.094***	0.024
	(0.007)	(0.007)	(0.004)	(0.012)		(0.004)	(0.64)	(0.004)	(0.015)
1998 population (000s)^2	−0.003***	−0.003***	−0.002***	−0.001***	xx	−0.002***	0.99***	−0.002***	1×10^{-9}
	(0.001)	(0.001)	(0.0001)	(0.0003)		(0.0002)	(0.02)	(0.0001)	(0.0003)
PC fixed effects	Y	Y	Y	Y		Y	Y	Y	Y
R-squared		0.48							
Adjusted R-squared	0.40		0.38			0.38	0.86	0.38	
F-stat (instrument = 0)	33.80								
Prob > Chi-square				0.00					
Observations	23756	25874	23756	23756	23756	22845	23756	23698	27819
Number of PCs (1998)				7142					

Standard errors in parentheses with * indicating significance at 10%, ** at 5%, and *** at 1%. This table replicates some of the main regressions in the previous tables to demonstrate that the results hold in the full sample as well. Columns (1) and (2) correspond to Table 2, Columns (2) and (5), respectively. Columns (3), (4), and (5) correspond to Table 3, Columns (1), (3), and (4), respectively. Columns (6), (7), and (8) correspond to Table 4, Columns (1), (3), and (7), respectively. Column (9) corresponds to Table 5, Column (2). Column (9) includes squared terms for exposure in the expectation that short-term exposure decreases wages by increasing supply, while in the longer term, exposure may increase wages as educated women become mothers who increase demand for teachers.

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