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Abstract

Do locally hired teachers benefit pupils' school achievements more than governmental employed teachers? This is the question to examine in this paper. Although social experiment results have shown that the marginal product in terms of test score is positive and significant when pupils are taught by PTA teachers, it is not yet known about the "relative" effectiveness between government teacher and locally hired teachers. This paper is going to find whether the PTA teacher ratio (the ratio of locally hired PTA teachers against total number of teachers in one primary school) has statistically significant explanatory power on pupil test score, after controlling various factors.

In Republic of Kenya (below referred as Kenya), there are two types of teachers teaching in public primary schools. One is those teachers employed by the government and the other is those hired by the local school community, named "PTA teacher". Although wage level for PTA teachers in public primary schools in Kenya is one fourth of that of government teachers, school outcomes of pupils taught by locally hired contract teachers are higher than those of pupils taught in controlled group schools, according to the result of social experiment (Duflo et al. 2012).

This paper will examine, by using nationally representing observational data, to estimate the relative effect of PTA teachers on school outcome. In the end, by using Propensity Score Matching Estimation method, the result shows that the effect of PTA teacher ratio is positive and significant on school test score in all three subjects for lower standard grade pupils except Kernel and Radius matching and in Kiswahili subject for all seven different matching algorithms, though the magnitude of coefficient is relatively small. Although background mechanism of this finding is not solely determined, this paper is to assume that the effort level of PTA teacher in teaching tends to be higher than that of governmental teachers, based on several reasons.

JEL code: I21, I28, J18

Keywords: Absenteeism, PTA teacher, Locally hired teacher, test score

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1. Introduction

For the concerns of education policy, the “contract” teacher or locally hired teacher has become one of the substantial topics in education sector. As Millennium Development Goals (below referred as MDGs) declares high priority on the Universal Primary Education (below referred as UPE) putting it as Goal Two, UPE has been perceived as one of the most important issues by the international community.¹ Since then, the gross enrollment rate for primary education has increased drastically in developing countries; however supply of education input was not kept up with the pace. One of the issues is to supply school teachers.

In order to tackle with high demand of primary school teachers within the limited budget, various developing countries were to introduce the system of “contract teachers” whose contracts are fixed and shorter term and with lower qualifications in general than governmentally hired teachers and with lower salaries (Duthilleul 2005). For example, in West African countries where many countries had started to introduce the “contract teacher” policy in national scale, over 50 percent of primary school teachers are contract teachers on average of 12 West African countries, either employed by the government or by the parents with government subsidies. Those teachers are employed primarily because of the shortage of teachers and of the relatively high salary of government teachers, whose average salary in Sahel countries remained at 6.4 times the GNP per capita, while in the rest of Africa it was about 4.4, in Asia about 2.9, in Middle East and North Africa about 2.3 and in Latin America 2.3 times the GNP per capita (Duthilleul 2005).

There are two types of contract teachers; one is hired by the government with fixed term contract and the other is hired by the local community surrounding the school. The former type of teachers is well observed in Western African countries. For example, in Senegal about 50.2 percent of total teachers

¹ The MDG Goal Two says, “Ensure that by 2015 all children, particularly girls, children in difficult circumstances, and those belonging to ethnic minorities, have access to and complete free and compulsory primary education of good quality.”

and in Niger 41.5 percent of total teachers are composed of “contract teachers” hired by the government in 2003 (Duthilleul 2005). This paper is to focus solely on the latter type of teachers, called “PTA teachers”. As for PTA teachers, it is said there are advantages not only because of less cost, but also that it may result in stronger accountability towards the school community if the direct employer is located at the school level.

It is the motivation of this paper, in addition to the importance of educational policy concern, to contribute to the academic research which has paid attention to the incentive of teachers. The academic research about education outcome is shifted from the educational inputs to analysis of incentives and institutional conditions of teaching and learning. Relevant to teacher incentives and monitoring effects by school communities, one of those policies coming under the spot light is “contract teacher” policy, which is to hire locally available teachers whose contract is in general “short term”, “not fixed” wage rate and directly hired and monitored by the school communities.

2. Preceding Studies

2.1 Social Experiment Result

In spite of the significant meaning of contract teachers in developing countries, not many preceding studies have examined the effect of “contract teachers” on school outcome. It is true that many studies have focused on incentives and institutional conditions of teaching and learning, such as “teacher performance pay” contract, or “teacher monitoring” effect as well as “community monitoring effect” on school outcome. However, publications which solely deal with locally hired “contract teacher” effect is scarce. The table in Appendix 1 shows a part of previous studies and estimation results for “contract teacher” effect on school outcome in developing countries. While some are using experimental data and others use observational data, motivation is the same as to estimate the effect of “contract teacher”. Firstly, by using experimental data, there are three literatures.

- i) Duflo et al. (2012) showed the result of randomized social experiment in Kenya from 2005 to 2006, in Western Province. The result is that the marginal product of contract teachers is positive and significant for pupils' test score assigned by PTA teachers.
- ii) Bold et al. (2012) introduced a similar evaluation study to Duflo et al. (2012), however their contribution is i) expanding the area from one region to eight regions. In addition, ii) they used two separate implementation method by the Ministry of Education Science and Technology (MoEST) and by the International NGO (INGO) and compared the result. In the end, the program impact is positive and significant on pupil test score.
- iii) Sundaraman et al. (2010) showed the impact of hiring additional "contract teachers", and their main findings is marginal product of contract teachers is positive and significant on pupils school outcome.

From these social experiment results, the effect of adding one locally hired teacher is significantly positive on school test score, however it is not yet known if locally hired teachers can raise test score better than governmental teachers, even if the marginal product is positive and significant. To this question, following literature introduces the relative effect of PTA teachers.

2.2 Observational data research

The Sundaraman et al. (2010) study shows the result of estimation using observational data, comparing the effect of governmental teachers versus locally hired teachers. In short, by using pupil level and school level panel observational data, it concluded that they cannot reject the null hypothesis that existing contract teachers are as effective as government teachers in improving student learning outcomes. On the other hand, Bourdon, J. et al. (2006), by using observational data for Niger with Propensity Score Matching Estimation, the estimated effect of contract teacher is positive and significant in grade 5th for Math, French and combined score, but not significant for the 2nd grade pupils in any subjects. Therefore, it is still remained uncertain whether the existing PTA teacher is

more effective to school achievement or not, and if so, in which grade and subject, they are more effective to the outcome.

In this paper, the objective is to find the relative effect of “existing” PTA teachers on pupils’ school outcome, not to measure the marginal effect of “newly” hired teacher. Therefore we use non experimental data. It is worth noting there is a clear difference between newly hired teacher by experimental programs and existing PTA teachers paid by school communities in terms of contract and payment scheme which is likely to affect motivation of teachers. Firstly, in setting of social experiment, in order to secure randomness, recruitment of local community teacher should be perfectly independent from school community characteristics; therefore the decision to recruit has to be exogenous. On the other hand, as for existing PTA teachers, it is endogenous decision for the school community to hire PTA teachers. This paper will focus more on school outcome by existing PTA teachers who are supported by parents’ contributions or school community contributions to supplement the governmental teachers. Hence we use non experimental data.

In addition to preceding literature, contribution of this paper is as follows:

- 1) In addition to Bold et al. (2012), it is estimated by using more nationally representing data and increased number of samples from 192 primary schools (Bold et al. 2012) to 2216 primary schools.
- 2) As for preceding literatures in Kenya, there is no study to estimate the relative effect of PTA teachers hired by local community.

2.3 PTA teacher ratio and concerns

Due to data limitation, it is not possible to identify whether pupils are taught by PTA teachers or not; however it is possible to identify the ratio of PTA teachers and school average test score. Therefore, this paper puts a certain assumption that if PTA teachers are more effective to raise pupil test score

than government teachers, then the higher ratio of PTA teachers might have the positive effect on pupil education outcome, after controlling class size and pupil teacher ratio. The validity of this assumption is discussed more detailed in the section 5. Another concern remained unsolved is whether the PTA teacher ratio does not always represent PTA teachers' actual teaching practice. It is because data does not tell who and which subject is taught by PTA teacher. Therefore, in following estimation, cases where PTA teachers are likely to teach are specified. In detail, it will be explained in section 6.

In order to estimate precisely the effect of PTA teacher ratio, it is necessary to control other school or village characteristics where higher PTA teacher ratio is observed. Therefore, the following section explains about who are PTA teachers in the context of Kenya.

3. Characteristics of PTA Teachers in Public Primary Schools in Kenya

As for the qualification, government (TSC) teachers and PTA teachers differ. In order for teachers to be certified by TSC, one needs to have "academic qualifications", ranging from P4 (the lowest grade and graduates of primary schools) to Diploma. If non-graduate primary school teacher wishes to be a teacher, they need to acquire a relevant degree or qualification from a recognized institution (UNESCO 2010). There are 25 public and 8 private colleges for training primary school teachers. These provide pre-service teacher training courses which take two years.

As for the number of teacher, although PTA teachers are not offered "legitimate status" to teach in public primary schools, the number of PTA teachers in Kenya is not small. One survey under "Community Teachers Research Project" conducted in 2009 reported that out of all teachers in surveyed schools, 17 percent of teachers were hired under PTA contract and another report says, "on average, 1 out of 5 teachers is employed by parents" (UWEZO 2010).

In terms of salary, although the wage level of PTA teacher differs among schools, one report estimated that the average payment for PTA teachers was 4,151 Kenya Shillings, which is one fourth of the average salary 19,372 Kenya Shillings of TSC teachers. The source of the salary for PTA teachers differs from school to school. It might be paid from the collected fund by local community members or from the school capitation grant provided by the central government (Nishimura et al. 2009; World Bank 2009). Therefore, it is not yet clear where the source of salary has come from, however it is clear that decision to allocate the pooled fund is left with the school community. It is reasonable to assume that PTA teachers would work hard, since PTA teacher wage is determined by the school community, while that of TSC teachers is managed by the MoEST, the central government.

4. Conceptual Framework and Hypothesis

It is not possible for us to observe “PTA teacher effort level” from the current dataset, however often pointed out that contract teacher have superior performance in terms of teaching effort level, for example, attendance rate or teaching activities. Duflo et al. (2012) shows that contract teachers are 27.8 percentage points more likely to be found in a classroom during random visits than government teachers. Sundaraman et al. (2010) also shows significantly lower level of absence compared to government teachers. These superior performances are due to combination of factors, such as “being from local area and feeling more connected to the community, living much closer to the school and therefore having lower marginal costs of attendance, or the superior incentives from being on annually renewable contracts without the job security of civil-service tenure” (Sundaraman et al., 2010).

In this paper, it is not possible to decompose the relative importance of these factors; however, as a concept, there are possible explanations as below why PTA teachers tend to have better incentive to work harder than TSC teachers.

i) Less monitoring on TSC teachers:

Government teachers (TSC teachers) are not as closely monitored by principles, that is, the Central Government, the Ministry of Education Science and Technology (MoEST), as PTA teachers monitored by the school surrounding communities. In Kenya, country is divided into eight administrative regions (known as provinces). Each province has a Provincial Director of Education Office. In each province, there are districts, and in total 158 districts exist in the entire land. The work of primary school teachers are principally monitored by each district, the District of Education Office. However, due to the large number of schools, district education officers are not well checking the work of each primary school teacher. On the other hand, PTA teachers are working harder because they are under direct monitoring by the school community.

ii) Accountability of usage of schools fund:

Before introducing the Free Primary Education policy, public primary schools were in charge of collecting school fees from parents and were entitled to decide how to spend the collected money. In that time, schools were obliged to make efforts to be accountable to payers, that is, parents of pupils. However after introducing the FPE (Free Primary Education) policy, schools need to be more accountable to the district level of education officers as well as to the Central Government where the capitation fund has allocated to each school (Sasaoka et al. 2007). In this way, while the Free Primary Education has succeeded in assisting low income parents to send their children to school, however it happened to deprive the interest of parents to manage schools or incentive to monitor schools (Sawamura 2004a).

iii) Future Job opportunity for PTA teachers:

Moreover, the job opportunity for PTA teachers to become registered government teachers is open after teaching and when they go to school. Though quantitative information is not found, in qualitative study, it reveals that a PTA teacher works hard to be a registered TSC teacher (Ito 2011). Also, new graduates of teacher training colleges often work for several years as PTA teachers and

obtain positions as civil service teachers (Duflo et al. 2009). In the system of registration, it holds the opportunity open for non-graduate teacher to become a registered teacher.

iv) Wage payment system:

The difference in teaching effort level can be also explained by the clearly different payment system as well. It is often observed that in developing countries, hiring, salaries and promotion are decided by educational qualifications and seniority, with less scope for performance than developed countries (Chaudhury et al. 2006). In Kenya, the wage for TSC teachers is determined by school education history of teachers, not by their performance (Sawamura 2004b). Moreover, not only the wage level, but also decisions regarding hiring, firing, and transferring teachers in Kenya have long been made centrally by the Ministry of Education. It is famous that Kenyan public school teachers have strong civil service and union protection and are difficult to fire (Glewwe et al.2010). On the other hand, if PTA teacher is hired by the community decision, it's more likely for PTA teacher's performance to be reflected in the wage. To put this in more simplified manner, borrowing from Sawada (2000), it is assumed the linear function of wage as below for both TSC and PTA teachers.

$$1) \quad W = a_1 + a_2 OE$$

“OE” stands for “observable effort” by the community and note that a case of $a_1 > 0$ and $a_2 = 0$ represents a fixed wage contract, while $a_2 > 0$ is a piece rate contract. Though the payment scheme for each PTA teachers are not certain, it is clear that TSC teachers have the fixed wage contract, where wage function (1) has $a_2 = 0$, in other words, wage level does not depend on the level of “OE”. From this condition, TSC teachers would make less effort to teach, since $a_2 = 0$ and it does not change wage level. On the other hand, it is assumed that PTA teachers are more likely to make efforts than TSC teachers, because wage is endogenously determined by the “observed effort”.

v) Based on those various reasons mentioned above, it is reasonable to assume PTA teachers have better incentive to make more efforts in teaching than that of TSC teachers. However, it is remained uncertain how effectively PTA teachers can teach with their higher effort level. In other words, since there are no variables to estimate the ability of PTA teachers, it is not yet known if the level is efficient or not. In short, if test score Y of the i^{th} pupil in j^{th} school can be written as

$$2) \quad Y_{ij} = F(X_{ij} \ Z_j \ E_j \ a_j \ e_j)$$

where Y is a function of school observed characteristics Z , pupil and household characteristics X , Environment (Village) characteristics E , a_j is the total ability of PTA teachers at j^{th} school and e_j is the total effort level of PTA teachers. Although it is not possible to estimate the level of effort and ability for PTA teachers directly, the ratio of PTA and TSC teachers are observable in dataset. In this paper, under the simplest assumption, PTA teacher represents higher effort level with lower ability in teaching, while TSC teacher represents lower effort level with higher ability in teaching as table 1 below. Therefore, under this simplified assumption, by looking at the coefficient of PTA teacher ratio, it is possible to estimate which marginal effect, ability or effort level, would bring stronger impact on test score.

Table 1 Simplified category of PTA teacher and TSC teacher ability and effort level

	Ability Level	Effort Level
High	TSC teacher	PTA teacher
Low	PTA teacher	TSC teacher

If the coefficient of PTA teacher ratio is positive and significant, it means that the effort level has stronger impact on pupil education outcome than that of ability. If the coefficient of PTA teacher ratio is negative and significant, it can interpret that the ability is stronger impact than that of effort level.

5. Identification Strategy

In order to estimate the impact of PTA teacher on school outcome, there are two different estimations made in this paper. First is to estimate the impact of whether at least one teacher exists in school or not. Second, since the impact of the average treatment on the treated (below referred as TOT) is heterogeneous among schools as following section presents, in the second estimation, the outcome (TOT) will be regressed on PTA teacher ratio, so as to see if the ratio of PTA teacher has explanatory power on heterogeneous variation of TOT.

5. 1 Propensity Score Matching Estimation Concept

Now, Y_{0j} denotes the average test score outcome in j^{th} school where there is no PTA teacher, while Y_{1j} denotes the average test score outcome in j^{th} school where there is at least one PTA teacher. To define the average treatment effect on the treated (TOT), it is derived as follows:

$$(1) \quad TOT \equiv E(Y_{1j} - Y_{0j} | D_j = 1) \\ = \{E(Y_{1j} | D_j = 1) - E(Y_{0j} | D_j = 0)\} - \{E(Y_{0j} | D_j = 1) - E(Y_{0j} | D_j = 0)\}$$

The observable difference in test score between treated and controlled group in the second equation of left hand side denoted as $E(Y_{1j} | D_j = 1) - E(Y_{0j} | D_j = 0)$, which is not precisely estimating TOT, since this includes the selection bias term of $E(Y_{0j} | D_j = 1) - E(Y_{0j} | D_j = 0)$. In order for us to estimate the $TOT \equiv E(Y_{1j} - Y_{0j} | D_j = 1)$, we need to know the value of counterfactual $E(Y_{0j} | D_j = 1)$. By putting the Conditional Independence Assumption $\{ Y_{0j}, Y_{1j} \} \perp D_j | X_j$, equation (1) can be rewritten

$$(1)' \quad TOT \equiv E(Y_{1j} - Y_{0j} | D_j = 1) \\ = \{E(Y_{1j} | X_j, D_j = 1) - E(Y_{0j} | X_j, D_j = 0)\} - \{E(Y_{0j} | X_j, D_j = 1) - E(Y_{0j} | X_j, D_j = 0)\} \\ = \{E(Y_{1j} | X_j, D_j = 1) - E(Y_{0j} | X_j, D_j = 0)\}$$

The second term of right hand side equation of (1)' $E(Y_{0j} | X_j, D_j = 1) - E(Y_{0j} | X_j, D_j = 0)$ become zero, since Conditional Independence Assumption (below referred as CIA) assures that the PTA teacher existence is independent from the outcome of school test score average, conditioned on X_j .

However, if there are many covariates, such strategies may not be feasible nor impractical, since the dimension of X could be very high. Therefore as Rosenbaum and Rubin (1983) explained, an alternative approach is based on the propensity score, the conditional probability of receiving treatment given covariates. They had proved that if the treatment assignment is “strongly ignorable” given covariates X, then it is strongly ignorable given any balancing score b(X), and the propensity score is defined as one of the balancing score. As a result, adjusting solely for differences in propensity score between the treated and control units removes all biases under the CIA, and reduces a potentially high-dimensional matching problem to a single-dimensional problem. In the formula, under the CIA, the outcome of Y is independent distribution from D_j if the propensity score is similar, that is,

$$\{ Y_{0j}, Y_{1j} \} \perp D_j | P(X_j)$$

In the end, the average treatment effect on the treated (TOT) can be derived with the estimated Propensity Score as follows;

$$(1)'' \quad TOT \equiv E \{ E(Y_{1j} | P(X_j), D_{j=1}) - E(Y_{0j} | P(X_j), D_{j=0}) | D_{j=1} \}$$

5.2 Advantages and Concerns in using PSM Estimation

There are several reasons the PSM estimation is preferred in this paper to the traditional regression analysis, though CIA is not perfectly satisfied. Even so, it is still more preferable to use PSM than OLS. One reason is that PSM estimation does not require functional form to be linear. Because of nature of relationship between educational inputs and school achievement, it is more appropriate to assume nonlinear functional form.

In addition, as the second point, in order to estimate consistent parameter by PSM method, it requires good number of variables which exist for both treated and controlled group. In this paper, because of the characteristics of the dataset, aiming to cover most of important variables to estimate pupil school outcome, it is reasonable to judge that number of variables are not too small to estimate the propensity score appropriately.

In addition, according to Khandker (2010), given two broad provisions, the bias in PSM program estimates can be low. First, it is preferred to use the same data source for treatment and controlled group, which ensures the observed characteristics are measured similarly. Regarding this point, the dataset satisfies that both treated and controlled groups were drawn from the same dataset. As for the second point, it is preferable to use the representative sample survey of nonparticipants as well as participants. In this point, the survey constructing the data is well corresponded since the UWEZO takes the nationally representing survey scheme.

In the end, from a part of descriptive statistics table below, it is obvious that characteristics of villages and educational inputs differ greatly between PTA teacher zero school and PTA teacher none zero school. The difference is clear in school test score and other village and regional characteristics. In terms of Kiswahili and English average test score difference, the null hypothesis that mean between two groups is zero is rejected. Hence, PSM estimation is more sensible to compare across treated and matched control units by using the Propensity Matching Score.

Table 2 Descriptive Statistics for PTA teacher zero school and for PTA teacher none zero school

<u>School Level Variable</u>	(1) PTA Teacher RATIO=0			(2) PTA Teacher RATIO>0			Ho: diff = 0 (P-value)
	Sample(#)	Mean	Std. Dev.	Sample(#)	Mean	Std. Dev.	
School Average Kiswahili Score	414	4.032	0.718	1802	3.941	0.710	0.0191
School Average English Score	414	4.000	0.714	1802	3.909	0.686	0.0169
School Average Numeracy Score	414	6.311	1.252	1802	6.321	1.127	0.8804
<u>Village Level Variable</u>							
Village has electricity infra	414	0.528	0.499	1802	0.403	0.490	0.0000
Village has concrete paved roads	414	0.207	0.406	1802	0.136	0.343	0.0002
<u>Household Level Variable</u> (School Average)							
Parents who paid tuition	414	0.409	0.388	1802	0.438	0.362	0.1509
Mother Education History	414	0.797	0.332	1802	0.808	0.318	0.5397

5.3 Estimation of Propensity Score

In order to find appropriate propensity score, it requires variables which would affect the likelihood of having at least one PTA teacher as well as variables which influence the outcome. The propensity

score is estimated as follows. First, let us assume that the latent variable of D_j^* can be written as below:

$$(2) D_j^* = X_j B + \mu_j$$

When the latent variable D_j^* is greater than 0 then D_j denotes 1 and when

D_j^* is equal to or smaller than 0 then D_j denotes 0. X_j includes a vector of followings: 1) average household and pupils characteristics attending on j^{th} school, 2) j^{th} school characteristics and 3) village characteristics where j^{th} school is located as well as 4) a vector of district dummy, existing one hundred twenty one districts in the dataset. μ_j is a vector of error term, by assumption $E(\mu_j) = 0$ and $\text{Var}(\mu_j) = \sigma^2$. The descriptive statistics of those variables from 1) to 4) are attached in the Appendix 1 and probit estimation result is found in Appendix 2. The error term of μ_j is assumed to follow the Normal Distribution. Then, the propensity score can be written

$$P(D_j = 1|X_j) = \Phi(X_j B / \sigma)$$

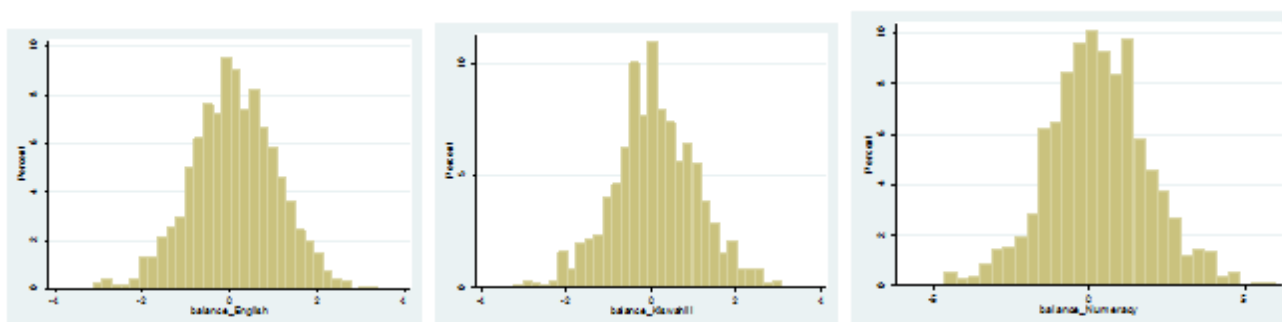
5.4 Average Treatment Effect on the Treated (TOT)

After estimation of Propensity Score, the predicted value of Propensity score is used to estimate the TOT by matching treated schools and none treated schools. There are different matching criteria used to assign the treated and none treated schools. In this paper, seven different methods of matching were tested to see the robustness as follows:

- i) Nearest neighbor Matching: The each treated school is matched to none treated schools which have the 1st, 2nd and 4th nearest or closest propensity score obtained.
- ii) Radius Matching: There is a possibility that the matched propensity is very different from the nearest one of those treated school. Therefore, the radius matching limits propensity score within a certain range to be matched.
- iii) Kernel Matching: In order not to use only small number of controlled group schools as matched schools, the kernel matching can use a weighted average of all nonparticipants to construct the counterfactual match for each participant.

5.5 Heterogeneous Impact of PTA teacher ratio on the outcome

The following histograms are the TOT distribution of Numeracy, English and Kiswahili test score. By looking at the TOT distribution among treated schools, it is widely distributed from negative to positive point. If PTA teacher has only positive impact on test score at any school, it is assumed that TOT can be always positive. However, it does not hold true. Rather the impact of at least one PTA teacher existence is heterogeneous among treated schools.



From the left, Figure 1 Histogram for TOT of English for one to one nearest matching estimation
 In the middle, Figure 2 Histogram for TOT of Kiswahili for one to one nearest matching estimation
 From the right, Figure 3 Histogram for TOT of Numeracy for one to one nearest matching estimation

Hence, as Lin et al. (2009) explores the heterogeneity feature of the effectiveness of the treatment, in order to examine the causes of this heterogeneous impact on the treated, TOT is regressed on PTA teacher ratio so as to see if heterogeneous impact can be explained by the PTA ratio or not. Followed by preceding studies of education production function, the outcome of production function can be written by equation (3). For the j^{th} school, Y , the education outcome of Numeracy, English and Kiswahili, can be written as function of school and village characteristics Z , school averaged pupil and household characteristics H , district dummy variables E and D_{ratio_j} is PTA ratio value for the j^{th} school, ranging from a value of 0 to 1 if all teachers are PTA teachers.

$$(3) Y_j = F(H_j, Z_j, E_j, D_{ratio_j})$$

By linearizing and adding a stochastic term, the equation (3) can be rewritten as follows.

$$(4) Y_j = H_j\beta + Z_j\gamma + E_j\alpha + D_{ratio_j}\delta + \mu_j$$

by assumption, $E(\mu_j) = 0$ and $\text{Var}(\mu_j) = \sigma^2$.

Now, it is our interest to estimate the coefficient of PTA teacher ratio, that is, δ for the PTA ratio effect on outcome, TOT. Therefore the estimation model of (4) should be rewritten as below:

$$(5) E \{E(Y_{1j}|P(X_j), D_{j=1}) - E(Y_{0j}|P(X_j), D_{j=0}) | D_{j=1}\} = H_j\varepsilon + Z_j\eta + E_j\lambda + D_{ratio_j}\omega + \mu_j$$

6. Data

6.1 Nature of Data

This paper uses dataset available through website of UWEZO Kenya, which is a part of Twaweza, “an independent East African initiative” supported by donors, such as the World Bank and others (UWEZO East Africa 2012). For education individual data, UWEZO dataset contains the largest national assessment results conducted in three Eastern African countries of Tanzania, Kenya and Uganda, “350,000 children in over 150,000 households across the three countries were tested in their ability to perform basic numeracy and literacy tasks at the Standard 2 level” (UWEZO East Africa 2012).²

In Kenya, there are two surveys conducted by UWEZO Kenya in September to October in 2009 and in February to March in 2010. Both 2009 and 2010 UWEZO assessments adopted survey methods that produced a nationally representative random sample of the target population.³ In total, 2009 and 2010 UWEZO Kenya has covered following number of schools, villages, households and children.⁴

However, due to the large number of missing values in 2009 dataset, this paper chooses to use 2010 dataset for estimation.

² Other surveys conducted to test the education achievement in eastern African regions, such as SACMEQ I, II, and III, those surveys do not have much samples as UWEZO.

³ Those samples are children of primary school age up to and including children aged 16. Though there are some districts not surveyed in 2009 (88 districts) and in 2010 (36 districts), the random sample selection method was maintained as follows: First, all the surveys have followed a three stage random sampling process, 1) selection of districts (strata) by simple random selection, with each district given an equal probability of selection; 2) selection of enumeration area (typically villages) with probability proportional to population size and 3) selection of households in each enumeration area by systematic sampling.

⁴ The dataset which was available from the website slightly differ in number of samples from what the report says. For example, the dataset available from website contains 179,370 samples for individuals, 3,565 villages surveyed and 3,448 schools were surveyed in UWEZO Kenya dataset 2010. As for UWEZO Kenya dataset 2009, it contains 106,273 samples for individuals, 2,160 villages and 2,160 primary schools surveyed.

Table 3 2009 and 2010 UWEZO Kenya Surveyed Samples

Survey Round	Districts	Schools	Villages	Household	Pupils
2009 (Sep/Oct)	70	2,029	2,029	33,760	79,693
2010 (Feb/Mar)	122	3,474	3,628	55,843	131,971 ⁵

(Source: UWEZO East Africa at Twaweza, 2012 August)

6.2 Descriptive Statistics and Variables

From UWEZO dataset 2010, the effective sample size for this estimation is 2,216 public primary schools. The descriptive statistics is attached in Appendix 2.

1) Independent Variables

Test score of Kiswahili, English and Numeracy which were tested at time of household survey. Score of Kiswahili and English is rated from 1 to 5 while Numeracy is rated from 1 to 8 as follows:

Kiswahili; 1; Nothing, 2; Able to read Letter, 3; Words, 4; Paragraph, and 5; Story

English; 1; Nothing, 2; Able to read Letter, 3; Word, 4; Paragraph, and 5; Story

Numeracy; 1; Nothing, 2 ;Able to count 1-9, 3; Able to count 10-99, 4; Able to count greater than 10-99, 5; Able to calculate addition, 6; Able to calculate subtraction, 7; Able to calculate multiplication, and 8; Able to calculate division.

In order to control other effects than PTA teacher ratio, following variables are selected as controlling variables, based on preceding estimations for education production function.

2) Class size, Pupil Teacher Ratio (PTR) and PTA teacher ratio Variables

It is our interest to estimate the effect of PTA teacher ratio, which is closely related with pupils per class size and pupils per government teacher. Therefore, it is essential to control these two effects to TOT, otherwise PTA teacher ratio is likely to estimate the effect of large class size or large number of

⁵ Initially, the surveyed dataset has 179,411 samples of individuals. After grouping samples who have been to those surveyed public primary schools and grade less than 8th (this is the highest grade of public primary schools in Kenya), the sample size has reduced to 65,541. Due to the large number of missing values, the effective samples are 30,633 individuals and 2,216 primary schools.

pupils per one teacher. That is because the motivation for public primary schools to hire a PTA teacher is to compensate the shortage of TSC (government) teachers. To control the effect of high pupil teacher ratio (PTR), there are two variables: one is pupil teacher ratio (PTR) and the other is pupil TSC (government) teacher ratio. The former is to control the effect of teacher shortage in general after they hire PTA teachers, while the latter variable is specifically controlling the shortage of government teacher. Since both are highly correlated, this paper chooses to select the pupils TSC teacher ratio as control variable. That is because if otherwise, the PTA teacher ratio variable is only to capture the effect of government teacher shortage. In addition to pupil TSC teacher ratio, the variable for class size is included. As those above variables are skewed to the left, they were converted to logarithm and used in the estimation, which histogram is available in Appendix 3.

3) Household and Pupil Variables

As in preceding studies, the socio-economic index based on family possessions is included as control variables (Bourdon, J. et al., 2007), household decision to invest in children is closely related with the household socio-economic characteristics. As proxies for wealthiness of a household, the asset variables were used, such as Type of house and possession of telephone. Also, there might be a resource allocation issue about who to be invested most if the number of children is large. There is no variable for the number of siblings; however as the proxy variable, total number of household members is used to control the effect of resource competition. In addition, the effect of mother's education whether they have graduated primary school or not is controlled, since it directly affects living standards of children as well as indicates socio economic status of family. In order to control preference over children education, the variable if parents pay tuition or extra fee to school is added.

As for pupil characteristics, though it is impossible to control the innate ability directly, variables included are age, age squared and their school grade, since the older they are, it becomes much easier to take good score, since the test level is set for Standard grade two level. However, the effect of

getting “old” is none linear to school outcome, therefore the squared term is added. To control the physical health which directly affects the school outcome, the number of meal in one day that pupil can take is also controlled.

4) School Input Variables

In the early study of education production function, Heyneman and Loxley (1983) explained that “the poorer the national setting in economic terms, the more powerful this (school inputs and teacher quality) effect appears to be”. Since this “H-L effect” has been widely recognized and supported by several preceding studies, it is necessary to control the supply side information in estimating pupils school outcome. This paper includes three variables for school inputs. 1) Dummy variable if school has learning supplement materials or not. 2) Dummy variable if the classroom is suitable for learning space or not. These two variables are to capture the primary condition of learning space and materials. 3) Dummy variable if school is fenced or not, since the security in some areas in Kenya are still remained fragile especially after the large scale of post-election violence in 2008. The variable indicates if school is careful in surrounding security incident or not.

5) Village and District Variables

Since there are large disparities between regions in Kenya, environmental factors are important to be controlled. In order to control the similarity at the district level, one hundred twenty one district dummy variables are added. It is very likely that the characteristics of the district area is similar each other therefore, it is possible to see if PTA teacher ratio still has explanatory power on the outcome, after controlling the district level similarities. As for village where school is located, the dummy variable if roads are paved by concrete is added. Also, dummy variable is selected to show if village has an electricity infrastructure or not. Those variables are proxy variable to control the access and ease of transportation to villages.

7. Result and Interpretation

In this section, it is divided into three. First, it shows the result of probit estimation, which is to construct the propensity score. Second, the average treatment effect on the treated (TOT) is reported for different matching algorithms. At last, heterogeneity of TOT will be regressed on PTA teacher ratio and other controlling variables so as to find if PTA teacher ratio can explain the heterogeneous impact on the treated with statistical significance.

7.1 Probit Estimation Result

First, the probit model is used to generate a propensity score that assesses a school or village's likelihood of hiring at least one PTA teacher. Table in Appendix 4 shows the estimation result that variables of village characteristics and school inputs are statistically significant. For example, whether village has electricity or not is negative and the size of class as well as supplementary materials in school are negative and significant. This means that PTA teacher is likely to be hired where villages do not have electricity or have less educational input such as learning supplementary materials, in addition to less number of pupils in one class after controlling the TSC teacher shortage. In terms of government teacher shortage, it is obvious that PTA teacher is likely to be hired where pupil government teacher ratio (PTR) is high in school, indicating positive and one percent statistical significance.

On the other hand, none of the average household and pupil characteristics variables become statistically significant. From this result, though it seems less important to include household and individual characteristics in the estimation of propensity score, it is essential to do so since the propensity score must be calculated on the basis of all observed covariates X that jointly affect participation and the outcome of interest, that is, the school average test score.

7.2 Average treatment on the treated

In addition to the CIA, in order to make PSM estimation appropriately, it is necessary to confirm that the common support exists and overlapping condition is satisfied. The histogram in Appendix 3 is to compare the distribution of Propensity Score for both treated and controlled for Kiswahili and English as an example. The shape of distribution does not look similar between treated and controlled; however the propensity score of the treated group is mostly covered by the distribution area of the controlled group. In the end, total effective samples become 1887 for all standard grade estimation and to 1720 for standard grade below three pupils.

The following table 4 presents TOT for seven different matching algorithms by subject, Numeracy, English and Kiswahili and two different grade groups. 95 percent of confidence intervals are estimated using bootstrapped standard errors (500 replications). With different matching algorithms, in nearest matching estimation one to one, one to two and one to four as well as kernel normal matching estimation, it is consistent for Numeracy subject, estimated TOT is positive and statistically different from zero. In other subjects, TOT does not become statistically significant by any matching criteria. In spite of the significance in Numeracy, that magnitude is relatively small. For example in the nearest one to one matching estimation, the impact of the treatment on outcome is 0.29 score higher on school average than those controlled schools with similar characteristics. Also in the 95 percent confidence interval, the minimum value of TOT includes negative value in the nearest matching estimation.

There are possible explanations why the treatment effect on the treated is weak in Numeracy and not significant in any other subjects. One of the reasons could be that TOT only shows the effect of whether one PTA teacher exists or not. It does not specify the level of treatment, since treatment dummy is 1 even if ten PTA teachers exist in a school or only one PTA teacher exists in a school. In short, it is natural that the PTA teacher effect on outcome should differ, depending on level of treatment, that is, ratio of PTA teachers. However this TOT estimation

does not differentiate the impact of it.⁶ Hence, it is more sensible to find the relative effect, that is, PTA teacher ratio on outcome in the next estimation.

⁶ In separate estimation, TOT was estimated by different group of PTA teacher ratio. Schools with PTA teacher are divided into 5 groups from the highest PTA teacher ratio to the lowest ratio group. Then, in each group, the matching was done with the controlled group. As a result, TOT is positive and significant in the highest PTA teacher ratio group in Numeracy. The detailed estimation result is available from author.

Table 4 Treatment effect on the treated (TOT) with different matching criteria

[Nearest Matching: N=1]		Coef.	Std. Error	z	P> z	[95% Conf. Interval]	
Kiswahili		0.099094	0.0839997	1.18	0.238	-0.065542	0.2637304
English		0.1086848	0.0795833	1.37	0.172	-0.047296	0.2646652
Numeracy		0.2979102	0.1441951	2.07	0.039	0.0152931	0.5805274
Kiswahili	Std<=3	-0.090576	0.0939274	-0.96	0.335	-0.27467	0.0935186
English	Std<=3	0.0085987	0.0915486	0.09	0.925	-0.170833	0.1880306
Numeracy	Std<=3	0.0266911	0.1609512	0.17	0.868	-0.288768	0.3421497
[Nearest Matching: N=2]		Coef.	Std. Error	z	P> z	[95% Conf. Interval]	
Kiswahili		0.0630791	0.0774228	0.81	0.415	-0.088667	0.2148249
English		0.0715681	0.0678459	1.05	0.291	-0.061408	0.2045436
Numeracy		0.2328433	0.1235065	1.89	0.059	-0.009225	0.4749115
Kiswahili	Std<=3	-0.032194	0.0920423	-0.35	0.727	-0.212594	0.1482054
English	Std<=3	0.0131391	0.082894	0.16	0.874	-0.14933	0.1756083
Numeracy	Std<=3	0.1024195	0.1588129	0.64	0.519	-0.208848	0.4136871
[Nearest Matching: N=4]		Coef.	Std. Error	z	P> z	[95% Conf. Interval]	
Kiswahili		0.0630791	0.0774228	0.81	0.415	-0.088667	0.2148249
English		0.0715681	0.0678459	1.05	0.291	-0.061408	0.2045436
Numeracy		0.2328433	0.1235065	1.89	0.059	-0.009225	0.4749115
Kiswahili	Std<=3	-0.032194	0.0920423	-0.35	0.727	-0.212594	0.1482054
English	Std<=3	0.0131391	0.082894	0.16	0.874	-0.14933	0.1756083
Numeracy	Std<=3	0.1024195	0.1588129	0.64	0.519	-0.208848	0.4136871
[Kernel Epanechnikov]		Coef.	Std. Error	z	P> z	[95% Conf. Interval]	
Kiswahili		-0.003638	0.0534219	-0.07	0.946	-.1083428	.1010673
English		0.005942	0.0484326	0.12	0.902	-.0889843	.1008682
Numeracy		0.1304541	0.0911568	1.43	0.152	-.04821	.3091182
Kiswahili	Std<=3	-0.055638	0.0663704	-0.84	0.402	-.1857211	.0744459
English	Std<=3	-0.023244	0.0594192	-0.39	0.696	-.1397037	.0932153
Numeracy	Std<=3	0.0627457	0.1130825	0.55	0.579	-.1588919	.2843833
[Kernel normal Matching]		Coef.	Std. Error	z	P> z	[95% Conf. Interval]	
Kiswahili		0.099094	0.0834914	1.19	0.235	-0.064546	0.2627341
English		0.1086848	0.0795895	1.37	0.172	-0.047308	0.2646774
Numeracy		0.2979102	0.1410998	2.11	0.035	0.0213597	0.5744607
Kiswahili	Std<=3	-0.090576	0.1014663	-0.89	0.372	-0.289446	0.1082946
English	Std<=3	0.0085987	0.0886113	0.1	0.923	-0.165076	0.1822737
Numeracy	Std<=3	0.0266911	0.164207	0.16	0.871	-0.295149	0.348531
[Radius 0.05]		Coef.	Std. Error	z	P> z	[95% Conf. Interval]	
Kiswahili		-0.007359	0.0489946	-0.15	0.881	-0.103387	0.0886686
English		0.003339	0.048436	0.07	0.945	-0.091594	0.0982719
Numeracy		0.125088	0.0897142	1.39	0.163	-0.050749	0.3009247
Kiswahili	Std<=3	-0.05563	0.0689579	-0.81	0.42	-0.190784	0.0795254
English	Std<=3	-0.022831	0.0643576	-0.35	0.723	-0.14897	0.1033076
Numeracy	Std<=3	0.0599964	0.1143695	0.52	0.6	-0.164164	0.2841564
[Radius 0.1]		Coef.	Std. Error	z	P> z	[95% Conf. Interval]	
Kiswahili		-0.032346	0.0476492	-0.68	0.497	-0.125737	0.0610445
English		-0.02563	0.0446959	-0.57	0.566	-0.113232	0.0619727
Numeracy		0.0599805	0.0794656	0.75	0.45	-0.095769	0.2157303
Kiswahili	Std<=3	-0.083115	0.066229	-1.25	0.209	-0.212921	0.046692
English	Std<=3	-0.051569	0.0616157	-0.84	0.403	-0.172333	0.0691958
Numeracy	Std<=3	0.0479331	0.1038951	0.46	0.645	-0.155697	0.2515637

7.3 Heterogeneous Impact of the treatment

As it was briefly explained in the previous section showing the histogram of TOT, the treatment effect has differed greatly from school to school. In some schools, TOT is negative, while others present positive outcome. To analyze this heterogeneous effect on outcome, TOT will be regressed by the PTA teacher ratio. This estimation is to find if the magnitude of TOT for each treated school can be explained by the PTA teacher ratio. The following table 5 is only to report the estimated coefficient of PTA teacher ratio by different matching algorithm. There are seven different matching algorithms used for the estimation of TOT and detailed estimation result is attached in Appendix 5. From table 7 to 20 in Appendix 5, in column (1) is the result of TOT regressed merely by PTA teacher ratio. From column (2) to (7), it adds following variables to column (1) estimation as independent variables accordingly: column (2) village variables, column (3) education resource variables, column (4) average household socio economic characteristics for pupils variables, column (5) average pupil characteristics variables, column (6) average of age and age squared for pupils as well as log of pupils per classroom and pupil teacher ratio in school and lastly column (7) estimation includes one hundred twenty one district dummies.

In summary of the result from table 7 to table 20, after column (5), controlling the household and pupil characteristics on school average, the estimated coefficient of PTA teacher ratio is always positive and significant effect to TOT. Also, as the number of variables becomes increased from column (1) to (6), it is observed that the magnitude of coefficient has become larger in all estimation result. This means that after controlling various factors which would affect TOT, the explanatory power of PTA teacher ratio has become more distinctive. However, once it adds one hundred twenty one district dummies in column (7), the statistical significance of PTA teacher ratio is observed only in the standard grade below three pupils except Kernel and Radius matching algorithm. Only Kiswahili subject, it is consistently observed positive and significant in seven algorithm.

Table 5 PTA teacher ratio coefficient

	Kiswahili	English	Numeracy	Kiswahili	English	Numeracy
	All Grades			Standard Grade below 3		
<u>Nearst Matching 1 to 1 matching</u>						
PTA teacher ratio	0.2722 [1.02]	0.3047 [1.22]	0.8297 [1.97]**	0.955 [2.95]***	0.6457 [2.11]**	1.1477 [1.97]**
<u>Nearst Matching 1 to 2 matching</u>						
PTA teacher ratio	0.3061 [1.47]	0.2451 [1.21]	0.6752 [1.88]*	0.9238 [3.28]***	0.6316 [2.54]**	1.0439 [2.07]**
<u>Nearst Matching 1 to 4 matching</u>						
PTA teacher ratio	0.3806 [2.05]**	0.2939 [1.67]*	0.7192 [2.28]**	0.7149 [2.86]***	0.4113 [1.82]*	0.8392 [1.90]*
<u>Kernel Matching</u>						
PTA teacher ratio	0.2389 [1.57]	0.069 [0.47]	0.4182 [1.60]	0.5171 [2.22]**	0.2319 [1.10]	0.6444 [1.56]
<u>Kernel Normal</u>						
PTA teacher ratio	0.2722 [1.02]	0.6457 [2.11]**	0.8297 [1.97]**	0.955 [2.95]***	0.6457 [2.11]**	1.1477 [1.97]**
<u>Radius 0.05</u>						
PTA teacher ratio	0.2229 [1.46]	0.0527 [0.36]	0.3838 [1.46]	0.4907 [2.11]**	0.2065 [0.98]	0.612 [1.47]
<u>Radius 0.1</u>						
PTA teacher ratio	0.1561 [1.03]	-0.0015 [-0.01]	0.2639 [1.01]	0.4149 [1.78]*	0.1865 [0.89]	0.5968 [1.45]

Robust standard errors are used for estimation and the estimated t-values are in parentheses. *, **, and *** are indicated to show p-value to reject null hypothesis with $p < 0.1$, $p < 0.05$, $p < 0.01$ respectively.

It is natural that there is a difference in the statistical significance and magnitude of PTA teacher ratio between the school average and lower standard grade average of TOT, since it is said that PTA teacher tends to teach lower grade pupils where the largest enrolled pupils exist. In order to compensate the teacher shortage, PTA teachers are often assigned to teach lower standard grade pupils. In this sense, if effort level in teaching of PTA teachers is higher than those of ability level, then it should be more apparent in lower grade pupils test score. Therefore, the statistical significance and sign of PTA ratio is understandable. On the other hand, in terms of magnitude, for example if PTA teacher ratio increases 1 percent, then the test score of Kiswahili is increased 0.0095 point, based on the result of nearest one to one neighbor matching. In spite the fact that the test score ranges from 1 to 5 in Kiswahili and the

percentage of PTA ratio does not increase by 1 percent, rather it increases in larger percentage point by adding one PTA teacher, the magnitude of 0.009 point increase by PTA ratio one percent increase is relatively small.

As for other control variables, the coefficient of log of pupil government teacher ratio is statistically significant and positive in column (7) for the nearest neighbor one to one, one to two and one to four matching as well as for kernel normal matching algorithm as it shows in Appendix 5 table from 7 to 20. This is a counter intuitive sign, since the large number of pupils per one government teacher should negatively affect the test score of pupils. However, it is understandable, if the independent variable is TOT, not actual average test score of each school. TOT was estimated by matching with similar characteristics of controlled schools. Therefore, if the shortage of government teacher is serious, that is, the value of log of pupil government teacher ratio is large, and still there is no PTA teacher to compensate the shortage in control schools, that leads to assume that the value of TOT is likely to be large, since TOT is a test score difference between control and treated schools. On the other hand, if the shortage of government teacher is not serious, then TOT value is not assumed to be large. In this way, by the value of log of pupil government teacher ratio, the difference between the treated and controlled is likely to differ. As the value of log of pupil government teacher ratio becomes larger, the outcome difference between the treated and controlled schools would become larger.

In order to confirm this finding, following section is to estimate the effect of PTA teacher ratio in shortage of teacher. If the interaction term of PTA teacher ratio and shortage of teacher dummy is positive and statistically significant, then it means that the PTA teacher ratio effect to TOT is more distinctive in those schools where teachers are short than those schools where sufficient teachers exist. The dummy variable of shortage of teacher is made by the log of pupil teacher ratio. If the pupil teacher ratio is higher than the average, the dummy takes 1 and otherwise, zero.

7.4 PTA teacher and their roles in primary schools

Table 6 shows the coefficient of PTA teacher ratio and of interaction term as well as the result of joint test that the sum of total effect is zero. There are several findings from table 6. First, 1) All the estimation result except Numeracy of lower standard grade pupils has showed that the interaction term of coefficient of PTA teacher ratio and Teacher shortage dummy is positive and significant. This is consistent through all estimated TOT by seven different matching algorithms.⁷ Moreover, 2) as for the coefficient of PTA teacher ratio, none of the estimation result has become negative and significant except radius 0.1 matching, after controlling the shortage of teachers. This means that PTA teacher ratio does not have negative effect on TOT, even in schools where teachers are sufficient. Third, 3) although it is not statistically significant, signs of some PTA teacher ratio coefficients are negative. However, based on the result of joint hypothesis test, the total effect of PTA teacher ratio to TOT is statistically different from zero with less than one percent significance, except Numeracy of lower standard grade pupils in. Even in Numeracy of lower standard grad pupils, TOT estimated by nearest matching and kernel normal matching algorithms are statistically different from zero with five percent significance. In this way, it can be inferred that PTA teacher ratio itself has positive effect on TOT without specifying type of schools.

⁷ Nearly the same finding was confirmed in the estimation of “government” teacher shortage. In the separate estimation, the interaction term of PTA teacher ratio and shortage of “government” teachers was replaced with the shortage of teachers. The finding is that in any cases, the interaction term is not negative and statistically significant. Also, even if the negative value of coefficient of interaction term was estimated, the joint test result rejects with the statistical significance the null hypothesis that sum of coefficient of PTA teacher ratio and the shortage of teacher is zero.

Table 6

	Kiswahili	English	Numeracy	Kiswahili	English	Numeracy
	All Grades			Standard Grade below 3		
Nearest Neighbor Matching (one to one)						
PTA Ratio and Teacher shortage Dummy	0.9228	1.0117	1.5553	1.1075	0.9613	1.0575
	[2.55]**	[2.98]***	[2.76]***	[2.35]**	[2.18]**	[1.25]
PTA Teacher Ratio	0.2427	0.2617	0.6489	0.049	-0.0778	0.2947
	[0.78]	[0.89]	[1.35]	[0.13]	[-0.21]	[0.42]
Teacher shortage Dummy	-0.1263	-0.1515	-0.238	-0.4069	-0.2945	-0.379
	[-1.25]	[-1.62]	[-1.48]	[-2.98]***	[-2.33]**	[-1.57]
F statistics	20.22	27.72	27.63	11.84	7.69	4.55
P value (Ho: PTA Ratio+Interaction Term =0)	0.0000	0.0000	0.0000	0.0006	0.0056	0.0331
Nearest Neighbor Matching (one to two)						
PTA Ratio and Teacher shortage Dummy	1.1517	1.1854	1.6532	1.4304	1.3776	1.6069
	[3.79]***	[4.09]***	[3.30]***	[3.50]***	[3.80]***	[2.19]**
PTA Teacher Ratio	0.0618	0.0315	0.4197	0.0096	-0.1258	0.0891
	[0.26]	[0.14]	[1.00]	[0.03]	[-0.43]	[0.14]
Teacher shortage Dummy	-0.2053	-0.1931	-0.2383	-0.4113	-0.3306	-0.4057
	[-2.46]**	[-2.47]**	[-1.74]*	[-3.54]***	[-3.26]***	[-1.97]**
F statistics	27.78	31.65	30.23	24.37	22.5	10.29
P value (Ho: PTA Ratio+Interaction Term =0)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014
Nearest Neighbor Matching (one to four)						
PTA Ratio and Teacher shortage Dummy	1.0816	1.088	1.6199	0.9924	1.1061	1.0643
	[3.95]***	[4.28]***	[3.60]***	[2.75]***	[3.38]***	[1.67]*
PTA Teacher Ratio	0.0896	0.0334	0.3833	-0.0425	-0.2845	0.0883
	[0.40]	[0.16]	[0.99]	[-0.15]	[-1.05]	[0.16]
Teacher shortage Dummy	-0.2119	-0.1942	-0.2639	-0.3237	-0.2866	-0.3143
	[-2.76]***	[-2.77]***	[-2.10]**	[-3.12]***	[-3.13]***	[-1.75]*
F statistics	35.14	38.86	35.52	14.23	12.67	6.4
P value (Ho: PTA Ratio+Interaction Term =0)	0.0000	0.0000	0.0000	0.0002	0.0004	0.0115
Kernel Matching						
PTA Ratio and Teacher shortage Dummy	0.7672	0.7802	1.0017	0.9981	1.0058	0.5489
	[3.57]***	[3.91]***	[2.74]***	[3.04]***	[3.40]***	[0.93]
PTA Teacher Ratio	-0.1254	-0.2423	0.0173	-0.188	-0.3692	0.1258
	[-0.70]	[-1.45]	[0.06]	[-0.71]	[-1.48]	[0.25]
Teacher shortage Dummy	-0.1933	-0.1729	-0.213	-0.3131	-0.2583	-0.2137
	[-3.15]***	[-3.12]***	[-2.10]**	[-3.37]***	[-3.13]***	[-1.31]
F statistics	17.85	16.26	13.77	11.62	9.11	2.67
P value (Ho: PTA Ratio+Interaction Term =0)	0.0000	0.0001	0.0002	0.0007	0.0026	0.1028
Kernel Normal Matching						
PTA Ratio and Teacher shortage Dummy	0.9228	1.03	1.5553	1.1075	0.9613	1.0575
	[2.55]**	[2.22]**	[2.76]***	[2.35]**	[2.18]**	[1.25]
PTA Teacher Ratio	0.2427	-0.0958	0.6489	0.049	-0.0778	0.2947
	[0.78]	[-0.25]	[1.35]	[0.13]	[-0.21]	[0.42]
Teacher shortage Dummy	-0.1263	-0.3237	-0.238	-0.4069	-0.2945	-0.379
	[-1.25]	[-2.47]**	[-1.48]	[-2.98]***	[-2.33]**	[-1.57]
F statistics	20.02	27.72	7.47	11.84	7.69	4.55
P value (Ho: PTA Ratio+Interaction Term =0)	0.0000	0.0000	0.0064	0.0006	0.0056	0.0331
Radius (0.1) Matching						
PTA Ratio and Teacher shortage Dummy	0.671	0.7118	0.8611	0.8999	1.0065	0.5085
	[3.14]***	[3.59]***	[2.38]**	[2.75]***	[3.42]***	[0.86]
PTA Teacher Ratio	-0.2595	-0.3653	-0.265	-0.3227	-0.4457	0.1216
	[-1.46]	[-2.21]**	[-0.88]	[-1.23]	[-1.80]*	[0.24]
Teacher shortage Dummy	-0.196	-0.18	-0.2364	-0.3199	-0.2731	-0.2112
	[-3.20]***	[-3.24]***	[-2.34]**	[-3.46]***	[-3.33]***	[-1.30]
F statistics	7.35	5.45	5.77	5.81	7.03	2.34
P value (Ho: PTA Ratio+Interaction Term =0)	0.0068	0.0197	0.0165	0.0161	0.0081	0.1265
Radius (0.05) Matching						
PTA Ratio and Teacher shortage Dummy	0.7223	0.7331	0.9182	0.9939	0.9805	0.4886
	[3.37]***	[3.68]***	[2.51]**	[3.05]***	[3.33]***	[0.82]
PTA Teacher Ratio	-0.1404	-0.2541	-0.0122	-0.2027	-0.3767	0.1113
	[-0.78]	[-1.52]	[-0.04]	[-0.77]	[-1.52]	[0.22]
Teacher shortage Dummy	-0.1877	-0.1658	-0.2025	-0.3106	-0.2515	-0.205
	[-3.06]***	[-2.98]***	[-2.00]**	[-3.36]***	[-3.06]***	[-1.26]
F statistics	14.97	12.78	11.11	11.13	8.25	2.1
P value (Ho: PTA Ratio+Interaction Term =0)	0.0001	0.0004	0.0009	0.0009	0.0041	0.1478

Robust standard errors are used for estimation and the estimated t-values are in parentheses. *, **, and *** are indicated to show p-value to reject null hypothesis with p<0.1, p<0.05, p<0.01 respectively.

8. Policy Implication and for further analysis

Based on the above result, the policy implication is summarized as below:

1. The empirical result of this paper supports that the impact of at least one PTA teacher exists in school is effective to the test score in Numeracy for all grade pupils, however in other subject, in English and Kiswahili, the impact is not statistically different from zero. Also, the magnitude of TOT in Numeracy is relatively small and 95% confidence interval includes the negative value of TOT. Therefore, though the subject of Numeracy is exceptional, this is rather consistent result from the Sundaraman et al. (2010) which uses the observational data, concluding that it cannot reject the null hypothesis that the PTA teacher effect to the school outcome is the same as governmentally hired teacher effect on test score.
2. On the other hand, after being matched with seven different matching criteria, the PTA teacher ratio effect on TOT, difference of test score between the treated and matched none treated schools is statistically significant in the lower grade in all three subjects on average. This result is intuitively understandable, for younger grade pupils tend to be taught by PTA teachers in Kenya public primary schools. The largest number of enrolled pupils is the pupil in the first grade. Therefore, to tackle with the large number of pupils, PTA teachers tend to teach lower grads. If there should be positive effect of PTA teacher ratio on outcomes, it should be found in the education outcome of lower grade pupils.
3. Regarding the implication of the finding, although the higher PTA teacher ratio has statistically significant explanatory power to TOT in lower grades, it does not mean that all teachers have to be replaced with PTA teachers. Rather, this result leads an important implication that government hired teachers need to put more efforts on teaching, since the result of estimation shows that if pupils are in lower grades, the ratio of government teacher should be less than PTA teacher, though they are paid better and “certified” by the national education system. This result is well reflecting one of the problems that Kenya public primary schools have faced. It is often criticized that the primary education is so much oriented toward the entrance exam of secondary school and the score of final exams at the 8th grade for which many governmental primary school teachers have

put the highest priority in teaching higher grade pupils in the school (Ito et al. 2011). Results on the national primary school leaving exam (KCPE) determine what secondary schools, if any, enroll graduating primary school students, and this is one of the highest concerns of headmaster of primary schools (Glewwe et al. 2010). However teaching in younger grade should not be substituted because of following reasons, therefore the well-designed mechanism for government teachers to be motivated for making as much efforts as PTA teachers do is necessary.

4. First, it is because of the repetition rate and dropout rate. They are both high in rural primary schools in Kenya, especially for those pupils who do not attend the nursery schools before entering the primary schools. This is partly because those pupils without going to nursery schools could not catch up with school learning in the middle of grades. This is also one of the reasons why there is a high correlation found between dropout pupils and pupils who had not enrolled in nursery schools. In this sense, for those pupils still in the lower grades, it is crucial for them to learn better, especially where the school is located in disadvantaged area in terms of educational resources and living infrastructure.
5. Also, it is pointed out that after the FPE policy, number of enrolled pupils who had not been able to come to school has newly joined schools. Therefore that leads parents with higher preferences on education decided to leave public primary schools to join private ones, since they worried about the deteriorated education quality with those pupils who had never been enrolled in schools (Sasaoka 2007). From these facts, it is essential to control the education quality, even after the FPE has been introduced. Otherwise, the FPE policy is going to create another disparity between household which could afford to access better quality of education and those who do not.
6. Concerning the background mechanisms why PTA teacher ratio has positive effect on TOT, it cannot be determined solely. However, it is partly because teaching in lower grades does not need high pedagogical input; rather other factors are more important. For example, Banerjee et al. (2010) shows that village volunteer teachers who were only trained by a week training of pedagogical technique for basic reading skills, those volunteer teachers have effectively increased

1.7 percent more likely to read at least letters for those who had not been able to read. This shows that not only the pedagogical technique, rather other factors effect on raising score in the early time of learning.

7. For further study, it requires not only to find the mechanism for PTA teacher to maintain the incentive to teach, rather it is also essential to search better institutional mechanism for government teachers to have better incentive.

Appendix 1 Chart of Preceding Studies
The Quantitative Analysis of Impact of locally hired contract teachers

<u>Author</u>	<u>Year</u>	<u>Country (Area)</u>	<u>Data</u>	<u>Outcome</u>	<u>Variable of Interest</u>	<u>Identification Strategy</u>	<u>Control Variables</u>	<u>Result</u>
Duflo et al. (2012)	2005-2006	Kenya, Western Province	Experimental Data	End line Test Score for Grade one for subject of Math, Literacy and Total score	Treatment Dummy (If PTA teacher is assigned or not)	Ordinary Least Squares Estimation	<ul style="list-style-type: none"> ➤ No control Variables ➤ School size, Share of female among TSC teacher, Girl, Age, Baseline Test Score 	<ol style="list-style-type: none"> 1) With control or without control variables, Treatment Dummy in Math and total score is statistically significant with 1 percent and in Literacy; it is statistically significant 5 percent. 2) After one year, the statistical significance fell down to 10 percent in Total score and Literacy and it vanished in Math.
Bold et al. (2012)	2010	Kenya, eight Provinces	Experimental Data	End line Test Score for Grade one, two and three pupils for combined total score	<ul style="list-style-type: none"> ➤ Treatment Dummy (If PTA teacher is assigned or not) ➤ Month (Length) of Treatment 	Ordinary Least Squares Estimation Instrument Variable Estimation	<ul style="list-style-type: none"> ➤ No Control Variables ➤ Baseline Score ➤ School Fixed Effect 	<ol style="list-style-type: none"> 1) Without control Variable, Treatment Dummy and Length of Treatment become statistically significant with 10 percent. 2) By adding baseline score, the Treatment Dummy and length of Treatment becomes positive and 5 percent significant. 3) In School Fixed Effect, the Treatment Dummy and Months of Treatment are both positive and statistically significant with 5 percent on outcome.
Sundaraman et al. (2010)	2005-2006	India (AP state)	Experimental Data	End line Test Score from Grade one to five in Numeracy, Language and Combined score	➤ Treatment Dummy (If contract teacher is assigned or not)	Ordinary Least Squares Estimation	<ul style="list-style-type: none"> ➤ No Control Variables ➤ Household, School and Pupil characteristics 	1) Compared to the baseline score, the Treatment dummy is statistically significant with 1percent for Numeracy, Literacy and Combined tests with or without controlled variable.
			Observational Data		➤ Treatment Dummy (If Contract teacher exist or not)	Panel School Fixed Level	<ul style="list-style-type: none"> ➤ School Fixed Level ➤ Household level and classroom level controls 	1) Without any control variables in school level fixed effects, or with all control variables in school fixed effects, in either case, the null hypothesis that difference between contract teacher and regular teacher is zero cannot be rejected
			➤ Treatment Dummy (if pupil is taught by Contract teacher or not)		Panel Pupil Fixed Level	➤ Pupil Fixed Level	1) Without any control variables, with pupil level fixed effects, with pupil fixed effects and all control variables, the null hypothesis that difference between contract teacher and regular teacher is zero cannot be rejected	
Bourdon, J. et al. (2006)	2000-2001	Niger	Observational Data (PASEC data)	Outcome is test score of Math and French	➤ Treatment effect on treated by estimating the average difference between classes taught by contract teacher and classes by regular teacher, conditioned that conditional independence holds true.	Propensity score matching (classes taught by contract teachers and taught by regular teachers)		<ol style="list-style-type: none"> 1) In grade 5th, the difference between the score of classes with a contract teacher with counterfactual outcome of the same classes is positive and significant for French, Math and Combined test score. The author concludes that contract teacher program is positive for grade 5. 2) On the hand, in the second grade, the difference is not statistically significant in any of subjects.

Appendix 2 Descriptive Statistics

Descriptive Statistics for School Level Estimation

Variable	Obs	Mean	Std. Dev.	Min	Max
<u>Dependent Variables</u>					
Average Test Score of Kiswahili	2216	3.958214	0.712659	1	5
Average Test Score of English	2216	3.926845	0.692587	1	5
Average Test Score of Numeracy	2216	6.319342	1.151761	1	8
<u>Independent Variables</u>					
Household and Individual Characteristics					
Total Number of family (School average)	2216	6.726254	2.331877	2	85
Sex of Household Head (School average, 1 is Male)	2216	0.789774	0.27704	0	1
Type of House(School average, 1 is the lowest quality and 5 is the finest quality)	2216	2.283702	1.400782	1	5
Possession of telephone (School average, Dummy)	2216	0.651886	0.314935	0	1
Number of meal in one day (School average)	2216	2.73166	0.409718	1	3
Age (School average)	2216	10.81903	1.346922	6	16
Age square (School average)	2216	125.3273	29.31611	36	256
Boy (School average, Dummy)	2216	0.510334	0.210786	0	1
Mother Age (School average)	2216	36.25552	4.857104	20	72
Mother Education History (School average, Dummy 1 if graduated of primary)	2216	0.806514	0.321416	0	1
Grade in School (School average)	2216	4.359844	1.192257	1	11.5
Parents paid tuition (School average, Dummy)	2216	0.433179	0.367398	0	1
School Characteristics					
Supplement for school material is available at classroom (Dummy)	2216	0.762184	0.425842	0	1
Classroom is suitable for learning (Dummy)	2216	0.672383	0.46945	0	1
School is fenced (Dummy)	2216	0.671931	0.469616	0	1
PTA Teacher Dummy (At least one PTA teacher exist in school)	2216	0.813177	0.389857	0	1
PTA Teacher ratio	2216	0.190611	0.152874	0	0.857143
Log Pupil Teacher Ratio for TSC teacher	2216	3.773858	0.460016	2.371578	6.539586
Log Pupils per classroom	2216	3.644802	0.400623	1.904238	6.263398
Village Characteristics and District Dummy					
Electricity Infra is available in village (Dummy)	2216	0.427347	0.494805	0	1
Road is tarmac in village (Dummy)	2216	0.14982	0.356975	0	1
Percent of Unemployment (District Level)	2216	0.06072	0.051004	0.010581	0.403876
Level of Unemployment rate (1 is the lowest and 4 is the highest)	2216	2.374097	1.089841	1	4
Province Dummy (Central Province)	2216	0.111913	0.315331	0	1
Province Dummy (Coast Province)	2216	0.081227	0.273246	0	1
Province Dummy (Eastern Province)	2216	0.192238	0.394148	0	1
Province Dummy (Nairobi Province)	2216	0.000903	0.030035	0	1
Province Dummy (North Eastern Province)	2216	0.056408	0.23076	0	1
Province Dummy (Nyanza Province)	2216	0.102437	0.30329	0	1
Province Dummy (Rift Valley Province)	2216	0.319495	0.466386	0	1
Province Dummy (Western Province)	2216	0.135379	0.342205	0	1

Descriptive Statistics in Common support samples for school average of all grade pupils

Variable	<u>All schools</u>			<u>Treated Schools</u>			<u>Controlled Schools</u>			<u>H0: Diff=0</u>
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	(P-value)
<u>Dependent Variables</u>										
Average Test Score of Kiswahili	1887	3.965652	0.7120691	1494	3.949017	0.7104351	393	4.028894	0.7156284	0.0478
Average Test Score of English	1887	3.932993	0.6921375	1494	3.916178	0.6868616	393	3.996919	0.709092	0.0396
Average Test Score of Numeracy	1887	6.330878	1.152425	1494	6.331772	1.129941	393	6.327476	1.235683	0.9476
<u>Independent Variables</u>										
Household and Individual Characteristics										
Total Number of family (School average)	1887	6.660244	1.657696	1494	6.704518	1.657934	393	6.491936	1.648056	0.0237
Sex of Household Head (School average, 1 is Male)	1887	0.7865646	0.2800994	1494	0.7891543	0.273554	393	0.7767199	0.3038674	0.4337
Type of House(School average, 1 is the lowest quality and 5 is the finest quality)	1887	2.294128	1.396627	1494	2.261457	1.379914	393	2.418326	1.453531	0.0475
Possession of telephone (School average, Dummy)	1887	0.6531852	0.3169442	1494	0.6509788	0.3136704	393	0.6615729	0.3293685	0.5556
Number of meal in one day (School average)	1887	2.72451	0.4167904	1494	2.728774	0.4136835	393	2.708302	0.4285461	0.3864
Age (School average)	1887	10.81892	1.34425	1494	10.84613	1.329278	393	10.71548	1.39661	0.0865
Age square (School average)	1887	125.3029	29.31103	1494	125.8955	29.02604	393	123.0502	30.30221	0.0868
Boy (School average, Dummy)	1887	0.5078172	0.2130589	1494	0.5114376	0.2084027	393	0.4940544	0.229661	0.1501
Mother Age (School average)	1887	36.25061	4.769957	1494	36.26247	4.792234	393	36.20555	4.690057	0.8333
Mother Education History (School average, Dummy 1 if graduated of primary)	1887	0.7985971	0.3283746	1494	0.801531	0.3259465	393	0.787444	0.3376368	0.4494
Grade in School (School average)	1887	4.355303	1.177131	1494	4.361513	1.169916	393	4.331696	1.205389	0.6551
Parents paid tuition (School average, Dummy)	1887	0.4344641	0.3705932	1494	0.441563	0.3650651	393	0.4074774	0.3902008	0.1047
School Characteristics										
Supplement for school material is available at classroom (Dummy)	1887	0.7657658	0.4236315	1494	0.7389558	0.439351	393	0.8676845	0.3392654	0.0000
Classroom is suitable for learning (Dummy)	1887	0.6645469	0.4722738	1494	0.6532798	0.4760851	393	0.7073791	0.4555458	0.0433
School is fenced (Dummy)	1887	0.6693164	0.470584	1494	0.6740295	0.4688933	393	0.6513995	0.4771347	0.3964
PTA Teacher Dummy (At least one PTA teacher exist in school)	1887	0.7917329	0.4061765	1494	1	0	393	0	0	n/a
PTA Teacher ratio	1887	0.180955	0.1526263	1494	0.2285557	0.1361614	393	0	0	n/a
Log Pupil Teacher Ratio for TSC teacher	1887	3.758036	0.4572262	1494	3.801277	0.4459378	393	3.593656	0.462822	0.0000
Log Pupils per classroom	1887	3.639635	0.4082227	1494	3.642761	0.3963924	393	3.627751	0.4507172	0.5167
Village Characteristics and District Dummy										
Electricity Infra is available in village (Dummy)	1887	0.427663	0.4948708	1494	0.4056225	0.4911765	393	0.5114504	0.5005061	0.0002
Road is tarmac in village (Dummy)	1887	0.154213	0.3612486	1494	0.1419009	0.3490653	393	0.2010178	0.4012722	0.0039
Percent of Unemployment (District Level)	1887	0.0605733	0.0482161	1494	0.0580445	0.0461341	393	0.0701865	0.054423	0.0000
Level of Unemployment rate (1 is the lowest and 4 is the highest)	1887	2.355591	1.10585	1494	2.292503	1.091027	393	2.59542	1.130143	0.0000

Descriptive Statistics in Common support samples for Standard grade below three

Variable	<u>All schools</u>			<u>Treated Schools</u>			<u>Controlled Schools</u>			<u>H0: Diff=0</u>
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	(P-value)
<u>Dependent Variables</u>										
Average Test Score of Kiswahili	1720	2.952054	0.8969595	1371	2.91174	0.8914024	349	3.110423	0.9024505	0.0002
Average Test Score of English	1720	2.919097	0.8275752	1371	2.882853	0.8144723	349	3.061475	0.8637394	0.0003
Average Test Score of Numeracy	1720	4.694302	1.516378	1371	4.671458	1.503788	349	4.78404	1.563829	0.2157
<u>Independent Variables</u>										
Household and Individual Characteristics										
Total Number of family (School average)	1720	6.596458	1.780762	1371	6.630485	1.787954	349	6.462787	1.748346	0.1163
Sex of Household Head (School average, 1 is Male)	1720	0.7917327	0.3022176	1371	0.7955257	0.2928241	349	0.7768321	0.3366352	0.3024
Type of House(School average, 1 is the lowest quality and 5 is the finest quality)	1720	2.197293	1.434143	1371	2.169003	1.427705	349	2.308429	1.455908	0.1049
Possession of telephone (School average, Dummy)	1720	0.6367892	0.3526677	1371	0.6334648	0.3499144	349	0.6498489	0.3635006	0.4386
Number of meal in one day (School average)	1720	2.715625	0.4447905	1371	2.720163	0.4429728	349	2.6978	0.4520616	0.4019
Age (School average)	1720	8.326783	1.209341	1371	8.337125	1.195061	349	8.286156	1.264831	0.4822
Age square (School average)	1720	72.91323	22.64777	1371	73.03283	22.29828	349	72.44339	23.9991	0.6644
Boy (School average, Dummy)	1720	0.5201871	0.2934888	1371	0.525176	0.2913417	349	0.5005891	0.3014022	0.1624
Mother Age (School average)	1720	34.25272	5.504335	1371	34.32356	5.557959	349	33.97441	5.286964	0.2902
Mother Education History (School average, Dummy 1 if graduated of primary)	1720	0.7983608	0.3398301	1371	0.7993519	0.3401934	349	0.7944675	0.3388582	0.8106
Grade in School (School average)	1720	2.050793	0.4647443	1371	2.056746	0.449175	349	2.027408	0.5214757	0.2925
Parents paid tuition (School average, Dummy)	1720	0.2660371	0.3787845	1371	0.2643525	0.3741058	349	0.2726548	0.3971173	0.7148
School Characteristics										
Supplement for school material is available at classroom (Dummy)	1720	0.7622093	0.4258541	1371	0.7374179	0.4401977	349	0.8595989	0.3479015	0.0000
Classroom is suitable for learning (Dummy)	1720	0.6616279	0.4732934	1371	0.6491612	0.4774067	349	0.7106017	0.4541342	0.0303
School is fenced (Dummy)	1720	0.6668605	0.471473	1371	0.6725018	0.4694719	349	0.6446991	0.4792915	0.3255
PTA Teacher Dummy (At least one PTA teacher exist in school)	1720	0.797093	0.4022808	1371	1	0	349	0	0	n/a
PTA Teacher ratio	1720	0.1847168	0.1533508	1371	0.2317381	0.1363912	349	0	0	n/a
Log Pupil Teacher Ratio for TSC teacher	1720	3.76627	0.458448	1371	3.809041	0.4461851	349	3.598252	0.4679027	0.0000
Log Pupils per classroom	1720	3.635846	0.4045139	1371	3.639205	0.3927561	349	3.622648	0.4480921	0.495
Village Characteristics and District Dummy										
Electricity Infra is available in village (Dummy)	1720	0.4145349	0.4927848	1371	0.3924143	0.4884663	349	0.5014327	0.5007158	0.0002
Road is tarmac in village (Dummy)	1720	0.1494186	0.3566043	1371	0.134938	0.341782	349	0.2063037	0.4052321	0.0008
Percent of Unemployment (District Level)	1720	0.0609334	0.04887	1371	0.058783	0.0472281	349	0.0693809	0.0540972	0.0003
Level of Unemployment rate (1 is the lowest and 4 is the highest)	1720	2.361628	1.099756	1371	2.307805	1.084767	349	2.573066	1.133841	0.0001

Appendix 3 Figures

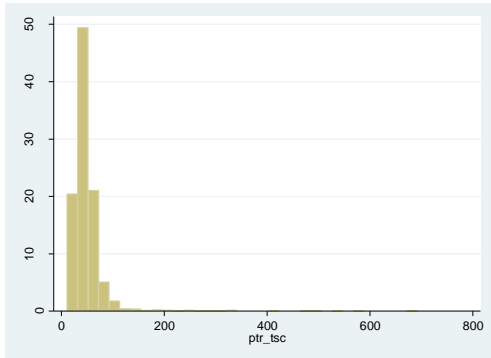


Figure 4 Pupil TSC teacher ratio

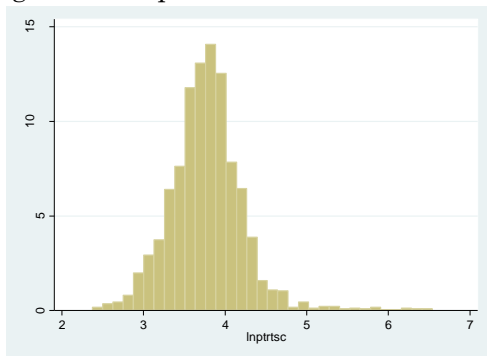


Figure 5 Log of Pupil TSC teacher ratio

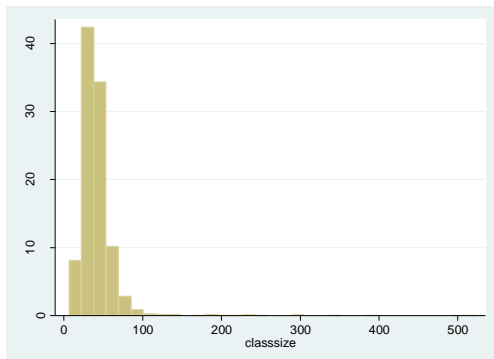


Figure 6 Pupil per class

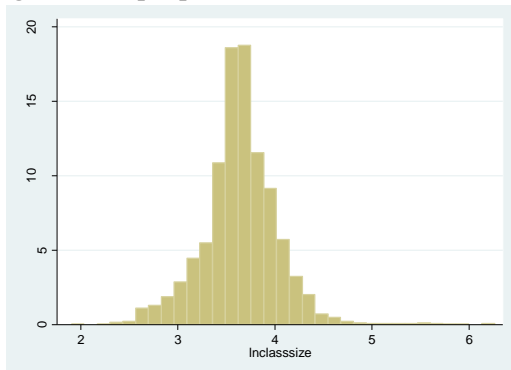


Figure 7 Log of Pupil per class size

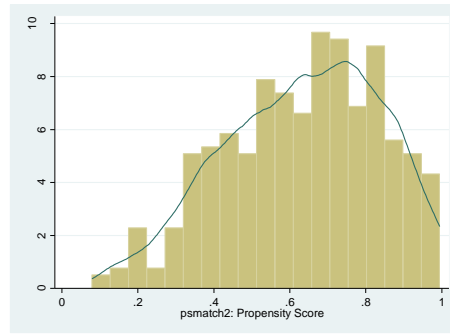


Figure 8 Propensity Score Distribution for Controlled Group for Kiswahili for all grades

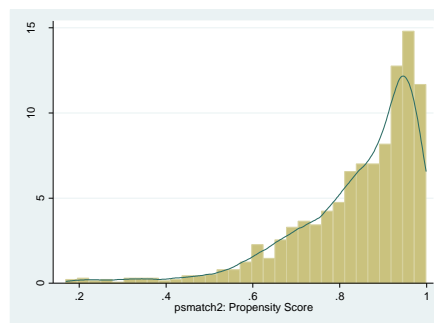


Figure 9 Propensity Score Distribution for Treated Group for Kiswahili for all grades

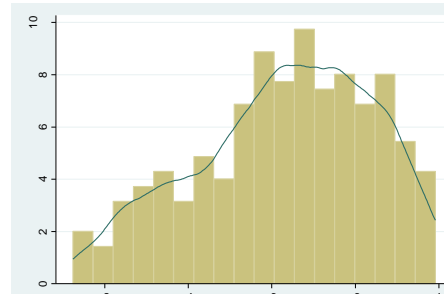


Figure 10 Propensity Score Distribution for Controlled Group for English grade below 3

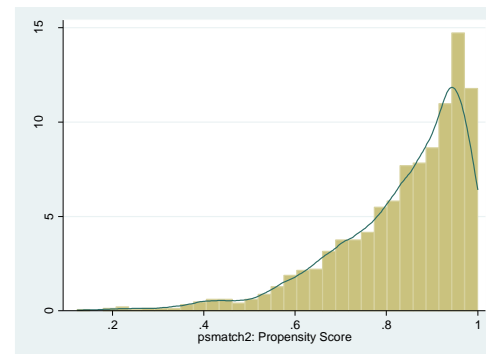


Figure 11 Propensity Score Distribution for Treated Group for English grade below 3

Appendix 4 Probit Model Estimation Result

Probit Estimation Result

Independent Variable is PTA Teacher Dummy (0 or 1)

	All grades	Std <=3
Electricity Infra is available in village (Dummy)	-0.2191 [-2.50]**	-0.23 [-2.52]**
The road is tarmac in village (Dummy)	-0.1389 [-1.32]	-0.2117 [-1.90]*
Supplement for school material is available at classroom (Dummy)	-0.3598 [-3.56]***	-0.3285 [-3.18]***
Classroom is suitable for learning (Dummy)	-0.0343 [-0.43]	-0.0704 [-0.84]
School is fenced (Dummy)	-0.0652 [-0.73]	-0.0033 [-0.04]
Log Pupil Teacher Ratio for TSC teacher	0.7409 [4.21]***	0.7768 [4.21]***
Log Pupils per classroom	-0.3049 [-2.36]**	-0.3334 [-2.36]**
Total Number of family (School average)	-0.0093 [-0.37]	-0.009 [-0.40]
Sex of Household Head (School average, 1 is Male)	0.1371 [0.95]	0.1969 [1.37]
Type of House(School average, 1 is lowest quality and 5 is the finest quality)	-0.0429 [-1.12]	-0.0001 [-0.00]
Possession of telephone (School average)	0.1101 [0.74]	0.0598 [0.45]
Number of meal in one day (School average)	0.1283 [1.24]	0.1345 [1.32]
Age (School average)	0.2754 [1.14]	0.2668 [1.17]
Age square (School average)	-0.0122 [-1.10]	-0.015 [-1.28]
Boy (School average)	0.1857 [1.14]	0.1056 [0.81]
Mother Age (School average)	-0.0054 [-0.64]	0.009 [1.20]
Mother Education History (School average)	-0.1116 [-0.58]	-0.1445 [-0.76]
Grade in School (School average)	0.0306 [0.66]	0.0566 [0.63]
Parents paid tuition (School average)	0.0966 [0.79]	-0.0277 [-0.25]
Constant	-2.727 [-1.69]*	-2.8467 [-1.98]**
Wald chi2(121) = 313.79		Wald chi2(121) = 301.93
Prob > chi2 = 0.0000		Prob > chi2 = 0.0000
Pseudo R2 = 0.1887		Pseudo R2 = 0.1984
N	1887	1720

Robust standard errors are used for estimation and the estimated t-values are in parentheses. *, **, and *** are indicated to show p-value to reject null hypothesis with p<0.1, p<0.05, p<0.01 respectively.

District Dummy is excluded from table, because it becomes long.

Table 8 TOT (Nearest One to One Matching Estimation for Lower standard grade below three) regressed on PTA teacher ratio

	Kiswahili for All Standard Grades							English for All Standard Grades							Numeracy for All Standard Grades							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
PTA teacher ratio	0.0396 [0.18]	0.336 [1.49]	0.3966 [1.75]*	0.5201 [2.24]**	0.5695 [2.42]**	0.8853 [3.35]**	0.955 [2.95]**	-0.0472 [-0.23]	0.2258 [1.03]	0.2707 [1.23]	0.3745 [1.66]*	0.4191 [1.84]*	0.6525 [2.59]**	0.6457 [2.11]**	0.2983 [0.75]	0.8036 [1.92]*	0.8696 [2.05]**	1.0975 [2.54]**	1.1839 [2.69]**	1.6111 [3.35]**	1.1477 [1.97]**	
Electricity infra is available in village		0.3492 [4.86]**	0.3372 [4.66]**	0.2756 [3.68]**	0.2552 [3.39]**	0.2605 [3.47]**	0.1515 [1.92]*		0.311 [4.58]**	0.3057 [4.45]**	0.2393 [3.39]**	0.2211 [3.11]**	0.225 [3.17]**	0.1193 [1.63]		0.3569 [2.93]**	0.3376 [2.76]**	0.23 [1.83]*	0.1952 [1.55]	0.2024 [1.60]	0.1177 [0.84]	
The road is tarmac in village		-0.0535 [-0.53]	-0.0588 [-0.58]	-0.1032 [-1.03]	-0.1013 [-1.01]	-0.1082 [-1.08]	-0.149 [-1.41]		-0.0722 [-0.72]	-0.0751 [-0.76]	-0.1247 [-1.27]	-0.1189 [-1.20]	-0.124 [-1.25]	-0.1967 [-1.89]*		0.086 [0.50]	0.0787 [0.46]	0.0128 [0.08]	0.0378 [0.22]	0.0285 [0.17]	-0.0693 [-0.37]	
Unemployment Level (1-5)		-0.0005 [-0.02]	-0.006 [-0.20]	0.0299 [0.87]	0.0321 [0.86]	0.0428 [1.14]	0.0142 [0.13]		-0.0165 [-0.58]	-0.0251 [-0.85]	0.0061 [0.19]	0.0027 [0.08]	0.0105 [0.30]	0.0013 [0.02]		-0.1685 [-3.26]**	-0.168 [-3.13]**	-0.1191 [-2.03]**	-0.1176 [-1.83]*	-0.1032 [-1.60]	0.283 [1.23]	
Supplement for school material is available at classroom (Dummy)			0.1869 [2.62]**	0.1371 [1.90]*	0.1297 [1.79]*	0.1213 [1.68]*	0.0503 [0.63]			0.156 [2.31]**	0.1069 [1.56]	0.1004 [1.46]	0.0942 [1.37]	0.0259 [0.34]			0.1352 [1.09]	0.089 [0.71]	0.1271 [1.00]	0.1157 [0.91]	0.0922 [0.65]	
Classroom is suitable for learning (Dummy)			0.067 [1.02]	0.0587 [0.89]	0.0459 [0.70]	0.0445 [0.68]	0.0521 [0.75]			0.062 [0.99]	0.0487 [0.78]	0.0353 [0.57]	0.0343 [0.56]	0.0439 [0.68]			0.1205 [1.05]	0.1112 [0.97]	0.0925 [0.80]	0.0906 [0.79]	0.0528 [0.43]	
School is fenced (Dummy)			-0.0221 [-0.30]	-0.0436 [-0.60]	-0.0629 [-0.86]	-0.052 [-0.71]	-0.0053 [-0.07]			-0.0601 [-0.88]	-0.0816 [-1.19]	-0.0977 [-1.42]	-0.0896 [-1.31]	-0.0445 [-0.60]			0.0451 [0.36]	0.0083 [0.07]	0.0082 [0.07]	0.0231 [0.18]	-0.035 [-0.25]	
Total Number of family (School average)			-0.0408 [-2.05]**	-0.039 [-1.92]**	-0.0312 [-1.54]	-0.0323 [-1.52]				-0.0608 [-3.21]**	-0.0607 [-3.11]**	-0.0549 [-2.81]**	-0.0531 [-2.51]**					-0.0837 [-2.39]**	-0.0926 [-2.57]**	-0.082 [-2.28]**	-0.0906 [-2.30]**	
Sex if Household Head (School average, 1 is Male)			0.1226 [0.97]	0.1441 [1.14]	0.1368 [1.08]	0.1428 [1.04]				0.0515 [0.43]	0.0784 [0.65]	0.0729 [0.60]	0.1164 [0.89]					0.1521 [0.68]	0.2199 [0.98]	0.21 [0.93]	0.2253 [0.88]	
Type of House (School average, 1 is lowest quality and 5 is the finest quality)				0.0657 [2.47]**	0.0529 [1.93]*	0.0472 [1.73]*	0.0902 [2.22]**				0.0545 [2.19]**	0.0454 [1.77]*	0.0411 [1.60]	0.0846 [2.21]**					0.037 [0.84]	0.044 [0.97]	0.0362 [0.80]	0.1064 [1.64]
Possession of telephone (School average)				0.1633 [1.33]	0.1406 [1.10]	0.1269 [1.00]	0.1377 [1.00]				0.2109 [1.81]*	0.1968 [1.61]	0.1867 [1.53]	0.1576 [1.21]					0.6095 [2.89]**	0.5236 [2.38]**	0.505 [2.29]**	0.4688 [1.96]**
Number of meal in one day (School average)				-0.0112 [-0.14]	-0.0094 [-0.11]	-0.0176 [-0.21]	-0.0303 [-0.32]				-0.0434 [-0.56]	-0.0378 [-0.47]	-0.0439 [-0.54]	-0.0418 [-0.47]					-0.1741 [-1.30]	-0.1545 [-1.11]	-0.1656 [-1.19]	-0.2119 [-1.29]
Age (School average)					0.5652 [2.30]**	0.5619 [2.30]**	0.5048 [2.04]**					0.5932 [2.47]**	0.5908 [2.48]**	0.626 [2.61]**						1.7787 [3.96]**	1.7744 [3.96]**	1.7799 [3.82]**
Age Square (School average)					-0.0279 [-2.43]**	-0.0274 [-2.39]**	-0.0251 [-2.17]**					-0.0288 [-2.56]**	-0.0284 [-2.54]**	-0.0293 [-2.60]**						-0.0796 [-3.82]**	-0.079 [-3.80]**	-0.0791 [-3.64]**
Boy (School average)					0.2352 [1.31]	0.2262 [1.26]	0.2459 [1.30]					0.1194 [0.71]	0.1127 [0.67]	0.0862 [0.49]						-0.0257 [-0.08]	-0.0378 [-0.12]	-0.0249 [-0.08]
Mother Age (School average)					-0.0005 [-0.06]	-0.0009 [-0.11]	-0.0064 [-0.77]					0.0008 [0.11]	0.0005 [0.07]	-0.0052 [-0.66]						0.0134 [0.97]	0.0129 [0.94]	0.0059 [0.40]
Mother Education History (School average)					-0.1615 [-1.16]	-0.1661 [-1.20]	-0.1159 [-0.61]					-0.1908 [-1.44]	-0.1943 [-1.47]	-0.0833 [-0.47]						-0.1105 [-0.45]	-0.1168 [-0.48]	-0.109 [-0.33]
Grade in School (School average)					0.1257 [2.65]**	0.1175 [2.48]**	0.1086 [2.16]**					0.1169 [2.55]**	0.1108 [2.43]**	0.0867 [1.81]*						0.029 [0.34]	0.0179 [0.21]	0.0474 [0.53]
Parents paid tuition (School average)					0.1603 [1.58]	0.1584 [1.57]	0.1391 [1.23]					0.1266 [1.29]	0.1252 [1.29]	0.1349 [1.25]						0.1092 [0.62]	0.1066 [0.61]	0.0553 [0.29]
Log Pupil Teacher Ratio for TSC teacher						-0.2377 [-2.88]**	-0.1948 [-2.04]**						-0.1756 [-2.23]**	-0.1155 [-1.24]							-0.3214 [-2.27]**	-0.1719 [-1.03]
Constant	-0.0998 [-1.58]	-0.297 [-2.92]**	-0.4593 [-3.38]**	-0.5229 [-1.56]	-3.6863 [-2.98]**	-2.8517 [-2.23]**	-2.7425 [-2.05]**	0.0195 [0.33]	-0.1179 [-1.20]	-0.2209 [-1.67]*	0.0089 [0.03]	-3.2675 [-2.67]**	-2.651 [-2.11]**	-3.2667 [-2.51]**	-0.0424 [-0.39]	0.0778 [0.44]	-0.1385 [-0.59]	0.2604 [0.47]	-9.5827 [-4.11]**	-8.4539 [-3.53]**	-9.535 [-3.63]**	
R-squared	0	0.0187	0.0244	0.0358	0.0512	0.0569	0.1701	0	0.0173	0.0222	0.0377	0.0534	0.0568	0.1902	0.0004	0.0183	0.0203	0.0328	0.0495	0.053	0.1364	
Adj-R-squared	-0.0007	0.0158	0.0194	0.0273	0.0378	0.0429	0.0897	-0.0007	0.0144	0.0172	0.0292	0.0401	0.0429	0.1117	-0.0003	0.0154	0.0152	0.0243	0.0361	0.039	0.0527	
N	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	

Robust standard errors are used for estimation and the estimated t-values are in parentheses. *, **, and *** are indicated to show p-value to reject null hypothesis with p<0.1, p<0.05, p<0.01 respectively.

District Dummy is excluded from table, because it becomes long.

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