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Redistributing Teachers using Local Transfers[1]

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Abstract

In this paper we show that local redistribution of educational resources via teacher transfers between neighboring public schools can improve equity in access to teachers. Transfers from teacher surplus schools to deficit schools within a 10 km radius in Haryana, a state of India for which we have geo-coded location of schools in 2013, enables 19 percent of deficit schools to meet the minimum requirement. Using estimates from other studies, we posit that the impact of this redistribution on girl's primary completion rates (PCR) could be as high as 1.2 percentage points for those from poor households: roughly the annual growth of the PCR in the state. We also show that the donor and recipient schools are, on an average, matched in characteristics: in terms of the development of the region, its rural/urban location, connectivity and school characteristics. A comparison of transfers that follow our redistribution rule to transfers resulting from an actual transfer policy shows that while our rule removes deficits in rural areas, the actual transfers favored more developed regions.

KEYWORDS: Equity, Transfer, Pupil Teacher Ratio, Primary Schooling, India

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1. Introduction

As countries move to set new targets for education parameters as a part of the Sustainable Development Goals (SDGs), they are fettered by two persistent problems in schooling outcomes: the quality of primary education[2] and the inequity in access to schools and school inputs. In this paper, we address inequity in access to teachers among those enrolled in public primary schools and suggest a way to redress this shortage in the short run. We focus on India as it ranks as one of the worst in terms of regional disparities in pupil-teacher ratios in primary education (Sherman and Poirier, 2007).

The inequity in access to teachers in the public schooling system can be addressed by recruitment of teachers, by consolidation of multiple schools into one big school and by teacher transfers.[3] Mass recruitment requires larger public funds[4] where as consolidation increases distances students may have to travel. Hence we focus on the third mechanism, teacher transfers. Redistribution of teachers has been attempted all over the world and is still considered an important part of education policy. For example, the Right to Education act (RTE) in India, 2009 calls for teacher transfers to redress problems of inequity in access to teachers. There is mixed evidence on the impact of such policies. In India, Operation Blackboard (OB), a central government program launched in 1987, lead to a de facto redistribution of teachers from larger schools to one-

[2] See, for example, the vast literature on the impact of teacher incentives on quality of primary education: Lavy, 2009; Muralidharan and Sundararaman, 2011, Glewwe et. al., 2010

[3] The transfer of teachers to correct imbalance in the distribution of teachers is technically referred to as rationalization. In principle, teacher transfers can also take place due to other reasons: preference of teachers or administrative concerns. When we refer to teacher transfers in this paper, we are referring to rationalization.

[4] Moreover such appointments are intertwined with a debate on what form of hiring is optimal: contractual or permanent (Muralidharan and Sundararaman, 2013).

teacher schools.[5] While such a program had positive effects on the children's attendance outcomes, only one quarter of the OB teachers were in fact sent to the intended place (Chin, 2005). The problem of such misallocation of teachers is also well documented in other developing countries in Africa (Mulkeen, 2006) and increases the cost of teacher redistribution.

The main problem with redistribution policies is that teachers prefer not to be posted in remote rural places (Fagernäs and Pelkonen, 2012; Kremer et al. 2005). Hence a patronage- based system exists where powerful politicians and bureaucrats oblige politically-helpful teachers with transfers of their choice, regardless of school need, and punish disobedience with undesirable transfers (Sharma and Ramachandran, 2009).[6] This often leads to schools in remote places to be deficit in teachers (Mehrotra, 2006).

To address these concerns, this paper proposes redistributions that are local in nature. In particular, we propose teacher transfers from schools that have "surplus" teachers to schools that have a "deficit" in teachers within a specific distance radius. The concept of surplus and deficit are derived from mandated pupil-teacher ratio (PTR) requirements under the Right to Education Act passed in India in 2009.[7] Local transfers may have two features that may be attractive

[5] Operation blackboard paid for 140,000 teachers to be appointed to one-teacher primary schools. However, the policy turned out, de facto, to be a redistribution as the average number of teachers per primary section did not increase (Chin, 2005).
[6] Beteille (2009), in her study of 2340 public school teachers, across 930 randomly selected schools in selected districts of three states of India (Rajasthan, Madhya Pradesh and Karnataka) found that in every district over 50 percent of teachers agreed that if a teacher wanted to be transferred, he/she would need connections. Moreover, over 30 percent of teachers in every district agreed that they would still have to pay some money to get the posting they want. These concerns are not restricted to India.
[7] While the schools that don't meet the minimum teacher requirement under RTE Act are "deficit" schools, we define "surplus" schools as those that would meet the mandated requirement even if teachers were transferred out. We discuss this in detail in a later section.

to teachers: First, for those whose current school postings are driven by a desire to work in a particular area, local transfers may be more palatable and the push back on transfers may be lower. For example, if teachers work in an urban area, then a displacement of 5 to 10 km is likely to keep them within the urban zone and may be palatable where as a transfer to a remote rural school or another district in the state may be opposed. In so far as teachers need to invest in a living arrangement that is compatible with workplace, such local transfer may be least disruptive leading to less opposition and consequent lobbying to oppose such transfers. Second, in so far as development often takes place in clusters, such local transfers may move teachers between schools that match on important dimensions: for example development of the region and connectedness.

We provide results of such a redistribution using data on the census of public primary schools in Haryana, a northern state of India for which detailed geocoded location of all schools are publicly available. In 2013, as high as 32.6 percent of government schools did not meet the PTR as mandated by the Right to Education Act. Our results for a 5 km local transfer show that such transfers result in a 14 percent reduction in proportion of deficit schools (422 schools out of 3041 deficit schools meet the law post transfer). At the 10 km range, almost 19 percent of the deficit schools meet the minimum teacher requirement (the corresponding number of schools is 568). This is a considerable decrease in deficit schools without new recruitment. Using estimates of the causal effect of redistribution of teachers calculated by Chin (2005), we find that the net effect of, say a 10 km redistribution, (involving 636 transferred teachers) would be a 1 percentage point increase in girl's primary completion rate. For girls in the poorest quartile of wealth this effect could be as large as 1.3 percentage points. By way of comparison, this is roughly the average annual growth rate of PCR for girls in the state (Prakash, 2015).

Moreover, we find that on important dimensions: connectedness of the school, development of the area around the school, whether it is in the rural school district and school infrastructure, there is no statistical difference between the source and the destination school. Thus this local redistribution mechanism may make a large number of transfers palatable by not changing drastically the environment in which teachers currently work.

It may be contended that while government redistribution rules are opaque, education departments in fact do follow such kind of rules. To examine this, we contrast results of local redistribution suggested by our paper to a real transfer policy that was carried out in the same state after 2011. Fixing school enrolments at their 2011 levels, we find that while the actual redistribution may have resulted in 26 percent of the deficit schools to meet the PTR rules (by 2013), a 5 and 10 km redistribution would have addressed the deficit in a larger proportion of schools (38 and 48 percent respectively). Moreover, while the actual policy seems to have resulted in a larger proportion of deficit schools meeting the threshold in developed areas, the local redistribution rule suggested in this paper would have led to a higher proportion of deficit schools in rural areas meeting the mandated threshold.

The paper is organized thus: in section 2, we provide description of the context. A characterization of schools is provided in section 3. Section 4 discusses the local redistribution algorithm. In Section 5 we conduct a comparison of the results of the suggested redistribution with actual net increases in teachers in schools that were deficit in 2011. We conclude with a discussion in section 6.

2. Description of the context.

In this paper, the context chosen is that of government primary schools for the state of Haryana (a northern state of India). The dataset covers the census of 9255 such schools, which are administered by the state government's department of education.[8] The choice of the context is purposive. Teacher transfers require administrative control over a large number of schools across which reallocation is possible. Government schools are therefore the natural candidates for this study since teachers can be transferred across schools in the system. However, to ensure such transfers, we need to ensure that the teachers are homogenous in what their duties are. We therefore focus on primary schools. Teachers for such schools are not hired for any subject and are meant to teach any class (I-V) in these schools. Hence redistribution rules do not need to take into account subject as well as class specific teacher needs.

A potential complication in teacher transfers is how to deal with schools that offer primary sections as well as other levels of education (secondary/higher secondary). Any transfer rule would then require knowledge of teachers specific to a class, but these are usually not available. This potential complication motivates why we choose the state of Haryana for our analysis. In this state, "Primary-only" schools form 99 percent of the government schools where instruction is offered at the primary level.

[8] There are 9333 schools but some of them have missing information on enrolment as well as missing latitude-longitude coordinates that are crucial for our study.

The teacher transfer rules suggested in this paper require accurate data on where schools are with respect to each other. GIS data on latitude and longitude for all schools, including the government primary schools, are available for the state. Moreover, this data is merged with data on school characteristics and enrolment from DISE (District Information System for Education) in 2013 for our main results and with similar data from DISE in 2011 for auxiliary results. These records are collected by the National University of Educational Planning and Administration (NUEPA) and, most importantly for this paper, are used by the administrative officials. [9]

The choice of the state may be purposive but it is not an atypical state in the importance of public schooling. The National Sample Survey (2014) measures school attendance from household surveys and finds that in Haryana, 41 percent of children going to primary schools go to Government primary schools (around 987,000 students). The corresponding proportion for India is in fact higher at 62 percent. Hence the teacher transfer rules for government schools, reported here, might be even more important in other states.[10]

The DISE data set reports whether the school district is rural or urban. However, these classifications often do not capture the level of development of the region. Hence for each school, we construct an index of economic development measured by night lights captured from space.[11] To construct this index, we

[9] The veracity of some of the output variables reported (for example, enrolment) is often questioned. However, that discussion is not relevant for this paper since administrative decisions are made on the basis of these data.

[10] The lack of accurate location data is one of the main reasons this exercise has not been attempted at an all India level. However, there is a drive among public officials to geocode public facilities. Hence such data will be available for all states in the near future.

[11] This proxy is motivated by Henderson et. al. (2012)

calculate the average luminosity density (total luminosity per square km) for a radius of 5 kilometers around each school.[12]

It is also important to know how accessible these schools are. To construct accessibility, we extract data on kilometers of various types of roads in a radius of 0.25 km of each school.[13] We label a school as connected if there are metaled roads within this radius.[14]

2. Which schools meet the PTR Rules?

The Right to Education Act was enacted in 2009 to improve access to schooling to all children in India. A key component of this act is access to teachers. However, the progress on PTRs has been slow in the context of India. The PTR after the third year assessment post RTE came down to 27 in 2012-13 from 32 as in 2009-10 (RTE 2012). However the percentage of schools with single teacher (and therefore violating the minimum required for school of any size) remained unchanged at 9%. To address some of these anticipated problems the act called directly for teacher transfers, where possible, to ensure that all schools meet the minimum teacher requirement. Hence one of the main objectives of this paper is to suggest teacher transfers that increase the proportion of schools that meet the legal minimum requirement of teachers in public schools.

In Haryana, this act was notified in 2011. A cumulative distribution of pupil-

[12] The data is sourced from http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html is extracted using ARC GIS.
[13] Road maps are sourced from http://download.geofabrik.de/asia/india.html
[14] We calculate whether there are primary, secondary, tertiary or trunk roads in the radius of the school. The definitions of these are given in http://wiki.openstreetmap.org/wiki/India:Tags/Highway

teacher ratio based on data for primary government schools in Haryana in 2013-14 reveals that there is a fair heterogeneity (Figure 1). 55 percent of schools have PTR below 30 where as 10 percent of schools have a PTR above 50. According to the act however, the stipulation for pupil teacher ratio is not a fixed number. The act states that there needs to be no less than 2 teachers for a school with 1-60 students, no less than 3 teachers for a school with 61 to 90 students, no less than 4 teachers for a school with 91 to 120 students, no less than 5 teachers for a school with 121 to 200 students and that the school should maintain a pupil teacher ratio of 40 if it has more than 200 students.[15]

Based on this legal requirement, we classify schools into three kinds: Deficit schools (that do not meet the mandated threshold), Just meet schools (that meet the threshold and which wouldn't if they lost any teacher) and Surplus schools (that meet the threshold and which would continue to do so even if they lost one teacher, in some cases more). Based on this classification, 32.57 percent of schools in 2013-14 are deficit schools. This is accompanied by 7.27 percent of schools that are surplus schools while others (60.16 percent) just meet the requirement (Table 1).[16]

What characterizes the schools in deficit? To answer this question, we undertake a regression analysis to describe such schools.[17] Let us define a variable *deficit*, that takes the value 1 if it's a deficit school, 0 otherwise. Given that the pupil-teacher ratio rules depend on the size of the school (as defined by enrolment),

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[15] The number of students refers to enrolled students.

[16] That there is an improvement compared to 2011 is apparent since the percent of deficit schools then was around 41 percent. Part of this improvement is misleading and we return to this in a later section.

[17] We make no claims here of causality.

we define indicator variables for the size classes of schools that determine the teacher requirement. Figure 2 reveals that in fact the proportion of schools that meet the deficit vary across size classes, with a higher proportion of larger schools not meeting the PTR requirement. This is in fact paradoxical since the PTR requirements are more lax for bigger schools. However, it may be explained partly by the fact that enrolment is endogenous and it could well be the case that some schools that have seen, in the near past exodus of students, are now less likely to be in deficit due to the low student population, even with a small number of teachers. Therefore this should be merely taken as a characterization of deficit schools that policy makers face as of today. We will return to this point later in the paper.

We take into account the rural-urban categorization of school district by including an indicator variable that the school lies in a rural district. Since teachers may be hesitant to join schools that are less connected, we include connectedness (as defined above) as a explanatory variable. To take into account that schools may have both a higher demand for schooling as well as higher supply of teachers in economically developed regions, we include luminosity density as a regressor. The PTR may be correlated to provision of other characteristics of the school. Either the school may not get the resources it asks for, or teachers may be unwilling to join schools without complementary infrastructure inputs. To investigate if there is a correlation between the two, we construct an infrastructure index that takes into account proportion of classrooms that are deemed good, the proportion of toilets that are deemed good, for boys and for girls separately; the proportion of toilets that have functional water supply, for boys and girls separately. The index is created by a principle component analysis of these variables.[18] Further, we take into account the age of the school, as older schools may have better reputation and may attract teachers.

With these variables in mind, we run three sets of probit estimation exercises.[19][20] We report marginal effects in all tables. As a baseline, we run the specification without controlling for any geographical dummy variables (Table 2, column (1)). Hence deficit schools are compared to non-deficit schools all over the state. In the second exercise, we include district dummy variables (column (2)). This makes all comparisons intra district. Block level dummies are included in the third exercise to make intra-block comparisons (column (3)). A comparison of the three regression results is important to throw light on what are the difference between deficit and surplus schools as we narrow, on an average, the distance between them. All regression results report robust standard errors, clustered at the level of the school district.

The observation in Figure 2 that schools with larger enrolment have a greater deficit is borne out even in regression results reported in columns (1) to (3). As compared to the reference category (schools with enrolment between 1 and 60), schools with 201 or more students are 40 percentage points more likely to be in deficit. Interestingly, the magnitude is invariant to inclusion of fixed effects at various geographical levels. In other words, even within blocks, the schools that are bigger are more likely to be in deficit.

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[18] We use the first factor.

[19]Some missing covariates imply that we run these regressions on 8558 schools. Summary statistics are provided in Table A.1.

[20] Results are similar even if estimate a Linear Probability Model.

Anecdotal evidence often suggests that rural areas have a greater probability of being deficit in teachers. However, this result is not borne out in our results. Connectedness, on the other hand, is an important covariate of a school being in deficit. An intra block comparison yields that connected schools are 2.7 percentage points less likely to be in deficit. Moving on to the level of economic development, as proxied by light density, it seems that it matters what region we are looking at. For the whole state, the more luminous places in fact have a greater deficit. However, as we make the comparison groups geographically narrower, thus taking into account other region level unobservable factors, we find that more developed places have a lower probability of having a deficit school.

Are schools that lack adequate number of teachers poorer in other school infrastructure? All three estimation exercises seem to suggest that this is so. The partial correlation is more precisely estimated when we compare schools within a block. This suggests a possible neglect of certain schools as compared to others in most school inputs. This also suggests that the deficit we observe is not an idiosyncratic phenomenon that may have been brought about by retirement of teachers. Rounding up the results, we find that older schools are less likely to be in deficit. These results are consistent with the notion that some schools are discriminated against, even after 2 years of the enactment of a policy drive to enact the Right to Education policy in the state.

Given the profile of the deficit schools, in this paper, we will attempt to transfer teachers locally from surplus schools. However, are surplus schools very different from deficit schools? We explore this in an analogous estimation exercise where the variable *surplus* takes the value 1 if the school has surplus teachers, relative to that mandated by law. Surprisingly, our results suggest it is the biggest schools that are in surplus. Schools with 201 students and above are 3.5 percentage points more likely to be in surplus, as compared to the reference category of schools (which also includes schools that just meet the mandated threshold). Hence, it would seem that, even within a block, big schools are both in surplus as well as in deficit. They are more likely to be in a rural district even though they don't correlate with economic development as measured by luminosity. Two factors that mirror the results from deficit schools are that they are likely to be in more connected schools as well as in older schools, even when we compare the schools within blocks. They are not better off in terms of school infrastructure.

Some of the differences between deficit and surplus schools, even in intra block comparisons, imply that block level transfers are unlikely to match source (the school that provides the teacher) and destination schools (the school which gets a teacher) in terms of many characteristics. The transfers therefore have to be more local to have any chance of matching source and destination schools. Hence we investigate possibilities of distance based local transfers in the next section.

3. Distance based Transfers

In this section, we discuss an algorithm that transfers teachers within a distance of 5 Km. We also conduct this exercise for a maximum distance of 10 Km. To begin with, in Figure 3, note the spatial distribution of surplus and deficit schools. As can be seen there are many pockets where surplus and deficit schools are contiguous and thus amenable to local teacher transfers. Of course given the relative differences in proportions of deficit and surplus schools, the gap can only be bridged by more teachers being hired in the aggregate. However, as the figure shows, there is a margin on which improvements can be made by such local teacher transfer policies.

There can be many possible objectives in designing redistribution rules. The one we choose is to minimize the proportion of schools with deficit. Even with this fixed objective, there can be many algorithms. Since the characterization of the optimal algorithm will depend on the specific spatial distribution of schools, we focus here on a simple algorithm that is feasible for policy. The algorithm involves a transfer between a surplus and deficit school as long as they are within a specified distance cut off. To consider what is ruled out are algorithms of the following type: Say the distance cut off is 10 km. Consider three schools A, B and C on a line where B is in the centre and A and C are on it's either side within the specified distance. Let A be surplus and C be deficit and B just meet the teacher requirement. Now, one can consider a transfer from A to B and then another transfer from B to C. This would not violate the distance criterion. However this would involve multiple transfers and would include a transfer from a surplus school to a school that meets the teacher requirement already. This would involve a substitution of a teacher in school B. We want to rule out these transfers as it may be hard to get across to policy makers why ones wants to transfer a teacher to a school that already meets the teacher requirement. It is much easier to convince policy makers of the need to move a teacher from a surplus school to a deficit school. Moreover, once one allows transfers involving school B, while one can do better, it is hard to compute what the optimal algorithm is, especially with the large number of schools involved. Hence in this paper we stick to simple transfers that always have as the source a surplus school and a deficit destination school, and we allow transfers within the stated distance range.[21]

The teacher transfer algorithm protocol is the following: Among schools that have a shortfall, we rank them in an ascending order: that is, starting with those with the least shortfall in teachers to those with the most shortfall.[22] The motivation for doing this, as mentioned above, is that we would like to minimize the proportion of schools with deficit. At the same time, we rank surplus schools in descending order of surplus teachers. The motivation for doing this is that taking away surplus teachers from schools that have more surplus is perhaps better than where there are less surplus teachers.[23] The algorithm is as follows: Begin with the first deficit school in the ordered list. The set of feasible surplus schools are the schools within the prescribed distance cut off. The surplus schools in this set are ordered by the initial ranking. Transfer as many surplus teachers from the most surplus school in the set as the deficit school needs. If the deficit is completely met, then we move to the school with the next rank in the

[21] More sophisticated exercises that use genetic algorithms do a better job in more complicated settings where there are lesser restrictions imposed (Chen et. al, 2015). However, experience from policy implementation of some recent matching algorithms have suggested that if the exact reasoning of the algorithms does not seem clear and fair to agents (teachers in this case) and policy makers (state education departments), these are protested and often reversed. For example, in a slightly different context, Pathak (2016) makes the point that school authorities often feel that algorithms that match students to schools are "unnecessarily complex".

[22] Shortfall is defined as the number of teachers needed to meet the teacher requirement as defined by the right to education act.

[23] We also ran algorithms where we sort surplus in ascending order and deficit schools in descending order but the protocol we follow is indeed the best procedure in terms of outcomes (results of other protocols available on request).

deficit set and continue the same exercise. If the deficit is not met, then we transfer teachers from the next ranked school in the surplus set and continue the process till the deficit is filled up. In case of ties, we choose randomly.[24]

An important piece of information that is needed for the local teacher transfer is the latitude and longitude of where the school is located. While the record for this state is fairly good, even here this information is lacking for 575 schools. Hence, we use information on the 8712 schools for which this information is available. The results provided can therefore be potentially improved if these latitude-longitude information are available.[25] Among 8712 schools, 31.94 percent of schools are in deficit where as 7.37 percent are in surplus.

The results of this algorithm are encouraging (Table 3). Given a surplus of 819 teachers, we find that the algorithm is able to make 636 transfers in the case of 10 km transfers and 484 transfers in the case of 5 km transfers. The proportion of deficit schools falls to 27.10 (from 31.94) in the case of a 5 km transfer. In the case of a 10 km transfer, the proportion of deficit schools is 25.42. In the case of the 5 km transfer this represents a fall in deficit schools by 14 percent where as the corresponding fall is 19.4 percent for a 10 km transfer (we compare the post transfer figures to 3041 deficit schools: this assumes that the deficit for 252 schools with missing geocodes would not be met even if location information were available for them). Even with this conservative assumption, this represents a non-trivial lowering of deficit, a fall in deficit of 400 to 600 schools, depending on the cut off distance for transfer.

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[24] As an alternative, one can begin with surplus schools and make transfers to deficit schools around. We find that these are equivalent procedures for most of the cases. In some cases, with ties, there can be some minor differences.

[25] Interestingly, it's the deficit schools that are more likely to have missing geo-codes.

There does remain, as one would imagine in such simple local transfers, some inefficiency. There are still 147 schools that are left with a surplus, where as there are still 2215 deficit schools. Figure 4 shows why this inefficiency remains. The spatial distribution of deficit schools are in many cases such that there are no neighboring surplus schools around them. Hence they are stuck with deficits. A state wide transfer would of course eliminate such inefficiencies but would require, in many cases, large dislocations: something that we are trying to avoid through local teacher transfers. However, our interpretation is that even with such simple rules, one can easily eliminate 14 to 19 percent of the deficit.

While a case for such redistribution can be made purely on equity grounds, there is some evidence that such redistribution can have over all positive effects. To give a sense of what this positive effect could be, we use the estimates calculated by Chin (2005) in the context of Operation Blackboard in India. As stated above, Operation Blackboard had a provision that a second teacher would be provided to primary schools with only one teacher. However, after implementation of the policy, there was no increase in the average number of teachers per school (also class sizes did not decrease). Hence the policy effectively redistributed teachers.[26] In this setting, Chin calculated that the most important impact of such a policy was that girls primary school completion rate increased by 1.6 percentage points for each OB teacher provided per 1000 students. This effect was as high as 2.23 percentage points for girls that came from households in the poorest income quartile. Moreover, the primary completion rates increased by about 1 percentage point for boys belonging to households in the bottom two

[26] The calculated effects are not the effect of one- teacher schools receiving a second teacher. In effect only one quarter to half OB teachers may have been sent to one-teacher schools but the policy led to a better distribution of teachers across schools.

quartiles of income. We use these estimates for calculating the impact of the increase in the number of transferred teachers. Recall that when teachers are transferred within 5 kms, the number of transferred teachers is 484 while the number of such transfers when the specified distance cut off is 10 kms is 636. Given the total number of children enrolled in primary school, these amount to 0.41 transferred teachers per 1000 students for a 5 km transfer rule. In the case of a 10 km transfer rule, the corresponding number of transferred teachers per 1000 students is 0.58. Thus the implied impact on girls primary completion rates are 0.65 and 0.9 percentage points for a 5 and 10 km transfer respectively. For girls in the poorest wealth quartile the corresponding impact on girls completion rates are 0.9 and 1.2 percentage points for a 5 and 10 km transfer respectively. To put these numbers in perspective, the primary completion rate for girls grew from 0.8 in 2008 to 0.85 in 2012. (Prakash, 2015) Hence the impact of even such a small redistribution is not insignificant given the demonstrated progress of primary completion rate of girls in the state. As a caveat, it must be pointed out that this is a back of the envelope calculation and the impact of redistribution in more recent settings is unknown and a topic for future research.

4. Source and destination schools: Characteristics

The local transfer policy has been designed with minimizing teacher displacement in mind. However being contiguous in a local area may imply that the source schools (where teachers are transferred from) and destination schools (where they are transferred to) share many characteristics. This would be especially true for the level of development of the local area. This is especially important keeping in mind the reluctance of many teachers to live close to village schools.

Our algorithm does very good in the context of Haryana in matching local development characteristics. We find that there is no difference between the source and destination schools in terms of whether they are in a rural school district or in terms of the luminosity based development indicator (Table 4).[27] Similarly, we find no difference in the connectivity between source and destination schools. This is especially important because, as we saw earlier, even at the level of a block, there were differences in connectivity between deficit and surplus schools.

The local nature of the transfers however doesn't necessarily imply that the source and destination schools should match in terms of school characteristics. We however find that the source and destination schools match up to each other, on an average in terms of school level infrastructural characteristics. There are two characteristics on which source schools are higher than destination schools. Source schools are statistically bigger in terms of enrolled students than destination schools. To an extent, this is an outcome of our transfer protocol. Bigger schools (in terms of enrolment) are not just more likely to be in surplus, but in fact have larger number of surplus teachers. On the other hand, schools with the lowest shortfall are in fact small. Hence a local transfer protocol that starts with the most surplus schools and least deficit schools will involve

[27] A t test of the difference in means is reported in Table 4.

transfers from bigger schools to smaller schools. Coincidently, this matches the evidence from Operation Blackboard analyzed by Chin (2005) where there was a de facto re-distribution from larger schools to smaller schools.

One big difference between the source and destination school is in terms of their vintage. Source schools are at least 4 to 5 years older than destination schools. This is an extension of the characterization obtained earlier and it remains intact even after a local transfer. We will come to an explanation of this later in the paper and show that this is a construct of a previous transfer policy.

To summarize, it would seem that local transfers do fairly well in terms of matching source and destination schools. However, the result is auxiliary in the sense that there may be ways to match schools within the district or block that do a better job but require great dislocation.

How does the suggested algorithm match up with teacher transfers that have occurred in the past? An argument can be made that what we suggest is not novel and that while not transparent, teacher transfers followed by the government also aim at low displacement. Hence we contrast our suggested redistribution rule to an actual policy that was followed post the passage of the Right to Education act in the state of Haryana in 2011.[28] A contrast would also help us evaluate how our algorithm compares to a real teacher transfer exercise in terms of the number of deficit schools that meet the law. We undertake such an exercise in the next section.

[28] The Right to Education act was passed by the Indian Parliament in 2009. But it had to be passed also by each state legislature.

5. Comparison to an Actual Transfer Policy

A large teacher transfer program was undertaken in the state under study. This was done post the passing of the Right to Education Act in 2011 by the state legislature. While details of what exactly was the protocol of the transfer are not available, a comparison of school level data on teachers for the years 2011-12 and 2013-2014 shows a rapid decline in the proportion of schools that were in deficit: a fall from 41 percent to 32.5 percent. In this section, we attempt to benchmark our algorithm against the actual outcome of this transfer policy. There are however three complications that arise in such a comparison. First, the rapid fall may hide a perverse fall in the PTR owing to a decline in students studying in government schools. In other words, if the schools that were initially in deficit saw an exit of students, then the proportion of deficit schools would fall without any increase in teachers. This is not what an ideal policy to improve equity across government schools should aim for. Whether this is indeed the case is therefore important to ascertain for a fair comparison of the algorithm to reality. A second complication is that since teacher transfers are not documented in government documents available publicly, it is not possible to match the source and destination schools. Third, there may some teacher attrition due to natural causes (for example, retirement) that cause teacher shortage in erstwhile non-deficit schools.

To address these complications, we first explore whether, by 2013, the number of students had declined in schools with low PTR in 2011-12. We use data from 9236 common schools between the two years and define as a dependent variable, *Less Students*, which takes the value 1 if there is a fall in total number of students in 2013, 0 otherwise.[29] Comparing across all schools, there is a positive correlation between initial PTR and the probability of lesser students in 2013 (Table 5), but this result is not statistically significant. However, once we control for block fixed effects, the coefficient of PTR becomes significant. It continues being significant even after we control for other covariates. These results are similar if, instead of PTR, we include a dummy for deficit schools. Hence the number of students in 2013 is endogenous to the initial deficit in teachers in 2011. Therefore, in order to compare with the algorithm, we fix the number of students to the 2011 level.[30]

Secondly, in order to lessen the impact of teacher loss which may render a non deficit school in 2011 as a deficit school in 2013, let us restrict our analysis to only deficit schools in 2011. We compare what proportion of these schools continue to be in deficit in 2013 with what our redistribution rule would have implied.

Since we compare the changes over 2011-2013 to outcomes of the 5 and 10 km transfer algorithms, we restrict our results to those schools for which we have geocoded information. There are 8794 schools for which we have such information. If we fix the number of the students in each school to what it was in 2011, then 26.62 percent of the 3625 deficit schools in 2011 would cease to be in

[29] The marginal fall in number of schools in 2013-14 is mostly due to issues of missing data in enrollment.

[30] An interesting result is that the number of enrolled students has fallen in older schools. This also explains why when we characterize the schools in 2013, we find that older schools are less likely to be in deficit.

deficit given the actual number of teachers in 2013.[31] If instead, one implemented a 5 km transfer rule, a larger 38.3 percent of deficit schools would come out of deficit. If a 10 km transfer rule were implemented, then 48.25 percent of the deficit schools would not remain in the red. Hence our algorithm outperforms the actual transfers made.

While the protocol of a distance based transfer is transparent, actual transfers are not always so. As a concluding exercise, it is interesting to contrast the results of the transfer from the algorithm to the actual transfer (Table 6). We look at the probability of a deficit school in 2011 remaining in deficit in 2013. Hence we define a variable *Still deficit* that takes the value 1 if the school is short of teachers, 0 otherwise. We correlate this probability to observable characteristics of the development, connectedness, school infrastructure and vintage of school. For calculating actual deficits, we consider deficits at 2011 student strength (Column 3) as well as 2013 student strength (Column 4). The actual deficits (Column 4) show that there is no correlation with any characteristic except the vintage of the school. However we have argued against using 2013 student strength given that it is a function of initial PTRs. Hence the relevant results are in column 3. Interestingly, the results are different using the local redistribution rule (columns 1 and 2) as compared to results obtained in column (3). We find that more developed areas (see coefficients of rural dummy as well as luminosity) are more likely to remain in deficit under our algorithm. When we consider the outcome of transfers in column (3), we find that the more developed areas are less likely to still remain in deficit. This means that transfers

[31] If we did not take into account the fall in students, 51 percent of the schools would not remain in deficit.

that have taken place have largely favored deficit schools in more developed regions.[32] Thus while the objective algorithm favors rural and less developed areas, the actual transfers favor the more developed regions.

6. Conclusion

Most developing countries of the world are marked by unequal access to teachers. Redistribution through transfers is a mechanism to bring equity to the system. However, teachers have preferences on where they want to work. Hence, there is a push back against an iron hand approach to transfers. For example, teachers in urban centers often refuse to move to rural places. Against this back-drop, we propose a transparent redistribution mechanism that dislocates teachers in surplus schools by less than a pre decided distance cut off. In this paper, we show that this has the potential to reduce the proportion of deficit schools that meet the law post transfer by 14 to 19 percent depending on whether we fix the cut off at 5 or 10 km. Further, given the local nature of the transfers, the donor and recipient schools are not significantly different, on an average, in terms of the development and connectivity of the area around the work place. A back of the envelope calculation yields a net positive impact of around 1.2 percentage points in girls primary completion rates for poor households from a 10 km transfer rule. Further, we contrast our redistribution rule to a real life transfer and show that while actual transfers may favor developed areas, our transparent rule provides better outcomes for village and economically disadvantaged places.

[32] We get similar results if consider the net increase in teachers as the dependent variable.

Most of the results obtained in this paper are dependent on the spatial distribution of schools and the distribution of characteristics across schools. Our work brings out the possibility that such local transfers may have the potential to make distributions of PTR better without hiring of more teachers. While the results are specific to the context of state, the rationale for using such redistribution rule using GIS tools is more broadly applicable. Given the recent availability of geocoded information for a vast number of public goods, our analysis calls out to larger role for using spatial location information for policy and planning.

References:

1. Beteille, Tara (2009). Absenteeism, Transfer and Patronage: The political Economy of Teacher Labor Markets in India. Stanford University.

2. Chen Chiu-Hung, Tung-Kuan Liu, Jyh-Horng Chou, Chung-Hung Tasi, Hsiu Wang (2015), Optimization of teacher volunteer transferring problems using greedy genetic algorithms, *Expert Systems with Applications*, Volume 42 (1), Pages 668–678

3. Chin, A. (2005), "Can redistributing teachers across schools raise educational attainment? Evidence from Operation Blackboard in India", *Journal of* Development Economics, 78, 384–405.

4. Fagernas, S. and P. Pelkonen (2012), "Preferences and Skills of Indian Public Sector Teachers", *IZA* Discussion Paper 6563.

5. Glewwe, P., N. Ilias, and M. Kremer (2010), "Teacher Incentives", *American Economic Journal: Applied Economics:* 2 (July): 205–227

6. Henderson, J. V., A. Storeygard and D. N. Weil (2012). "Measuring Economic Growth from Outer Space." *American Economic Review*, Vol. 102(2), 994-1028.

7. Kremer M., K. Muralidharan, N. Chaudhury, J. Hammer, and F. Halsey Rogers (2005), "Teacher Absence in India: A Snapshot", *Journal of the European Economic Association*, 3 (2-3), 658-67

8. Lavy V. (2009), "Performance Pay and Teachers' Effort, Productivity, and Grading Ethics," *American Economic Review*, 99, 1979 - 2011

9. Muralidharan, K. and V. Sundararaman (2013) Contract Teachers: Experimental Evidence from India, *NBER* Working Paper 19440

10. Muralidharan, K. and V. Sundararaman (2011): "Teacher Performance Pay: Experimental Evidence from India," *Journal of Political Economy*, Vol. 119, No. 1, pp. 39-77

11. Mulkeen, A. (2006), Teachers for Rural Schools: A challenge for Africa. World Bank, Association for the Development of Education in Africa.

12. Mehrotra, S. (2006), "Reforming Elementary Education in India: A menu of Options", International Journal of Educational Development, 26, 261 – 277.

13. Pathak, P. (2016), "What Really Matters in Designing School Choice Mechanisms", Prepared for Plenary talk of the 2015 World Congress of the Econometric Society in Montreal.

14. Prakash, N. (2015), "The Impact of Change in Primary Completion Rate on Learning Outcomes in India", Background paper prepared for the Education for All Global Monitoring Report 2015, UNESCO.

15. RTE (2012): The 3rd Year: The Right of Children to Free and Compulsory Education Act, 2009. A Publication of Department of School Education and Literacy, MHRD, Govt. of India.

16. Sharma, R. and V. Ramachandran (2009). The Elementary Education System in India: Exploring Institutional Structures, Process and Dynamics. Routledge.

17. Sherman D. J. and J.M. Poirier (2007), "Educational Equity and Public Policy: Comparing Results from 16 Countries", UNESCO Institute for Statistics, Working Paper No. 6, Montreal.

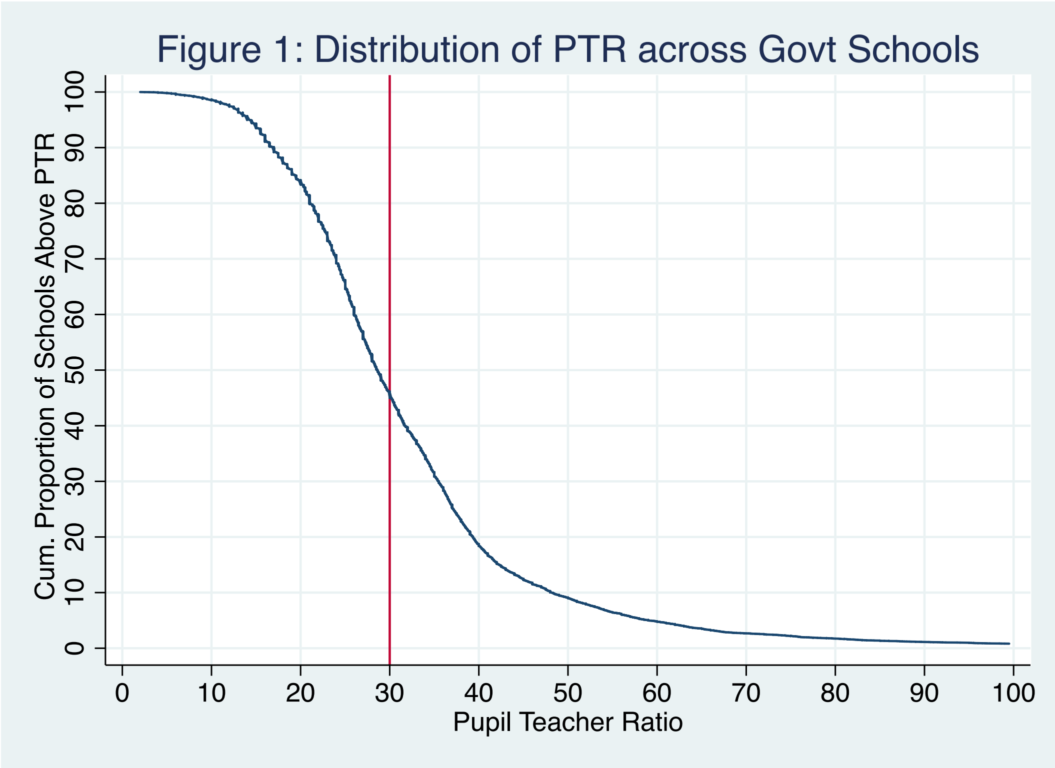
Figure 1: Distribution of PTR across Govt Schools
Cum. Proportion of Schools Above PTR
0
10
20
30
40
50
60
70
80
90
100
Pupil Teacher Ratio

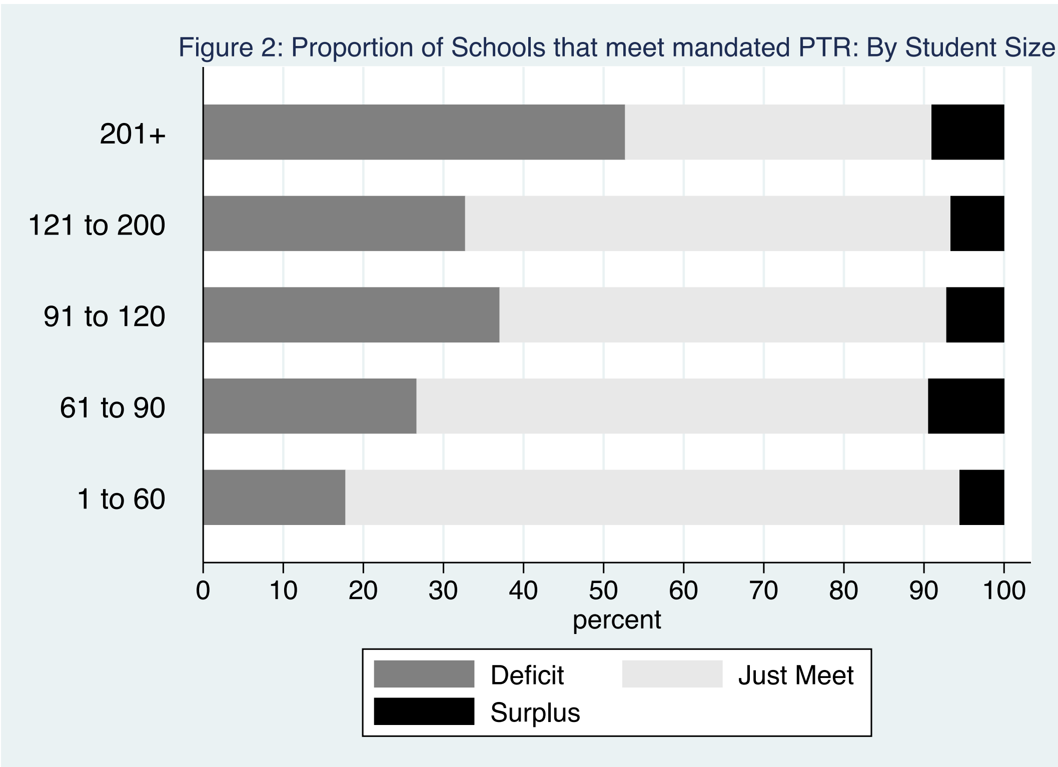
Figure 2: Proportion of Schools that meet mandated PTR: By Student Size
201+
121 to 200
91 to 120
61 to 90
1 to 60
0
10
20
30
40
50
60
70
80
90
100
percent
Deficit
Just Meet
Surplus

Figure 3: Spatial Distribution of Schools

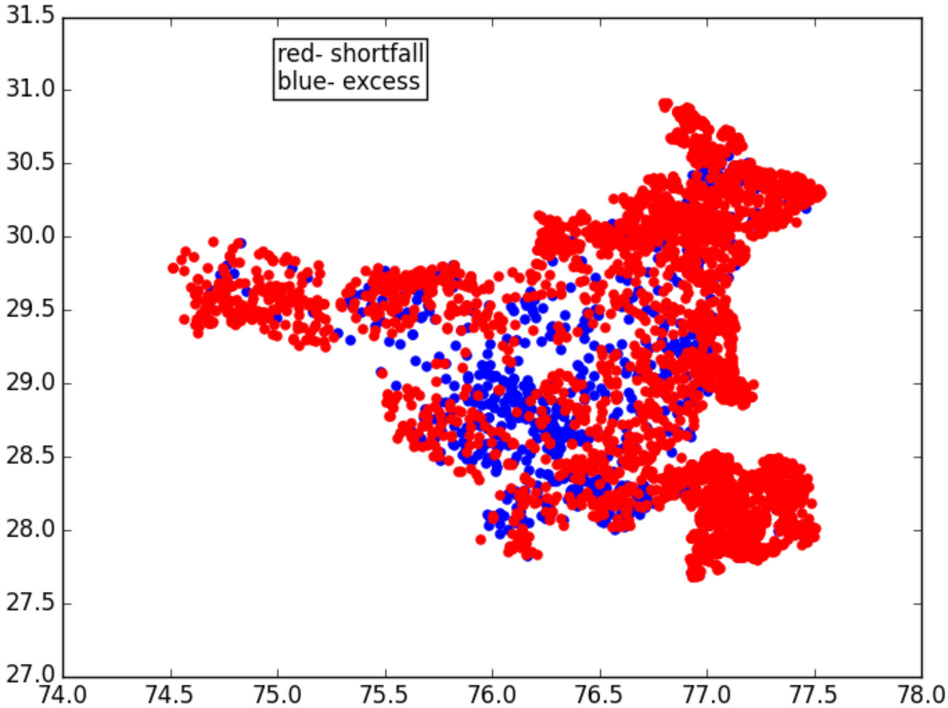

Figure 4: Post Transfer Distribution of Schools (5 Km)

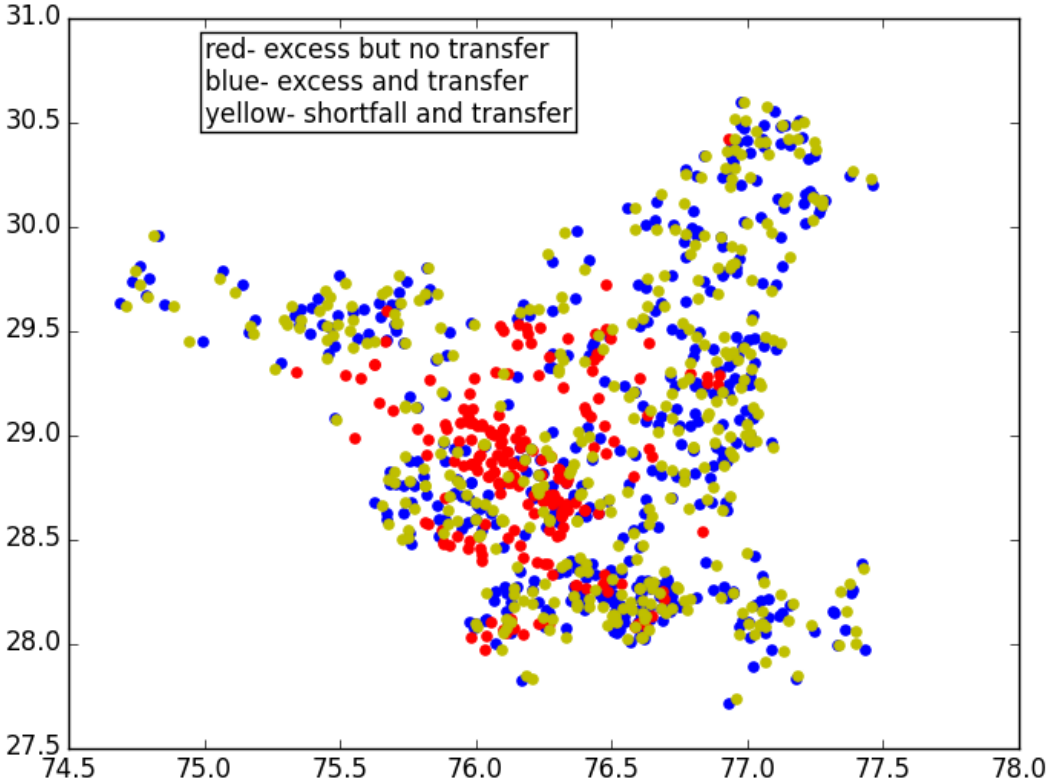

Table 1: Meeting Pupil Teacher Ratios: 2011-2013

Proportion of Schools	Percent 2011-12	Percent 2013-14
Deficit	41.11	32.74
Just Meet the Norm	41.03	60.01
Surplus	17.86	7.25
Total	9396	9287

Table 2: Correlates of Schools Deficit and Surplus in Teachers: Probit Marginal Effects

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Deficit	Deficit	Deficit	Surplus	Surplus	Surplus
Reference Category: School with No of Students 1-60						
Dummy: School with No. of Students 61-90	0.122***	0.133***	0.141***	0.0284***	0.0213***	0.0206**
	(0.0203)	(0.0211)	(0.0217)	(0.0104)	(0.00766)	(0.00828)
Dummy: School with No. of Students 91-120	0.246***	0.283***	0.289***	0.00528	0.00588	0.00274
	(0.0211)	(0.0220)	(0.0228)	(0.0103)	(0.00728)	(0.00763)
Dummy: School with No. of Students 121-200	0.203***	0.243***	0.260***	-0.00280	-0.000609	-0.00448
	(0.0194)	(0.0207)	(0.0216)	(0.00858)	(0.00606)	(0.00663)
Dummy: School with No. of Students 201 and above	0.390***	0.401***	0.407***	0.0252**	0.0336***	0.0350***
	(0.0214)	(0.0218)	(0.0228)	(0.0112)	(0.00959)	(0.0103)
Dummy: Rural India	0.00986	-0.0332	-0.0362	0.0166	0.0193***	0.0223***
	(0.0291)	(0.0283)	(0.0279)	(0.0124)	(0.00624)	(0.00674)
Dummy School is well connected	-0.0450***	-0.0195	-0.0278**	0.00933	0.00704*	0.0114**
	(0.0121)	(0.0123)	(0.0130)	(0.00596)	(0.00410)	(0.00458)
Total Local Night Lights Luminosity	0.00240***	-0.00138*	-0.00214**	-0.000910***	8.30e-05	0.000143
	(0.000710)	(0.000783)	(0.000848)	(0.000335)	(0.000241)	(0.000286)
School Infrastructure Index	-0.00481	-0.00565	-0.00919*	-0.00922***	-0.00208	-0.00161
	(0.00428)	(0.00436)	(0.00469)	(0.00217)	(0.00148)	(0.00172)
Years in Operation	-0.00296***	-0.00250***	-0.00231***	0.00116***	0.000644***	0.000718***
	(0.000288)	(0.000276)	(0.000296)	(0.000128)	(9.31e-05)	(0.000105)
District Fixed Effects	No	Yes	.	No	Yes	.
Block Fixed Effects	No	No	Yes	No	No	Yes

Table 3: Results of Transfer Algorithms

Pre Transfer Status	Pre Transfer (All)	Pre Transfer (GPS coded data)	5 Kms		10 Kms	
			Post Transfers	Change	Post Transfers	Change
Deficit	3041 (32.74)	2783 (31.94)	2361 (27.10)	-422	2215 (25.42)	-568
Just Meet	5573 (60.01)	5287 (60.69)	6095 (69.96)	808	6350 (72.89)	1055
Surplus	673 (7.25)	642 (7.37)	256 (2.94)	-386	147 (1.69)	-495
Total	9287	8712	8712		8712	

Table 4: Difference between the Source and Destination Schools

	Difference: Source - Destination	
	5 Km Transfer	10 Km Transfer
Location: Rural India	0.008	0.015
	(0.015)	(0.015)
School is Connected	0	0.012
	(0.028)	(0.026)
Night Luminosity	-0.057	-0.103
	(0.21)	(0.335)
School Infrastructure Index	0.011	-0.073
	(0.076)	(0.07)
Total Students	14.13**	12.31**
	(6.47)	(5.45)
Years in Operation	4.97***	5.65***
	(1.27)	(1.13)
	484	636

Table 5: Change in the Number of Students (2011-2013): Probit Marginal Effects

Less Students=1 if students in 2013 is less than students in 2011, 0 otherwise	(1)	(2)	(3)
VARIABLES	Less Students	Less Students	Less Students
Pupil- Teacher Ratio (2011)	0.000364	0.00220***	0.00277***
	(0.000282)	(0.000385)	(0.000412)
Dummy: Rural India			0.0941***
			(0.0266)
Dummy School is well connected			0.00794
			(0.0109)
Total Local Night Lights Luminosity			-3.41e-05***
			(7.07e-06)
Years in Operation			0.00252***
			(0.000259)
Block Fixed Effects	No	Yes	Yes
Observations	9,216	8,761[$]	8,497[#]

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

$: Block Dummies predict perfectly. Hence observations dropped

#: $ plus Missing data on covariates

Table 6: Probability of Deficit Schools in 2011 remaining Deficit in 2013: Marginal Effects

Dependent Variable: Still Deficit=1 if school in deficit, 0 otherwise	(1)	(2)	(3)	(4)
VARIABLES	5 Km Transfer	10 Km Transfer	Deficit (2011 student strength)	Deficit (2013 student strength)
Dummy: Rural India	-0.166***	-0.164***	0.0535	-0.0650
	(0.0325)	(0.0393)	(0.0339)	(0.0406)
Dummy School is well connected	-0.00795	-0.00999	0.00891	0.00806
	(0.0203)	(0.0219)	(0.0174)	(0.0220)
Total Local Night Lights Luminosity	0.000410	0.00257**	-0.003***	-0.000926
	(0.00112)	(0.00122)	(0.000927)	(0.00118)
School Infrastructure Index (2013)	-0.00372	0.00124	-0.00653	0.000671
	(0.00713)	(0.00765)	(0.00639)	(0.00743)
Years in Operation	0.000374	-7.34e-05	0.000525	-0.0010**
	(0.000415)	(0.000471)	(0.000372)	(0.000450)
District Fixed Effects	Yes	Yes	Yes	Yes
Observations	3,440	3,440	3,440	3,440

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A.1: Summary Statistics

Variables	Observations	Mean	St. Dev.
Dummy: Deficit School	8,558	0.32	0.47
Dummy: Surplus School	8,558	0.07	0.26
Dummy: School with No of Students 61 to 90	8,558	0.16	0.37
Dummy: School with No of Students 91 to 120	8,558	0.14	0.34
Dummy: School with No of Students 121 to 200	8,558	0.22	0.42
Dummy: School with No of Students 201 and above	8,558	0.20	0.40
Dummy: Rural India	8,558	0.92	0.27
Dummy: School is well connected	8,558	0.49	0.50
Total Local Night Lights Luminosity (in 00s)	8,558	17.28	11.91
School Infrastructure Index	8,558	0.03	1.38
Years in Operation	8,558	49.31	20.56