Enhancing educational outcomes: Non-compliance and non-response in a randomized school meals experiment*

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Abstract

Improving educational outcomes is at the centre of educational public policy in many developing countries. As part of this policy, school feeding interventions have recently been introduced as important devices. This study uses a unique and large-scale randomized field experiment to assess the effectiveness of such programmes on educational outcomes in rural Senegal. Test statistics indicate that overall, before the intervention, beneficiaries and non-beneficiaries are more homogenous at school level than at pupil level. We observe that attrition and partial adhesion coexist in the experiment, calling for a framework that embeds them simultaneously. Relying on the intention to treat (ITT) and the complier average causal effects (CACE), we find that the programme has a positive and significant impact on pupils' scores (aggregate, French and mathematics). It also increases enrolment and reduces dropout rates. However, it increases repetition rates. Cost-benefit analysis shows that the meals programme is a worthwhile investment for educational policy.

Key words: randomized experiment, school meals, educational outcomes, public policy, non-compliance and non-response
JEL Classification: I21, I38, C31, C34, C93, H43

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1 Introduction

In most developing countries, education policies and education inputs are the responsibility of the public sector. The demographic structure, especially youth population in these countries puts pressure on governments to implement appropriate policies to improve educational outcomes such as academic success, school participation and the literacy rate. This has become a priority goal of public education policy in sub-Saharan African (SSA) countries (CONFEMEN, 1999). Many development aids and programmes have been launched recently by international organizations and NGOs in partnership with national governments to support education in developing countries. These include school feeding programmes for which the most important vehicles in SSA are run by the Food for Education (FFE). Indeed, school meals are considered a policy instrument for achieving the Millennium Development Goals (MDGs), especially primary universal education and for reducing hunger. This paper aims to assess the effectiveness of such program in rural Senegal based on a randomized experiment featuring both non-compliance and non-response. We shall also elaborate on the public educational policy and how such programmes may be conducted alongside cost-effectiveness and cost-benefit analyses.

School feeding and other nutrition programmes are also part of strategies to achieve the goals of 'Education for All' set by the international community in 2000 in Dakar. To meet these objectives, the Global Initiative Food for Education was launched in 2001 by the USA, then replaced in 2002 by the FFE. The latter is the activity through which the World Food Programme (WFP) has supported the education sector in Senegal since the 1960s. This intervention aims at providing pupils with a regular diet and to promote children's access, especially girls, to basic education quality. It supports the government in achieving universal education for all children by the year 2015, which is one of the goals of the 10-Year Education and Training scheme (PDEF) and MDGs. WFP activities were implemented within the framework of two programmes, namely: the Country Programme (CP) from 2007-2011 and the Programme of Protracted Relief and Recovery Operation (IPSR) from 2008-2009 onwards.

These programs had three objectives: i) to improve the academic performance of pupils by contributing to better food quality supply, ii) to attract and keep pupils in school because in rural areas, school participation remains very low due to a widespread practice of child labour, and iii) to contribute to reducing household food poverty as the share of food expenditure in total household expenditure is very high (more than 70%). In this context, a large-scale randomized experiment of school meals was initiated in 2009 and 2010 in four rural regions of Senegal: two in the centre of the country (Diourbel and Fatick) and two in the south (Sédhiou and Kolda).[1] This programme was supported by the Senegalese, in particular the Ministry of National Education. The experiment focused on 120 schools covering about 4,110 pupils including 2,122 boys and 1,988 girls. Two surveys were conducted: the baseline data (before intervention) and the post-treatment data collection.

Experimental studies are increasingly used to measure the impact of policies or development programmes. However, they are not without their pitfalls. Horiuchi et al. (2007) pointed out that 'randomized experiments are more likely to yield unbiased estimates of causal effects than typical observational studies. This is because, the randomization of treatment makes the treatment and control groups equal on average in terms of observed and unobserved characteristics'. However, despite their benefits on observational studies, randomized experiments are often faced with drawbacks. Likewise, in controlled social science experiments, researchers often do not have perfect control of their target population because participants may choose not to follow instructions on the random assignment treatment or indeed not respond at all. This may lead to invalid causal inference due to partial adhesion (non-compliance) or attrition (non-response) or both simultaneously when they are not taken into account (see e.g. Horiuchi et al., 2007 and Esterling et al., 2011).

[1] It is worth noticing that several school feeding programmes were administered in Senegal. They were not implemented as randomized experiments, a fact that prevents their rigorous evaluation.

Very few studies report cases of attrition and/or non-compliance in the context of randomized school programmes. Vermeersch and Kremer (2004) examine the effects of subsidized school meals on school participation and educational achievement in pre-schools in Western Kenya. Despite sampling effort to minimize attrition, they observe high attrition rate (about 58%) among the core sample children. Kazianga et al. (2014) addressed the issue of the effect of school feeding on the nutritional status of children not yet in school using a randomized design of a programme in Burkina Faso. They found attrition to be balanced across treatment and control groups, and therefore did not introduce any bias into the treatment impacts. Linnemayr and Alderman (2011) investigates the impact of health inputs (from the 'Programme de Renforcement de la Nutrition': Nutrition Enhancement Programme, PRN) on the anthropometric status of children in three regions in rural Senegal. They mention the presence of non-compliance also termed as 'crossover effects' (individuals selected for the treatment may not take it up or individuals assigned to the control group who obtain the treatment).

Unlike these works, which report one of the problems (either attrition or non-compliance), our study deals with both issues simultaneously. Indeed, in this experiment, some pupils in the treatment group did not receive the school meals programme while other pupils in the control group did exhibit non-compliance. In addition, during the post-programme survey, the outcome of some pupils has not been collected, hence the presence of attrition (non-response) is likely. We will return to these issues in-depth in Sections 3 and 4. Given that non-compliance and non-response in our experiment do not occur completely at random, ignoring them can seriously distort the causal effect of the programme. Furthermore, in the presence of partial adherence, a standard intention-to-treat (ITT) effect which is informative for policy makers provides a valid inference of the effect of the assignment on outcome. However, one seeks to calculate the effect of receiving the treatment rather than the effect of the assignment. That is why in addition to ITT, the effect of receiving the treatment, which is called "complier average causal effect (CACE)", becomes essential. In this paper, in studying the impact of the experimental school meals programme on educational outcomes, we use a framework that simultaneously overcomes the issues of partial adherence and attrition (Horiuchi et al., 2007).

Three key findings have emerged from this study. The first step of our study was to conduct several tests to scrutinize the experimental design: homogeneity of the two groups (treatment and control), attrition and partial adherence. Relying on the baseline survey, we performed various tests (parametric and non-parametric) to check whether the two groups were homogeneous (treatment and control) before the implementation of the programme. The tests use outcome variables (aggregate, French and mathematics scores; enrolment, repetition, promotion and dropout rates) and are implemented at two levels: school and pupils. Recall that the unit of observation is the pupil but schools were also selected based on a number of criteria as we will describe in the next section. Test statistics show that, overall, before the implementation of the programme, the two groups are more homogenous at school level than pupil level.

The status of attrition indicates a significant difference between attritors and non-attritors. On average, the scores of non-attritors are higher than those of attritors. The differences are significant and are about 4 points. Repetition and dropout rates of attritors are significantly higher than those of non-attritors. There is also a significant difference between attritors in the treatment group and those in the control group. Therefore, attrition in the experiment does not occur at random. To test whether partial adhesion (non-compliance) occurs randomly, we compared the outcomes of pupils assigned to the treatment group and those who actually received the treatment and pupils assigned to the treatment group but who have not received the treatment. Pupils in the group assigned to treatment but who did not receive the treatment have the highest scores. There are no significant differences between the two groups for enrolment and dropout rates. For the repetition rate, the group of pupils who did not receive the treatment displayed the lowest rate, while the group that received the treatment showed the lowest rate of promotion. Therefore, partial adhesion does not occur at random either.

Using baseline and follow up surveys, we conduct comparison tests of the average outcomes for

the treatment and control groups. Contrary to what is observed before the implementation of the programme we find that the average scores of pupils in the treatment group are higher than those of pupils in the control group. There is almost a doubling of educational outcomes in the control group. This could be justified by two reasons. Firstly, when the implemented programme has a positive effect on academic achievement, the presence of a partial adhesion may increase pupils' achievement in the control group. Secondly, the first-pass score evaluations were carried out just after the summer holiday which officially lasts for three months, while those of the second passage took place at the end of the school year. The fact that the children remained a long time without learning may explain the poor results of the first evaluation compared to the second for the control group.

The second set of results concerns the effects of treatment. Given the presence of partial adherence, we compute the effect of intention-to-treat (ITT) and the complier average causal effect (CACE). We find that the meals programme has a positive and significant impact on the scores (aggregate, French and mathematics). The impact is greater on the mathematics score than on the French. We also observe that the CACE is larger than the ITT. For the aggregate and mathematics scores, the impact of the programme on girls is greater than on boys. By contrast, for the French score, the impact on boys is greater than on girls. We also find evidence of class effect, meaning that the programme more generally affects CE2 class pupils than those in CP.

Regarding the internal efficiency of schools, the results show that the meals programme increases enrolment and reduces dropout rates. However, it increases repetition. This result could be explained by the action taken by the government to remove repetition during the first year of each stage of primary school, and capped repetition rate at 5% maximum at the end of step (meaning second year - CP - and fourth year - CE2). The effect of the meals programme on dropout in the class CP is larger than that on the class CE2. This effect is higher for girls compared to boys. Regarding enrolment rate, we observe the reverse.

The last result is about policy analysis. In a context of scarce resources, the effectiveness of an educational public policy to promote quality of educational outcomes is determined by its effects and costs. On the one hand, cost-effectiveness and cost-benefit analyses enable the prioritization the levers of educational policy. On the other hand, they determine whether the programme is economically sustainable. To conduct the cost-effectiveness analysis, we used the information on the cost of school meals and the effect of the programme on beneficiaries. The results indicate that a deworming intervention is more cost-effective than school meals. The cost-benefit analysis assigns a monetary value to the measure of the effect before comparing the cost of the intervention. In other words it enables an understanding of whether the gains from school meals exceed the costs incurred. The gains were limited to additional revenues following from increasing the number of years of primary education obtained by pupils involved in the meals programme. We did not take into account other benefits arising from the programme. Such benefits could be for instance, an improvement in health or social welfare resulting from a change in the distribution of income in favour of the poorest households entailed by raising their level of primary education. We show that the meals programme is a worthwhile investment. However, we believe that this result underestimates the benefits of the programme, because it ignores other benefits arising from the programme (as we have mentioned above).

The following section places the study in the literature highlighting the main contributions. Section 3 describes the experimental design, data and variables. In Section 4 we present the validation of the experimental design with the descriptive statistics before and after the programme. Section 5 describes the analytical framework and the model used to assess the programme's impact. Section 6 presents estimation results. In Section 7 we undertake a policy analysis and discuss public policy challenges. Section 8 concludes the paper.

2 Contribution to the literature

Our results aim to contribute to the literature in three ways. Firstly, this paper aims to increase our knowledge on the operation and impacts of school feeding programmes in sub-Saharan Africa (SSA). Indeed, this study is among the first Randomized Control Trials (RCT) in the field of education in SSA, in particular francophone West Africa. In this literature, the main and commonly used outcomes to measure the effect of the intervention are test scores, enrolment, attendance, dropout and repetition rates. While some studies find that meals programmes have a positive impact on educational outcomes (Kazianga et al., 2009; Vermeersch and Kremer, 2004), others find negative impacts (Ahmed, 2004; Kazianga et al., 2009). Some other studies find no evidence that school feeding improves educational outcomes (Kazianga et al., 2009; Ahmed, 2004; Buttenheim et al. 2011).

Kazianga et al. (2009) evaluated an experimental programme of on-site meal and take home ration in Burkina Faso. They found a positive impact of the intervention on girls' schooling. However, contrary to our results where the meal programme positively impacts pupils' scores (agregate, French and mathematics), they did not find any significant impact on pupils' achievement (mathematics score) and cognitive development (the WISC and Ravens progressive matrices tests, and a digital span test). Consistent with our study, Kazianga et al. (2009) showed that there were no significant differences between treatment and control groups before implementation of the programme. They then conclude that the random assignment of villages to the treatment and control groups has been reasonably successful. Vermeersch and Kremer (2004) studied the impact of a randomized school breakfast programme on attendance and school achievement in Kenya. They found a positive impact of the programme on the school attendance of pupils benefiting from the programme. Contrary to our results, their analysis shows that the programme has only a positive impact on the educational outcomes of pupils who are in schools where there were experienced teachers before the start of the intervention. Ahmed (2004) evaluated the impact of school meals in Bangladesh on pupils' achievement of fifth-grade class in primary school. The author finds that the programme can only increase the score in mathematics. This result points to the same direction as the one we obtained in our analysis. Ahmed (2004) also found that the programme has a negative and significant impact on scores in English, but the size of the impact is very low.

Powell et al. (1998) estimated the impact of a breakfast programme at school in Jamaica on school attendance and pupils' achievement. Like in our field experiment, the programme has been implemented in schools where pupils come from poor families and travel long distance to reach school. The randomized selection has been made at schools and classes level. They conclude that the programme has a minor effect on school attendance and on pupils' achievement. Jacoby et al. (1996) found that an experimental breakfast program in Peru increased attendance rates of pupils in fourth and fifth year of primary school. The intervention lasted 30 days, which is too short to notice a sizable effect of the program. Using pre- program data, the authors found that there was no significant difference in school attendance rates between treatment and control groups. They also found that the program has a positive impact on attendance rates of beneficiaries. To fight against dropouts in the Philippines, the government has initiated a pilot school feeding between 1990 and 1992 in low-income areas. Tan et al. (1999) used the experimental data of this intervention to evaluate the impact of the programme on dropout rates and pupils' achievements. They found that the school feeding programme (alone or with a partnership between parents and teachers) reduces dropout rates. However, their results are not statistically significant, contrary to our analysis where we found that the meal programme significantly reduces dropout rates. Regarding the educational outcomes of pupils, the authors found that school feeding alone or with involvement of parents and teachers has a positive and significant effect on scores in English. In addition, school feeding through the involvement of parents and teachers had a positive and significant impact on mathematics scores, though very small.

The second contribution of our study concerns the simultaneous consideration of attrition and partial adhesion in assessing the impact of the school feeding programme. Indeed, very few studies

have been confronted with these problems in a context of randomization. The best known studies in the literature on nutritional and health programmes are those of Linnemayr and Alderman (2011), Kazianga et al. (2014) and Bobonis et al. (2006). However, these studies mention either one or the other of these issues: Linnemayr and Alderman (2011) for partial adhesion, Kazianga et al. (2014) and Bobonis et al. (2006) for attrition.

Kazianga et al. (2014) used an experiment in Burkina Faso to evaluate the impact of an on-site meal and take-home ration programme on the nutritional status (weight and height) of of-school children in the presence of attrition. They reported an attrition rate of about 7%. This rate is significantly lower than the attrition rate in our analysis which is approximately 28%. Unlike our study where the attrition does not occur at random, the authors argue that the attrition did not differ between treatment and control groups. Consistent with Kazianga et al. (2014), we find no significant differences between treatment and control groups before the intervention. They found that the take-home ration programme significantly increases the nutritional status of children while that of school meals had no significant effect. The correction of attrition has not changed significantly the results they obtained without attrition. Vermeersch and Kremer (2004) also faced with attrition issue. Their attrition rate (58%) is significantly higher than the attrition rate in our analysis. As in our study, they found that there were significant differences between the treatment and control group regarding attrition. To account for attrition, they used a replacement design of missing pupils.

Linnemayr and Alderman (2011) used an RCT in Senegal to evaluate the impact of a pilot nutrition programme on the nutritional status of children under 5 age in the presence of partial adhesion. The programme involved three poorest regions of Senegal (Fatick, Kaolack and Kolda) and took place between 2004 and 2006. The intervention consisted of a package of nutritional programme that includes deworming, iron supplementation, vitamin A and exclusive breastfeeding. They computed an effect of Intention-to-Treat (ITT) and an effect of treatment on the treated (TT) which corresponds to the CACE in our analysis. Relying on the baseline data, Linnemayr and Alderman (2011) concluded that before implementation of the programme, the treatment and control groups have similar outcomes. Our findings point to the same direction. Moreover, as regard the nature of partial adherence, our results are consistent with Linnemayr and Alderman (2011). Indeed, comparing the village group initially assigned to the treatment who actually received and those who did not receive, they found that the partial adhesion does not occur randomly. They found a significant ITT for most components of the package of nutrition. Similarly, they got a positive and significant treatment effect on the treated.

The third contribution of our study concerns the cost-benefit and cost-effectiveness analysis. Cheung and Perrotta (2011) reported that there are few studies that address the issue of cost-effectiveness analysis in the assessment of school feeding programmes. Based on an experiment conducted in Cambodia, the authors found that school feeding is more cost-effective than take-home rations when the goal is school attendance. They also found that the combination of school meals and take-home rations with deworming makes the package much more cost-effective thanks to the fact that the entire package attracts many more pupils. Miguel and Kremer (2004) found that deworming is far more cost-effective than other interventions with the aim of increasing school participation. Kazianga et al. (2014) found that take-home rations are more cost-effective than meals programme with the aim of increasing the nutritional status of young boys who do not attend school. The cost-effectiveness analysis by Tan et al. (1999) shows that meals programme that involves parents and teachers is more cost-effective than school meals only with the goal of increasing educational outcomes. So far, all these contributions undertake a cost-effectiveness analysis. In our research, in addition to conducting a cost-effectiveness study we also adopt a cost-benefit approach. The cost-effectiveness analysis shows that deworming is more cost-effective than the school feeding programme in terms of increasing pupils' performance. The cost-benefit analysis shows that the school feeding programme is economically profitable.

3 Experimental design

Different actors were involved in the implementation of this experiment. The main ones includes the World Food Programme (WFP), the Department of School Canteens (DSC) of the Ministry of Education, the National Institute of Study and Action for the Development of Education (INEADE), the Inspections of Education and Training (IEF)' school directors, teachers and communities. WFP provides food during each quarter and transports them to the beneficiary schools location. The DCS provides monitoring and coordination of the device of canteens management. Regarding IEF, the persons in charge of canteens have to monitor the functioning of canteens and write quarterly reports to WFP and to DSC. In each school, the operation of canteen is provided by a management committee which includes the school director, teachers, two representatives of pupils (one boy and one girl) and a representative of village notables. The management committee has three specialized committees responsible for food management, community participation to kitchen and meals. Teachers fill tracking sheets of the canteen under the supervision of the director who collects and transmits the documents to IEF.

The INEADE was responsible of the design and implementation of test scores and of the recruitment of evaluators. Pupils' parents are grouped into associations such as the Association of Parents or the Associations of Pupils' Mothers. These associations are responsible for ensuring the smooth operation of canteens and the payment of the financial contribution of households to the meals programme. Indeed, for a child to benefit from canteen, the household must pay a lump sum contribution of 200 FCFA per pupil and per month.[2] However, a pupil is not excluded from canteen if her/his family does not pay the contribution. Unfortunately, we did not have the identification of households who pay and those who do not. We do know that most households make the payment. There is a debate in the literature about the role of price in evaluating programmes (see, e.g. Cohen and Dupas, 2010). The idea is that people value more the interventions if they don't have it for free. In our case, the meals programme does not suffer from this problem.

3.1 Sampling

The intervention consisted of providing hot meals through school canteens located in rural primary schools in Senegal. Four regions (Fatick, Kolda, Diourbel and Sédhiou) of Senegal were chosen to conduct the experiment. The central regions (Diourbel and Fatick) are mainly composed of farmers and are closer to the capital (Dakar). The two others (Kolda and Sédhiou) are very isolated and located in the South of the country with mainly ranchers. These areas are characterized by high prevalence of poverty and vulnerability. Furthermore, food insecurity due to poor harvests, reduces household income and impoverishes the diet. Therefore the children are mostly at risk of acute malnutrition. The sample consists of pupils in the second and in fourth year of primary school (also termed CP and CE2 levels or grades in Senegal). Several reasons have guided the selection of these two grades. On the one hand, for reasons of cost of investigation, it was difficult to involve all pupils in each school. On the other hand, at the end of the second year of primary school, if the child cannot read and write, the probability to leave school before completing the cycle is very high. In addition, if after four years of primary education, skills in reading and writing are not vested, it is unlikely that the child can acquire the basic skills that education is supposed to provide him. Regarding the duration of treatment exposure, it is about 13 months, so the experiment lasted a little more than one school year.

The sampling strategy has been to first identify the geographic areas (regions) and to establish a population of eligible schools based on some criteria which are defined below. Then, a random sampling was drawn to select schools for participation in the programme. Finally random drawing

[2]Note that 200 CFA is equivalent to 0.419 U.S. dollars. Although this amount is very small, it is sufficient to sensitize rural households. This contribution is used to purchase ingredients which are not provided by the WFP such as fresh vegetables, fish, meat, cereals other than maize. Parents also supplies firewood for cooking meals and support the construction of kitchens and store rooms for the food. Communities are in charge of providing kitchen utensils for preparing meals.

was conducted in each school to select beneficiary pupils of the programme. Eligible geographical areas should meet the following criteria: i) be among the poorest regions of Senegal, ii) have a system of standardized assessment and iii) be in a priority area of partners involved in the implementation of the programme. Primary schools eligible for the experiment came from a set of schools provided by the Ministry of Education based on the following criteria: i) non availability of meals programme and health service package including deworming in schools, ii) have a number of pupils between 50 and 600, iii) have education grades of CP and/or CE2 iv) have a functional management committee and v) be located in a rural area. The selection criteria for pupils are: i) be in a class of CP or CE2 and ii) attend the class the day of the random selection of pupils.

On the basis of the above eligibility criteria, 167 schools were originally identified as eligible of which 120 are selected. Each region is administratively divided into departments and schools were distributed as shown in the Table 1. As can be observed, in addition to the four regions (Diourbel, Fatick, Kolda and Sédhiou), two others were originally eligible (Foundioune and Velingara) and are kept for use in case replacement in needed. Pupils in these two schools have also followed the treatment process and were divided between treated and control groups. The distribution of the final sample of schools across regions is proportional to the number of eligible schools by region.

Include Table 1

Once schools in the experiment have been stabilized, a random selection of pupils within each school was made. In schools where there has been more than one class of CP or CE2, a random drawing was conducted to have the class in which pupils will be drawn randomly. In each class, 20 pieces of paper were marked out of a total number of paper equal to the size of the class. Each pupil was then asked to choose a piece of paper. After the draw, the 20 pupils who got the marked papers were taken. In classes where the number of pupils was less than 20, pupils who attended the class the day of the draw were all taken.

After the random selection of pupils, standardized tests core were conducted before and after the intervention. The selected topics were mathematics and French and both tests were done at the same time. The INEADE was in charge of conducting and supervising the tests and also for the data entry. The INEADE has developed assessment booklets which are submitted to pupils to evaluate their academic performance. A collective of school directors (thereafter CODEC) was trained to implement the tests to pupils. The completed assessment booklets were then sent to CRES by the IEF. Correction, coding and computerization of notebooks from standardized tests was done by INEADE. The baseline survey in mathematics and French took place before March 2009. After implementation of the programme, the second survey took place throughout the month of June 2010. After the programme, another test was given to pupils passing in higher class and the old test was given to repeaters.

Despite the efforts of coordination, after the first survey, an audit of the entire experimental design conducted. It revealed that 20 schools in the control group were already equipped with canteens few years ago. Therefore, these schools were replaced by new schools and pupils who were already tested in the replacement group. In addition, some field issues occur during the second survey which result in non-response (attrition) and non-compliance (partial adherence). Indeed, some schools were already on vacation before the arrival of the persons in charge to test the pupils. Also, some classes in temporary shelters were closed early because of the raining season. Another problem is related to the delivery of completed books and questionnaires to persons in charge of canteens and then to CRES. Unlike the baseline survey, this device had not worked well during the second survey, and this causes a delay in the treatment of notebooks and questionnaires. Furthermore, to implement canteens, WFP and the Ministry of Education direct their annual resources to schools in the treatment group and not to those in the control group. The establishment of school canteens has taken much longer than expected. Canteens have actually started operation in January 2010 except for some which started in December 2009. Lastly, the audit also reveals that some pupils in the treatment group did not receive the school meals while other pupils in the control group did yielding the issue of non-compliance.

To conclude the sampling, it is worth to mention an interesting aspect of the planned experiment. Originally an experimental deworming programme at school was scheduled at the same time as the school lunch programme. Deworming is a health programme and its implementation conditions are subject to public health standards. Both interventions are designed to improve educational outcomes. In addition, in rural Senegalese context, deworming at school also aims to fight against deworming at home which is based on the use of traditional medicines without medical supervision. Unfortunately, owing to difficulties encountered in the field (logistical and financial), the deworming experiment was forsaken. However, we will use positively this 'disappointed hope' as policy based in Section 7.

3.2 Data and variables

3.2.a Data

We used two primary data set collected by CRES before and after the implementation of the school meals programme. The sample size is about 4,110 pupils including 2,122 boys and 1,988 girls, enrolled in rural primary schools in Senegal, particularly in CP and CE2 classes. The data provide information on educational outcomes (pupils academic achievements and internal efficiency of schools), characteristics of pupils and their households, characteristics of schools, teachers and classes and the characteristics of the community within which pupils live.

A school questionnaire were provided by directors selected by CODEC. The questionnaire includes information on school infrastructure, characteristics of teachers and of pupils. Information are also collected on how school canteens operate. They were filled by teachers under the supervision of school directors. In addition to the surveys, data on the academic performance of pupils were collected at the beginning and the end of the 2009-2010 school year through standardized assessments as earlier described. A household survey records information on all households of selected pupils, and the population census within five kilometres around each school was carried out by CRES. For the baseline survey, the investigation began in March, 2009 and spread until May, 2009. For the second one, the investigation began on June, 2010 and ended in mid-July, 2010. This survey collects information on pupils' household characteristics, on pupils themselves, on their environment and the community in which they live.

To check the accuracy of the survey, we also used a secondary data obtained from the Ministry of Education. These are about pupils' enrolment, school infrastructure, the number of repeaters by level of study and for the entire school, as well as the number of promotion by study level. This secondary data do not contain information on the number of dropouts. So, information on the admission to the college entrance examination from the Directorate of services and examinations can then be used to calculate the promotion and the dropout rates. The list and definition of all variables are given in the Appendix (Table 31). In the following, we highlight salient features of the outcome and control variables.

3.2.b Outcomes

The outcome variables used are gathered into two categories: pupils' performances (aggregate, French and mathematics scores) and the internal efficiency of schools (repetition, promotion, dropout and enrolment rates).

i) *Pupils' performances.* The scores were calculated in terms of items by taking the sum of correct answers given by pupils. Missing responses were considered incorrect responses (wrong answer). Each correct answer equal one, whilst each incorrect answer is zero. The score was then reported to 100, which is the overall percentage of correct answers. Each score was calculated as follows: for scores in French, it corresponds to the ratio of total good responses over the total items (questions) in French then multiplied by 100. Then this result represents the score of the pupil in French. The same procedure is used to calculate the mathematics score. The aggregate score is a weighted average of French and mathematics scores based

on the number of items in each discipline: the sum of total items obtained in French and in math divided by the total number of questions in French and in mathematics which is reported to 100 (multiplied by 100).

ii) *Internal efficiency of schools.* Data collected provide information about the total number of repetitions, dropouts and pupils per school for the six grades of the whole primary school including CP and CE2, as well as enrolment in the first grade (CI) from 2007 to 2010. The same data allows us to have the information on repetition of the school year 2010 which is only reported in 2011. Remember that the experiment was conducted in the 2009-2010. As the data collected was limited to the years 2009-2010, we used secondary data from the Ministry of Education to compute the repetition, dropout and promotion rates after programme. For the calculation of repetition rate for the year 2009, we take the ratio of the sum of repeaters of 2009 reported in 2010 over the total number of pupils in the school for 2009 school year.

3.2.c Controls

Our control variables are grouped into four categories: the characteristics of pupils, households, schools and teachers and the community where pupils live. We briefly reflect on them.

i) *Pupils characteristics.* We use the gender, age, grade (class or level of education), Koranic school, institution of childhood and the number of hours of work that the child spends doing housework per day.

ii) *Household characteristics.* Variables related to household characteristics are households' size per adult equivalent, literacy of the household head, gender of household head, number of livestock owned by the household, possession of arable land and marital status.

iii) *Characteristics of schools and teachers.* These include the number of classes in temporary shelters, the number of pupils per manual, the distance between the school and pupil home, the disturbances that have resulted to delays in the start of classes. Teacher characteristics considered are gender, age, training received by the teacher, academic qualifications and teacher absenteeism.

iv) *Community characteristics.* The environment where pupils live are the existence of a secondary school in the village, the number of primary schools in the community, and the variable 'Koranic school in the community' meaning whether the pupil live in a community where attending Koranic school prevent children from going to school.

4 Testing the experimental design

In this section, we explore the homogeneity of the treatment and control groups before the implementation of the programme. Firstly, we perform various tests to check whether there exists any differences in the mean or in the distribution of variables of interest (outcomes) for the treatment and the control group before the implementation of the programme. Secondly we study the attrition status as well as non-compliance in the experiment.

4.1 Before programme

As indicated earlier, the experimental design has defined two levels of selection: school and pupils. So, the unit of assignment in the current study combines these two entry points, although the ultimate beneficiaries of the programme are pupils. We then conduct the homogeneity test both at school and at pupil level. For each variable, we conduct the test of equality of mean of Student and the test of distribution of Mann-Whitney and Kolmogorov-Smirnov. The latter is performed only on continuous variables. The Levene test of equality of variance is conducted before the test

of equality of mean of Student. Lastly, we implement an overall test (for variables taken together) of homogeneity using multiple variances (MANOVA) and the Hotelling statistics.

4.1.a Homogeneity between groups at school level

The results of the Levene test at schools level are reported in Table 2. They indicate that the null hypothesis of equal variances for the variables household size, primary schools, livestock, number of hours, disturbance and marital status is rejected. Therefore, we perform the Student test of inequality of variances for these variables, and the Student test of equal variances for the remaining variables.

Include Table 2

The last column of Table 2 shows that, on average, there is no significant difference between schools in the treatment group and those in the control group for most variables. We do not observe significant differences between the two groups for all outcomes and for a number of control variables including: temporary shelters (1.718 for the treatment group against 1.576 for the control group); distance between school and home (0.814 for the treatment group against 0.809 for the control group); school manual (1.114 for the treatment group against 1.089 for the control group) and literacy of household head (0.180 for the treatment group and 0.166 for the control group). The results of the Student test shows that the two groups are homogeneous with respect to all outcomes of schools internal efficiency except for the enrolment rate for which the significance level is 10%. For control variables number of hours (0.19 hours per day in the treatment group against 0.13 in the control group); disturbance (0.845 in the treatment group against 0.614 in the control group) and Koranic school community (61.6% in the treatment group against 38.7% in the control group). For livestock, we have 8.95% for the treatment group against 14.8% for the control group.

The results of the non-parametric tests of Mann-Whitney and Kolmogorov-Smirnov are reported in Tables 3 and 4. They support the results from the parametric of Student for some variables. For example, we observe that there is no significant difference between the treatment and control groups for all score outcomes and for other variables including temporary shelters, school manual, teacher age, pupil age and primary school.

Include Tables 3 and 4

However, before the implementation of the programme, there are significant differences between the two groups of schools for a some other variables including enrolment rate, livestock, disturbance and Koranic school and variables. Regarding pupils' scores, on average, there is no significant difference between the two groups. However, the average performance of pupils in the treatment group are lower than those in the comparison group. Likewise, aggregate, French and mathematics scores are 37.743, 37.602 and 37.871 for the treatment group, whereas these scores are 41.357, 41.247 and 41.467 for the control group respectively. The differences are about four points in favour of pupils in the control group.

In terms of the internal efficiency of schools, there are no differences between the two groups for outcome variables except for the enrolment rate (-8.021% for the treatment group and -26.197% for the control group). Indeed, schools in the treatment group show the lowest promotion rate, but the highest dropout and repetition rates. In those schools, promotion, dropout and enrolment rates are about 80.617%, 14.706% and -8.021% respectively, while those in the control group are 83.200%, 12.564% and -26.197% respectively.

For variables such as livestock, number of hours, disturbance, Koranic school and Koranic school in the community, there is a significant difference between the two groups. Also, non-parametric tests in Tables 3 and 4 show that there are significant differences between the two groups for some variables. In Table 3 we observe a significant difference between schools in the treatment group and those in the control group for the outcomes French score, dropout and enrolment rates, and

for the variable livestock. In Table 4 we note a significant difference between the two groups for the outcomes dropout, promotion and enrolment rates, and for the variables number of hours and livestock.

As a whole, the results from the parametric (Levene and Student) and non-parametric (Mann-Whitney and Kolmogorov-Smirnov) tests at school level indicate that the two groups are homogeneous in most of variables. We then check the overall homogeneity of the two groups tacking all the variables simultaneously. To that end, we use the Hotelling test which is a generalization of the Fisher test and the MANOVA which is a multiple variance analysis. Table 5 report on the Hotelling test for equality of means. We see the two groups are identical regarding all variables taken together. The four tests performed by the MANOVA are show evidence of homogeneity, supporting the results from the Hotelling test. Therefore, the hypothesis of equality of mean vectors between the two groups is not rejected.

Include Tables 5 and 6

In conclusion, before implementing the programme, the tests at school level show that there is no significant differences between the two groups for most variables; whereas overall homogeneity tests show that there is no significant differences between the two groups. In what follows, we check the homogeneity of the two groups at pupil level.

4.1.b Homogeneity between groups at pupil level

Levene's test of equality of variances (see Table 7) shows that we cannot reject the hypothesis of equal variances for variables enrolment rate, school manual, household size, teacher age, grade, absenteeism, gender of teacher, continuing training, High school diploma and more, national certificate, gender of pupil, literacy of household head, and college. Therefore, we compute a Student test with the null hypothesis of equal variances for these variables while a Student test of unequal variance is computed for the remaining variables for which the assumption of equal variances is rejected.

Include Table 7

Contrary to the results of the tests performed at the school level, we see that, for most variables, there is a significant difference between the treatment group and the control group before implementation of the programme. Pupils' performances in the treatment group are lower than those in the control group. The aggregate, French and mathematics scores, are 37.158, 37.095 and 37.202 respectively for the treatment group, while in the control group these scores are 41.872, 41.627 and 42.117. The differences are around five percent points in favour of pupils in the control group. For the internal efficiency of schools outcomes, the average dropout rate is 17.784% for the treatment group and 12.204% for the control group, promotion rate (80.624% for treatment group and 84.408% for the control group), enrolment rate (-10.085% for the treatment group against -35.226% for the control group). The results show significant differences between the two groups. For the repetition rate (5.781% for the treatment group and 5.492% for the control group), there is no significant difference between the two groups.

For some control variables, schools in the treatment group display the most important means with significant differences. Among others, those variables are temporary shelters, distance to school, number of hours, disturbance, continuing training, high school diploma and more, Koranic school and Koranic school in the community. On average, we noted that in the treatment group, 1.7 classes are in temporary shelters (against 1.6 classes in the control group), 82.5% of pupils have their house located less than a kilometre from the school (against 78.1% of pupils in the control group) and 61.7% of teachers received a continuing training against 58.5% of teachers in the control group. Note that 45.9% of teachers in the treatment group have high school diploma and more, while they are 40.1% in the control group. Pupils in the treatment group work around 0.2 hours per day against 0.14 hours for pupils in the control group.

For variables household size, pupils' age, primary schools, livestock, absenteeism, national certificate, gender of pupil, land and college, the control group display the highest average compared to the treatment group. The household size in the control group is 9.883 persons on average against 9.526 persons in the treatment group. About 53% of pupils in the control group are boys against 50% of pupils in the treatment group. About 9% of schools in the control group report that their teachers are often absent from school against 5% of schools in the treatment group. We also observed that approximately 58.9% of teachers have an academic degree against 54.9% in the treatment group. Regarding community characteristics, 27% of schools in the control group are in villages where a college exists compared to 24% of schools in the treatment group.

However, for a number of variables, such as school manual, teacher age, gender of teacher, early childhood institution, gender of household head, literacy of head of household and marital status, there is no significant difference between the two groups. 18% of household heads are literate in the treatment and control groups and around 91% of them are men. Concerning the characteristics of pupils in each group, about 5% of them have gone through an earlier childhood institution.

In addition to the Levene test, the Kolmogorov tests of equal distribution are performed on continuous variables which indicates that the two groups are not equal in all variables (see Tables 8 and 9).

Include Tables 8 and 9

The Mann-Whitney test in Table 9 shows that the two groups are not homogeneous for continuous variables taken separately, except for the following variables: repetition rate, number of hours, teacher age and pupil age. As in the case of tests performed at school level, we check the overall homogeneity of the two groups by taking all the variables together. The Hotelling and the MANOVA test indicate that the two groups are not homogeneous in the baseline data (see Tables 10 and 11).

Include Tables 10 and 11

4.2 After programme: Status of non-response

In randomized experiments, non-response (or attrition) is likely. It occurs when outcome data are not recorded for some units after implementing the intervention. In our experiment, despite efforts to prevent attrition, from 4110 pupils, 1150 pupils have not been tested in the second survey (after the programme). We note an attrition rate of 27.98%. For the non-response, 518 pupils are part of the control group, while 632 pupils are part of the treatment group. The attrition rates for the treatment and control groups are 28.35% and 26.53% respectively. In terms of geographic distribution, over the 1150 pupils that have not been tested, 97 (8.43%) are in Diourbel, 266 (23.13%) in Sédhiou, 376 (32.7%) in Fatick and 411 (35.74%) in Kolda.

The non-response problem is mainly due to the fact that the team responsible for administering the tests went to regions during the rainy season. During this season, some pupils help parents in the fields. In addition, in some schools, classes in temporary shelters were not working because of the rainy season and therefore the pupils were absent. To check whether non-response occurred randomly, it is important to compare pupils for which we noted non-response, with those for which we do not have non-response problem. We distinguish two groups of pupils: pupils without non-response (hereafter non-attritors) and pupils with non-response (attritors). In what follows, we first compare attritors and non-attritors. Then, we compare the treatment status of pupils within each group (attritors and non-attritors). Finally, we compare attritors in the control group with those in the treatment group.

4.2.a Comparison of attritors and non-attritors

Comparing attritors to non-attritors enables to check whether non-response has occurred randomly or not in the sample (Duflo et al., 2008). Descriptive statistics of such comparison are reported in Table 12 using the baseline survey.

Include Tables 12 and 13

We observe that non-attritors have the highest scores. Indeed, the aggregate, French and math scores for non-attritors are 40.516, 40.370 and 40.663 respectively, while those for attritors are 36.082, 35.929 and 36.193. The differences are significant and are about four points in favour of non-attritors. For the internal efficiency of schools outcomes, the repetition rate of attritors is 6.435% and is significantly higher than that for non-attritors (5.373%). Likewise, the dropout rate of attritors (16.865%) is significantly higher than that of non-attritors (14.721 %). The promotion rate of non-attritors (82.882%) is also significantly higher than the promotion rate of attritors (80.739%). Considering some control variables, about 19% of household head in the non-attritors are literate against 16% in attritors. Also, attritors work in average 0.20 hour per day against 0.16 hour for non-attritors. On average, 1.7 classes in temporary shelters concern attritors compared to 1.6 classes for non-attritors. Overall, attritors have less literate household heads, the largest number of classes in temporary shelters and are mostly located more than one kilometre from school compared to non-attritors. Furthermore, the last column of Table 12 shows that there is or are no significant differences between the two groups of pupils for variables such as household size and primary schools. However, for other control variables such as school manual, pupil age, and Koranic school in the community, attritors display the highest value with significant differences.

Table 13 reports Hotelling test. For all outcomes and control variables taken together, there is a significant difference between the two groups of pupils at 1% level. In conclusion, before the implementation of the programme, attritor and non-attritors are not homogeneous.

4.2.b Comparison of attritors and non-attritors by treatment status

Table 12 also reports the comparison of attritors to non-attritors by treatment status. For the treatment group, there is significant differences between attritors and non-attritors for all outcomes. For some of the control variables, household size, literacy of household head, number of hours and Koranic school in the community, there is no significant differences between pupils according to their treatment status. However, for some other control variables, there are significant differences: temporary shelters (2.017 classes in temporary shelters for attritors against 1.665 for non-attritors), school manual (1.321 pupils per manual for attritors against 1.066 for non-attritors), pupil age (9.86 years for attritors against 9.49 for non-attritors) and land (89% of households have farmland for attritors against 94% of households for non-attritors).

For the control group, pupils' achievement shows significant differences between attritors and non-attritors. Also, there is significant differences for promotion and dropout rates. However, we do not find significant differences for the repetition rate. Unlike the treatment group, in the control group, there is no significant difference between attritors and non-attritors for most control variables. However, for temporary shelters, distance to school, number of hours and literacy of household head for other control variables, we find significant differences between attritors and non-attritors.

Include Tables 14 and 15

Tables 14 and 15 record the results of the Hotelling test for the treatment and control groups. They indicate, all variables taken together (outcomes and controls), a significant difference between attritors and non-attritors in the treatment group and in the control group.

4.2.c Comparison of attritors in the treatment group with those in the control group

Table 16 shows that, on average, attritors in the control group have the highest scores (aggregate, French and mathematics) with significant differences. The aggregate, French and mathematics scores for attritors in the control group are 39.762, 39.053 and 40.471, while for those in the treatment group we have 33.172, 33.459 and 32.811 respectively. The repetition and dropout rates in the treatment group (7.156% and 18.965%, respectively) are higher than those in the control

group (5.457% and 14.013%, respectively), with significant differences. The average for household size, livestock and land is higher for attritors in the control group. For variables temporary shelters, school manual, literacy of household head and pupil age, attritors in the treatment group have the highest averages.

Include Tables 16 and 17

Table 17 shows the results of the Hotelling test. There is significant differences between attritors in the treatment group and those in the control group. In conclusion, it is clear non-response does not occur randomly. Therefore, it is important to correct the attrition problem when assessing the impact of school meals programme on educational outcomes. We now proceed to compare the treatment and control groups after implementation of the programme.

4.3 After programme

4.3.a Descriptive statistics

Table 18 provides descriptive statistics for treated and control groups after implementation of the programme, as well as the evolution of each group between the two periods (see last two columns of the table).

Include Table 18

Contrary to what is observed before the implementation of the programme, on average, pupils' scores in the treatment group are higher than those in the control group. The scores in the treated group are 59.851, 56.694 and 62.563 for aggregate, French and mathematics scores, respectively. For pupils in the control group we have 54.308, 51.819 and 56.423. There is a significant difference in scores between the two groups. It is worth to note that educational outcomes have almost doubled in the control group. This may be due to two reasons. Firstly, when the programme has a positive effect on academic achievement, the presence of a partial adhesion (non-compliance) can contribute to increase the scores of pupils in the control group. Secondly, the first-pass tests were carried out just after the big holidays that officially lasted for three months, while second passage tests took place at the end of the school year. The fact that pupils remained a long time without learning may explain the poor results of the first test compared to the second.

On the internal efficiency of schools, the average repetition, promotion, dropout and enrolment rates in the control group are, 1.596%, 85.113%, 11.323% and -22.705%, respectively. For For the treatment group, we have 3.830%, 80.580%, 11.845% and -7.439%. The difference between the two groups is clearly significant.

However, for some variables, we do not find significant differences between the two groups after the experiment. These variables are, among others, dropout rate, temporary shelters, household size, teacher age, pupil age, absenteeism, continuing training, Koranic school, earlier childhood institution, literacy of household head and gender of household head. For variables: distance to school, number of hours, disturbance, gender of teacher, high school diploma and more, marital status and Koranic school in community, pupils in the treatment group have the highest average with significant differences. For variables: school manual, livestock, primary schools, gender of pupil, national certificate, land and college, pupils in the control group have the highest average with significant differences.

In terms of evolution between the two periods, there are no significant changes in the control group for some variables including temporary shelters, distance to school, household size, livestock, number of hour, primary schools, gender of teacher, continuing training, gender of pupil and college as can be seen in the last column of Table 18. In the treated group, there is no significant change between the two periods in the variables: distance to school, school manual, livestock, number of hours, land and continuing training. For instance, one observes that the number of classes under temporary shelters in the treatment group decreased from 1.71 to 1.65 between the two periods. For the control group, the figure remains almost invariant (it increases from 1.57 to 1.60).

4.3.b Partial adherence

Table 19 shows evidence non-compliance or partial adherence. All schools assigned to the treatment group did not receive the programme and some schools assigned to the control group received the programme. In fact, of 62 schools (2160 pupils) assigned to the treatment group, only 54 schools (1887 pupils) have actually benefited from the programme (87% of compliance). Of 58 schools (1950 pupils) assigned to the control group, 46 (1510 pupils) have not benefited from the programme (79% of compliance). So, 8 schools (273 pupils) in the treatment group have not benefited from the programme (13% of non-compliance), while 12 schools (440 pupils) in the control group benefited (21% of non-compliance). Table 20 presents the comparison between pupils assigned to the treatment group and those who actually received the treatment, and pupils assigned to the treatment group that did not received.

Include Tables 19 and 20

Regarding the academic performance of pupils, the group initially assigned to the programme, but did not receive treatment has the highest scores with significant differences. We do not find significant differences between the two groups of pupils in terms of dropout and enrolment rates. However, the repetition rate for the group of pupils that did not receive treatment is the lowest, while the group that received the treatment as planned displays the lowest promotion rate. As a result, partial adhesion did not occurs randomly. In the next section, we use the framework developed by Horiuchi et al. (2007) which has the advantage of addressing non-compliance and non-response simultaneously.

5 Econometric specification

Removing observations with non-response, as is often the case in experiments, produces biased and inefficient estimates (Horiuchi et al., 2007). Even if non-response occurs randomly, deleting observations with non-response changes the target population for which causal effects are estimated. This is true even when the missing data is not affected by the assignment mechanism and the treatment as non-attritors are generally systematically different from attritors. In addition to bias, inefficiency may follow from the loss of information due to the exclusion of some observations. Several approaches have been developed to correct attrition and partial adhesion simultaneously (Imai, 2006; Horiuchi et al., 2007; Esterling et al., 2011).[3] This section presents the empirical strategy of the study. Firstly, we introduce the framework of non-compliance and non-response. Then, we present the econometric specification.

5.1 Partial adhesion

The general statistical framework of random experiments with partial adherence and attrition was introduced by Angrist et al. (1996) and generalized by Frangakis and Rubin (2002). Let Z_i be the status of initial treatment equal to 1 if it is expected that pupil i receives a school meals and 0 otherwise. Let $T_i(z)$ be a potential treatment given the assignment to treatment $Z_i = z$. The effective treatment which is equal to 1 if the pupil has actually benefited from school meals and 0 otherwise is defined as follows: $T_i \equiv Z_i T_i(1) + (1 - Z_i)T_i(0)$. If it is anticipated that pupil i receives school meals (does not receive) but he does not (he receives), then $Z_i = 1$ ($Z_i = 0$) and $T_i(0) = 0$ ($T_i(0) = 1$) then $T_i = 0$ ($T_i = 1$). Remember that in our experiment, 13% of pupils in the treatment group do not benefit from the programme, while 21% in the control group does finally benefit from the programme.

Given the assignment to treatment, the potential outcome variable is: $Y_i(z) \equiv Y_i(Z_i = z)$. The actual outcome variable is: $Y_i \equiv Z_i Y_i(1) + (1 - Z_i)Y_i(0)$. We also define two types of individuals,

[3]Instrumental variables are often used to correct for non-compliance. However, the method becomes inefficient in the presence of attrition (Horiuchi et al., 2007; Esterling et al., 2011).

compliers and noncompliers. Compliers are pupils who remain in their initial treatment status ($T_i(1) = 1$ and $T_i(0) = 0$) while noncompliers are those who deviate from their initial treatment assignment status.

Let C_i be a variable of indicator of compliance that equal to 1 if the pupil i is a complier and 0 otherwise. One can distinguish three types of non-compliers. The 'always-takers' namely those who benefit from meals independently of whether they are assigned to the treatment group ($T_i(1) = T_i(0) = 1$), the 'never-takers', meaning those who do not benefit from the programme independently of whether they are assigned to the group of beneficiary ($T_i(1) = T_i(0) = 0$) and the 'defiers', those who benefit from the programme only when they are assigned to the control group ($T_i(1) = 0$ and $T_i(0) = 1$). In our experiment, there are always-takers because we have information on the status of adherence of pupils in the control group. Table 21 shows that from the observed data, we have the adhesion status of pupils in the treatment and control groups. A high proportion of compliers are paramount for a successful statistical analysis of randomized experiments. In this study, the proportion of complier is about 83%, which is higher than what is usually found in randomized experiments. For example in Horiuchi et al. (2007), the proportion of compliers is about 70%.

Include Table 21

5.2 Attrition

Since attrition may be affected by the assignment to treatment, it is important to introduce a potential response which is an indicator variable, $R_i(z)$ for $z \in \{0, 1\}$. For example, $R_i(1) = 1$ and $R_i(0) = 0$ means that pupils i will be tested (for scores collection) if assigned to the treatment group, but will not be tested if assigned to the control group. The observed indicator variable is given by $R_i \equiv Z_i R(1) + (1 - Z_i)R(0)$. Three approaches have been developed in the literature to capture attrition and partial adherence. The first (Little and Rubin, 1987) assumes the missing at random hypothesis (hereafter, MAR):

$$\mathbb{P}\left[R_i(z) = 1 | Y_i(z) = 1, T_i(z), Z_i, \mathbf{x}_i\right] = \mathbb{P}\left[R_i(z) = 1 | Y_i(z) = 0, T_i(z), Z_i, \mathbf{x}_i\right] \tag{1}$$

for all $t, z \in \{0, 1\}$, where $\mathbf{x}_i$ denotes a vector of pre-treatment variables. This hypothesis implies that after conditioning on the observed treatment status, as well as on pre-treatment covariates, attrition is no longer systematically related to the outcome. The latent ignorability (hereafter, LI) approach is an alternative hypothesis (Barnard et al., 2003; Frangakis and Rubin, 1999). It postulates:

$$\mathbb{P}\left[R_i(z) = 1 | Y_i(z) = 1, C_i, Z_i, \mathbf{x}_i\right] = \mathbb{P}\left[R_i(z) = 1 | Y_i(z) = 0, C_i, Z_i, \mathbf{x}_i\right] \tag{2}$$

for all $c, z \in \{0, 1\}$. In this assumption, the probability to observe the potential response $R_i(z)$ is conditional on the unobserved compliance covariate C_i rather than the observed treatment T_i. This makes the LI approach a more general than the MAR. The third hypothesis is the non-ignorability approach, NI (Imai, 2006). Contrary to the MAR and LI assumptions, the NI assumption relates the missing data mechanism directly to the values of the outcome variable itself. Formally we have:

$$\mathbb{P}\left[R_i(z) = 1 | T_i(1) = t, Y_i(1) = y, Z_i = 1, \mathbf{x}_i\right] = \mathbb{P}\left[R_i(z) = 1 | T_i(1) = t, Y_i(1) = y, Z_i = 1, \mathbf{x}_i\right] \tag{3}$$

for all $t, y \in \{0, 1\}$. This assumption means that the missing data mechanism does not depend on the assignment to the treatment once we condition on the outcome as well as the actual treatment received and observed pre-treatment covariates. The relevance of each assumption depends on the context of the experience. As a result, sensitivity analysis plays an important role when considering the robustness of the findings. It is worth to notice that, in order these assumptions to be fulfilled, it is important to include relevant predictors of the outcome variable among the $\mathbf{x}_i$. The use of

these variables also leads to an effective estimation of the causal effects as they allow to have an accurate prediction of the missing values of the outcome. Finally, it is important to note that in our experiment, there are no missing values on the outcome variables before the programme. We observe missing scores only after the intervention.[4] In the econometric framework below, we will use the LI assumption.

5.3 Model of partial adhesion and attrition

The model consists of two parts Bayesian modelling: the first describes the process of compliance and the second reflects on the outcome given the compliance status. We assume that the conditional probability of being a complier given pupils' covariates can be modelled within a probit framework with linear predictors:

$$\mathbb{P}(C_i = 1|\mathbf{x}_i) = \Phi(\mathbf{x}_i'\boldsymbol{\alpha}), \tag{4}$$

where $\Phi(.)$ is the cumulative distribution function of the standard normal distribution, $\mathbf{x}_i$ includes control variables that determine the compliance process, $\boldsymbol{\alpha}$ is the vector of coefficient to be estimated. Given the status of adhesion C_i, the assignment to treatment Z_i and observable variables $\mathbf{x}_i$, we model the outcome equation as a linear relation:

$$Y_i = \theta C_i Z_i + \beta C_i(1 - Z_i) + \mathbf{x}_i'\boldsymbol{\gamma} + \varepsilon_i \tag{5}$$

where ε_i is an iid error term, θ and β are intercepts related to compliers of the treatment and control groups respectively, and $\boldsymbol{\gamma}$ is the vector of parameters for the $\mathbf{x}_i$ which includes an intercept. Combining the two relations (4) and (5) we can write the likelihood function:

$$L = \prod_{i=1}^{N} \Big[\Phi(\mathbf{x}_i'\boldsymbol{\alpha})\varphi(Y_i|Z_i, \mathbf{x}_i)\Big]^{C_i} \Big[\big\{1 - \Phi(\mathbf{x}_i'\boldsymbol{\alpha})\big\}\varphi(Y_i|Z_i, \mathbf{x}_i)\Big]^{1-C_i} \tag{6}$$

with $\varphi(Y_i|Z_i, \mathbf{x}_i) = \frac{1}{\sigma_\varepsilon}\phi\left(\frac{Y_i - \theta C_i Z_i - \beta C_i(1-Z_i) - \mathbf{x}_i'\boldsymbol{\gamma}}{\sigma_\varepsilon}\right)$ where ϕ denotes the univariate standard normal density function. This likelihood function cannot be estimated directly because the value of the outcome variable Y_i is missing for some pupils due to attrition. We use the imputation method for missing data suggested by Horiuchi et al. (2007). This process is repeated until convergence holds. In the estimation procedure, independent prior distributions are assigned to θ, β and $\boldsymbol{\gamma}$ and the joint posterior distribution is sampled using a Markov chain Monte Carlo (MCMC) method.

5.4 Treatment effects

In this framework, two types of treatment effects can be computed, the intention to treat effect (ITT) and the complier average causal effect (CACE). The ITT is given by:

$$\text{ITT} = \frac{1}{N}\sum_{i=1}^{N}\Big[Y_i(1) - Y_i(0)\Big] \tag{7}$$

It represents the effect of being assigned to the treatment group rather than the effect of actually benefiting from the school feeding programme. Although the ITT does not represent the effect of the treatment actually received, from the perspective of the decision maker who would generalize the programme, ITT can be of great interest. However, in the presence of attrition, the estimated effect of ITT is not easy and requires additional assumptions about the missing data mechanism. Frangakis and Rubin (1999) show that taking this simple average difference yields biased estimation of the effect.

[4] See Barnard et al. (2003) for the problem of missing data before and after programme.

In addition, we may also be interested in estimating the effect of a programme on individuals who actually received the treatment. Given the assumptions on partial adherence and attrition, it is possible to identify the causal effect on beneficiaries (Angrist et al., 1996). We focus on the causal effect of treatment on participants. The complier average causal effect (CACE) is defined as:

$$\text{CACE} = \sum_{i=1}^{N} C_i \frac{[Y_i(1) - Y_i(0)]}{\sum_{i=1}^{N} C_i} \tag{8}$$

In this experiment, CACE represents the causal effect of the programme on pupils who benefit from the programme only when they are assigned to the treatment group. It is important to note that this effect is different from the sample average treatment effect (ATE), which concerns the entire population. Another interpretation of CACE is that it represents the ITT effect for compliers. As the ITT effect for non-compliers is zero under the assumption that the assignment to treatment does not directly affect the outcome variable, the CACE will always be larger than the ITT.

6 Estimation results

Recall that we study the effect of the school meals programme on two types of educational outcomes: pupils' performance (aggregate, French and mathematics scores) and internal efficiency of schools (enrollment, promotion, repetition and dropout rates). The presence of partial adhesion led us to first compute the intention to treat effect (ITT) before calculating the effect of the programme on those who actually received it (CACE).

In maximizing the likelihood function (Eq.6), we base our inference on Monte Carlo samples using three independent Markov chains, each of which has a length of 50,000 and is initiated at different sets of starting values. We found out that all parameters have the values of the Gelman-Rubin (GR) convergence statistic that are less than 1.01 (meaning $1 < \text{GR} < 1.01$). This statistic suggests that a satisfactory degree of convergence has been achieved. We discard the first 20,000 draws from each chain and retain the last 30,000. Thus, we based our inference on a combined total of 90,000 posterior draws. In the following subsections, we summarize the results focussing on the impact of the school meals experiment on educational outcomes.[5]

6.1 Impact of school meals on educational outcomes

Table 22 reports the ITT and the CACE effect for score outcomes. We observe that the school meals intervention has a positive effect on pupils' scores. For the aggregate score, the ITT is 4.318, while the CACE is 7.616 with a standard deviation of 0.726 and 1.267 for the ITT effect and the CACE, respectively. The confidence intervals show that these effects are significant.

Include Table 22

For the French score the ITT effect is 3.767 and the CACE is 6.645 with a standard deviation of 0.817 and 1.431, respectively. For the mathematics score, the ITT effect is 4.740 the CACE is 8.406 with a standard deviation of 0.804 and 1.407, respectively. Therefore, the effect of the intervention on mathematics score is higher than that of the French. As expected, we also observe that for all scores, the CACE is larger than the ITT effect.

Figure 1 plots the posterior distribution of the CACE and the ITT effects for the aggregate score, French and mathematics scores, respectively. All histograms show an almost normal distribution.

[5]To save space, further results including the estimation of the determinants of educational outcomes are not reported here but are available from authors upon request.

Include Figure 1

For the aggregate score, we observe that the CACE range between 4.5 and 10.5 and the ITT effect varies between 2 and 6.5. For the French and mathematics scores, one also sees that the CACE ranges from 4.5 to 10.5 and from 4 to 12.5 respectively. The ITT effects which are smaller than the CACE range from 1 to 6 and from 2.5 to 7.5 respectively. For policy makers this finding this patter is interesting because the effect of the school meals on pupils' achievements is positive everywhere. This means that on average, the impact of the programme is positive for all simulated parameters.

As for the internal efficiency of schools, Table 23 reports the impact of the intervention on enrolment, repetition, promotion and dropout rates. We observe that school meals lowers dropout rate and increases enrollment rate. However, the programme increases the repetition rate. This could be explained by the following situation. In order to fight repetition, the Government of Senegal has implemented some policies, namely suppressing repetition during the first year of each level in the primary cycle and cap at 5% the rate of repetition at the end of each level. The first year of each level in primary cycle are CI (first year), CE1 (third year) and CM1 (fifth year). The end of year in each step is CP (second year), CE2 (fourth year) and CM2 (sixth year). Probably, if some schools in the control group apply the measure while some schools in the treatment group did not, this can explain our findings. Our findings on dropout and enrolment rates are consistent with the results Kazianga et al. (2009). Relying on experimental data from Burkina Faso, they found that a school meals programme has a positive effect on enrolment. Our results are also consistent with Cueto and Chinen (2007) who found that an experimental programme of school breakfasts in primary schools lowered the dropout rates of pupils.

Include Table 23

Figure 2 displays the posterior distribution of the CACE and the ITT effects for enrolment and dropout rates. The ITT and the CACE are everywhere positive. The ITT effect ranges from 0 to 16 while the CACE is between 0 and 25. For the dropout rate, the ITT and the CACE are everywhere negative. The ITT ranges between -2 and 0 while the CACE between -3 and 0. These results indicate that the school meals programme lowers the dropout rate and boots the enrolment. Figure 3 shows the posterior distribution of ITT and CACE regarding repetition and promotion rates. For the repetition rate, one observes that the ITT and the CACE effects are everywhere positive. The ITT effect also ranges from 1.2 to 2.0 while the CACE ranges from 2 and 3.3. For promotion rate, we see that ITT and CACE are not everywhere negative. The ITT lies is between -1 and 1 while the CACE is between -2 and 1.9.

Include Figures 2 and 3

6.2 Impact heterogeneity

The treatment effects we calculated so far are averages over the entire population given treatment status. However, these effects may vary according to groups or types of pupils. In this section, we consider the effect of treatment on sub-groups according to gender and level of study. The gender effect of the programme is interesting for policymakers in poor countries. Particularly in rural areas as is the case of our experiment, several families see no need to educate girls who are often disadvantaged and kept home doing housework. An education policy that aims at promoting the enrolment and success of girls must take into account these rural characteristics. The heterogeneity of effects by level of study is also interesting. Indeed, recall that the target population of pupils is divided into two levels of study: CP and CE2. Therefore, scores tests administered to pupils reflect the level of study.

6.2.a Gender effect

Table 24 provides the treatment effects (ITT and CACE) of the programme by gender with regards pupils' achievements. For aggregate and mathematics scores, the impact of the programme on girls is greater than boys, while the effect on French score is greater for boys. According to the confidence intervals, all effects are significant. In fact, in the literature, results used to be mixed about the gender effect of schools meals programme (Ma, 2007). Table 25 gives the treatment effects of the meals programme for internal efficiency outcomes by gender. The enrolment rate of boys is greater than that of girls. In contrast, the table shows that dropout rates for girls are lower than those for boys.

Include Table 24 and 25

6.2.b Grade effect

We also examined whether the impact of the meal programme varies by level of study of the pupil. Table 26 shows positive effects. The impact of the programme on scores for pupils in grade CE2 is greater than those in grade CP. However, the difference is small.

Include Tables 26 and 27

The impact of the meal programme on internal efficiency by grade or class is given in Table 27. The programme has a positive impact on the promotion rate of pupils in grade CP. Clearly, the results presented in Table 23 indicate that the meal programme lowers the promotion rate. In addition, the impact of the programme in reducing dropout rate is greater for the youngest pupils which are in class CP than for those in grade CE2.

7 Policy analysis

The relevance of courses of action to improve educational outcomes is determined not only by the effects of interventions but also by their cost. An important issue in the analysis of a programme is then whether other options are more effective or beneficial than the evaluated programme. In a context of scarce resources, the effectiveness of an educational policy to promote quality is determined by the effects of the programme on educational outcomes and also the cost to achieve them. The cost-benefit and cost-effective analysis allow to inform policy about the relevance of program. The cost-effectiveness analysis is distinct from the cost-benefit. The latter assigns a monetary value to the measure of the effect before comparing the total expected costs of each option to the total expected benefits to see whether the benefits outweigh the costs and by how much. Cost-effectiveness analysis is used when it may be inappropriate to monetize the effect of an intervention. In this section, we conduct both analyses.

7.1 Cost-effectiveness

We use the cost-effectiveness analysis to relate the cost of the school meals programme to the impact on educational outcomes. The analysis provides a framework to inform policy about the investment options in the presence of resource constraints. The alternative option we use here is deworming. The rationale of this choice is four folds. Firstly, deworming and school meals are two interventions that can be complementary or substitutes depending on the objectives (e.g, Azomahou et al. 2014). Both interventions are often mentioned in the literature as candidates to improve educational outcomes (Miguel and Kremer, 2004; Linnemayr and Alderman, 2011; and Kazianga et al. 2014). Secondly, as we indicated in Section 3, a deworming programme at school was also considered at the same time as the meal programme. Unfortunately, field issues did not permit its implementation. For example, drugs had been already acquired but the establishment of

the medical team was delayed due to a lack of financial support.[6] In a sense, the abandonment of the deworming experiment motivates a cost-effectiveness analysis. Indeed, this allows us to inform policy on what would have been the best alternative between deworming and school meals. Lastly, such comparative approach using different interventions in different studies has been adopted in the literature. For example, Dhaliwal et al. (2012) show how to compare cost-effectiveness analysis using results from several programmes having the same objective (i.e. same outcome variable for all programmes) in different countries.[7]

To conduct the analysis, we need the cost of the meal programme and the cost related to each input. For the cost of the canteen, relying on information from the Ministry of education and the WFP, the annual cost per pupil is estimated to be approximately 13100 CFA. For the cost of the deworming, the Ministry of education documents that the annual cost per pupil is approximately 74 CFA. Given the costs of different interventions and the impact of each programme on outcomes as previously discussed, we can then combine the cost of each policy and its impact in calculating the cost-effectiveness ratio. By dividing the cost of each option by its effect, we get the cost of producing one unit of a given outcome. Therefore, for each option, we will have the cost of improvement of the academic achievement of 1 point. Once this is done, we can then define which programme requires the lowest cost to improving educational outcome by 1 point.

The percentage of additional score for deworming is taken from Azomahou et al. (2014). Table 28 reports the cost and impact of each intervention on scores as well as the ratio between the cost and percentage of additional scores for each intervention.

Include Table 28

This analysis shows that the deworming is by far the most cost-effective option in improving pupils' performance. It is important to remember that school feeding can have positive implications on the environment of the school, child health, poverty and well-being of households. However, in a context of scarce resources, sustainability of school feeding programmes shall largely depend on reducing related cost when the objective is to improve scores. Compared to previous results, relying on an experiment in Cambodia, Cheung and Perrotta (2011) noted that there are few studies that address the issue of cost-effectiveness analysis in assessing the impact of school feeding programmes. They found out that school feeding is more profitable than the rations on improving enrolment and attendance. They also found that the combination of school meals and rations with deworming is more profitable thanks to the fact that the entire package attracts many more pupils. Moreover, drugs against parasites are not cheaper and designing school canteen structure for meals programme. In the same vein, Miguel and Kremer (2004) found that deworming is far more cost effective than other options if the goal is to increase school participation.

7.2 Cost-benefit

We perform a cost-benefit analysis to determine whether the gains from school feeding programme exceed the costs engaged. The gains were limited to the additional incomes generated by an increasing years of primary education of pupils beneficiaries. So we did not take into account other benefits that would result from the programme like better health, or the welfare resulting from a change in the distribution of income in favour of the poorest households that will generate the increase of their level of primary education. To perform the cost-benefit analysis, we successively estimated the number of additional years of primary education, the additional incomes that are generated by the school feeding programme and the cost of the intervention for a pupil.

For the cost of intervention, we used the annual cost of the canteen per pupil which is about 13100 CFA as stated earlier. Without information allowing direct assessment of the increase in

[6] Given that the planning of the deworming experiment was relatively advanced before cancelation, opportunity arose for us to know the components of its cost.

[7] Their study includes 11 programmes in 6 countries (Kenya, India, Nepal, Dominican Republic, Madagascar and Mexico).

the number of years of education resulting from participating in treatment, in order to calculate the number of additional years of education (the experiment lasted about 13 months), we simulate the effects on the average years of schooling that we would obtain if we had several years of experiments. Relying on the post programme survey, we construct a pseudo-cohort after the programme implementation (year 2010). More specifically, we compute the transition rates by grade from the first year of primary school (CI) to the sixth and final year (CM2). The product of these quantities gives the expected number of years of schooling for a child who enters school in 2009.[8] This calculation is done for the treatment group and the control group. The difference is 1.8 which is the number of additional years of education gained from the treatment (denoted as). Moreover, we compute the additional incomes over the entire period of active life of the future adult with and without participation in the school feeding programme. We assumed as in the literature that active life begins at age 15 and ends at age 65. we adopt the following approach:

i) Relying on Mincer (1974) framework and data from the households' survey on follow-up of the poverty in Senegal (ESPS) conducted in 2011, we estimate the return of an additional year of primary education in Senegal (tr). To estimate this return, we used as dependent variable the income. As control variables, we used the highest grade completed by the individual, age, household head education level, marital status, gender, occupational category, number of years of experience, type of working contract. See Appendix for data and detailed results on the estimation of Mincer equation. This return is estimated as 0.069. This figure corresponds to the estimated coefficient of the co-variate 'highest grade completed by the individual'.

ii) The ESPS data are also used to estimate the average annual income of the pseudo-cohort at age 15, 16,..., and 65.

iii) From the estimated annual average income, we computed the present value of future incomes of a pupil in the control group using the following relation:

$$Y_{T=0} = \sum_{i=15}^{65} \frac{Y_i}{(1+r)^i}, \tag{9}$$

where Y_i denotes the annual income in millions of CFA currency corresponding to the year of active life i, and r the real discount rate which is assumed to be 3% and 5% as in Behrman et al. (2005).

iv) The present value of future incomes of a pupil in the treatment group is computed as:

$$Y_{T=1} = \sum_{i=15}^{65} \frac{Y_i(1+tr*as)}{(1+r)^i} \tag{10}$$

v) The economic gain or benefit of the school feeding program is obtained by computing the difference between the discounted income of pupils who benefit from the program and those who do not.

vi) Lastly, the ratio between economic gain and the cost of the school meals provides a measure of the rate of performance of the intervention. It is calculated as 3.43 (for the discount rate 3%) and 3.07 (for the discount rate 5%). As a result, the school meals programme is a worthwhile investment because its economic benefits exceed the costs involved. However, this result underestimates the benefits of the programme because it does not account for the improved health and social well-being due to programme participation.

[8] It is also possible to use Markov transition matrices to evaluate the treatment effect in terms of additional years of education (Behrman et al., 2005).

7.3 Public policy challenges

In many developing countries, school feeding is one of the strategies to reduce poverty, often in connection with educational, agricultural, health or social protection sectors.

In Senegal, the most disadvantaged geographic areas in education are those most affected by poverty, food insecurity and child malnutrition. Efforts that have been made by the government since the 2000s helped raise the gross enrolment and reduce dropout rates. However, primary education is still characterized by very high dropout rates with levels of knowledge of pupils below the minimum threshold of mastery (50%) or the level of mastery required which is 75%. The evaluations of pupils' achievement show that their knowledge levels are below these levels. In our study, before the implementation of the school lunch programme, we observe that the scores were below 50% of correct answers. After implementation of the programme, scores exceed 50% but do not reach the threshold mastery required (75%). It worthwhile noticing that in our study, the canteen programme lasted only one year. One may expect that with a long lasting intervention, the pupils' score would have reached the mastered required target.

To fight against hunger, improve health and nutritional status of children and the quality of education as well as the internal efficiency of schools, several food projects were implemented by the Senegalese government and international organizations, NGOs since the 1970s. Among these projects, the Senegalese government in collaboration with the World Food Programme set up social policies based on school canteens. The latter are designed to contribute to the development of public education in promoting equal opportunities, keeping children in school, improving enrolment rates, increased academic achievement and the fight against nutritional deficiencies of children. Our analysis shows that school feeding programmes can achieve the goals of keeping children in school, improving enrolment and improving academic achievement. The resulting first challenge in terms of policy will be the ability of policy makers to mobilize resources in order to generalize these pilot programs.

However, in our study, we do not address the issues of equal opportunities and the fight against nutritional deficiencies. School feeding can reduce inequalities between boys and girls and contribute to the empowerment of women. Drèze and Kingdon (2001) showed that a meal programme in India has a significant positive impact on the likelihood of completion of primary education by girls. Regarding the effect on the nutritional status of children measured through anthropometric indicators, the results are mixed (Arsenault et al., 2009; Ahmed, 2004; Buttenheim et al., 2011; Kazianga et al., 2014).

School feeding can also offer broader socio-economic benefits that remain as challenges for policy makers. These benefits focus on:

i) *The promotion of the local economy.* Promoting the local economy by purchasing local products fits within the scope of what is called 'Home Grown School Feeding (hereafter, HGSF)'. HGSF aims at promoting local agriculture to support and develop the local economy by increasing employment and income through school canteens (Sumberg and Sabates-Wheeler, 2011). A school feeding programme that uses local procurement can stimulate the growth of agriculture. Indeed, buying locally produced food prepared is an important factor in spreading the benefits of meal programmes to the people beyond the school (Kristjansson et al. 2007). Sonnino (2007) showed that local purchasing systems implemented in middle-income and high income countries have a positive effect on the local economy. Brinkman et al. (2007) showed that the annual income of smallholders in Kenya increase by $50 if the corn was purchased locally through school feeding programmes.

   In Senegal, since 2012, initiatives along the lines of integrated school feeding to local production have been set up. In this context, a pilot project of purchasing local products in the area of Kédougou (purchase of rice from local producers for school canteens) and an experimental project of community fields in the region of Kaolack to supply canteens school were initiated. No assessment of the impact of these pilot projects is made yet. These initiatives are still underway and should be strengthened.

ii) *New opportunities for development and investment.* School feeding programmes can also serve as a channel for new opportunities for development and investment. Indeed, governments and development partners can use school meal programmes to introduce basic infrastructures (clean water, sanitation, etc.), nutrition, health and hygiene, as well as protective technologies and environmental practices (efficient cooking stove, etc.). Investment in school feeding can also generate significant economic value and the combination of different direct effects of school feeding as privileged social protection that provides benefits in the short, medium and long run.[9]

In Senegal, school feeding is also considered as food safety net in the National Agricultural Investment Programme (hereafter, PNIA). In this programme, there is an investment plan for the period 2011-2015 which aims to give a major role to agriculture in economic growth, food security, poverty alleviation and ensure a more balanced distribution of agricultural activities between agro-ecological zones. The implementation of the PNIA will increase food availability and help reduce malnutrition.

As a social safety net, school feeding appears as a form of conditional transfer that promotes a transfer of significant value. According to Grosh et al. (2008), meals delivered at school represent alone about 11% of household income. This transfer of frees up resources within households, which allows them to buy food and invest in productive assets. This translates into improved livelihoods, nutrition and education. Transfer value may also induce an increase in enrolment and attendance, even in times when families who are vulnerable to food insecurity and whose purchasing power is weak would be tempted to withdraw their children from school.

In our study, the findings of the cost-benefit analysis showed that the costs of implementing school feeding are outweighed by the benefits that the programme has generated. These benefits were measured by the additional revenues generated by an increase in the number of years of primary school for beneficiaries pupils. As part of a cost benefit analysis they performed for Kenya and Laos in 2009, the Boston Consulting Group and World Food Programme have compared the costs corresponding to school feeding interventions and the benefits derived using three indicators: increase the level of education, improved nutrition and health and value transfer in favour of beneficiaries. It is clear from their analysis that school feeding leads to progress in terms of enrolment, attendance and cognition, lower dropout rates and morbidity and better disease awareness. All these factors have led to an increase in earnings and a lengthening of working life, so an increase in the amount of income received during life.

8 Conclusion

In this study, we use experimental data to assess the impact of a school meals programme on educational outcomes in the presence of attrition and partial adherence. We used outcome variables related to the academic performance of pupils (aggregate, French and mathematics scores) and the internal efficiency of schools (enrolment, repetition, promotion and dropout rates). We also conducted a cost-effectiveness and cost-benefit analyses. We use the baseline data to test the random assignment to the treatment. To this end, we carried out several tests: Kolmogorov-Smirnov, Mann-Whitney and Student. The results show that on average, the two groups are relatively homogeneous at the school level. However, at pupil level, the results show that differences exist between treatment and control groups. The results that emerge from this study show that the school meals programme significantly improve pupils' performances and enrolment rate, while reducing the dropout rate. The posterior distribution of the ITT effect and the CACE shows that the impact of the programme is not homogeneous across outcomes. The impact of the programme is positive for all scores (aggregate, French and mathematics) and is pronounced for the score in mathematics compared to French score. The impact is also greater for girls compared to boys for

[9]Social safety nets are a subset of social protection system. They are generally transfers in cash or in kind, with or without conditions and without contributions (e.g. school feeding, food against work, food stamps).

the mathematics score, while for the French score the impact is greater for boys than for girls. For policy analysis, the results show that despite the motivation of the meal programme in terms of economic gains, the cost-effectiveness analysis indicates that an alternative deworming programme would be more cost-effective.

This study calls for several research perspectives. The first is the impact heterogeneity of the school meals programme. Two types of heterogeneity can be accounted for. In our experiment, meals are not served every day and the number of days per week meals are served varies from one school to another (the number of days of preparation ranges between two and five per week). Hence there is a clear need to address the issue of heterogeneity caused by differences in treatment. Moreover, given the same treatment, the magnitude of treatment effects may vary from one pupil to another. Such heterogeneity is known as heterogeneity of treatment effect. Thus, the magnitude of treatment effects may depend on the beneficiaries. Another extension would be to study the long-term impact of the school meals programme by estimating the impact of the programme on health, nutrition and social welfare.

References

Ahmed, A. (2004): "Impact of feeding children in school: Evidence from Bangladesh," *International Food Policy Research Institute, Washington, D.C. Mimeo.*

Angrist, J., G. W. Imbens, and D. Rubin (1996): "Identification of Causal Effects Using Instrumental Variables," *Journal of the American Statistical Association*, (91), 444–472.

Angrist, J., and V. Lavy (1997): "The Effect of a Change in Language of Instruction on the Returns to Schooling in Morocco," *Journal of Labor Economics*, (15), S48–S76.

Arsenault, J., M. Mora-Plazas, Y. Forero, S. López-Arana, C. Marin, A. Baylin, and E. Villamor (2009): "Provision of a School Snack is Associated with Vitamin B-12 Status, Linear Growth, and Morbidity in Children from Bogota, Colombia," *The Journal of Nutrition*, (139), 1744–1750.

Azomahou, T., F. Diallo, and W. Raymond. (2014): "The Harmony of Programs Package: Quasi-experimental Evidence on Deworming and Canteen Interventions in Rural Senegal," *UNU-MERIT Working Paper 2014-026.*

Barnard, J., C. E. Frangaskis, and J. L. Hill (2003): "Principal Stratification Approach to Broken Randomized Experiments: A Case Study of School Choice Vouchers in New York (with Discussion)," *American Statistical Association*, (98 (462)), 299–311.

Becker, G. (1975): *Human Capital.* University of Chicago Press, Chicago, 2nd edn.

Behrman, J., P. Sengupta, and P. Todd (2005): "Progressing through Progresa: An Impact Assessment of a School Subsidy Experiment in Mexico," *Economic Development and Cultural Change*, 54(1), 238–275.

Bobonis, G., E. Miguel, and C. P. Sharma (2006): "Iron Deficiency Anemia and Shool Participation," *Journal of Human Ressources*, (41(4)), 692–721.

Bowles, S. (1972): "Schooling and Inequality from Generation to Generation," *Journal of Political Economy*, (80), S219–S251.

Brinkman, H., N. Aberman, M. Baissas, D. Calef, C. Gingerich, L. Subran, A. Gelli, M. Sharma, and A. Stoppa (2007): "Home-Grown School Feeding to Support Local Farmers in Africa," *Paper presented to the World Food Programme; Home-Grown School Feeding Project Debriefing Meeting, Rome, July.*

Buttenheim, A., H. Alderman, and J. Friedman (2011): "Impact Evaluation of School Feeding Programs in Lao PDR," *Journal of Development Effectiveness*, (3), 11–25.

Cheung, M., and M. Perrotta (2011): "The Impact of a Food For Education Program on Schooling in Cambodia," *Institute for International Economic Studies*, (766).

Cohen, J., and P. Dupas (2010): "Free Distribution or Cost-Sharing? Evidence from a Randomized Malaria Prevention Experiment," *The Quarterly Journal of Economics*, (125), 1–45.

CONFEMEN (1999): "Les facteurs de l'efficacité dans l'enseignement primaire: les résultats du programme PASEC sur neuf pays d'Afrique et de l'Océan indien," *Dakar: Secrétariat Technique Permanent de la CONFEMEN.*

Cueto, S., and M. Chinen (2007): "Educational Impact of a School Breakfast Programme in Rural Peru," *International Journal of Educational Development.*

Dhaliwal, I., E. Duflo, R. Glennerster, and C. Tulloch (2012): "Comparative Cost-Effectiveness Analysis to Inform Policy in Developing Countries: A General Framework with Applications for Education," *Abdul Latif Jameel Poverty Action Lab (J-PAL), MIT.*

Drèze, J., and G. G. Kingdon (2001): "School Participation in Rural India," *Review of Development Economics*, (5), 1–24.

Duflo, E., R. Glennerster, and M. Kremer (2008): "Using Randomization in Development Economics Research: A toolkit," *Handbook of Development Economics. In: Schultz, T.P., Strauss, J. (Eds.)*, (Volume 4), Chapitre 61.

Esterling, K. M., M. A. Neblo, and D. M. J. Lazer (2011): "Estimating Treatment Effects in the Presence of Noncompliance and Nonresponse: The Generalized Endogenous Treatment Model," *Political Analysis Advance Access.*

Frangakis, C. E., and D. B. Rubin (1999): "Addressing Complications of Intention-to-Treat Analysis in the Combined Presence of All-or-None Treatment- Noncompliance and Subsequent Missing Outcomes," *Biometrika*, (86(2)), 365–379.

——— (2002): "Principal Stratification in Causal Inference," *Biometrics*, (58(1)).

Grosh, M., C. del Ninno, E. Tesliuc, and A. Ouerghi (2008): "For Protection and Promotion: The Design and Implementation of Effective Safety Nets," *Washington, DC: World Bank.*

Heckman, J., A. Layne-Farrar, and P. Todd (1996): "Human Capital Pricing Equations with an Application to Estimating the Effect of Schooling Quality on Earnings," *The Review of Economics and Statistics*, (LXXVIII), 562–610.

Heckman, J., and S. Polachek (1974): "Empirical Evidence on the Functional Form of the Earnings-Schooling Relationship," *Journal of the American Statistical Association.*

Horiuchi, Y., K. Imai, and N. Taniguchi (2007): "Designing and Analysing Randomized Experiments: Application to a Japanese Election Survey Experiment," *American Journal of Political Science*, (51), 669–687.

Imai, K. (2006): "Statistical Analysis of Randomized Experiments with Nonignorable Missing Binary Outcomes," *Technical report. Princeton University.*

Jacoby, E., Cueto, and E. Pollitt (1996): "Benefits of a School Breakfast Programme Among Andean Children in Huaraz, Peru," *Food and Nutrition Bulletin*, (17), 54–64.

Kazianga, H., D. de Walque, and H. Alderman (2009): "Educational and Health Impacts of Two School Feeding Schemes: Evidence from a Randomized Trial in Rural Burkina Faso," *The World Bank Policy Research Working Paper*, (4976).

Kazianga, H., D. de Walque, and H. Alderman (2014): "School Feeding Programs, Intrahousehold Allocation and the Nutrition of Siblings: Evidence from a Randomized Trial in Rural Burkina Faso," *Journal of Development Economics*, (106), 15–34.

Kristjansson, B., M. Petticrew, B. MacDonald, J. Krasevec, L. Janzen, T. Greenhalgh, G. A. Wells, J. MacGowan, A. P. Farmer, B. Shea, A. Mayhew, P. Tugwell, and V. Welch (2007): "School feeding for improving the physical and psychosocial health of disadvantaged students," *Cochrane Database of Systematic Reviews*.

Linnemayr, S., and H. Alderman (2011): "Almost Random: Evaluating a Large Scale Randomized Nutrition Program in the Presence of Crossover," *Journal of Development Economics*, (96), 106–114.

Little, R. J., and D. B. Rubin (1987): *Statistical Analysis with Missing Data*. New York: JohnWiley & Sons.

Ma, X. (2007): "Gender differences in learning outcomes," *Document de référence pour le rapport mondial de suivi sur l'EPT*.

Miguel, E., and M. Kremer (2004): "Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities," *Econometrica*, (72(1)), 159–217.

Mincer, J. (1974): "Schooling, Experience and Earnings," *National Bureau of Economic Research*.

——— (1993): *Human Capital and Earnings*. Cambridge University Press, in mincer j., studies in human capital edn.

Powell, C. A., S. P. Walker, S. M. Chang, and S. M. Grantham-McGregor (1998): "Nutrition and Education: A Randomized Trial of the Effects of Breakfast in Rural Primary School Children," *American Journal of Clinical Nutrition*, (68), 873–879.

Sonnino, R. (2007): "Local School Meals in East Ayrshire, Scotland: A Case Study," *Paper presented to the World Food Programme*.

Sumberg, J., and R. Sabates-Wheeler (2011): "Linking agricultural development to school feeding in sub-Saharan Africa: Theoretical perspectives," *Food Policy*.

Tan, J. P., J. Lane, and G. Lassibille (1999): "Student outcomes in Philippine Elementary Schools: An Evaluation of Four Experiments," *World Bank Economic Review*, (13(3)).

Vermeersch, C., and M. Kremer (2004): "School Meals, Educational Achievement and School Competition: Evidence from a Randomized Evaluation," *Oxford University, Oxford Mimeo*.

Table 1: Schools eligible and selected for the experiment, 2009

Regions	Department	Schools eligible	Schools selected
Diourbel	Diourbel	18	11
Fatick	Fatick	41	37
	Foundioune	41	22
Kolda	Kolda	33	29
	Velingara	20	14
Sédhiou	Sédhiou	14	7
Total		167	120

Table 2: Levene and Student tests: School level, 2009

Variable	Treatment Mean	Treatment St.Dev.	Treatment # Obs.	Control Mean	Control St.Dev.	Control # Obs.	Levene test $Pr(F > f)$	Student test $Pr(\|T\| > \|t\|)$
Aggregate score	37.743	12.469	60	41.357	13.766	60	0.464	0.151
French score	37.602	11.652	60	41.247	14.025	50	0.173	0.139
Mathematics score	37.871	14.224	60	41.467	14.830	50	0.754	0.198
Enrolment rate	-8.021	47.299	60	-26.197	48.408	50	0.981	0.050^{*}
Repetition rate	5.656	7.160	60	5.277	6.345	49	0.389	0.772
Promotion rate	80.617	9.681	60	83.200	9.207	49	0.724	0.159
Dropout rate	14.706	7.604	60	12.564	7.716	50	0.909	0.1406
Temporary shelters	1.718	1.367	60	1.576	1.291	50	0.908	0.579
Distance to school	0.814	0.215	60	0.809	0.213	50	0.973	0.901
School manual	1.114	1.183	60	1.089	1.082	50	0.526	0.910
Household size[a]	9.566	2.687	60	10.193	3.711	50	0.018^{**}	0.322
Teacher age	32.009	4.627	60	32.378	4.520	50	0.871	0.674
Pupil age	9.670	0.660	60	9.744	0.667	50	0.931	0.562
Primary schools	1.233	0.499	60	1.551	1.308	49	0.000^{***}	0.113
Livestock	8.949	9.461	60	14.838	15.930	50	0.000^{***}	0.024^{**}
Number of hours	0.193	0.163	60	0.138	0.103	50	0.001^{***}	0.033^{**}
Disturbance	0.845	0.359	60	0.614	0.487	50	0.026^{**}	0.006^{***}
Absenteeism	0.083	0.278	60	0.08	0.274	50	0.908	0.949
Gender of teacher	0.810	0.309	60	0.842	0.309	50	0.986	0.593
Continuing training	0.618	0.358	60	0.613	0.401	50	0.404	0.944
High school diploma & more	0.439	0.391	60	0.427	0.369	50	0.684	0.866
National certificate	0.570	0.394	60	0.557	0.376	49	0.740	0.857
Gender of pupil	0.508	0.141	60	0.516	0.147	50	0.734	0.787
Koranic school	0.291	0.254	60	0.216	0.232	50	0.516	0.110
Early childhood inst.	0.038	0.088	60	0.052	0.093	50	0.674	0.432
Gender of household head	0.922	0.089	60	0.911	0.092	50	0.757	0.503
Lit. of household head	0.180	0.164	60	0.166	0.162	50	0.936	0.647
Marital status	0.953	0.048	60	0.947	0.070	50	0.006^{***}	0.586
Land	0.928	0.115	60	0.947	0.093	50	0.138	0.369
Koranic school com.	0.616	0.490	60	0.387	0.492	49	0.969	0.017^{**}
College	0.233	0.426	60	0.225	0.417	50	0.880	0.922

Note [a]: Household size per adult equivalent.
Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 3: Kolmogorov-Smirnov test: School level, 2009

Variable	Treatment Stat.	Treatment p-value	Control Stat.	Control p-value	Combined Stat.	Combined p-value	Corrected stat. p-value
Aggregate score	-0.163	0.233	0.030	0.941	0.163	0.461	0.382
French score	-0.223	0.066*	0.043	0.903	0.223	0.132	0.093*
Mathematics score	-0.140	0.343	0.016	0.985	0.140	0.659	0.582
Repetition rate	-0.072	0.753	0.078	0.717	0.078	0.996	0.993
Dropout rate	-0.024	0.969	0.302	0.007	0.302	0.014**	0.008***
Enrolment rate	-0.003	0.999	0.262	0.024	0.262	0.049**	0.032**
Promotion rate	-0.147	0.310	0.020	0.978	0.147	0.602	0.522
Temporary shelters	-0.023	0.971	0.083	0.685	0.083	0.991	0.985
School manual	-0.120	0.456	0.080	0.705	0.120	0.827	0.770
Number of hours	-0.026	0.962	0.203	0.105	0.203	0.209	0.156
Household size[a]	-0.126	0.417	0.063	0.803	0.126	0.774	0.709
Teacher age	-0.070	0.765	0.066	0.785	0.070	0.999	0.999
Pupil age	-0.180	0.171	0.093	0.622	0.180	0.340	0.269
Primary school	-0.089	0.652	0.000	1.00	0.089	0.983	0.972
Livestock	-0.236	0.047**	0.001	1.000	0.236	0.094	0.064*

Note [a]: Household size per adult equivalent.
Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 4: Mann-Whitney test: School level, 2009

Variable	Treatment # Obs.	Control # Obs.	rank test z	rank test $p > \|z\|$
Aggregate score	60	50	1.375	0.169
French score	60	50	1.615	0.106
Mathematics score	60	50	1.051	0.293
Repetition rate	60	49	-0.420	0.674
Dropout rate	60	49	-2.365	0.018**
Promotion rate	60	49	1.297	0.194
Enrolment rate	60	49	-2.144	0.032**
temporary shelters	60	50	-0.656	0.511
School manual	60	50	0.525	0.599
Number of hours	60	50	-1.981	0.047**
Household size[a]	60	50	0.600	0.548
Teacher age	60	50	0.213	0.831
Pupil age	60	50	0.702	0.482
Primary schools	60	49	0.557	0.577
Livestock	60	50	1.945	0.051*

Note [a]: Household size per adult equivalent.
Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 5: Hotelling test: School level, 2009

2-group Hotelling's T-squared = 44.253132
F test statistic: ((110-25-1)/(110-2)(25)) x 44.253132 = 1.3767641
H0: Vectors of means are equal for the two groups
F(25,84) = 1.3768
Prob > F(25,84) = 0.1416

Table 6: MANOVA: School level, 2009

Test	Statistic	dof	dof1	dof2	F	Prob > F
Wilks' lambda	0.7093	1	25.0	84.0	1.38	0.1416
Pillai's trace	0.2907		25.0	84.0	1.38	0.1416
Lawley-Hotelling trace	0.4098		25.0	84.0	1.38	0.1416
Roy's largest root	0.4098		25.0	84.0	1.38	0.1416
Number of obs.		110				

Table 7: Levene and Student Tests: Pupil level, 2009

Variable	Treatment Mean	Treatment St.Dev.	Treatment # Obs.	Control Mean	Control St.Dev.	Control # Obs.	Levene test $Pr(F > f)$	Stud. test $Pr(\|T\| > \|t\|)$
Aggregate score	37.158	18.720	1886	41.872	20.717	1648	0.000^{***}	0.000^{***}
French score	37.095	20.334	1886	41.627	22.639	1648	0.000^{***}	0.000^{***}
Mathematics score	37.202	20.951	1886	42.117	22.283	1648	0.000^{***}	0.000^{***}
Repetition rate	5.781	6.739	1886	5.492	5.951	1532	0.000^{***}	0.183
Promotion rate	80.624	12.634	1886	84.408	11.167	1532	0.000^{***}	0.000^{***}
Dropout rate	17.784	11.945	1886	12.204	10.252	1532	0.000^{***}	0.000^{***}
Enrolment rate	-10.085	54.123	1886	-35.226	53.365	1532	0.563	0.000^{***}
Temporary shelters	1.754	1.330	1886	1.655	1.438	1649	0.001^{***}	0.034^{**}
Distance to school	0.825	0.380	1886	0.781	0.413	1649	0.000^{*}	0.001^{***}
School manual	1.136	1.165	1886	1.164	1.159	1649	0.830	0.479
Household size[a]	9.526	5.704	1886	9.883	5.795	1649	0.508	0.065^{*}
Teacher age	31.828	5.742	1886	31.902	5.917	1649	0.207	0.707
Pupil age	9.623	1.687	1886	9.730	1.826	1649	0.000^{**}	0.071^{**}
Primary school	1.251	0.516	1886	1.680	1.411	1532	0.000^{***}	0.000^{***}
Livestock	9.098	17.721	1886	14.315	35.009	1649	0.000^{***}	0.000^{***}
Number of hours	0.202	0.632	1886	0.149	0.358	1649	0.000^{***}	0.001^{***}
Disturbance	0.847	0.359	1886	0.628	0.483	1649	0.000^{***}	0.000^{***}
Absenteeism	0.054	0.226	1886	0.092	0.290	1649	0.602	0.000^{***}
Gender of teacher	0.810	0.391	1886	0.808	0.393	1649	0.881	0.895
Continuing training	0.617	0.486	1886	0.585	0.492	1649	0.567	0.053^{*}
High school diploma & more	0.459	0.498	1886	0.401	0.490	1649	0.491	0.000^{***}
National certificate	0.549	0.497	1886	0.589	0.492	1532	0.643	0.018^{**}
Gender of pupil	0.504	0.500	1886	0.534	0.498	1649	0.925	0.080^{*}
Koranic school	0.290	0.454	1886	0.232	0.422	1649	0.002^{***}	0.000^{***}
Early childhood inst.	0.046	0.210	1886	0.056	0.230	1649	0.000^{***}	0.192
Gender of household head	0.918	0.273	1886	0.904	0.293	1649	0.002^{***}	0.141
Lit. of household head	0.189	0.391	1886	0.178	0.382	1649	0.332	0.400
Marital status	0.953	0.209	1886	0.947	0.223	1649	0.007^{***}	0.365
Land	0.925	0.263	1886	0.941	0.234	1649	0.000^{***}	0.048^{**}
Koranic school com.	0.569	0.495	1886	0.329	0.470	1649	0.033^{**}	0.000^{***}
College	0.249	0.432	1886	0.274	0.446	1649	0.196	0.092^{*}

Note [a]: Household size per adult equivalent.
Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 8: Kolmogorov-Smirnov test: pupil level, 2009

Variable	Treatment Stat.	Treatment p-value	Control Stat.	Control p-value	Combined Stat.	Combined p-value	Corrected stat. p-value
Aggregate score	-0.092	0.000	0.000	1.000	0.092	0.000	0.000***
French score	-0.091	0.000	0.000	1.000	0.091	0.000	0.000***
Mathematics score	-0.072	0.000	0.001	0.995	0.072	0.000	0.000***
Repetition rate	-0.084	0.000	0.081	0.000	0.084	0.000	0.000***
Dropout rate	0.001	0.995	0.304	0.000	0.304	0.000	0.000***
Promotion rate	-0.145	0.000	0.000	1.000	0.145	0.000	0.000***
Enrolment rate	-0.004	0.960	0.306	0.000	0.306	0.000	0.000***
Temporary shelters	-0.054	0.006	0.098	0.000	0.098	0.000	0.000***
School manual	-0.130	0.000	0.064	0.001	0.130	0.000	0.000***
Number of hours	0.000	1.000	0.029	0.222	0.029	0.440	0.423
Household size[a]	-0.041	0.047	0.011	0.795	0.041	0.095	0.088*
Teacher age	-0.053	0.006	0.078	0.000	0.078	0.000	0.000***
Pupil age	-0.033	0.138	0.021	0.454	0.033	0.076	0.261
Primary schools	-0.114	0.000	0.000	1.000	0.114	0.000	0.000***
Livestock	-0.096	0.000	0.000	1.000	0.096	0.000	0.000***

Note [a]: Household size per adult equivalent.
Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 9: Mann-Whitney test: Pupil level, 2009

Variable	Treatment # Obs.	Control # Obs.	rank test z	rank test $p > \|z\|$
Aggregate score	1886	1648	6.225	0.000***
French score	1886	1648	5.454	0.000***
Mathematics score	1886	1648	5.802	0.000***
Repetition rate	1886	1532	-1.255	0.209
Dropout rate	1886	1532	-14.242	0.000***
Promotion rate	1886	1532	8.256	0.000***
Enrolment rate	1886	1532	-13.366	0.000***
Temporary shelters	1886	1649	-3.724	0.000***
Distance to school	1886	1649	-3.243	0.001***
School Manual	1886	1649	3.508	0.000***
Number of hours	1886	1649	-1.036	0.300
Household size[a]	1886	1649	2.173	0.029**
Teacher age	1886	1649	-0.781	0.435
Pupil age	1886	1649	1.279	0.200
Primary schools	1886	1532	5.851	0.000***
Livestock	1886	1649	6.712	0.000***

Note [a]: Household size per adult equivalent.
Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 10: Hotelling test: Pupil level, 2009

2-group Hotelling's T-squared = 487.64363
F test statistic: ((3534-25-1)/(3534-2)(25)) x 487.64363 = 19.373203
H0: Vectors of means are equal for the two groups
F(25,3508) = 19.3732
Prob > F(25,3508) = 0.0000***

Significance levels: * : 10% ** : 5% *** : 1%

Table 11: MANOVA: Pupil level, 2009

Test	Statistic	dof	dof1	dof2	F	Prob>F
Wilks' lambda	0.8787	1	25.0	3508.0	19.37	0.000***
Pillai's trace	0.1213		25.0	3508.0	19.37	0.000***
Lawley-Hotelling trace	0.1381		25.0	3508.0	19.37	0.000***
Roy's largest root	0.1381		25.0	3508.0	19.37	0.000***
Number of obs		3418				

Significance levels: * : 10% ** : 5% *** : 1%

Table 12: Descriptive statistics on the attrition status, 2009

	Attritors			Non attritors			t-test
Variable	Mean	St.Dev.	# Obs.	Mean	St.Dev.	# Obs.	$p > \|t\|$
Full sample							
Aggregate score	36.082	19.332	924	40.516	19.856	2610	0.000***
French score	35.929	20.896	924	40.370	21.669	2610	0.000***
Mathematics score	36.193	21.338	924	40.663	21.736	2610	0.000***
Repetition rate	6.435	7.560	896	5.373	5.908	2522	0.000***
Promotion rate	80.739	12.563	896	82.882	11.944	2522	0.000***
Dropout rate	16.865	11.810	896	14.721	11.412	2522	0.000***
Temporary Shelters	1.793	1.289	925	1.678	1.413	2610	0.029**
Number of hours	0.205	0.508	925	0.167	0.528	2610	0.053*
Distance to school	0.741	0.437	925	0.827	0.378	2610	0.000***
School manual	1.251	1.264	925	1.113	1.121	2610	0.003***
Household size[a]	9.616	5.820	925	9.719	5.724	2610	0.638
Pupil age	9.864	1.882	925	9.605	1.701	2610	0.000***
Primary schools	1.436	0.990	896	1.446	1.059	2522	0.803
Livestock	10.027	19.668	925	12.065	29.532	2610	0.051***
Lit. of household head	0.161	0.367	925	0.192	0.394	2610	0.035**
Land	0.915	0.278	925	0.939	0.239	2610	0.014**
Koranic school com.	0.489	0.500	896	0.452	0.497	2522	0.052*
Treated group							
Aggregate score	33.172	18.195	516	38.659	18.702	1370	0.000***
French score	33.459	19.804	516	38.465	20.369	1370	0.000***
Mathematics score	32.811	20.187	516	38.856	21.003	1370	0.000***
Repetition rate	7.156	8.081	516	5.263	6.081	1370	0.000***
Promotion rate	79.324	13.177	516	81.113	12.394	1370	0.006***
Dropout rate	18.965	12.372	516	17.339	11.754	1370	0.008***
Temporary shelters	2.017	1.242	516	1.655	1.350	1370	0.000***
Number of hours	0.220	0.560	516	0.194	0.657	1370	0.425
Distance to school	0.792	0.405	516	0.837	0.369	1370	0.023**
School manual	1.321	1.386	516	1.066	1.062	1370	0.000***

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Table 12 – continued

Variable	Attritors Mean	St.Dev.	# Obs.	Non attritors Mean.	St.Dev.	# Obs.	t-test $p > \|t\|$
Household size[a]	9.289	5.592	516	9.615	5.745	1370	0.269
Pupil age	9.868	1.824	516	9.493	1.614	1370	0.000***
Primary schools	1.312	0.565	516	1.229	0.495	1370	0.001***
Livestock	7.868	16.387	516	9.561	18.183	1370	0.064***
Lit. of household head	0.180	0.384	516	0.192	0.394	1370	0.538
Land	0.891	0.311	516	0.937	0.241	1370	0.000***
Koranic school com.	0.577	0.494	516	0.567	0.495	1370	0.685
Control group							
Aggregate score	39.762	20.108	408	42.566	20.874	1240	0.017**
French score	39.053	21.828	408	42.474	22.845	1240	0.008***
Mathematics score	40.471	22.002	408	42.659	22.357	1240	0.085***
Repetition rate	5.457	6.657	380	5.503	5.695	1152	0.895
Promotion rate	82.659	11.418	380	84.985	11.028	1152	0.000***
Dropout rate	14.013	10.354	380	11.607	10.152	1152	0.000***
Temporary shelters	1.511	1.293	409	1.703	1.480	1240	0.019**
Number of hours	0.186	0.435	409	0.136	0.328	1240	0.013**
Distance to school	0.677	0.468	409	0.816	0.387	1240	0.000***
School manual	1.162	1.087	409	1.164	1.182	1240	0.975
Household size[a]	10.028	6.078	409	9.835	5.700	1240	0.558
Pupil age	9.733	1.947	409	9.729	1.785	1240	0.972
Primary schools	1.605	1.353	380	1.704	1.429	1152	0.233
Livestock	12.750	22.886	409	14.832	38.166	1240	0.297
Lit. of household head	0.136	0.344	409	0.191	0.393	1240	0.011**
Land	0.946	0.225	409	0.940	0.236	1240	0.659
Koranic school com.	0.371	0.483	380	0.315	0.465	1152	0.047**

Note [a]: Household size per adult equivalent.
Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 13: Hotelling test: attritors vs. non-attritors, 2009

2-group Hotelling's T-squared = 169.32652
F test statistic: ((3534-25-1)/(3534-2)(25)) x 169.32652 = 6.7270378
H0: Vectors of means are equal for the two groups
F(25,3508) = 6.7270
Prob > F(25,3508) = 0.0000***

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 14: Hotelling test for treatment group: attritors vs. non-attritors, 2009

2-group Hotelling's T-squared = 160.62421
F test statistic: ((1886-25-1)/(1886-2)(25)) x 160.62421 = 6.3431219
H0: Vectors of means are equal for the two groups
F(25,1860) = 6.3431
Prob > F(25,1860) = 0.0000***

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 15: Hotelling test for control group: attritors vs. non-attritors, 2009

2-group Hotelling's T-squared = 117.9328
F test statistic: ((1648-24-1)/(1648-2)(24)) x 117.9328 = 4.8452038
H0: Vectors of means are equal for the two groups
F(24,1623) = 4.8452
Prob > F(24,1623) = 0.0000***

Significance levels: * : 10% ** : 5% *** : 1%

Table 16: Descriptive statistics of attritors by treatment status, 2009

	Attritors in control			Attritors in treatment			t-test
Variable	Mean	St.Dev.	# Obs.	Mean	St.Dev.	# Obs.	$p > \|t\|$
Aggregate score	39.762	20.108	408	33.172	18.195	516	0.000***
French score	39.053	21.828	408	33.459	19.804	516	0.000***
Mathematics score	40.471	22.002	408	32.811	20.187	516	0.000***
Repetition rate	5.457	6.676	380	7.156	8.081	516	0.000***
Promotion	82.659	11.418	380	79.324	13.177	516	0.000***
Dropout rate	14.013	10.354	380	18.965	12.372	516	0.000***
Temporary shelters	1.511	1.293	409	2.017	1.242	516	0.000***
Distance to school	0.677	0.468	409	0.792	0.405	516	0.000***
Number of hours	0.186	0.435	409	0.220	0.560	516	0.312
School manual	1.162	1.087	409	1.321	1.386	516	0.057**
Household size[a]	10.028	6.078	409	9.289	5.592	516	0.055**
Pupil age	9.733	1.947	409	9.968	1.824	516	0.058**
Primary schools	1.605	1.353	380	1.312	0.565	516	0.000***
Livestock	12.750	22.886	409	7.868	16.387	516	0.000***
Lit. of household head	0.136	0.344	409	0.180	0.384	516	0.075**
Land	0.946	0.225	409	0.891	0.311	516	0.002***
Koranic school com.	0.371	0.483	380	0.577	0.494	516	0.000***

Note [a]: Household size per adult equivalent.
Significance levels: * : 10% ** : 5% *** : 1%

Table 17: Hotelling test on attritors: treatment vs. control, 2009

2-group Hotelling's T-squared = 159.46158
F test statistic: ((924-25-1)/(924-2)(25)) x 159.46158 = 6.2124295
H0: Vectors of means are equal for the two groups
F(25,898) = 6.2124
Prob > F(25,898) = 0.0000***

Significance levels: * : 10% ** : 5% *** : 1%

Table 18: Descriptive statistics after programme, 2010

	After programme							Changes in groups	
	Treated			Control			t-test	$p > \|t\|$	
Variable	Mean	St.Dev.	# Obs.	Mean	St.Dev.	# Obs.	$p > \|t\|$	Control	Treated
Aggregate score	59.851	20.483	1370	54.308	20.477	1240	0.000^{***}	0.000^{***}	0.000^{***}
French score	56.694	22.155	1370	51.819	22.180	1240	0.000^{***}	0.000^{***}	0.000^{***}
Mathematics score	62.563	23.588	1370	56.423	23.182	1240	0.000^{***}	0.000^{***}	0.000^{***}
Repetition rate	3.830	4.301	1886	1.596	2.501	1532	0.000^{***}	0.000^{***}	0.000^{***}
Promotion	80.580	12.562	1886	85.113	10.907	1532	0.000^{***}	0.077^{*}	0.915
Dropout rate	11.845	9.567	1886	11.323	10.044	1532	0.120	0.016^{**}	0.000^{***}
Enrolment rate	-7.439	64.301	1886	-22.705	55.152	1532	0.000^{***}	0.000^{***}	0.171
Temporary shelters	1.658	1.388	1886	1.608	1.382	1649	0.292	0.341	0.029^{**}
Distance to school	0.829	0.375	1886	0.775	0.417	1649	0.000^{***}	0.644	0.698
School manual	1.125	1.630	1886	1.411	1.811	1649	0.000^{***}	0.000^{***}	0.806
Household size[a]	9.931	6.234	1886	10.130	6.217	1649	0.342	0.237	0.037^{**}
Teacher age	32.980	5.847	1886	32.793	5.842	1649	0.342	0.000^{***}	0.000^{***}
Pupil age	10.369	1.562	1886	10.306	1.595	1649	0.242	0.000^{***}	0.000^{***}
Primary school	1.251	0.516	1886	1.680	1.411	1532	0.000^{***}	1.000	1.000
Livestock	10.121	56.949	1886	12.695	23.682	1649	0.087^{*}	0.119	0.456
Number of hours	0.190	0.461	1886	0.152	0.386	1649	0.009^{***}	0.763	0.512
Disturbance	0.637	0.480	1886	0.506	0.500	1649	0.000^{***}	0.000^{***}	0.000^{***}
Absenteeism	0.029	0.168	1886	0.072	0.259	1649	0.173	0.037^{**}	0.000^{***}
Gender of teacher	0.870	0.335	1886	0.828	0.376	1649	0.000^{***}	0.135	0.000^{***}
Continuing training	0.620	0.485	1886	0.593	0.491	1649	0.105	0.645	0.866
High school diploma & more	0.524	0.499	1886	0.425	0.494	1649	0.000^{***}	0.168	0.000^{***}
National certificate	0.495	0.500	1886	0.578	0.493	1532	0.000^{***}	0.557	0.001^{***}
Gender of pupil	0.504	0.500	1886	0.534	0.498	1649	0.080^{*}	1.00	1.00
Koranic school	0.471	0.499	1886	0.471	0.499	1649	0.966	0.000^{***}	0.000^{***}
Early childhood inst.	0.046	0.210	1886	0.056	0.230	1649	0.190	1.00	1.00
Gender of household head	0.918	0.273	1886	0.904	0.293	1649	0.139	1.00	1.00
Lit. of household head	0.189	0.391	1886	0.178	0.382	1649	0.974	1.00	1.00
Marital status	0.966	0.181	1886	0.953	0.209	1649	0.064^{*}	0.377	0.056^{*}
Land	0.927	0.259	1886	0.950	0.216	1649	0.003^{***}	0.246	0.803
Koranic school com.	0.585	0.492	1886	0.291	0.454	1532	0.000^{***}	0.021^{**}	0.339
College	0.249	0.432	1886	0.274	0.446	1649	0.092^{*}	1.00	1.00

Note [a]: Household size per adult equivalent

Continued on the next page...

Table 18 – continued

	After programme							Changes in groups	
	Treated			Control			t-test	$p > \|t\|$	
Variable	Mean	St.Dev.	# Obs.	Mean	St.Dev.	# Obs.	$p > \|t\|$	Control	Treated

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 19: Treatment planned versus treatment received

		Treatment received		Total
		0	1	
Planned Treatment	0	46(79%)	12(21%)	58
	1	8(13%)	54(87%)	62
Total		54	66	120

Table 20: Comparison of adhesion status, 2009

	Planned treatment, received		Planned treatment, not received		t-test
Variable	Mean	Std. Err.	Mean.	Std. Err.	p-value
Aggregate score	36.269	17.542	43.746	24.258	0.000***
French score	36.117	19.438	44.640	24.113	0.000***
Mathematics score	36.412	19.768	42.918	27.046	0.000***
Repetition rate	6.718	7.752	3.965	4.390	0.000***
Dropout rate	17.264	11.993	18.197	11.281	0.227
Promotion rate	76.360	12.554	77.836	11.209	0.066*
Enrolment rate	17.264	11.993	18.197	11.281	0.227
Temporary shelters	1.921	1.383	1.294	0.957	0.000***
Distance to school	0.822	0.382	0.897	0.304	0.002***
School Manual	1.112	1.250	1.261	0.757	0.055*
Household size[a]	10.992	6.394	13.455	9.072	0.000***
Teacher age	32.035	5.735	28.904	4.442	0.000***
Pupil age	9.642	1.662	9.828	1.954	0.093*
Primary school	1.257	0.526	1.235	0.424	0.515
Livestock	7.074	14.499	19.566	26.855	0.000***

Note [a]:Household size per adult equivalent.
Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 21: Complier vs. Noncomplier

		Treatment planned	
		$Z_i = 1$	$Z_i = 0$
Treatment received	$T_i = 1$	**C**:$Y_i(1)$ observed; $C_i = 1$	**NC**:$Y_i(0)$ observed; $C_i = 0$
	$T_i = 0$	**NC**:$Y_i(1)$ observed; $C_i = 0$	**C**:$Y_i(0)$ observed; $C_i = 1$

C: Complier; **NC**: Noncomplier.

Table 22: Effect of school meals on pupils' performance

			Confidence interval	
	Mean	S.D	2.5%	97.5%
Aggregate score				
Intention to treat effect (ITT)	4.318	0.726	2.899	5.746
Complier average causal effect (CACE)	7.616	1.267	5.133	10.109
French score				
Intention to treat effect (ITT)	3.769	0.817	2.180	5.377
Complier average causal effect (CACE)	6.645	1.431	3.858	9.459
Mathematics score				
Intention to treat effect (ITT)	4.740	0.804	3.171	6.311
Complier average causal effect (CACE)	8.406	1.407	5.659	11.162

Table 23: Effect of school meals on internal efficiency of schools

			Confidence interval	
	Mean	S.D	2.5%	97.5%
Enrollment rate				
Intention to treat effect (ITT)	12.807	4.344	3.725	21.028
Complier average causal effect (CACE)	7.717	2.651	2.100	12.673
Repetition rate				
Intention to treat effect (ITT)	1.599	0.105	1.394	1.805
Complier average causal effect (CACE)	2.712	0.173	2.373	3.049
Promotion rate				
Intention to treat effect (ITT)	-0.186	0.334	-0.842	0.467
Complier average causal effect (CACE)	-0.301	0.541	-1.359	0.758
Dropout rate				
Intention to treat effect (ITT)	-0.868	0.295	-1.446	-0.291
Complier average causal effect (CACE)	-1.423	0.479	-2.355	-0.480

Table 24: Effect of school meals on pupils' achievements by gender

	Boys		Confidence interval		Girls		Confidence interval	
	Mean	S.D	2.5%	97.5%	Mean	S.D	2.5%	97.5%
Aggregate score								
Intention to treat effect (ITT)	3.810	0.958	1.932	5.686	4.718	1.093	2.599	6.869
Complier average causal effect (CACE)	7.356	1.825	3.782	10.922	7.853	1.784	4.376	11.359
French score								
Intention to treat effect (ITT)	3.957	1.071	1.859	6.066	3.669	1.212	1.317	6.073
Complier average causal effect (CACE)	7.576	2.039	3.569	11.565	6.057	1.988	2.188	9.971
Mathematics score								
Intention to treat effect (ITT)	3.712	1.040	1.676	5.766	5.588	1.191	3.249	7.947
Complier average causal effect (CACE)	7.362	2.035	3.374	11.369	9.296	1.938	5.466	13.129

Table 25: Effect of school meals on internal efficiency by gender

	Boys		Confidence interval		Girls		Confidence interval	
	Mean	S.D	2.5%	97.5%	Mean	S.D	2.5%	97.5%
Enrolment rate								
Intention to treat effect (ITT)	8.345	2.980	2.865	14.647	3.661	3.709	-3.141	11.178
Complier average causal effect (CACE)	16.549	5.514	5.755	27.490	5.626	5.715	-5.356	16.892
Repetition rate								
Intention to treat effect (ITT)	1.555	0.149	1.262	1.846	1.728	0.151	1.432	2.027
Complier average causal effect (CACE)	3.464	0.384	2.631	4.182	2.775	0.235	2.315	3.237
Promotion rate								
Intention to treat effect (ITT)	-0.296	0.431	-1.144	0.545	0.670	0.527	-0.360	1.701
Complier average causal (CACE)	-0.507	0.737	-1.955	0.934	1.044	0.823	-0.557	2.660
Dropout rate								
Intention to treat effect (ITT)	-0.854	0.401	-1.634	-0.055	-0.976	0.455	-1.861	-0.081
Complier average causal effect (CACE)	-1.494	0.695	-2.833	-0.097	-1.496	0.694	-2.846	-0.125

Table 26: Effect of school meals on pupils' achievement by grade

	CP[a]		Confidence interval		CE2[b]		Confidence interval	
	Mean	S.D	2.5%	97.5%	Mean	S.D	2.5%	97.5%
Aggregate score								
Intention to treat effect (ITT)	3.284	0.924	1.464	5.096	4.227	0.775	2.751	5.794
Complier average causal effect (CACE)	7.590	2.119	3.388	11.712	7.952	1.386	5.198	10.646
French score								
Intention to treat effect (ITT)	2.936	1.079	0.823	5.057	3.806	0.817	2.207	5.408
Complier average causal effect (CACE)	6.667	2.438	1.879	11.465	7.089	1.488	4.165	9.993
Mathematics score								
Intention to treat effect (ITT)	3.438	0.905	1.661	5.219	4.590	0.970	2.697	6.505
Complier average causal effect (CACE)	8.182	2.132	3.977	12.364	8.685	1.797	5.150	12.195

[a]: Second year; [b]: Fourth year

Table 27: Effect of school meals on internal efficiency of school by grade

	CP[a]		Confidence interval		CE2[b]		Confidence interval	
	Mean	S.D	2.5%	97.5%	Mean	S.D	2.5%	97.5%
Repetition rate								
Intention to treat effect (ITT)	1.427	0.108	1.215	1.641	1.864	0.139	1.587	2.138
Complier average causal effect (CACE)	3.936	0.467	3.163	4.809	3.674	0.293	3.088	4.238
Promotion rate								
Intention to treat effect (ITT)	0.988	0.906	-1.193	2.210	-0.897	0.410	-1.692	-0.079
Complier average causal effect (CACE)	2.180	2.164	-3.159	4.816	-1.604	0.733	-3.024	-0.140
Dropout rate								
Intention to treat effect (ITT)	-2.000	0.296	-2.586	-1.425	-0.613	0.377	-1.343	0.138
Complier average causal effect (CACE)	-5.047	0.742	-6.498	-3.588	-1.014	0.625	-2.226	0.227

[a]: Second year; [b]: Fourth year

Table 28: Cost effectiveness

	Aggregate score	French score	Mathematics score
Cost			
Canteen	13100	13100	13100
Deworming	74	74	74
Percentage of additional score			
Canteen	7.593	6.665	8.396
Deworming	17.295	2.002	48.124
Cost per percentage of additional score			
Canteen	1725	1965	1560
Deworming	4	37	2

Table 29: Descriptive statistics (variables in the Mincer equation)

Variable	Mean	St.Dev.	Min	Max
Income	674.8922	899.0451	0	6000.000
Highest grade in education	4.526	1.414	0	6
Age	30.796	11.735	15	65
Years of experience	8.781	8.508	0	52
Household head education level				
Without education[a](1=yes)	0.522	0.499	0	1
Primary(1=yes)	0.361	0.480	0	1
Secondary(1=yes)	0.098	0.297	0	1
Higher education(1=yes)	0.017	0.130	0	1
Gender (1=male)	0.641	0.479	0	1
Type of working contract				
With contract(1=yes)	0.087	0.282	0	1
Without contract(1=yes)	0.260	0.439	0	1
Unreported[a](1=yes)	0.652	0.476	0	1
Married(1=yes)	0.508	0.500	0	1
Occupational category				
Employee(1=yes)	0.294	0.455	0	1
Independent[a](1=yes)	0.390	0.487	0	1
Others(1=yes)	0.315	0.464	0	1
# Obs.		2641		

Note [a]: refer to reference group.

Table 30: Estimation of Mincer equation

Variable: log (Income)	Coef.	Std. Err.
Highest grade in education	0.069**	0.035
Age	0.165***	0.024
Age square	-0.001***	0.0003
Years of experience	-0.036**	0.015
Years of experience square	0.0001	0.0004
Household head education level		

Continued on next page...

Table 30 – continued

Variable: log (Income)	Coef.	Std. Err.
Primary(1=yes)	0.185*	0.099
Secondary (1=yes)	0.263**	0.115
Higher education(1=yes)	0.891***	0.143
Gender(1=male)	0.654***	0.099
Type of working contract		
With contract(1=yes)	0.608***	0.079
Without contract(1=yes)	0.606***	0.070
Married(1=yes)	-0.181*	0.107
Occupational category		
Employee(1=yes)	0.549***	0.091
Others(1=yes)	-0.103	0.144
Intercept	8.383***	0.477
R^2	0.1508	
$Prob > F$	0.0000	
# Obs.	2641	

Significance levels: $*$: 10% $**$: 5% $***$: 1%

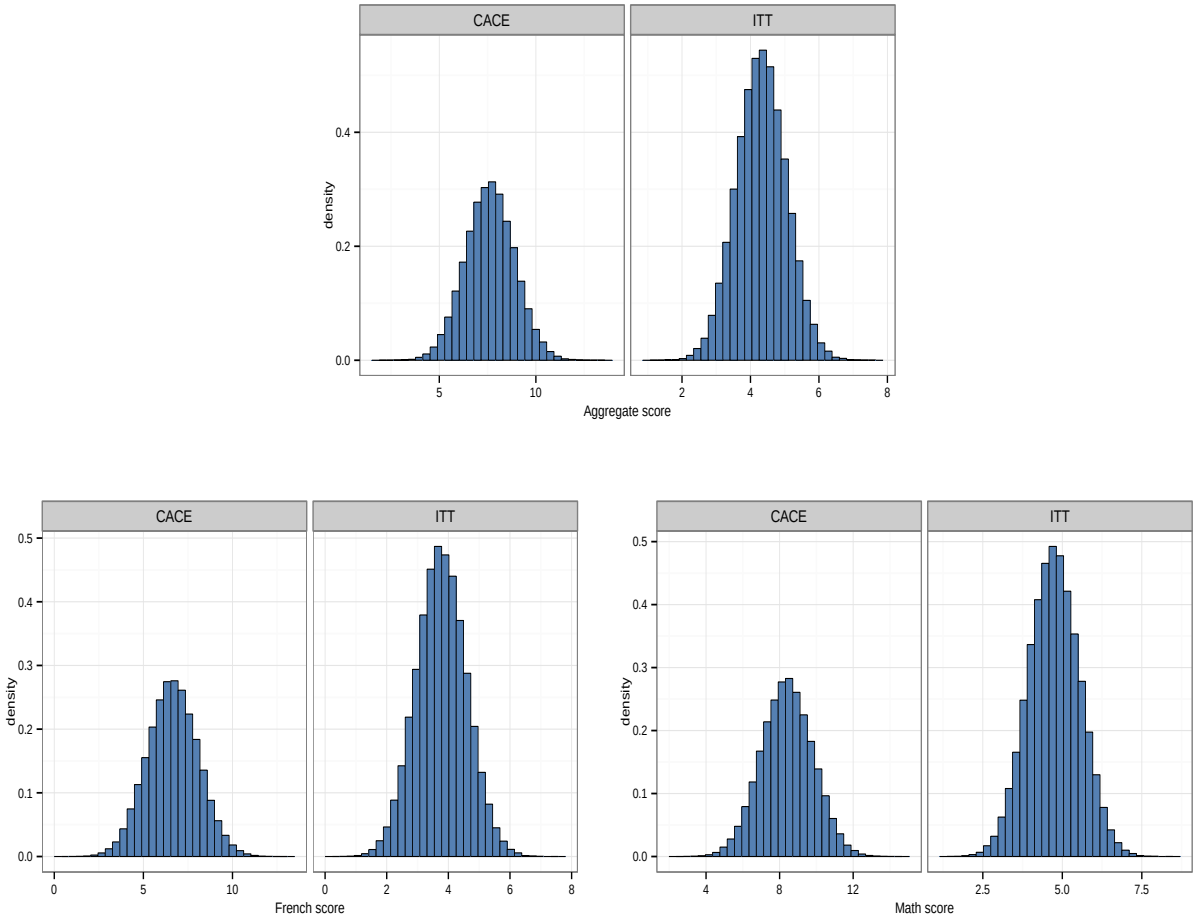

Figure 1: Posterior distribution of CACE and ITT. [Top]: Aggregate score. [Bottom-left]: French score. [Bottom-right]: Mathematics score

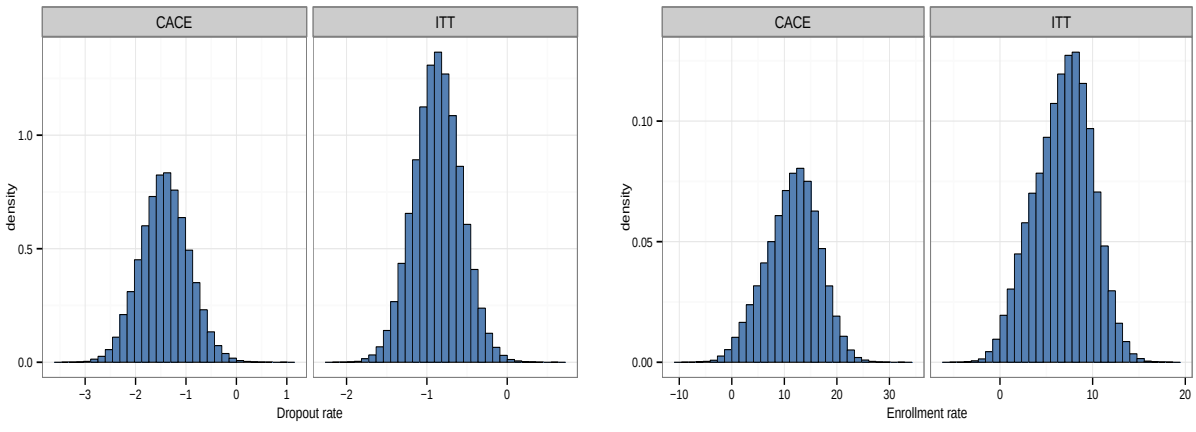

Figure 2: Posterior distribution for dropout and enrolment rates: CACE and ITT. [left]: Repetition rate [right]: Promotion rate

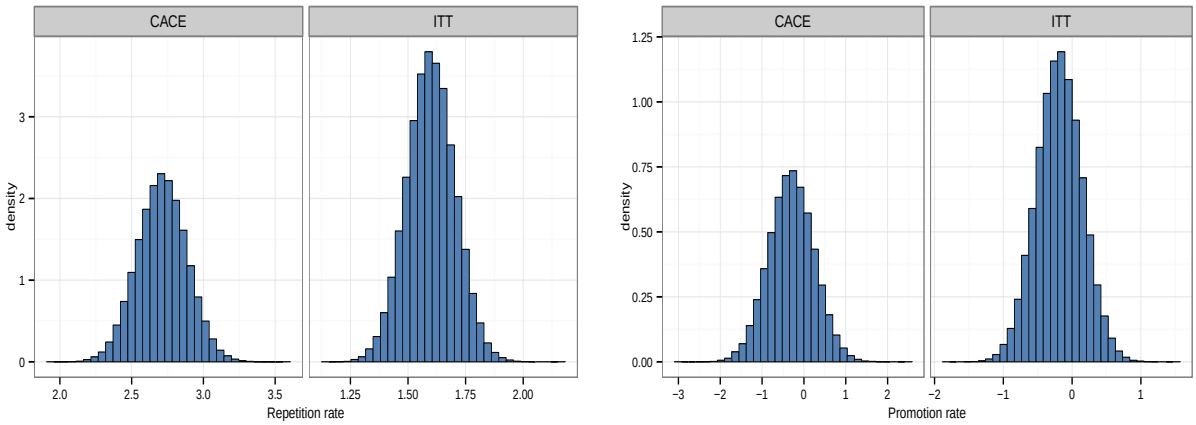

Figure 3: Posterior distribution for repetition and promotion rates: CACE and ITT. [left]: Repetition rate [right]: Promotion rate

Appendix

A List and definition of variables

Table 31: List and definition of variables

Variable name	Definition	Nature
Outcome variables		
Aggregate score	Aggregate test scores in French and Math	continuous
French score	Test scores in French	continuous
Mathematics score	Test scores in Mathematics	continuous
Enrolment rate	Enrollment rate of the school	continuous
Repetition rate	Repetition rate of the school	continuous
Promotion rate	Promotion rate of the school	continuous
Dropout rate	Dropout rate of the school	continuous
Treatment indicator		
Meal	Meal programme indicator	binary (yes=1)
Pupils characteristics		
Pupil's age	Age of the pupil (in year)	continuous
Number of hours [b]	The number of hours of work that the	
Gender of pupil	Gender of the pupil	binary (boy=1)
Grade	Education level of the pupil	binary (CE2=1)
Koranic school	Pupils who attended a islamic school	binary (yes=1)
Early childhood inst.	Pupils who attended an early child institution	binary (yes=1)
Households characteristics		
Household size	Household size per adult equivalent	continuous
Livestock	Number of head of livestock that the household owns	continuous
Gender of household head	Gender of the household head	binary (male=1)
Lit. of household head	Head of household is literate in French	binary (yes=1)
Marital status	Married people	binary (yes=1)
Land	Possession of cultivable land owned by the household	binary (yes=1)
Schools and teachers characteristics		
Temporary shelters	Number of classes in temporary shelters	continuous
School manual [a]	Number of pupils per manual in the school	continuous
Teacher's age	Age of the teacher (in year)	continuous
Distance to school	Distance between school to pupils's home (km)	binary (0-1km=1)
Gender of teacher	Gender of the teacher	binary (male=1)
High school diploma & more	Teachers having as academic qualification: baccalaureate or undergraduate or bachelor	binary (yes=1)
National certificate	Teachers having as academic qualification: national certificate 'brevet'	binary (yes=1)
Continuing training	Teachers have received continuing training	binary (yes=1)
Absenteeism	Indicates whether the teachers of the schools are often absent or not	binary (yes=1)
Disturbed courses	Disturbances that caused delay of the start courses	binary (yes=1)
Communities characteristics		
Primary schools	Number of primary schools in the community	continuous
College	Existence of a college in the school's village	binary (yes=1)

Continued on next page...

Table 31 – continued

Variable name	Definition	Nature
Koranic school com.	Child living in a community where attending Koranic school prevent children from going to school	binary (yes=1)

Note [a]: This variable is created using total pupil and number of school manual; [b]: This variable is created by doing the report between the total sum of hours spend in each housework by sevent (7);
[c]: Currency of the French colonies in Africa.

B Estimation of the Mincer equation

B.1 Background

The standard human capital model (Mincer, 1974 and Becker, 1975) assumes that workers are paid their marginal productivity and that the latter increases with the accumulated human capital. The net gain of an additional year of schooling can then be estimated for individuals whose level of education differs. Thus, the equation of Mincer (1974) can be used to determine the rate of return on years of schooling. The estimated coefficient on years of schooling provides the rate of return. It measures the increase in income resulting from an additional year of education related to the annual cost of that investment in school.

Although Mincer (1993) argues that education and experience alone explain a third of the variance in wage rates in Western countries, there are a number of limitations of the model of Mincer (1974). On the one hand, on can assume that the parental environment influences the economic value of time spent in school. According to Bowles (1972), due to the influence of family environment on the level of educational attainment, omitting the level of parental education or occupation would lead overestimation of returns to education. Bowles (1972) outline that Social class and level of education does not determine income but rather an opportunity. The latter corresponds to choosing among different jobs, each being characterized by various monetary and non-monetary aspects. Income received by an individual is the result of a choice, constrained by job opportunities available. As a result, on might assume that the parental environment has both a direct effect on the income of the individual and an indirect effect transiting through education.

On the other hand, assuming that the relationship between income and education is linear is equivalent to assuming that supply shocks and demand for labor have the same effects on the rate of return to education at all levels of education. Heckman et al. (1996) reject this hypothesis, arguing that years of schooling is not homogeneous, all years may not have the same efficiency. Heckman and Polachek (1974) have shown the existence of a degree effect according to which years of schooling that does not lead to graduation generate a lower return than the other. To allow the return to education to vary with the volume of investment in education, it is preferable to integrate the education level nonlinearily or by taking the highest level of education reached by individual (Angrist and Lavy, 1997). We adopt this approach in our estimation of the Mincer equation.

B.2 Data and variables

Descriptive statistics are reported in Table 29. The sample is composed of 2,461 individuals of which 64.1% are men and 50.8% are married. The number of years of higher studies completed by an individual is between zero and six, meaning the end of the primary cycle. On average, the highest grade completed by an individual is the fourth year. The average age is 30 years and the number of years of professional experience is eight on average.

Include Table 29

Regarding the level of education, uneducated household heads are most likely 52.2% followed by heads of households with primary education (36.1%), those with secondary education (9.8%) and those with higher education (1.7%). We also used the type of contract signed by the individual for his main activity. 65.2% are undeclared workers (reference group). 26% work without contracts and 8.7% with a contract. Regarding the professional status of individuals, 39% are independent workers (reference group) and 29.4% are employees.

B.3 Results

The estimations results of the Mincer equation are reported in Table 29.[10] The return of an additional year of education is 0.069 which corresponds to the estimated coefficient on the number of years of higher studies completed by an individual. For other control variables, the coefficients are of expected sign. For the variables age and professional experience, we introduced both the linear and the quadratic terms to account for nonlinearities. Indeed, the age covariate displays an inverted U shape relation with log of income. Conversely, the experience is negatively correlated with the log of income, but its square is positive though non significant.

Include Table 30

Regarding the level of education of household head, the results indicate that having literate household head (with primary or higher education) has a positive effect on income compared a household head without education. Having a household head with higher education will pay the largest, followed by secondary education and primary education. This result is rather intuitive and support our earlier motivation of the Mincer equation. Indeed, when the head of household is instructed, the individual might benefit from better opportunities regarding enrolment decision for schooling, private tutorials that might be usefull for academic achievements, knowledge networks that could enable to hold more rewarding positions in terms of position and salary. We also find being male has positive and significant impact on wages. Unlike living in a couple would have a negative impact on income.

Concerning the type of contract, having a contract or not has a positive effect on income compared to undeclared workers. Most likely, undeclared workers are those operating in the unformal sector. For occupational category, being employed has a positive effect on income to independent workers (reference group).

[10] The regression coefficients are estimated with OLS. The reported standard errors are robust to heteroskedasticity (Hubert-White).