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School Meals as a Market for Smallholder Agriculture

Experimental Evidence from Ghana

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Abstract

Governments and international development partners investing over $40 USD billion a year in school meals have shown interest in linking these programs with agriculture sector development, through what has become known as "Home-Grown" school feeding (HGSF). Nevertheless, evidence on the effectiveness of HGSF and agriculture is limited. This article reports on the findings of a three-year cluster randomized trial implemented in 58 districts of Ghana including a panel of 1,668 households. Communities were randomly assigned to 1) standard school meals; 2) HGSF or 3) control with no intervention. Post-intervention, the caterer-level analysis highlighted major challenges related to delayed program disbursements, resulting in a mismatch between budgeted and actual caterer outlay on food purchases per pupil equivalent to approximately 50% of the budgeted per child per day allocation. For caterers, by far the largest procurement channel was through traders, though there is evidence that HGSF may have increased the share of value purchased directly from smallholders. We find no strong evidence that the school feeding program or HGSF affected smallholders market structure, farm, non-farm and household income. When interpreting these null results, it is important to consider the findings of two parallel studies that showed positive effects of this national program on school children's learning, cognition, and nutrition outcomes. The national program can still be considered as an effective social protection strategy with multiple objectives, even if the agriculture objectives remain aspirational.

Keywords: School meals; agriculture; home-grown school feeding; impact evaluation.

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Introduction

School feeding, or school meals, is a multi-sectoral social protection intervention that is widely implemented. Globally, programs reach about 388 million children for a total investment of about $40 billion a year (World Food Programme, 2020). Rigorous studies and systematic reviews have shown that school feeding can improve children's schooling, as well as their physical and psycho-social health, with most benefits accruing for more disadvantaged children (Kristjansson et al. 2007). In high- and middle-income countries food procurement for school meals has been used as an outlet for commercial farmers to market their surplus. Recently direct procurement from farmers have been written into legislation in Brazil and India (Drake, Woolnough, Burbano, & Bundy, 2016; Levine, 2008; Schneider, Thies, Grisa, & Belik, 2016). In the last two decades, governments and international agencies have shown interest in promoting agriculture development through the market demand for school food and services in low- and middle-income countries (LMICs) through what has become known as "home-grown" school feeding (HGSF) (Espejo and Galliano 2009; WFP 2013). In 2003 the New Partnership for Africa's Development (NEPAD), for example, defined HGSF as a strategic initiative for promoting food security and rural development across the African continent (NEPAD, 2003). A global survey conducted in 2020 including data from 85 countries found that 43% of programs reported having farmers directly involved in school feeding-related operations (Global Child Nutrition Foundation, 2020). Despite this pervasive agricultural policy focus, to our knowledge currently there are no studies that document rigorous evidence on the agricultural impacts of school feeding, and the present study will fill this critical gap in the context of an evaluation of a national programme in Ghana. The seeming simple idea behind this framing is to create a win-win for school children and smallholder farmers. From a smallholder farmer's perspective, as school feeding programs require a regular supply of food throughout the year, they can provide a predictable market channel for food of known quantity, quality, and price (Sumberg & Sabates-Wheeler, 2011). In practice, however, the pathways linking investments in school feeding to welfare impacts in smallholder farmers are complex, including both direct and indirect effects, that depend, in part, on the efficiency of local markets and on the trust between farmers and institutions in charge of supplying school food. HGSF also relies on farmers' capacity to produce surplus (Ahmed & Sharma, 2007; Brinkman et al., 2007; Masset & Gelli, 2011; Sumberg & Sabates-Wheeler, 2011). Ironically, in terms of smallholder farmer engagement, if local markets were efficient, understood as integrated with a larger network, HGSF would have minimal impact, as farmers would already be able to sell their produce at prevailing prices. In cases where local demand does determine local price – for example, with some perishables – or in cases where HGSF offers prices above those that prevail there is a risk that such programs may create two tier price regimes with quotas and access restrictions. In areas prone to seasonal or interannual shortages, it is also not clear *a priori* whether relying on local supply increases the regularity and quality of meals (Sumberg & Sabates-Wheeler, 2011). Moreover, despite public procurement for school feeding often sharing a common goal across countries on the timely, uninterrupted delivery of school food of adequate quality and quantity, the design and implementation is heterogenous and context specific, involving different supply chain configurations and different levels of decentralization and private-sector engagement (Aulo Gelli, Kretschmer, Molinas, & Regnault de la Mothe, 2012). Despite the near ubiquity of school feeding, there is a dearth in the empirical evidence on the costs and effectiveness of different school feeding implementation models (Bundy et al., 2018).

This paper advances the evidence base on the agricultural effects of school feeding by providing an experimental analysis of a novel pilot designed to link procurement for the national school feeding program in Ghana to smallholder farmers. In 2015, the Ghana School Feeding Program (GSFP) reached over 2 million primary school children across the 170 districts of the country (Government of Ghana, 2015). The GSFP service is provided through caterers contracted directly by the program, and each caterer is responsible for buying food from local markets, preparing and distributing the meals in schools. In this experiment, an additional HGSF pilot component was designed to strengthen the commercial links between caterers and farmers. The HGSF pilot activities focused on facilitating the development of contractual agreements between caterers and farmers during a six-month period prior to the start of the program procurement in order to overcome potential issues of mistrust. Though the contracts were not legally binding, they specified food quantity and quality, timing of delivery, transportation and storage, payment schedules and penalties for non-compliance. The planning activities were designed to also provide farmers with information on the market opportunity that caterers provided throughout the school year.

In partnership with the Government of Ghana, the University of Ghana, the Partnership for Child Development at Imperial College and the International Food Policy Research Institute (IFPRI), this study evaluated the impact of the school meal program and HGSF pilot using a cluster-randomized control trial designed around the scale-up of the GSFP in all regions of the country. Using two rounds of household- and caterer-level surveys, including a panel of 1,668 households, we evaluate the impact of the intervention on agricultural outcomes over a three-year period. The analysis follows an intent to treat approach on pre-specified primary and intermediate outcomes along the main agriculture supply side pathway (A. Gelli et al., 2016). The caterer-level analysis highlighted major challenges related to delayed program disbursements resulting in implementation bottlenecks, including a mismatch between budgeted and actual expenditures on food purchases per pupil equivalent to approximately 50% of the budgeted allocation. The analysis suggested that after two years of program implementation, though there was evidence that the HGSF pilot increased the share of total value purchased from smallholders by school caterers, by far the largest procurement channel was still occurring through market traders. The household-level analysis found no evidence that the school feeding program or the HGSF pilot affected the market structure for smallholders. No impacts were also detected on impact-level indicators, including farm, non-farm and household income. Some heterogeneities were found in the pre-specified sub-group analysis, particularly in the Northern regions, where households exposed to the standard GSFP were less likely to be engaged in farming and more likely to have other business activities compared to households exposed to HGSF. In addition, relative to the standard GSFP, households in the HGSF group had lower other business and overall household incomes. When interpreting these null results of the national program in the agriculture domain, it is important to consider the results of two parallel studies that found positive effects of the program on school children's learning, cognition and nutrition outcomes (Aurino, Gelli, Adamba, Osei-Akoto, & Alderman, 2021; Aulo Gelli et al., 2019). As such, the national program can still be considered as an effective social protection strategy with multiple objectives, even if the agriculture objectives remain aspirational.

The rest of the paper is structured as follows: We first describe the country context and the national school meals program in Ghana, the challenges in linking with agriculture and the details of the HGSF pilot intervention; we then describe the study design, including the program theory for the intervention and the randomization details; we then present and discuss the main study findings and conclude.

Country context

The National School Feeding Program in Ghana

Funded entirely by the Government of Ghana, the program reaches over 2 million students through a 4-year budget of over 200 million USD (Government of Ghana, 2015). The GSFP is designed as a multisectoral strategy to increase food production, household income, and food security in deprived communities (A. Gelli et al., 2016). The implementation of the GSFP is managed through a National Secretariat, with oversight provided by the Ministry of Gender, Children and Social Protection. The school meals service is provided through caterers contracted directly by the GSFP based on an allocation of 40 Ghana pesewas (US$0.33) per child per day (**Figure 2**). Each caterer is responsible for buying food from markets, preparing, and distributing the meals in schools. Cash is transferred to caterers retrospectively covering a two-week period. Caterers are not allowed to serve more than three schools and their profits are made on margins after food procurement, preparation, and distribution. The school meal menus are designed at the district level to meet approximately 30% of recommended daily intake for children 6-12 years (Parish and Gelli 2015), and include foods grown by farmers in the community and the broader agroecological zone (Fernandes et al., 2016; Singh & Fernandes, 2018). School-level supervision on the quality of the service provision is provided by the School Implementing Committee.

The typical agricultural value chain prevailing in Ghana is stylised in Figure 1 (De Carvalho et al., 2011). Foods are predominantly produced by small farmers, with limited access to credit, who sell their produce by joining other farmers aggregated by a small trader. The aggregator trader purchases food from groups of farmers using their own cash or by borrowing from a wholesaler. A wholesaler purchases food from the aggregators and re-sells the same to local retailers who operate in consumer markets.

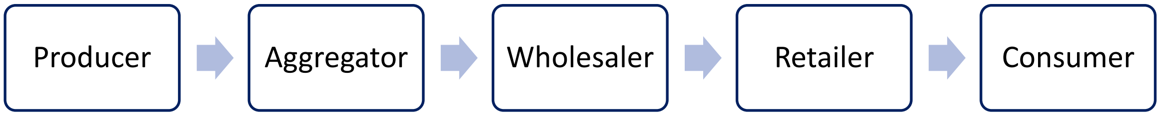

Figure 1: Stylised agriculture value chain prevailing in Ghana. Source: Authors.

In practice, the role of the aggregator and of the wholesaler is often taken by 'market queens' or 'market women'. They are often leaders of farmer-based organisations, who own sufficient wealth to advance cash to acquire a dominating position in the market (WFP, 2017). They travel to communities and play the role of aggregators by purchasing in bulk from groups of farmers. They store the commodities and provide the items to retailers directly, thus operating as wholesalers.

A supply chain study of the GSFP reported that the main challenges faced by caterers included changes in food prices, and the inability to mitigate price fluctuations due to payment delays (De Carvalho et al., 2011). As payments from the GSFP are retrospective, caterers often did not have the resources to buy in bulk at lower prices. Caterers also reported buying on credit from market queens, thus weakening their negotiation position. Caterers also highlighted that payments and budgets did not reflect actual numbers of children served, as enrollment tended to increase during the school year, resulting in higher costs for them. Caterers responded to these challenges by adapting the menus, reducing portion sizes or by adjusting the quality of the food (De Carvalho et al., 2011). The supply chain analysis highlighted a number of interrelated constraints in the current GSFP model including 1) cash flow timing, caterers receive money after serving children but smallholder farmers need money in advance or on delivery (or at planting, or when school fees are due (Dillon, 2020),; 2) lack of trust between farmers-caterers (especially for future payments) heightened by inconsistent payment from government; 3) high transaction costs for caterers to interact with farmers and no structure in place to facilitate caterers and farmers negotiations (De Carvalho et al., 2011).

The agriculture and nutrition pilot intervention

A HGSF pilot was designed to strengthen the commercial relations between caterers and farmers by enhancing communication and trust, improve financial flows, and enhance the overall quality of the school meal service by supplying locally grown produce (**Figure 3**). In the nutrition component of the pilot, caterers were trained to use district-specific menus developed to meet nutritional requirements using seasonal recipes that depended on fresh foods that could be purchased from producers in the targeted communities (Fernandes et al., 2016; Singh & Fernandes, 2018). In addition, caterers were supported to develop food sourcing plans based on the menus, portion sizes, and projected number of students to be fed. The planning activities were designed to provide farmers with information on the market opportunity that caterers provided throughout the school year. Other agriculture activities focused on facilitating the development of contractual agreements between caterers and farmers, based on the "roundtable model" proposed by a supply chain analysis that relied on four key strategies (De Carvalho et al., 2011), including: 1) the strengthening of farmer organizations by linking with Ministry of Agriculture extension and other activities; 2) establishment of a roundtable to bring farmers and caterers in a monthly discussion around prices and quantities at a district level. The roundtables would begin six months prior to the school year with the aim of facilitating contractual agreements between farmers and caterers; 3) building trust between caterers and farmers, through interactions facilitated by the District Assembly; and 4) defining ground rules for negotiation and disputes resolution, including facilitation for the development of mutually agreeable, non-binding, contracts to ensure that the interests of both parties are addressed.

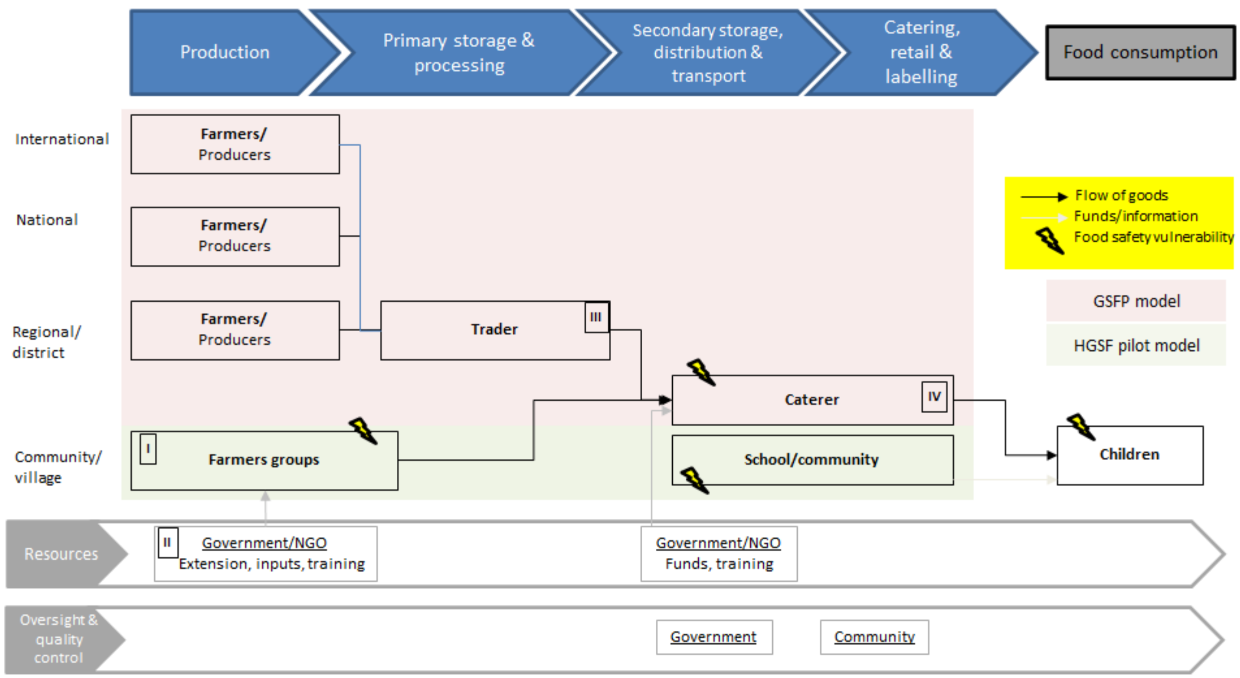

Figure 2: Stylised school feeding implementation models for GSFP and HGSF pilot in Ghana (Source: Authors, adapted from Gelli et al., 2012).

The HGSF pilot model essentially aimed to bring together the actors of the school feeding supply chain and GSFP to discuss demand and supply needs of the school feeding market. Farmers and caterers would then be able to negotiate an agreement backed by a master contract to address the issue of trust. Though the contract between farmers and caterers was not legally enforceable, it included information on the quantity and quality level of foodstuff deliveries for the school meal programme; the timing of deliveries and the pricing with any future price revisions explicitly stated (e.g., prices reviewed every term); provisions for transportation and storage costs; payment schedule (e.g., within one week of government money transfers to the caterers); and any penalties for non- compliance. An additional advantage of the model was the possibility to identify financing needs for timely transactions between farmers and caterers. Through the exploration of pre-financing options, caterers could receive advance funding from either community rural banks, or the district assembly (all members of the roundtable) for the timely payments of farmers. Payment would be automatically deducted at source (either caterer bank accounts or from the district assembly). This created an opportunity for the establishment of a system to address the payment challenges faced by caterers and the associated mistrust between farmers and caterers (De Carvalho et al., 2011). A Ghanaian NGO (ECASARD) was contracted to implement the agriculture pilot activities in the targeted districts.

Study design

Program theory for school meals and agriculture

In the standard GSFP program, caterers purchase food supplied to schools in the market. The HGSF pilot was designed to stimulate the local economy by promoting purchases directly from small-holder farmers. Based on the theoretical model presented in Masset and Gelli (2013), the impact of the intervention on smallholder farmers is mediated by how much the aggregate demand for school food is additional in the local market, and by farmers' supply response. The size of the aggregate demand shift produced by the intervention in the local market depends on the extent of the substitution effects among consumers[1]. This substitution occurs when households reduce food purchases because their children receive school meals. At one extreme, there is full substitution: food provided in school entirely substitutes for home meals. In this case, food demand does not change and the intervention cannot have an impact on output. Full substitution, while noted in some studies, is less likely than partial substitution, whereby households interpret school meals as if they were cash transfers (Afridi 2010; Kazianga, de Walque, and Alderman 2014). In this case the income equivalent of the meal is spent on food and non-food following income elasticities. However, evidence shows that households attach some preference to food received and thus consume food beyond what the income elasticities would suggest (Jacoby, 2002). Thus, the shift in demand produced by the project is likely to happen somewhere between the two extremes.

[1] Another level of substitution that may occur in the context of the Ghana procurement model involves sales to caterers substituting for previous sales to traders.

Of greater interest for the success of the intervention is its ability to trigger farmers' supply response. The supply response of smallholder farmers to prices and demand is relatively inelastic and farmers are unlikely to respond quickly to the demand changes induced by the project. This is particularly true after harvest when farmers can no longer change the quantity produced - although they can change to some extent the quantities supplied if they have access to storage facilities. This highlights the need for the project to establish contractual arrangements with farmers well before the planting season, when their supply response is more elastic. There is more that the project can do to increase farmers' supply in addition to offering contracts at planting season. Smallholder farmers have difficulties in mobilising inputs such as land, labour, and fertiliser in the short-run. The purchase of variable inputs, such as fertiliser, pesticides and seeds, is constrained by the inability to access loans. Few farmers are able to advance cash to purchase inputs at planting time, and few will be able to access loans from banks or other sources. The intervention can be more successful if it improves farmers' access to credit during the planting seasons. Finally, the project can stimulate supply by increasing the long-term profitability of the farm. Supply over the long run is more responsive to prices as farmers can change the scale of production by investing in fixed inputs. One way for the intervention to increase farms' profitability is by reducing production risk. A lower perceived price risk implies higher expected marginal returns and therefore a lower marginal cost curve. To the extent the intervention is able to offer fixed prices and sustained demand through credible contracts, it may stimulate investments in land and equipment, which make production more responsive to demand.

The analysis of the program theory of the intervention suggests that at impact-level, we expect an improvement in farmers' agricultural incomes, profits, and output. However, while the intervention potentially benefits all households with school-age children included in our sample through the provision of free school meals, the impact on farmers is more targeted to those farmers that are directly involved in the program, not all of whom are surveyed in our study. In addition, measures of incomes and farm outputs are notoriously noisy, which alongside the relatively small sample of farmers interviewed, increases the chances of not observing a significant change even if the intervention does have an impact. This warrants the examination of the intermediate outcomes of the intervention. We expect farmers to increase the production of food supplied to schools such as maize, rice, and vegetables. Ultimately an increase in production can only occur via an increase in variable inputs, and therefore we should also observe an increase in the use of family and hired labour, land, seeds, fertiliser, and other chemical products. In the long run, the project may lead farmers to purchase fixed inputs such as land and farm equipment, which we could also observe at the end of the project.

Randomization

A cluster randomized control trial was designed around the scale-up of GSFP across the 10 regions of Ghana. The GSFP secretariat developed criteria for the selection of the districts as captured in a retargeting exercise undertaken in 2012. Data from the Ghana Living Standards Survey (GLSS4) and the Core Welfare Indicators Questionnaire carried out in 2005/2006 and 2003 were used to develop poverty rankings. Other district-level indicators included in the ranking included the food consumption scores calculated using the Comprehensive Food Security and Vulnerability Assessment 2008/2009 and spatial data variables computed by the World Food Programme (Kennedy et al., 2010). These data were used to generate district-level aggregates for the share of national poverty and food insecurity that provided the basis to allocate program resources during the scale-up. As a result, over 70% of the government budget in the GSFP was targeted to the poorest areas of the country.

The HGSF pilot intervention was implemented at the district level for logistical purposes leading to a relatively small number of districts available for randomization. Due to the relatively small number of clusters in the study, to ensure balance in the comparison groups, random allocation was undertaken in two steps through a restricted randomization procedure that modelled selection of treatment groups using a set of school- and village- and district-level variables (Figure 2). The first step assigned schools to two groups (school meals or control) using a list of schools not currently covered by the GSFP and indicators obtained through the annual school census from 2011-2012. Following (Hayes & Moulton, 2017) the variables in the restricted randomization were selected on availability and their potential influence on the study outcomes. The variables in this first selection model included enrollment, gender ratio, classroom numbers and infrastructure conditions, accessibility, and NGO support, among other indicators. Within each district, the algorithm randomly assigned two schools to either school feeding or control groups, and regressed selection based on the village- and school-level covariates, testing 2,000 random allocations and selected the permutation that minimised the r^2 statistic for the predicted selection. The second restricted randomization procedure was developed to allocate the school feeding group into two sub-groups (GSFP and HGSF) by district. The Stata program for the second selection model, included additional variables that characterized the agricultural environment (i.e., agroecological zone, maize productivity, and employment), tested 2,000 random allocations and selected the permutation that minimised the r^2 statistic for the predicted selection.

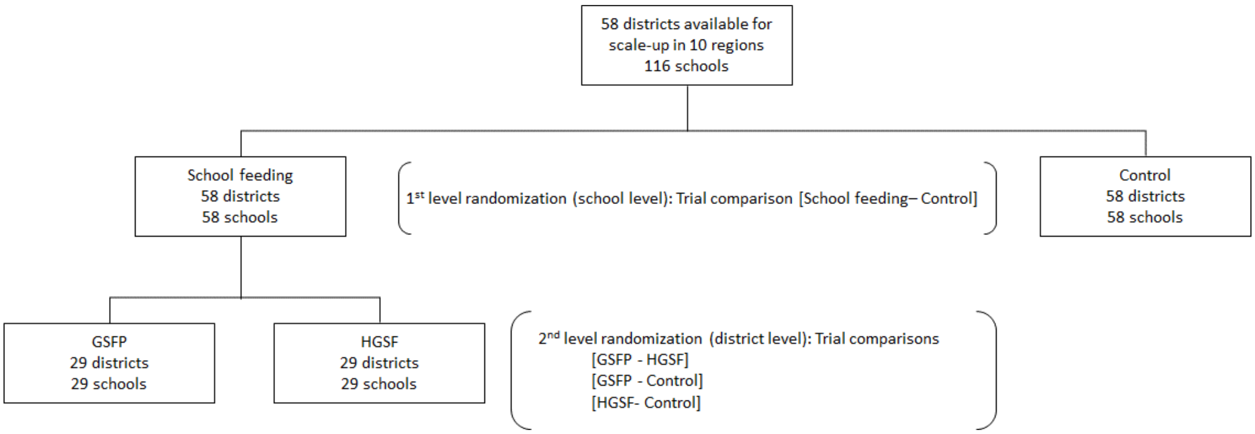

Figure 3: Randomized design.

Power calculations were undertaken using means, standard deviations, and intra-cluster correlations of the primary outcomes from the GLSS4. The results of our calculations suggested a sample of 25 households from the communities in the areas of the 58 schools receiving the intervention and of 20 households in the communities of the 58 control schools (A. Gelli et al., 2016). Ethical clearance was obtained from the Institutional Review Board of the Noguchi Memorial Medical Research Institute of the University of Ghana and at the Imperial College Research Ethics Committee. Informed consent was obtained from all heads of household prior to the survey interviews. This trial was registered at www.isrctn.com as ISRCTN66918874 and in the American Economic Association’s Social Science Registry.

Data collection

The study included two rounds of household survey data, with baseline and end line surveys undertaken in June 2013 and March 2016, respectively. Both surveys included school-, caterer-, household-, and child-level data collection. The household questionnaire included modules on demographic characteristics, farm assets, economic activities, expenditure, farming and other income. Structured interviews were also undertaken with the caterer providing the school meal service in each of the targeted schools. The caterer questionnaire included modules on the school meal service provision, including food sourcing, menus and food quantities provided to students, as well as information on the level of education, training, and supervision the caterers received.

Empirical strategy

The analysis follows an intention to treat approach as per the published protocol. The main outcomes of interest pre-specified in the protocol are related to smallholder farmer agricultural production, sales and income (A. Gelli et al., 2016). Using plot- and crop-level data aggregated at the household level, we created two dichotomous variables that capture participation in farming and ownership of a business. Continuous variables were created for value of sales, investments and income from agriculture, income from businesses and total household income, that were all log transformed for the regression analysis. We also examine total household expenditure, estimated as the value (in Ghanaian Cedi) of household food and non-food consumption.

The main specification exploits the randomized design to assess the impact of the intervention using a single difference analysis of covariance (ANCOVA) regression model given by

$$Y_{i1} = \beta_0 + \beta_1 T_i + \beta_2 Y_{i0} + H_i + \varepsilon_i \qquad (1)$$

where Y_{i0} is the outcome variable at baseline for the ith household, $Y_{i1}$is the outcome variable at endline, T_i is a dummy variable for the treatment assignment (set to 1 for communities receiving school feeding) and H_i is a set of household covariates (household size and age of head of household) to increase precision in the estimates and included as part of the robustness analysis. Equation (1) will be used to assess the impact for the first-level trial comparison comparing communities with and without school meals.

The second-level comparison compares communities receiving either the HGSF or GSFP interventions to the control group is given by

$$Y_{i1} = \beta_0 + \beta_1 T_i^{SF} + \beta_2 T_i^{HGSF} + \beta_3 Y_{i0} + H_i + \varepsilon_i \qquad (2)$$

Where T_i^{SF} is a dummy variable for the GSFP treatment assignment (set to 1 for communities receiving the standard GSFP) and T_i^{HGSF} is a dummy variable set to 1 for communities in the HGSF group.

The difference-in-difference (DID) specification was also included in the protocol with the following form

$$Y_i = \alpha + \beta T_i + \gamma t_i + \delta(T_i \cdot t_i) + \varepsilon_i \quad (3)$$

where T is a dummy for treatment status, t is dummy for survey round, α is the constant term, β is the treatment group specific effect, γ captures the time trend, δ is the coefficient for the treatment effect and ε_i is the error term.

The ANCOVA estimator has been shown to provide more efficient estimate of program impact compared to a DID estimator when auto-correlation of outcomes is low (McKenzie, 2012). However, as the answer to the question of which of the two estimators is most efficient for the range of outcomes in this analysis is an empirical one, we opted to report the results of both specifications in the main results, focusing on describing areas of convergence and divergence. For space considerations, the tables with the DID results are reported in the annex.

In all the specifications the standard errors are clustered at the village level for SF vs control (1^{st} level comparison) and at district level for the GSFP vs. HGSF comparison (2^{nd} level comparison). As also specified in the trial protocol, we also investigate the expected heterogeneities of impact by farming and non-farming households and region of residence.

Results

Baseline characteristics across treatment groups and loss to follow-up.

The baseline survey was conducted in June 2013 in 116 communities. Twenty-five schools were found to be receiving some form of free school meals at baseline (based on the response to a question at baseline on whether the school was involved in the GSFP) and had thus been erroneously included in the original sampling frame. These were therefore removed from the study population. Two communities could not be surveyed at end line in March 2016 due to insecurity problems. The end line survey included 1,668 households from the 91 eligible communities, leading to an attrition rate of 8 percent. The attrition rate was not significantly different across treatment groups nor was the probability of attrition correlated with treatment assignment (not reported). We assessed whether the randomization was successful by comparing baseline characteristics across the treatment groups (Table 1). Baseline characteristics were generally balanced across treatment groups, though substantive differences were found for the size of cultivated land, costs of agriculture inputs and value of agricultural sales.

Table 1: Baseline agriculture and socio-economic characteristics of the study population by treatment arm.

	Control (n=924)		SF (n=1,120)		GSFP (n=549)		HGSF (n=571)	
Indicators	mean	(sd)	mean	(sd)	mean	(sd)	mean	(sd)
Owns a business	0.34	(0.47)	0.39	(0.49)	0.35	(0.48)	0.42	(0.49)
Is a farmer	0.63	(0.48)	0.61	(0.49)	0.63	(0.48)	0.58	(0.49)
Household income*	9.84	(0.66)	9.87	(0.31)	9.87	(0.32)	9.86	(0.29)
Agriculture income*	9.80	(0.14)	9.79	(0.12)	9.80	(0.13)	9.78	(0.11)
Agriculture costs*	4.24	(2.47)	4.10	(2.48)	4.21	(2.39)	3.99	(2.55)
Value of agric. sales*	1.93	(2.3)	1.77	(2.21)	1.92	(2.24)	1.62	(2.17)
Value of business *	7.87	(0.71)	7.90	(0.87)	7.92	(0.78)	7.89	(0.94)
Age of head	44.48	(12.91)	45.29	(13.09)	45.46	(13.8)	45.12	(12.37)
Prop. spent on food	58.77	(15.9)	60.05	(15.4)	59.60	(15.4)	60.48	(15.39)
Per-capita expenditure*	7.56	(0.52)	7.55	(0.52)	7.52	(0.51)	7.58	(0.52)
Household size	5.66	(2.39)	5.64	(2.34)	5.55	(2.32)	5.72	(2.35)
Dependency ratio	1.72	(0.93)	1.66	(0.93)	1.66	(0.95)	1.66	(0.92)
Polygamous HH	0.01	(0.09)	0.01	(0.09)	0.01	(0.09)	0.01	(0.09)
Female headed HH	0.24	(0.43)	0.24	(0.43)	0.27	(0.45)	0.21	(0.41)
Urban	0.08	(0.27)	0.08	(0.28)	0.05	(0.21)	0.12	(0.32)
Size of cultivated land	7.11	(11.95)	6.06	(12.92)	6.23	(8.79)	5.90	(15.92)
Owns livestock	0.62	(0.49)	0.63	(0.48)	0.60	(0.49)	0.66	(0.48)

Notes: *Variables are log transformed; agric., agriculture; GSFP, Ghana School Feeding Programme; HH, household; HGSF, Home-Grown School Feeding; Prop., proportion; SF, school feeding; sd., standard deviation.

Baseline agricultural marketing characteristics

Table 2 summarises baseline characteristics of agricultural markets in the study area, highlighting a range of challenges with regards to the potential success of the HGSF pilot. Less than 20% of farmers utilize any type of credit, and less than 60% of loans, mostly through informal lenders, have a production purpose. More than 50% of farmers have access to some form of storage facility, but food is predominantly stored in the house rather than in specialised structures such as silos. Only about 35% of households report selling any food, maize and rice being the most common foods sold, suggesting that the majority of farmers in the area are small-holder subsistence farmers. As expected, food is predominantly sold to 'market queens.' Only 10% of sales transactions are made to consumers directly, and only 1% to schools. Food is sold under a contract in only 30% of cases, and sales mostly occur in markets.

Table 2: Baseline smallholder marketing characteristics in the study population

Indicators	Mean/prop.	(sd)	obs
Loans taken	0.19	(0.39)	1,616
of which have productive loan	0.58	(0.49)	312
of which informal loan	0.84	(0.37)	312
Access to storage	0.54	(0.50)	1,616
Maize storage	0.51	(0.50)	1,616
Rice storage	0.15	(0.36)	1,616
of which in house	0.86	(0.35)	878
of which in silo	0.07	(0.25)	878
Sold any food	0.35	(0.48)	1,616
to market queen	0.75	(0.43)	561
to trader	0.14	(0.35)	561
to consumer	0.10	(0.30)	561
to school	0.01	(0.10)	561

Notes: sd., standard deviation.

School food procurement at endline

At endline, the analysis of the survey data on payments to the school caterers with available records in the school feeding group (n=44) found that 89% had experienced irregular payments (85% in standard GSFP schools vs. 92% in HGSF schools). Approximately 80% of caterers also indicated that payments were often insufficient to cover operational costs, resulting in having to resort to credit to avoid changing the quality of meals (65%), reducing portion sizes (5%), or reducing operational costs by other means.

Analysis of the food procurement data from existing caterer records from the 30 calendar days prior to the endline survey found that monthly median spending on food per child was 2.7 USD (average=5.3 USD). The distribution of spending per child was skewed by one caterer's spending over 75 USD per child in a GSFP school that was involved in bulk buying that particular month. Median spend varied from 1.9 USD per child in regular GSFP schools to 2.7 in HGSF schools (average=8.7 in GSFP schools vs 3.1 in HGSF schools). The median spend per child was considerably lower than the expected budget per child based on Government allocations (0.33 USD per school day, ~6 USD per child per month), which highlights important challenges with the national program implementation.

Only fifty five of the 532 transactions processed during the previous 30 days by caterers involved direct purchases from smallholder farmers, 471 were with traders, five were for rice obtained through the national buffer stock and one was from a fisherman in the community. The share of total value purchased from smallholder farmers was only 10% (5% in GSFP schools vs. 12% in HGSF schools, p=0.06), compared to a total share purchased from traders of 88% (90% in GSFP schools vs 87% in HGSF schools), with the remaining share received from the national buffer stock (only concerning rice). The share of procurement transactions from smallholders varied considerably by food (at 100% for agushie (melon) seeds, cassava, cocoyam leaves, palm nuts, to 15% for beans, 8% for gari (cassava flour), groundnuts and rice, and 3 percent for onions). The mean value of procurement transactions from smallholder farmers by food item was 55.6 USD and was highest for beans (mean 177.8 USD over six purchases), rice (mean 145.9 USD, over three purchases), yams (mean 92.9 USD over 7 purchases) and maize (mean 52.9 USD over 10 purchases).

Impact of school feeding on agricultural outcomes

Intermediate outcomes: Agricultural marketing and market structure

Tables 3 summarize the results for ANCOVA models (and in annex A3 for DID) on the intermediate outcomes indicators on the agriculture program impact pathway, showing no large coefficients nor statistical significance on the effects on sales of maize, rice, vegetables, or on market structure (sales from different channels i.e., market queen, other trader, schools, market, or contract). A null result was also found on these indicators when assessing potential heterogeneities by program type (Tables 4 and A4).

Table 3: ANCOVA estimates of the impact of school feeding (GSFP+HGSF) on farmer sales

	(1) Seller	(2)* Maize sales	(3)* Rice sales	(4)* Veg sales	(5) Market queen sale	(6) Trader sales	(7) School sale	(8) Market sale	(9) Contract sale
School feeding	0.03	0.03	0.02	-0.18	0.02	-0.02	0.00	-0.01	0.01
(S.E.)	(0.04)	(0.28)	(0.11)	(0.18)	(0.04)	(0.01)	(0.00)	(0.03)	(0.03)
p-value	0.454	0.911	0.837	0.309	0.575	0.216	0.531	0.766	0.671
Constant	0.15	0.59	0.20	0.64	0.16	0.05	0.00	0.10	0.09
(S.E.)	(0.03)	(0.17)	(0.08)	(0.15)	(0.03)	(0.01)	(0.00)	(0.02)	(0.02)
p-value	0.000	0.001	0.013	0.000	0.000	0.000	0.152	0.000	0.000
n	1,879	1,879	1,879	1,879	1,879	1,879	1,879	1,879	1,879

Note: *Outcome variables are log transformed. S.E., Standard error.

Table 4: ANCOVA estimates of the impact of the GSFP and HGSF on farmer sales

	(1) Seller	(2)* Maize sales	(3)* Rice sales	(4)* Veg sales	(5) Market queen sale	(6) Trader sales	(7) School sale	(8) Market sale	(9) Contract sale
GSFP	0.07	0.27	0.05	-0.11	0.04	-0.01	0.00	0.01	0.03
(S.E.)	(0.05)	(0.38)	(0.13)	(0.20)	(0.05)	(0.02)	(0.00)	(0.04)	(0.04)
p-value	0.185	0.468	0.667	0.594	0.373	0.448	0.606	0.778	0.462
HGSF	-0.01	-0.20	-0.01	-0.25	0.00	-0.02	0.00	-0.03	-0.00
(S.E.)	(0.04)	(0.28)	(0.13)	(0.19)	(0.04)	(0.01)	(0.00)	(0.03)	(0.03)
p-value	0.848	0.465	0.951	0.181	0.990	0.157	0.627	0.361	0.939
Constant	0.15	0.59	0.20	0.64	0.16	0.05	0.00	0.10	0.09
(S.E.)	(0.03)	(0.17)	(0.08)	(0.15)	(0.03)	(0.01)	(0.00)	(0.02)	(0.02)
p-value	0.000	0.001	0.012	0.000	0.000	0.000	0.153	0.000	0.000
n	1,879	1,879	1,879	1,879	1,879	1,879	1,879	1,879	1,879
p-value HGSF=GSFP	0.135	0.183	0.652	0.358	0.385	0.627	0.971	0.320	0.415

Note: *Outcome variables are log transformed. S.E., Standard error.

Impact indicators: Smallholder farmer incomes and participation in farming

Tables 5 (and A5) summarize the results on the pre-specified final outcome and impact indicators, including value of agriculture sales and investments, farm and non-farm income and total household income across the school feeding to no school feeding comparison. The results suggest that the school feeding intervention tended to increase participation in farming and business ownership, though the coefficients were not statistically significant. No impacts were detected on farm, non-farm and household income.

Table 5: ANCOVA estimates of the impact of school feeding (GSFP+HGSF) on agriculture outcomes

	(1) Farmer	(2) Own business	(3)* Agriculture sales	(4)* Agriculture costs	(5)* Agriculture income	(6)* Business income	(7)* Household income
SF	0.22	0.19	0.12	-0.09	-0.00	0.02	-0.01
(S.E.)	(0.20)	(0.15)	(0.15)	(0.14)	(0.01)	(0.03)	(0.02)
p-value	0.260	0.194	0.415	0.558	0.688	0.542	0.626
Constant	0.11	-0.48	0.96	3.97	8.31	6.77	9.48
(S.E.)	(0.40)	(0.26)	(0.25)	(0.32)	(0.40)	(0.22)	(0.17)
p-value	0.779	0.066	<0.001	<0.001	<0.001	<0.001	<0.001
n	1,606	1,865	1,865	1,606	1,864	1,865	1,865

Note: *Outcome variables are log transformed. S.E., Standard error.

Examining the results of the second level comparison (HGSF vs GSFP) shows weak evidence of heterogeneities by school feeding program type (Tables 6 and A6). Consistent with the results on the intermediary outcomes, relative to the standard GSFP intervention, households in the HGSF pilot communities had lower values of agricultural sales, despite the objectives of the program[2].

Table 6: ANCOVA estimates of the impact of the GSFP and HGSF on agriculture outcomes

	(1) farmer	(2) Own business	(3)* Agriculture sales	(4)* Agriculture costs	(5)* Agriculture income	(6)* Business income	(7)* Household income
GSFP	0.10	0.20	0.31	0.05	-0.02	0.00	-0.02
(S.E.)	(0.28)	(0.19)	(0.17)	(0.20)	(0.01)	(0.04)	(0.02)
p-value	0.729	0.286	0.075	0.811	0.251	0.922	0.282
HGSF	0.26	-0.02	-0.38	-0.27	0.02	0.03	0.02
(S.E.)	(0.39)	(0.24)	(0.26)	(0.28)	(0.02)	(0.05)	(0.02)
p-value	0.503	0.949	0.153	0.328	0.154	0.597	0.282
Constant	0.12	-0.48	0.96	3.97	8.27	6.77	9.48
(S.E.)	(0.40)	(0.26)	(0.26)	(0.32)	(0.40)	(0.22)	(0.17)
p-value	0.769	0.066	<0.001	<0.001	<0.001	<0.001	<0.001
n	1,606	1,865	1,865	1,606	1,864	1,865	1,865
p-value HGSF=GSFP	0.791	0.580	0.077	0.471	0.133	0.775	0.217

Note: *Outcome variables are log transformed. S.E., Standard error.

Sub-group analysis

The pre-specified sub-group analysis by farmer type (as summarized in Annex table A7) found weak evidence that larger farmers (per protocol as defined by being above median in sales of agricultural sales or in plot size holdings) may have responded differently to the GSFP and HGSF interventions. Heterogeneities in the relative effects of the interventions were more evident when examining households in the Northern regions (Annex table A8). Households in the Northern regions exposed to the GSFP were less likely to be engaged in farming and more likely to have other business activities compared to households exposed to HGSF, where the hypothesis of equality of coefficients was rejected at the 5% level. In addition, relative to the GSFP, households

[2] In the DID specification, the HGSF households also had lower costs of production and since home consumption as well as sales contribute to income this resulted in a small increase in agricultural income, where the hypothesis $\beta_{sf} = \beta_{hgsf}$ was also rejected at the 5% level.

in the HGSF group had lower other business and overall household incomes, where the tests for equality of coefficients for these variables were also rejected at the 5% level.

Discussion

The aims of this field experiment were to rigorously assess whether the school meal program in Ghana could be leveraged to encourage caterers to buy food for the school feeding program from smallholder farmers, and if this in turn resulted in economic benefits for smallholders in the targeted communities. Despite the high-level policy interest across LMICs implementing school feeding programs in linking school feeding to agriculture through "Home-Grown" approaches, this study is the first to our knowledge to examine the agriculture impact of school meals on agriculture using a randomized design. The evidence presented in this study suggests that implementing school feeding programs with the aspiration of improving agriculture as designed in Ghana is not able to improve the income of smallholder farmers. Previous evaluations of the GSFP supply chain stressed the caterers' difficulty to purchase food directly from farmers (De Carvalho et al., 2011). Caterers are unable to advance cash and are unable to finance purchases. There are few direct purchases from farmers. Moreover, the intervention is unlikely to be successful if farmers are unable to respond to any changes in market demand because of credit and other supply-side constraints. In the absence of supply-side support to smallholder farmers that is at times explicitly included in HGSF programs, the success of HGSF hinges, in part, on the establishment of trusted contractual arrangements between caterers and farmers which are conditioned by the traditional market structure, which in turn could increase the share of purchases through smallholders. In this study, the analysis of caterer procurement data after two years of program implementation found that, despite challenges in terms of implementation and program financing, caterers in the HGSF pilot schools had higher shares of total value purchased from smallholders, a proxy for access to market from the school feeding program. However, by far the largest program procurement channel was still operating through traders. A back of the envelope calculation can illustrate the market opportunity for smallholders provided by the program in Ghana: Median purchases by caterers in HGSF schools were found to be approximately 3 USD per child over a 30-day period, 10% of which was procured directly from smallholders. Over a 180-day school year this would equate to 54 USD (3*0.1*180) per child per school year spent on smallholders. Multiplying that by the average number of pupils per school in our sample (271) equates to 14,634 USD per school per year (or about 1,600 USD per school per month), potentially channelled directly to smallholders. Even at the current estimated level of 10% of total volume procured by the program, this would not be a negligible source of revenue for smallholder farmers participating in the program (even though the null result at smallholder level suggests this likely substitutes for other sales rather than being additional). This is an important takeaway from the policy and program perspective, as this result can provide a benchmark for caterer procurement, with a view of setting verifiable targets for smallholder procurement that could be tracked and adjusted over time to gauge progress. In other words, governments could develop a procurement strategy for the school meals program with a set target for direct purchase from smallholders that could then be monitored during implementation. This type of target for procurement has been introduced with some reported success in countries like Brazil (Schneider et al., 2016).

Even if the direct procurement from smallholders can be maintained at high enough levels for long enough periods of time, and that is not a given, important questions remain, including questions on who these farmers are that participate and what their costs and benefits would be from participating in the program. The absence of average impacts observed in this study does not imply that the project did not benefit some smallholder farmers even in a significant way. The detection of such effects, however, would require a very large sample or a series of detailed farmer-level case studies. What our study shows is that the project did not benefit a sizeable group of small farmers in a significant way. Far from stimulating farmers' supply response by offering long-term and credible contracts in the planting season alongside other inputs, the pilot struggled to honor its commitments thus compromising the effectiveness of the intervention. Despite government's efforts and assurances to ensure prompt payment to caterers providing school feeding, delays in disbursements led to implementation delays of over one year and other bottlenecks were reported that will have likely affected the effectiveness of the intervention. Suboptimal disbursement to caterers will have affected the timing and payments to farmers, which will have had important repercussions on both the effects on households and on markets. Of particular concern is the mismatch between budgeted and actual caterer spend on food purchases per pupil resulting from the delays in program disbursements. The implications of this mismatch, equivalent to approximately 50% of the budgeted per child per day allocation, are likely to affect not only the different aspects of program fidelity but also to some degree likely explain the lack of effectiveness reported in this analysis. This particular financing challenge is also not uncommon in more traditional, centralized school feeding programs operated by WFP, for example: the implications of these "pipeline breaks" on program costs have been documented (Galloway et al., 2009; Aulo Gelli et al., 2011), though evidence on how this affects the effectiveness of programs is largely unknown.

An important policy implication of these findings is that despite the null result on smallholder agriculture, the national program as a whole can still be considered a sound investment from the Government of Ghana perspective (Turkson, Baffour, & Wong, 2020). More explicitly, when interpreting this result, it is important to contextualize this analysis alongside two parallel studies assessing the impact of the intervention on school children during the same study period (Aurino et al., 2021; Gelli et al., 2019). The studies found that despite the implementation challenges, the national school feeding program in Ghana had substantive positive effects on children's learning, cognition, and nutrition status. with larger effects in girls, children from households below national poverty line and those living in the Northern regions. No heterogeneities by program type (GSFP vs. HGSF) were found in these studies, suggesting that for school children these programs were equally effective.

In conclusion, this study in Ghana found that though a HGSF intervention may have provided increased access to a school feeding market for smallholders at the school-level, there were no effects of the intervention on smallholder agriculture outcomes. The analysis highlights a combination of program design and implementation fidelity constraints that require careful attention from policymakers and program implementers. As procurement models for school meal are heterogenous and context specific in terms of program design and implementation, further research is needed to understand the implications and trade-offs of the different configurations, including examination of financial flows, quality and quantity of food purchases, delivery requirements, price determination, contracting and other spatial and temporal characteristics involved in the procurement process (Sumberg & Sabates-Wheeler, 2011). However, despite this null result, as substantive benefits of the intervention were found in parallel studies examining the education and nutrition status of school children, with most benefits accruing from more disadvantaged children, the national program in Ghana can still be considered as an effective social protection strategy with multiple objectives, even if the agriculture objectives remain aspirational.

However, improved design and implementation of intervention components will be required to ensure that smallholders can benefit from the program investment.

Author contributions

The authors' responsibilities were as follows—AG, EM, HA, FA: conceived and designed the study; AG, EM, GF, and EA: contributed to the survey tools; GF, DA, CA, and IO-A: performed the data collection; AG, EM, IO-A: analyzed the data; AG, EM, EA, and HA: wrote the first draft of the manuscript; GF, DA, CA, IO-A and FA: contributed to the writing of the manuscript; and all authors: read and agree with the manuscript results and conclusions, and read and approved the final manuscript.

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Annex: Additional tables

DID results

Table A3: DID estimates of the impact of school feeding on smallholder farmer sales

	(1) Seller	(2)* Maize sales	(3)* Rice sales	(4)* Veg sales	(5) Market queen sale	(6) Trader sales	(7) School sale	(8) Market sale	(9) Contract sale
SF	0.05	0.18	-0.02	-0.13	0.04	0.01	-0.00	0.01	0.03
(S.E.)	(0.04)	(0.24)	(0.16)	(0.17)	(0.04)	(0.02)	(0.00)	(0.03)	(0.03)
p-value	0.196	0.463	0.916	0.433	0.283	0.672	0.549	0.664	0.364
Constant	-0.17	-1.00	-0.21	0.33	-0.07	-0.03	0.00	0.03	-0.12
(S.E.)	(0.03)	(0.18)	(0.13)	(0.15)	(0.03)	(0.01)	(0.00)	(0.02)	(0.02)
p-value	0.000	0.000	0.108	0.031	0.021	0.070	0.565	0.132	0.000
N	1,879	1,879	1,879	1,879	1,879	1,879	1,879	1,879	1,879

Note: *Outcome variables are log transformed. S.E., Standard error.

Table A4: DID estimates of the impact of school feeding and HGSF on agriculture outcomes

	(1) Seller	(2)* Maize sales	(3)* Rice sales	(4)* Veg sales	(5) Market queen sale	(6) Trader sales	(7) School sale	(8) Market sale	(9) Contract sale
GSFP	0.07	0.29	-0.09	-0.04	0.05	-0.01	-0.00	0.04	0.04
(S.E.)	(0.03)	(0.22)	(0.21)	(0.16)	(0.04)	(0.02)	(0.00)	(0.03)	(0.03)
p-value	0.057	0.181	0.673	0.813	0.135	0.709	0.522	0.182	0.302
HGSF	0.03	0.07	0.05	-0.23	0.03	0.02	-0.00	-0.01	0.02
(S.E.)	(0.04)	(0.28)	(0.15)	(0.18)	(0.04)	(0.02)	(0.00)	(0.03)	(0.04)
p-value	0.448	0.806	0.735	0.199	0.492	0.218	0.761	0.699	0.543
Constant	-0.17	-1.00	-0.21	0.33	-0.07	-0.03	0.00	0.03	-0.12
(S.E.)	(0.03)	(0.18)	(0.13)	(0.15)	(0.03)	(0.01)	(0.00)	(0.02)	(0.02)
p-value	0.000	0.000	0.112	0.033	0.023	0.074	0.568	0.136	0.000
n	1,879	1,879	1,879	1,879	1,879	1,879	1,879	1,879	1,879
p-value HGSF=GSFP	0.455	0.490	0.454	0.247	0.593	0.193	0.739	0.199	0.732

Note: *Outcome variables are log transformed. S.E., Standard error.

Table A5: DID estimates of the impact of school feeding on agriculture outcomes

	(8) Farmer	(9) Own business	(10)* Agriculture sales	(11)* Agriculture costs	(12)* Agriculture income	(13)* Business income	(14)* Household income
SF	0.31	0.26	0.21	0.01	0.00	-0.02	-0.04
(S.E.)	(0.17)	(0.12)	(0.16)	(0.17)	(0.01)	(0.06)	(0.03)
p-value	0.080	0.029	0.185	0.975	0.961	0.707	0.151
Constant	-0.92	-0.60	0.03	1.33	0.00	-0.07	0.04
(S.E.)	(0.29)	(0.20)	(0.25)	(0.32)	(0.02)	(0.09)	(0.07)
p-value	0.001	0.002	0.918	<0.001	0.816	0.439	0.583
n	1,606	1,865	1,865	1,606	1,864	1,865	1,865

Note: *Outcome variables are log transformed. S.E., Standard error.

Table A6: DID estimates of the impact of GSFP and HGSF on agriculture outcomes

	(8) farmer	(9) Own business	(10)* Production sales	(11)* Agriculture costs	(12)* Agriculture income	(13)* Business income	(14)* Household income
GSFP	0.29	0.22	0.32	0.12	-0.02	-0.05	-0.06
(S.E.)	(0.24)	(0.14)	(0.17)	(0.23)	(0.01)	(0.06)	(0.03)
p-value	0.212	0.119	0.067	0.608	0.100	0.437	0.051
HGSF	0.02	0.08	-0.22	-0.23	0.04	0.05	0.04
(S.E.)	(0.26)	(0.18)	(0.23)	(0.26)	(0.02)	(0.10)	(0.03)
p-value	0.934	0.651	0.356	0.391	0.010	0.615	0.164
Constant	-0.92	-0.60	0.03	1.33	0.01	-0.07	0.04
(S.E.)	(0.29)	(0.20)	(0.26)	(0.32)	(0.02)	(0.09)	(0.07)
p-value	0.001	0.002	0.921	<0.001	0.814	0.440	0.581
n	1,606	1,865	1,865	1,606	1,864	1,865	1,865
p-value HGSF=GSFP	0.549	0.618	0.126	0.448	0.007	0.483	0.046

Note: *Outcome variables are log transformed. S.E., Standard error.

Results of the sub-group analysis

Table A7: Heterogeneity analysis by commercial farmer status, ANCOVA and DID estimates of the impact of school feeding and HGSF on agriculture outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	ANCOVA					DID				
VARIABLES	Production sales	Agriculture costs	Agriculture income	Business income	Household income	Production sales	Agriculture costs	Agriculture income	Business income	Household income
SF	-0.010	-0.150	0.000	0.010	-0.010	0.190	-0.060	-0.010	-0.110	-0.090
	(0.34)	(0.13)	(0.01)	(0.05)	(0.02)	(0.19)	(0.30)	(0.01)	(0.09)	(0.05)
	0.979	0.254	0.820	0.879	0.799	0.314	0.833	0.633	0.195	0.069
hgsf	-0.260	-0.060	0.020	0.010	0.020	-0.320	-0.040	0.020	0.130	0.050
	(0.31)	(0.17)	(0.02)	(0.06)	(0.02)	(0.21)	(0.35)	(0.01)	(0.14)	(0.04)
	0.409	0.740	0.219	0.836	0.528	0.145	0.920	0.089	0.362	0.265
Largeseller (ls)	-1.250	0.090	0.030	-0.070	0.000	-2.800	-0.940	0.000	0.080	0.000
	(0.37)	(0.12)	(0.01)	(0.04)	(0.02)	(0.28)	(0.25)	(0.02)	(0.06)	(0.05)
	0.002	0.445	0.018	0.092	0.825	0.000	0.000	0.802	0.150	0.958
ls*sf	-0.110	0.210	-0.030	-0.010	-0.030	0.350	0.370	-0.030	0.150	0.060
	(0.38)	(0.12)	(0.01)	(0.05)	(0.02)	(0.30)	(0.36)	(0.01)	(0.09)	(0.05)
	0.775	0.089	0.050	0.908	0.223	0.260	0.320	0.060	0.124	0.243
ls*hgsf	0.330	-0.070	0.010	0.020	0.020	-0.140	-0.510	0.040	-0.160	0.000
	(0.35)	(0.18)	(0.02)	(0.06)	(0.03)	(0.48)	(0.44)	(0.02)	(0.14)	(0.05)
	0.348	0.693	0.707	0.739	0.581	0.766	0.249	0.084	0.275	0.972
Constant	4.920	5.130	8.350	6.850	9.490	1.070	1.770	0.010	-0.100	0.040
	(0.36)	(0.18)	(0.39)	(0.22)	(0.17)	(0.24)	(0.38)	(0.02)	(0.10)	(0.09)
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.737	0.312	0.636
P (ls*hgsf=ls*sf)	0.511	0.266	0.207	0.786	0.317	0.493	0.216	0.029	0.157	0.464
Observations	538	1,422	1,864	1,865	1,865	1,865	1,606	1,864	1,865	1,865

Table A8: Heterogeneity analysis by region of residence, ANCOVA and DID estimates of the impact of school feeding and HGSF on agriculture outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
				ANCOVA										
	Farmer	Own business	Production sales	Agriculture costs	Agriculture income	Business income	Household income	Farmer	Own business	Production sales	Agriculture costs	Agriculture income	Business income	Household income
GSFP	0.270	-0.150	0.320	0.180	-0.030	-0.070	-0.050	0.310	0.090	0.280	0.240	-0.040	0.000	-0.060
	(0.22)	(0.14)	(0.22)	(0.25)	(0.02)	(0.04)	(0.02)	(0.20)	(0.14)	(0.23)	(0.23)	(0.02)	(0.06)	(0.04)
	0.233	0.302	0.164	0.474	0.089	0.090	0.059	0.118	0.541	0.217	0.301	0.027	0.958	0.132
HGSF	-0.460	0.820	-0.470	-0.360	0.050	0.170	0.070	-0.160	0.260	-0.370	-0.380	0.070	0.140	0.040
	(0.29)	(0.20)	(0.41)	(0.29)	(0.02)	(0.05)	(0.03)	(0.23)	(0.19)	(0.38)	(0.25)	(0.03)	(0.13)	(0.04)
	0.107	0.000	0.257	0.226	0.047	0.003	0.040	0.468	0.183	0.333	0.132	0.012	0.308	0.275
north (n)	1.820	-1.060	-0.510	-0.410	-0.010	-0.250	-0.060	-0.950	-0.410	-0.390	-0.590	-0.050	-0.070	-0.060
	(0.27)	(0.27)	(0.33)	(0.23)	(0.03)	(0.04)	(0.03)	(0.27)	(0.22)	(0.33)	(0.25)	(0.02)	(0.07)	(0.05)
	0.000	0.000	0.131	0.080	0.575	0.000	0.029	0.001	0.061	0.239	0.023	0.049	0.357	0.180
n*GSFP	-1.140	1.020	-0.030	-0.410	0.040	0.200	0.070	0.040	0.370	0.090	-0.420	0.040	-0.130	0.000
	(0.44)	(0.45)	(0.35)	(0.39)	(0.03)	(0.07)	(0.04)	(0.36)	(0.31)	(0.35)	(0.47)	(0.02)	(0.12)	(0.06)
	0.009	0.024	0.934	0.297	0.157	0.006	0.053	0.912	0.233	0.795	0.375	0.088	0.281	0.975
n*HGSF	0.670	-1.600	0.330	0.470	-0.060	-0.250	-0.090	0.620	-0.320	0.380	0.650	-0.050	-0.100	0.020
	(0.60)	(0.41)	(0.50)	(0.51)	(0.03)	(0.08)	(0.04)	(0.35)	(0.37)	(0.48)	(0.49)	(0.03)	(0.19)	(0.06)
	0.262	0.000	0.510	0.365	0.066	0.002	0.032	0.074	0.386	0.433	0.192	0.106	0.594	0.769
Constant	-1.460	-0.140	1.130	4.090	8.250	6.920	9.510	-0.880	-0.470	0.150	1.530	0.020	-0.060	0.060
	(0.31)	(0.27)	(0.30)	(0.32)	(0.43)	(0.19)	(0.16)	(0.26)	(0.19)	(0.29)	(0.33)	(0.03)	(0.10)	(0.08)
	0.000	0.599	0.000	0.000	0.000	0.000	0.000	0.001	0.014	0.596	0.000	0.458	0.576	0.475
P (n*hgsf=n*sf)	0.043	0.001	0.627	0.298	0.062	0.001	0.019	0.327	0.258	0.686	0.234	0.045	0.911	0.881
n	2029	1865	1865	1606	1864	1865	1865	2029	1865	1865	1606	1864	1865	1865

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