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Subsidizing Resilience

Evaluating Kenya's Fertilizer Subsidy Program Amid Global Supply Chain Disruptions

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Abstract

Amid global supply chain disruptions and an escalating fertilizer crisis, Kenya's National Fertilizer Subsidy Program (NFSP) emerges as a critical intervention to enhance agricultural resilience. This paper investigates the NFSP's impacts on fertilizer adoption, maize productivity, and market dynamics, employing a quasi-experimental design with two-way fixed effects and two-stage least squares (2SLS) estimation. We leverage random variation in government-issued SMS notifications to identify causal effects. Results show that the NFSP increased fertilizer adoption by 7%, leading to maize yield gains of 26–37% (164–233.5 kg/acre), with greater benefits for younger and more educated farmers. However, the program caused a substantial crowding-out effect, reducing private-sector fertilizer use by 49–57%. Barriers such as financial constraints, delayed notifications, and logistical inefficiencies limited equitable access, undermining the program's potential. Despite these challenges, the NFSP was cost-effective, offering favorable value-cost ratios for farmers and the government. To enhance impact and sustainability, we recommend addressing participation barriers and integrating private-sector agro-dealers into the distribution framework. This study provides crucial insights for policymakers on designing subsidy programs that balance immediate productivity gains with market sustainability, especially during periods of global agricultural uncertainty.

Keywords: Fertilizer subsidy, Maize productivity, Global fertilizer crisis, Smallholder farmers, Quasi-experimental, Kenya

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1. Introduction

Agricultural productivity growth is central to the processes of structural transformation and poverty reduction in developing countries (Timmer, 1988; Diao et al., 2010; Christiaensen et al., 2011). The adoption of modern agricultural technologies—such as chemical fertilizers, improved crop varieties, irrigation systems, and other complementary agronomic practices—is essential for enhancing farm productivity and alleviating poverty (Ayalew et al., 2022). However, despite their potential, the uptake of these technologies in many developing regions has been slow, especially in Sub-Saharan Africa (SSA), where fertilizer adoption remains significantly lower compared to other regions, such as Asia and Latin America (Burke et al., 2016). This limited adoption is driven by a range of demand- and supply-side barriers, including inadequate information, liquidity constraints, poor infrastructure, and technologies that may not be well-suited to local conditions (Ashraf et al., 2009; Croppenstedt et al., 2003; Duflo et al., 2009, 2011; Emerick et al., 2016; Hanna et al., 2014; Karlan et al., 2014; Matsumoto and Yamano, 2011; Suri, 2011; Gine and Klonner, 2008; Zerfu and Larson, 2010).

Recent global disruptions, notably the Russian-Ukraine war and the ongoing effects of the COVID-19 pandemic, have exacerbated these challenges by driving up the cost of fertilizers and further hindering adoption rates. In response to these challenges, the Kenyan government introduced the National Fertilizer Subsidy Program (NFSP) in 2022, aiming to provide short-term relief to farmers while addressing long-term food security goals. The NFSP offers significant subsidies—up to 72.7% of the market price—on fertilizers, with the primary objective of increasing domestic agricultural production and stabilizing food prices. This program has been particularly focused on maize production, Kenya's staple crop, and has distributed millions of bags of subsidized fertilizer to farmers across the country. By mid-2023, millions of bags of subsidized fertilizer were distributed to farmers across 41 counties, with the program managed through government depots.

The NFSP represents a shift in Kenya's fertilizer subsidy strategy. Unlike earlier programs, which relied on targeting specific vulnerable groups, the NFSP adopts an open-access model, where any registered farmer can participate. Farmers must register at local administrative offices, providing details on land size and intended crops, after which they receive SMS notifications with details on fertilizer allocation and collection. This inclusive design provides an opportunity to examine the impact of a broadly accessible subsidy on fertilizer adoption, and agricultural productivity.

Farmers who register for the program receive SMS notifications detailing their fertilizer allocation and collection schedule, providing a unique opportunity to leverage exogenous random variation in SMS receipt as an instrument for subsidy access.

Employing a combination of fixed effects and instrumental variable estimation methods, this study evaluates the NFSP's impact on fertilizer adoption and maize productivity. Receipt of government-issued SMS notifications is used as an instrument for accessing subsidized fertilizer, as receiving the SMS is a prerequisite for purchase, and notifications were sent randomly without consideration of household characteristics. Our findings indicate that the NFSP led to a 7% increase in fertilizer adoption and a 26–37% (164–233.5 kg/acre) in maize yields among participating farmers. Additionally, we find that doubling the amount of subsidized fertilizer further boosts yields by 6% (37.9 kg/acre). However, the program also displaces commercial fertilizer use from private sector suppliers, reducing their usage by 49 to 57 percent, indicating a significant crowding-out effect. The impact of the NFSP varies across different demographic groups, with younger, more educated, and male-headed households benefiting the most.

The findings of this study contribute to the growing body of literature on fertilizer subsidy programs by providing insights into the effects of an open-access, national-level subsidy program in the context of a global fertilizer crisis. While much of the existing literature has focused on targeted subsidy programs and their impact on farm productivity, income, and food security (for example, Lunduka et al., 2013; Bunde et al., 2014; Joy, 2019; Paudel and Crago, 2017; Andani et al., 2020; Tsiboe et al., 2021; Zakaria et al., 2021; Alfa and Tsado, 2022; Khonje et al., 2022; Hazrana and Mishra, 2024; Smale et al., 2020; Robert and Nie, 2015), fewer studies have explored the effects of broadly accessible programs, particularly during periods of crisis. Our study also sheds light on the crowding-out effects of public subsidies on private markets, offering valuable policy insights for optimizing fertilizer subsidy programs.

The remainder of this paper is structured as follows: Section 2 provides an overview of the NFSP and the context of fertilizer subsidies in Kenya. Sections 3 and 4 outline the data and empirical strategy, and the results, respectively. Finally, Section 5 concludes with policy recommendations for optimizing the impact of the NFSP on agricultural productivity and food security.

2. Fertilizer subsidy programs in Kenya

Kenya, like many other developing nations, acknowledges the pivotal role of agriculture in its economic development. To support the sector, the government has implemented a range of policy measures, including fertilizer subsidy programs aimed at lowering fertilizer prices, increasing its usage, and ultimately enhancing food production (Ariga and Jayne, 2011; Nduati et al., 2015). Over the years, these efforts have significantly increased fertilizer use among farmers through subsidies and by creating an enabling policy environment that fosters private-sector investments in the fertilizer supply chain (Ariga and Jayne, 2009; Smale and Olwande, 2014). Fertilizer consumption in Kenya rose by 80% between 1999/2000 and 2021/22, reflecting the impact of these initiatives (Kirimi et al., 2023; Breisinger et al., 2024).

A. **Early Intervention and Targeted Subsidy Programs**

The government's first major subsidy initiative, the National Accelerated Agricultural Input Access Program (NAAIAP), was launched in 2007. It targeted resource-poor farmers with landholdings under one hectare, focusing on boosting maize production, the country's staple crop. By 2015, the program had reached over 530,000 farmers, distributing approximately 50,800 metric tons of fertilizer, valued at KES 2.73 billion. While the program effectively increased access to inputs for vulnerable farmers, its limited scope highlighted the need for broader and more inclusive approaches.

B. Response to Global Crisis: Price Stabilization Plan (2008-2019)

In response to the global food and fertilizer crisis of 2008, the Kenyan government introduced the National Fertilizer Price Stabilization Plan. This broad-based subsidy program aimed to stabilize domestic fertilizer prices, which had more than doubled due to the crisis (GoK, 2008; GoK, 2013). Under this plan, the government contracted suppliers through open tenders and distributed fertilizer through National Cereals and Produce Board (NCPB) depots. However, logistical challenges, including the long distances farmers had to travel to access fertilizers and cumbersome administrative processes, limited its effectiveness. These inefficiencies led to the plan's discontinuation in 2019, paving the way for the National Value Chain Support Program (NVSP).

C. Transition to Market-Driven Models: The NVSP

The NVSP, initially piloted in 2015 and officially launched in 2020, introduced an e-voucher system to improve the efficiency of fertilizer subsidy distribution. The program partnered with private agro-dealers as input suppliers, enabling farmers to redeem vouchers at local outlets. This system aimed to reduce bureaucratic hurdles by directly transferring funds from the government to commercial banks. Initially, the NVSP targeted four value chains—maize, coffee, rice, and Irish potato—and later expanded to include green grams, sorghum, and sunflower. Farmers cultivating less than five acres of land paid 60% of the market price for inputs, while the government subsidized the remaining 40%. Despite its innovative approach, the NVSP faced challenges. It was implemented in only 28 of the planned 40 counties due to limited agro-dealer participation. The selection of counties was based on the availability of redeeming outlets and agro-dealers, underscoring the program's reliance on private-sector engagement.

D. National Government Fertilizer Program (NFSP): A Crisis-Driven Pivot

The National Government Fertilizer Program (NFSP), launched in 2022 in response to rising fertilizer prices exacerbated by the Russia-Ukraine war, marked a shift from targeted subsidies to a universal distribution model. Unlike the NVSP, which included multiple inputs, the NFSP focused exclusively on fertilizers. Farmers registered through local chiefs and received SMS notifications about their allocated quantities and collection schedules. Fertilizer distribution was managed by NCPB and Kenya National Trading Corporation (KNTC) depots. Under the NFSP, farmers initially paid KES 3,500 per 50kg bag, with the government covering the difference between this amount and the market price. This price was further reduced to KES 2,500 per 50kg bag in August 2023 to boost agricultural production during the short rainy season. In the 2022/23 financial year, the government allocated KES 9.3 billion to the subsidy program, of which KES 3.79 billion was utilized.

The NFSP was piloted in 12 maize-producing counties, distributing 2,846,481 bags (142,324 metric tons) during the 2023 long rains season. Following the pilot, the program expanded to 29 additional counties, distributing a total of 654,720 bags (32,736 metric tons). By July 30, 2023, the NFSP had distributed 3,501,201 bags (175,060 metric tons) of fertilizer, amounting to KES 12.23 billion.

3. Data and Empirical strategy

This section outlines the data sources, and the empirical approach employed to assess the impact of the program (NFSP).

3.1 Data

The analysis utilizes two rounds of household surveys: a baseline survey conducted in 2014 and an endline survey carried out in January 2024. The baseline survey included 6,512 households sampled across 38 counties in Kenya, while the endline survey revisited a subset of these households. Both surveys employed a two-stage cluster sampling design. In the first stage, 350 rural clusters were randomly selected, and in the second stage, 20 households were systematically sampled within each cluster. Given that more than 90% of the subsidized fertilizer under the NFSP targets maize farmers, the endline survey focused on households in major maize-producing regions. Follow-up interviews were conducted with 815 households across five key counties: Bungoma, Kakamega, Nakuru, Trans-Nzoia, and Uasin Gishu. To maintain relevance, the analysis was confined to households actively engaged in maize cultivation during the 2023 agricultural season, resulting in a final panel dataset of 690 maize-producing farmers. The surveys collected comprehensive data, including household demographics, agricultural input use, maize production, access to credit and insurance, and participation in the NFSP. This dataset forms a robust basis for evaluating the program's effects on fertilizer use, productivity, and related outcomes.

Summary Statistics

Table 1 presents summary statistics of key variables analyzed over the two survey rounds (2014 and 2024) and their combined data. Maize yields improved significantly over the study period, increasing from an average of 631.0 kg/acre in 2014 to 828.9 kg/acre in 2024, with a combined mean yield of 730.0 kg/acre. Conversely, fertilizer use declined sharply, dropping from 226.0 kg/acre in 2014 to 84.5 kg/acre in 2024, resulting in a combined mean of 155.3 kg/acre. This decline can be attributed to the recent global surge in fertilizer prices, exacerbated by the Russia-Ukraine war, which more than doubled fertilizer costs and likely discouraged smallholder farmers from using inorganic fertilizers. The land area dedicated to maize production remained relatively stable, averaging 1.70 acres in 2014 and 1.54 acres in 2024, indicating consistent land use practices among the surveyed households. Household demographics and farming practices exhibited notable changes. The average household size increased from 6.07 members in 2014 to 6.41 in 2024, while the education level of household heads improved from 7.43 years to 8.16 years, reflecting enhanced access to education. The average age of household heads also increased, rising from 49.6 years to 54.7 years over the study period. Farm management practices displayed modest shifts. The use of organic matter in farming rose from 33% in 2014 to 37% in 2024, and the uptake of credit increased from 18% to 22%. One of the most significant changes was observed in irrigation usage, which surged from 0.3% in 2014 to 19% in 2024. This shift suggests an increasing inclination towards intensive farming practices that could enhance productivity in the face of input constraints.

Table 1: Summary Statistics of Main Variables for the two rounds

Variables	First Round (2014)		Second Round (2024)		Combined	
	Mean	SD	Mean	SD	Mean	SD
Maize yield (kg/acre)	631.0	459.0	828.9	527.2	730.0	503.9
Fertilizer use for maize production (kg/acre)	226.0	545.2	84.5	78.7	155.3	395.7
Plot area allocated for maize production (acre)	1.70	1.77	1.54	1.60	1.62	1.69
Household size	6.07	2.47	6.41	2.41	6.24	2.44
Head Male	0.82	0.38	0.79	0.41	0.81	0.40
Head Education	7.43	4.36	8.16	3.72	7.80	4.07
Head Age	49.6	14.6	54.7	12.9	52.1	14.0
Dummy for use of organic matter	0.33	0.47	0.37	0.43	0.35	0.48
Dummy for credit take-up	0.18	0.38	0.22	0.41	0.20	0.40
Dummy for irrigation use	0.003	0.05	0.19	0.39	0.10	0.30
Number of observations	690		690		1380	

Disaggregated Summary Statistics

Table 2 presents summary statistics disaggregated by household registration and subsidy take-up status for baseline and endline data, respectively. For most variables, there are no statistically significant differences between farmers who enrolled in the NFSP and those who did not, including maize yield, household head gender, age, and use of organic matter. However, there are notable differences in the amount of land area and inorganic fertilizer allocated for maize production, household size, educational attainment, and access to credit. Households registered in the NFSP tend to have higher levels of education, smaller household sizes, a higher likelihood of being headed by males, and greater access to credit compared to non-registered households. Participation in the NFSP requires farmers to register the size of their cultivated land for planting. Based on the registered land size, the government then allocates subsidized fertilizer quantities to farmers. A comparison between the land registered by participating farmers and non-participants reveals a significant difference. On average, farmers enrolled in the subsidy program registered more land

(1.86 acres) compared to those who did not participate in the subsidy (1.35 acres).

Table 2: Summary statistics - disaggregated by registration and subsidy take-up status

	Baseline (2014) – Full sample			End-line (2024) –Registered households only		
	Not Registered Household	Registered Household	Mean Difference	Not Collected Subsidy	Collected Subsidy	Mean Difference
Maize yield (kg/acre)	603.94	642.93	-39.00	735.88	1014.53	-278.65***
Fertilizer use for maize (kg/acre)	280.65	201.93	78.72	58.61	139.96	-81.35***
Plot area for maize (acre)	1.35	1.86	-0.51***	1.34	2.28	-0.94***
Household size	5.81	6.18	-0.38	6.58	6.32	0.26
Head Male	0.80	0.84	-0.04	0.77	0.86	-0.09**
Head Education	6.88	7.67	-0.79*	8.04	9.17	-1.12**
Head Age	50.15	49.37	0.78	54.61	54.45	0.16
Dummy for organic fertilizer	0.35	0.32	0.02	0.41	0.31	0.10**
Dummy for credit take-up	0.22	0.16	0.07*	0.19	0.29	-0.10**
Dummy for irrigation use	0.00	0.00	0.00	0.18	0.11	0.07**
Number of observations	211	479		275	204	

At the endline, among registered households, statistically significant differences are observed across most variables, except household size and household head age, based on subsidy take-up status. For instance, registered households that collected subsidies achieved a mean yield of 1,014.53 kg/acre, significantly higher than the 735.88 kg/acre for those who did not collect subsidies, resulting in a mean difference of 278.65 kg/acre. Additionally, regarding fertilizer use (excluding subsidized fertilizer), households that received subsidies reported a mean usage of 139.96 kg/acre, significantly more than the 58.61 kg/acre used by non-collectors. While total average fertilizer use in 2024 is lower than at baseline, the reduction is more pronounced among farmers who did not take the subsidy. This underscores the program's role in mitigating the adverse effects of rising global fertilizer prices and supporting fertilizer use among participating farmers.

In Table 3, we present additional summary statistics to provide insight into the effectiveness of the government-subsidized fertilizer program. Among the farmers in our sample, only 69.4% registered to receive the subsidized fertilizer. We further examined the reasons why 30.6% of farmers chose not to register for the NFSP. The most prominent reason identified was an information gap. Specifically, 35.1% of non-registrants were unaware of the program, indicating a significant need for improved outreach and information dissemination efforts within the farming community. Another 22.3% of farmers who did not register were informed about the program too late, suggesting that more timely communication and proactive engagement are needed to encourage participation. Financial constraints were cited by 19.9% of non-registrants, who reported insufficient cash or lack of access to credit as the primary barriers to participation. This highlights the necessity of financial support mechanisms or alternative payment options to make the program more accessible to economically vulnerable farmers.

Table 3: Summary statistics of the NFSP effectiveness – end-line data

Variable	Observations	Mean	Std. Dev.
Registered to receive the GoK fertilizer subsidy	690	0.69	0.461
Received phone SMS notification	690	0.44	0.497
Collected subsidized fertilizer at the NCPB or KNTC depot	690	0.32	0.467

An additional key finding concerns the percentage of registered farmers who ultimately purchased subsidized fertilizer. Of the 690 farmers in the sample, only 32% bought the subsidized fertilizer, meaning that among those who registered, just 46% proceeded to purchase the fertilizer. This indicates a substantial 54% gap between registration and actual purchase. The primary reasons for the low uptake are as follows: 26.2% of farmers cited financial constraints, highlighting the need for flexible payment options. Another 21.8% found the distance to the designated fertilizer distribution points prohibitive, pointing to the necessity for decentralized distribution or alternative delivery models. A further 26.2% of farmers reported not receiving SMS notifications to collect the fertilizer, emphasizing the critical role of effective communication in ensuring participation. Lastly, 7.3% of farmers noted delayed delivery of fertilizer or SMS notifications as reasons for not purchasing, underscoring the importance of timely and reliable logistics in sustaining program trust. Once farmers are registered, they are supposed to receive an SMS notification detailing when and where to collect their subsidized fertilizer. According to Table 3, only 44.1% of all farmers, or 63.5% of those who registered, reported receiving such notifications. Among those who purchased the subsidized fertilizer, 88.7% received it on time, and 76.0% received the correct type of fertilizer. On average, farmers spent 32.1 hours waiting to collect their fertilizer, adding to the overall transaction costs. Those who purchased the fertilizer received an average of 212.1 kilograms of the subsidized product.

3.2 Empirical Strategy

Establishing the causal impacts of an input subsidy program on various outcomes is a complex challenge, often described as a "wicked problem" (Ricker-Gilbert et al., 2013; Wossen et al., 2017). One major difficulty is that subsidies are rarely distributed randomly across villages and among farmers. Consequently, identifying the causal effects of an input subsidy program requires controlling for selection bias and endogeneity arising from both observable and unobservable factors (Wossen et al., 2017). Common approaches in non-experimental settings include fixed effects and instrumental variable (IV) regression models. In this study, we evaluate the impact of Kenya's NFSP on maize productivity using a combination of these methods.

We leverage receipt of a government-issued SMS notification as an instrument for accessing subsidized fertilizer. Farmers must register at their local agricultural office and subsequently receive an SMS indicating the quantity of fertilizer they are eligible to purchase and when to collect it from designated depots. Since receiving this SMS is a prerequisite for purchasing subsidized fertilizer, it serves as a plausible instrument for subsidy access. However, one might question whether households that received an SMS differ, for example, in terms of productivity, land size, etc., from those that did not. To address this potential concern, we conducted interviews with government officials responsible for SMS allocation and confirmed that notifications were sent randomly, without regard to household characteristics. Additionally, we performed robustness checks within our sample to validate the randomness of SMS distribution. First, we regressed SMS receipt on household characteristics, including maize yield, plot size, fertilizer usage, household head attributes, access to credit, and participation in county subsidy programs. Results, presented in Table A2, reveal no statistically significant differences between households that received the SMS and those that did not, reinforcing the validity of the instrument. This exogenous variation in SMS receipt thus serves as the basis for our IV strategy.

Our main empirical approach employs a Two-Stage Least Squares (2SLS) estimation. In the first stage, we estimate the effect of receiving the SMS on the quantity of subsidized fertilizer received. In the second stage, the predicted values from the first stage are used to estimate the causal effect of fertilizer access on farm productivity, measured as maize yield (kilograms per acre).

The model is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 \widehat{Subsidy}_{it} + \beta_2 X_{it} + \Gamma_i + \varepsilon_{it} \quad (1)$$

$$Subsidy_{it} = \alpha_0 + \alpha_1\ PhoneSMS_{it} + \alpha_2 X_{it} + \Gamma_i + v_{it} \quad (2)$$

Here, Y_{it} denotes the primary outcome of interest – for example, maize yield, serving as a proxy for farm productivity – measured for individual i at time t. Yield is calculated as the total maize harvest (in kilogram) per acre during the 2023 long rains season. $Subsidy_{it}$ is the amount of subsidized fertilizer purchased by the household i at time t from the NFSP in kilogram per acre. $PhoneSMS_{it}$ is a binary indicator for SMS receipt before the 2023 planting season.[1] X_{it} is a vector of household-specific control variables, including the age, gender, and education of the household head, household size, plot size allocated for maize production, use of organic matter and irrigation, access to credit and insurance, and participation in county subsidy programs. We also include household fixed effects, year fixed effects, and year-by-ward fixed effects (Γ_i) to control unobserved heterogeneity. The error terms in the first and second stage regressions are denoted as, respectively. β_1 represents the impact of the subsidy on productivity, and v_{it} and $\varepsilon_{it}$are error terms for the second and first stages, respectively.[2]

4. Results

This section presents the key findings of the study, starting with an analysis of the key factors affecting participation in the NFSP and the uptake of the subsidy. We first examine whether the program encourages the adoption of inorganic fertilizer for maize production by farmers who had not previously used it. Next, we assess the impact of the NFSP on maize productivity, measured by total maize production per acre, and explore any heterogeneity in the program's effects on maize yield based on household head characteristics such as gender, education, and age. We then investigate whether the NFSP has a crowding-out effect on private sector fertilizer use. Finally, several robustness checks are conducted to assess potential internal validity issues.

[1] It is important to note that households receiving an SMS after the planting period might not purchase the subsidized fertilizer. Therefore, we use the phone SMS notifications sent before the planting period as an instrument to examine the impact of the NFSP.
[2] We believe this 2SLS framework yields a local average treatment effect, providing a rigorous estimation of the program's impact on farm productivity while addressing potential biases arising from self-selection.

4.1 Participation and take-up of the NFSP

Participation in the NSFP and the decision to purchase subsidized fertilizer are shaped by several factors. Table 4 provides a detailed analysis of the key characteristics that significantly impact farmers' likelihood of registering for the NFSP and purchasing subsidized fertilizer. Columns 1 and 2 investigate the factors affecting the probability of registration, both with and without controls for household and year fixed effects. Columns 3 and 4 extend the analysis by examining the factors that determine the likelihood of subsidy uptake among those who register, again considering fixed effects to control for potential unobserved heterogeneity.

The results indicate that receiving a phone SMS from the government is a crucial determinant of subsidized fertilizer uptake. Among registered households, those who received the phone SMS were 46 percent more likely to purchase the subsidized fertilizer than those who registered and did not receive the notification[3]. This finding is unsurprising, considering that receiving a phone SMS notification specifying the collection details is a mandatory requirement for purchasing subsidized fertilizer. Farm size for maize production also plays a significant role in both registration and fertilizer uptake. Larger farms are more likely to participate in the NFSP and purchase subsidized fertilizer. Specifically, doubling the land allocated for maize production increases the probability of program registration by 6% and the likelihood of fertilizer purchase by 8%. This relationship is consistent with the fact that the amount of subsidized fertilizer allocated is based on the land size registered for maize production.

Previous experience with inorganic fertilizer and access to credit are additional factors that enhance the likelihood of both program participation and subsidy uptake. Farmers with prior experience using inorganic fertilizer are 12% more likely to register for the program and 10% more likely to purchase subsidized fertilizer. Similarly, farmers with access to credit are 6% more likely to participate in the NFSP and purchase subsidized fertilizer compared to those without access to credit.

[3] Receiving an SMS notification from the government about when and where to collect subsidized fertilizer is not sufficient for farmers to make the purchase. Financial constraints and the timing of the SMS, especially those received after the planting period, are among the factors that can hinder farmers from purchasing the subsidized fertilizer.

Table 4: Determinants of participation and take-up rate of the NFSP

	Registered to NFSP		Collected subsidized fertilizer dummy	
	(1)	(2)	(3)	(4)
Phone SMS from the government			0.44^{***}	0.46^{***}
			(0.04)	(0.04)
Log farm size for maize production (acre)	0.10^{***}	0.06^{**}	0.08^{***}	0.08^{***}
	(0.02)	(0.03)	(0.01)	(0.02)
Fertilizer use experience dummy	0.11^{***}	0.12^{*}	0.09^{***}	0.10^{***}
	(0.04)	(0.06)	(0.02)	(0.03)
Household size	0.00	-0.01	-0.01^{***}	-0.00
	(0.00)	(0.01)	(0.00)	(0.01)
Head Male	-0.02	-0.01	0.04^{**}	0.03
	(0.02)	(0.05)	(0.02)	(0.03)
Head Education	0.01^{***}	0.00	0.00	-0.01
	(0.00)	(0.01)	(0.00)	(0.00)
Dummy for use of organic matter	0.04^{*}	-0.00	-0.03	-0.02
	(0.02)	(0.03)	(0.02)	(0.02)
Dummy for credit take-up	-0.01	0.07^{**}	0.05^{**}	0.06^{**}
	(0.03)	(0.04)	(0.02)	(0.03)
Distance to the nearest fertilizer depot (km)	-0.63^{***}	0.08	-0.16^{***}	-0.04
	(0.03)	(0.07)	(0.02)	(0.06)
Dummy for subsidy take-up other than NFSP	0.00	0.00	-0.00^{**}	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Dummy for crop insurance take-up	0.22	0.07	0.33	0.33
	(0.23)	(0.20)	(0.23)	(0.25)
Constant	0.40^{***}	0.12	0.04	-0.03
	(0.07)	(0.09)	(0.04)	(0.06)
Household Fixed Effect	No	Yes	No	Yes
Year Fixed Effect	No	Yes	No	Yes
Number of observations	1380	1380	1380	1380

Note: The dependent variable in columns 1 and 2 is the dummy variable for registering in the NFSP, whereas in columns 3 and 4, the dependent variable is the purchase of the GoK subsidized fertilizer. In columns 1 and 3, we estimate the factors that affect participation and take-up rate in the GoK fertilizer subsidy program using OLS, while in columns 2 and 4, we control for household and year fixed effects. Enumeration area (cluster)-level clustered standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.2 Impact of subsidy on the adoption of inorganic fertilizer

The adoption of inorganic fertilizer use in Africa is much lower than the rest of the world (World Bank, 2007), highlighting the significance of assessing whether subsidies encourage farmers who have never used fertilizer to start using it. Table 5 presents the main results on the impact of participation and take-up of the NFSP subsidies on the probability of using inorganic fertilizer using fixed effect regression.

Our findings indicate that participation in the NFSP increases the adoption of inorganic fertilizer in maize production by 6 to 7 percent. Columns 1 and 2 show that, on average, farmers who registered for the NFSP are more likely to use inorganic fertilizer (either commercial or subsidized) in their maize production. Specifically, registering for the NFSP increases the probability of using inorganic fertilizer in maize production by 6 percent. Likewise, columns 3 and 4 reveal an approximate 7 percent increase in the likelihood of fertilizer use among those who purchased the subsidy compared to those who did not. Several studies have documented that liquidity constraints are one of the main factors behind the low adoption of inorganic fertilizer in developing countries (see for example, Croppenstedt et al., 2003; Gine and Klonner, 2008; Matsumoto and Yamano, 2011; Zerfu and Larson, 2010). Hence, providing subsidies can encourage farmers to adopt inorganic fertilizer, especially for those who have never used it in production.

Table 5: Impact of the NFSP on adoption of inorganic fertilizer (commercial plus subsidized)

Dependent Variable: Dummy for inorganic fertilizer use				
	(1)	(2)	(3)	(4)
Registered to NFSP	0.07**	0.06*		
	(0.03)	(0.03)		
Collect subsidized fertilizer (dummy)			0.08***	0.07***
			(0.02)	(0.02)
Control Variables	No	Yes	No	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Number of observations	1380	1380	1380	1380

Note: The dependent variable is an indicator variable for inorganic fertilizer use (commercial plus subsidized fertilizer). In columns 2 and 4, we control the household-specific control variables, including gender, education, age, dummy variables for the use of organic matter, irrigation, crop insurance, credit take-up, and the take-up of the county government subsidy. In all specifications, we control household and year fixed effects. Columns 1 and 2 present the effect of registering in the NFSP on the probability of using inorganic fertilizer, whereas in columns 3 and 4, we estimate the effect of purchasing the GoK subsidized fertilizer on the probability of fertilizer use using a two-way fixed effect estimation. Enumeration area (cluster)-level clustered standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3 Crowding out effect of the subsidy

We showed that the NFSP increased the use of inorganic fertilizer (both subsidized and unsubsidized), particularly among households previously not engaged in fertilizer application. However, the program substantially reduced the use of commercial fertilizer sourced from private providers. Table 6 presents the crowding-out effect of the subsidy program, the probability of using commercial fertilizer (excluding subsidized fertilizer). Columns 1 and 2 use OLS estimation to examine this effect, while columns 3 and 4 employ a two-way FE model, and columns 5 and 6 utilize a 2SLS approach. Columns 2, 4, and 6 incorporate household-specific controls, such as the gender and education of the household head, as well as dummy variables for organic matter use, irrigation, crop insurance, credit access, and county subsidy participation. Columns 3 through 6 also include year and household fixed effects to account for time-invariant characteristics influencing fertilizer use.

Table 6: Crowding out effect of NFSP on the probability of using commercial fertilizer use

Dependent variable: Commercial fertilizer use dummy						
	OLS		**FE**		**2SLS**	
	(1)	(2)	(3)	(4)	(5)	(6)
Collected subsidized fertilizer	-0.51***	-0.54***	-0.47***	-0.49***	-0.55***	-0.57***
	(0.05)	(0.05)	(0.06)	(0.05)	(0.08)	(0.08)
Baseline control mean (yield)	631.0	631.0	631.0	631.0	631.0	631.0
Control Variables	No	Yes	No	Yes	No	Yes
Household Fixed Effect	No	No	Yes	Yes	Yes	Yes
Year Fixed Effect	No	No	Yes	Yes	Yes	Yes
Number of observations	1380	1380	1380	1380	1380	1380

Note: The dependent variable is a dummy variable that equals one if the household uses commercial fertilizer (excluding NFSP-subsidized fertilizer) and zero otherwise. In columns 2, 4, and 6, we control the household-specific control variables, including gender, education, age, dummy variables for the use of organic matter, irrigation, crop insurance, credit take-up, and take-up of the county government subsidy. Columns 1 and 2 present the effect of the program on farm productivity using Ordinary Least Square (OLS) estimation, whereas in columns 3 and 4 we estimate the effect of the program using a two-way fixed effect model (FE). Finally, in columns 5 and 6, we use a two-stage least square (2SLS) estimation method. Enumeration area (cluster)-level clustered standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results reflect a significant crowding-out effect, driven by the transition of fertilizer distribution from private agricultural dealers under the e-voucher system to centralized distribution via government NCPB depots. This shift reduced the incentives for farmers to engage with private sector suppliers. Depending on the model specification, the probability of using commercial fertilizer declined by 49 to 57 percentage points. These findings align with prior studies (e.g., Minten and Kyle, 1999; Duflo et al., 2008; Ruben and van Schalkwyk, 2009; Nin-Pratt and Yu, 2012; Takeshima and Nkonya, 2014; Jayne and Rashid, 2013) that indicate subsidy programs often displace private-sector participation.

While the NFSP has succeeded in expanding inorganic fertilizer adoption among new users, its impact on commercial fertilizer markets raises concerns about sustainability and private sector displacement. Policymakers should weigh these findings when designing subsidy programs, as over-reliance on public distribution mechanisms may undermine long-term market development and private sector involvement. Future subsidy programs should consider integrating private sector channels to minimize market distortions.

4.4 Impact of subsidy on maize yield

Table 7 below presents the impact of the NFSP on maize yield, measured in kilograms per acre, using various model specifications. Panel A examines the effect of subsidy take-up on maize yield, while Panel B explores the impact of the subsidy amount on yield. The regressions use three estimation techniques: OLS (columns 1 and 2), two-way fixed effects (columns 3 and 4), and two-stage least squares (2SLS, columns 5 and 6). In columns 2, 4, and 6, we control for household-level variables, including the gender and education of the household head, use of organic matter, irrigation, crop insurance, credit uptake, and participation in the county government subsidy program. Additionally, the two-way fixed effects and 2SLS models (columns 3–6) incorporate household and year fixed effects, controlling for time-invariant factors that could influence productivity, such as inherent individual capabilities.

The results suggest that the NFSP significantly increases maize yield for farmers who participate in the program. Across all specifications, farmers who collect subsidized fertilizer show consistently higher yields compared to those who do not. In the OLS regressions (columns 1 and 2), farmers receiving the subsidy exhibit, on average, a 32% higher yield, equivalent to 201.9 kg/acre. Panel B indicates that doubling the subsidized fertilizer usage leads to a 6% increase in yield (37.9 kg/acre). However, self-selection into the program raises concerns about potential endogeneity, which may bias the estimates.

To address these concerns, we implement two alternative approaches: two-way fixed effects (columns 3 and 4) and 2SLS (columns 5 and 6). The fixed-effects model controls for unobserved heterogeneity at the household, ward, and year levels, providing robust evidence that the NFSP boosts maize yield. Specifically, in Panel A, columns 3 and 4 show that subsidy recipients achieve a 26% higher yield (164.1 kg/acre) than non-recipients. Panel B further reveals that doubling subsidized fertilizer results in a 4% (25.2 kg/acre) yield increase.

Table 7: Impact of the NFSP on maize yield

Dependent Variable: The logarithm of yield (kg/acre)	OLS		FE		2SLS	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Extensive Margin						
Collected subsidized fertilizer	0.46***	0.32***	0.18**	0.26***	0.34*	0.37**
	(0.08)	(0.08)	(0.08)	(0.07)	(0.19)	(0.17)
Baseline control mean (yield)	631.0	631.0	631.0	631.0	631.0	631.0
Panel B: Intensive Margin						
Log fertilizer subsidy (kg/acre)	0.08***	0.06***	0.03**	0.04***	0.06*	0.06**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
First Stage IV Regression						
					2.53***	2.49***
Phone SMS notification					(0.24)	(0.24)
F-test for excluded instruments:					114.9	105.0
Prob > F					(0.00)	(0.00)
Control Variables	No	Yes	No	Yes	No	Yes
Household Fixed Effect	No	No	Yes	Yes	Yes	Yes
Year Fixed Effect	No	No	Yes	Yes	Yes	Yes
Ward # Year Fixed Effect	No	No	Yes	Yes	Yes	Yes
Number of observations	1380	1380	1380	1380	1380	1380

Note: The dependent variable is the logarithm of yield (kg/acre). Columns 2, 4, and 6 control for household-specific variables such as gender, education, age, use of organic matter, irrigation, crop insurance, credit uptake, and county government subsidy participation. Columns 1 and 2 report the effects using OLS, while columns 3 and 4 estimate the effects using two-way fixed effects. Columns 5 and 6 use 2SLS with SMS notifications from the agricultural office as an instrument for subsidized fertilizer. Standard errors clustered at the enumeration area level are reported in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01.

The 2SLS results in columns 5 and 6, offer an additional level of robustness by addressing the potential endogeneity of subsidized fertilizer. By using the receipt of an SMS notification from the government agricultural office as an instrument for fertilizer use, we isolate exogenous variation in fertilizer uptake. This approach allows for a clearer identification of the causal impact of fertilizer on yield. Results show that the subsidy increases yield by 37% (233.5 kg/acre), and doubling fertilizer usage leads to a 6% (37.9 kg/acre) increase in maize yield, controlling for key household-level factors and fixed effects.

These results suggest that the NFSP significantly improves maize yields. The program's effectiveness is also supported by cost-effectiveness analysis, as evidenced by the favorable value-cost ratios (VCR) presented in Table A3, which suggest that both farmers and the government benefit substantially from the subsidy. Further involvement of the private sector could enhance the program's efficiency by minimizing market distortions.

4.5 Heterogeneity effect of the program on farm productivity

Building on the findings in Section 4.4, we now explore whether the NFSP's impact on maize yield varies by household head characteristics, including gender, age, and education. Table 8 provides estimates of these heterogeneity effects.

Panel A investigates whether the program's impact differs based on the gender of the household head. In columns 1 and 2, we examine the interaction between the fertilizer subsidy amount and an indicator for male-headed households, both with and without control variables. In column 2, we control household-specific factors such as gender, education, age, land allocated to maize, use of irrigation and crop insurance, credit uptake, and county government subsidy participation. The results show that the subsidy effect on maize yield is significantly larger (7%) for male-headed households compared to female-headed households.

Panel B analyzes whether the program's impact on yield varies by the age of the household head, comparing younger farmers (under 40 years old) with older farmers (over 40 years old). Results in columns 3 and 4 reveal that younger farmers benefit more from the subsidy, with doubling the fertilizer usage leading to an 8% higher increase in yield for younger farmers relative to their older counterparts. This difference may reflect younger farmers' greater propensity to adopt modern farming practices.

Finally, Panel C explores whether educational attainment of the household head influences the program's impact on yield. In columns 5 and 6, we show that more educated farmers experience a stronger positive effect from the subsidy, as evidenced by the statistically significant interaction between the subsidy and the educational level of the household head.

Table 8: Heterogeneity of the program on maize yield based on household head's characteristics.

Dependent Variable: The logarithm of maize yield (kg/acre)						
	(1)	(2)	(3)	(4)	(5)	(6)
Log total fertilizer subsidy (kg/acre)	-0.03	-0.01	0.03*	0.04***	-0.00	-0.00
	(0.04)	(0.04)	(0.01)	(0.01)	(0.04)	(0.03)
Panel A: Household Head Gender						
Log total fertilizer subsidy X Male Head	**0.07***	**0.07***				
	(0.04)	**(0.04)**				
Head Male	0.11	0.06				
	(0.11)	(0.12)				
Panel B: Household Head Age						
Log total fertilizer subsidy X Head age			**0.07****	**0.07****		
			(0.03)	**(0.03)**		
Head age less or equal 40 years			0.02	-0.05		
			(0.08)	(0.07)		
Panel C: Household Head Education						
Log total fertilizer subsidy X Head education					**0.04**	**0.06****
					(0.03)	**(0.03)**
Head education (at least primary school)					0.20***	0.13*
					(0.07)	(0.07)
Control Variables	No	Yes	No	Yes	No	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1380	1380	1380	1380	1380	1380

Note: The dependent variable is the logarithm of yield (kg/acre). Columns 2, 4, and 6 control household-specific variables including gender, education, age, use of organic matter, irrigation, crop insurance, credit take-up, and county government subsidy take-up. All models include household and year fixed effects. Standard errors clustered at the enumeration area level are reported in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01.

4.6 Internal Validity Test

Establishing the causal impacts of an input subsidy program such as the NFSP is inherently challenging due to potential selection biases and endogeneity issues. These challenges arise because participation in the subsidy program and subsequent uptake is rarely random, making it necessary to disentangle the program's effects from confounding factors. To ensure the robustness of our findings, we implemented several internal validity checks, focusing on selection at both the registration and SMS notification stages.

First, we examined whether systematic differences existed between households that registered for the NFSP but did not purchase subsidized fertilizer and those that never registered. If selection bias were present, it would manifest as significant differences in maize yields between these two groups, suggesting that unobserved factors influencing registration—such as farming ability, access to resources, or motivation—also affected productivity. Table A4 in the Appendix presents the results. Using a restricted sample of households that did not purchase subsidized fertilizer, we found no statistically significant differences in maize yields between registrants and non-registrants, even after controlling for household-specific characteristics. This result indicates that selection bias at the registration stage is unlikely to have influenced our findings.

Next, we assessed potential selection bias at the SMS notification stage. Since receiving an SMS notification is a prerequisite for purchasing subsidized fertilizer, any systematic targeting of more productive farmers during notification dissemination could compromise the randomness required for our IV strategy. In addition to the regression of phone SMS against all observed characteristics presented in table A2 in the Appendix[4], we restricted the sample to farmers who either received an SMS but did not purchase the fertilizer or registered but did not receive an SMS. The results are presented in Appendix A5. Comparisons between these groups revealed no significant differences in maize yields, suggesting that SMS notifications were indeed distributed randomly. This finding aligns with information obtained from government officials responsible for the notification process, who confirmed that SMS allocations were not based on household characteristics and were purely random.

Finally, to reinforce the validity of our IV approach, we conducted additional checks using the registered sample. Since receiving an SMS is conditional on registration, analyzing this subset controls for potential biases introduced during the registration phase. Our analysis confirmed that the estimated impacts of the subsidy program on maize yields remained robust when focusing exclusively on registered households. These results presented in Table A6 in the Appendix underscore the reliability of using SMS notifications as an instrument for accessing subsidized fertilizer.

These internal validity tests provide strong evidence that our findings are not driven by selection bias or endogeneity. By leveraging the exogenous variation in SMS notifications and controlling

[4] Table A2 in the Appendix shows no correlation between household characteristics and government phone SMS notifications. In other words, the government's phone SMS notifications appear to be random and are not correlated with the observed characteristics of households.

for observable and unobservable factors, we estimate the impact of the NFSP on fertilizer use and maize productivity, offering valuable insights for policymakers and researchers evaluating similar interventions.

5. Conclusions

The findings of this study offer critical insights into the effectiveness and challenges of Kenya's NFSP amid global supply chain disruptions and a volatile fertilizer market. By increasing fertilizer adoption and maize yields, the program has made significant strides in addressing short-term food security concerns and mitigating the adverse effects of the global fertilizer crisis. The results highlight a 7% increase in fertilizer adoption and maize yield improvements of up to 37% among participating farmers, with greater benefits observed for younger, more educated households. These outcomes underscore the potential of subsidies to catalyze agricultural productivity and stabilize food systems during periods of economic instability.

However, the study also identifies considerable challenges that threaten the program's long-term sustainability. Chief among these is the substantial crowding-out of private fertilizer markets, with private-sector fertilizer use declining by 49–57% due to the NFSP. This unintended consequence raises concerns about the program's market dynamics and the risk of dependency on government intervention. Furthermore, logistical inefficiencies, such as delayed notifications and limited access to distribution points, coupled with financial barriers, restricted equitable participation. These factors highlight the need for a more inclusive and efficient implementation framework that ensures benefits reach all farmers, particularly marginalized groups.

Despite these challenges, the cost-effectiveness of the NFSP remains evident, with favorable value-cost ratios for both farmers and the government. The findings suggest that targeted modifications to the program can significantly enhance its impact while addressing its shortcomings. Integrating private-sector distributors into the supply chain, for instance, could mitigate the crowding-out effect and promote sustainable market participation. This approach would also reduce logistical bottlenecks and improve the accessibility of subsidized inputs, thereby fostering a more resilient agricultural input system.

To further improve the NFSP's effectiveness, policymakers should consider enhancing program outreach through robust communication campaigns and timely dissemination of information about subsidy access. This would help bridge the information gap that currently excludes many eligible farmers. Additionally, simplifying the registration process and decentralizing distribution channels can alleviate logistical challenges and reduce transaction costs for farmers. Encouraging greater participation among women and less-educated farmers through tailored extension services and targeted financial assistance would also enhance the program's inclusivity.

Another critical recommendation is to adopt an e-voucher system that allows farmers to redeem subsidies through private-sector agro-dealers. This transition would help reinvigorate the private fertilizer market while maintaining access to affordable inputs. Furthermore, scaling up financing mechanisms, such as microcredit schemes tied to fertilizer purchases, could address liquidity constraints that prevent economically vulnerable farmers from fully utilizing the subsidy program. Investments in complementary infrastructure, such as rural roads and storage facilities, would also bolster the program's efficiency and reach.

In conclusion, the NFSP demonstrates the potential of well-designed subsidy programs to address short-term crises and improve agricultural productivity. However, its limitations call for strategic adjustments to enhance its inclusivity, efficiency, and long-term impact. By addressing participation barriers, strengthening private-sector engagement, and focusing on sustainable investments, the program can serve as a model for other countries facing similar challenges. As global agricultural systems continue to face mounting uncertainties, Kenya's experience offers valuable lessons for designing policies that enhance resilience, productivity, and equity in the agricultural sector.

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Appendix

Table A1: Prices of subsidized and unsubsidized fertilizer

Type of fertilizer(50kg)	Unsubsidized price (KES)	Subsidized price as of August 2023 (KES)
Urea	5,668	3,500
CAN	5,483	2,875
NPK	6,015	3,275
MOP	6,500	1,775
Sulphate Ammonia	7,700	2,220

Source: Ministry of Agriculture and Livestock Development (https://kilimo.go.ke/fertilizer-subsidy-2022)

Table A2: Relationship between receiving phone SMS and household characteristics-registered sub sample only

Dependent Variable: Dummy for phone SMS	Registered households only
Log maize yield (kg/acre)	0.03
	(0.03)
Dummy for inorganic fertilizer use	0.08
	(0.09)
Household size	-0.00
	(0.01)
Head Male	-0.03
	(0.06)
Head Education	0.01
	(0.01)
Dummy for organic fertilizer use	0.03
	(0.04)
Dummy for credit take up	-0.02
	(0.04)
Dummy for county government subsidy	-0.11
	(0.09)
Dummy for insurance	-0.11
	(0.19)
Constant	0.24*
	(0.13)
Household Fixed effect	Yes
Year Fixed effect	Yes
Number of Observations	958

Note: The dependent variable is the dummy variable for receiving phone SMS from the government. Robust and enumeration area (cluster)-level clustered standard errors are reported in parentheses in column 1 and 2 respectively. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: Value cost ratios of NFSP

	Subsidized fertilizer price, 2023 (KES. 3500/50kg)	Subsidized fertilizer price, 2023 (KES. 2500/50kg)
Maize price (KES/kg)	45.43	45.43
Nitrogen price for farmers (KES/kg)	278.66	199.04
Nitrogen subsidized price cover by the government (KES/kg)	149.78	229.40
Nitrogen to maize price ratio	6.13	4.38
Farmers' Value cost ratio (FVCR)	2.08	2.92
Government's Value cost ratio (GVCR)	3.88	2.53

Table A4: Impact of registration on maize yield (test for selection at registration)

Dependent Variable: The logarithm of maize yield (kg/acre)

	(1)	(2)
Registration into NSFP	-0.11	-0.09
	(0.08)	(0.07)
Constant	6.98***	6.85***
	(0.02)	(0.17)
Control Variables	No	Yes
Household Fixed Effect	No	No
Year Fixed Effect	No	No
Number of observations	938	938

Note: The dependent variable is the logarithm of yield (kg/acre). In columns 2, we control the household-specific control variables, including gender, education, age, dummy variables for the use of organic matter, irrigation, crop insurance, credit take-up, and take-up of the county government subsidy. Enumeration area (cluster)-level clustered standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Impact of receiving phone SMS on maize yield (test for selection at SMS level)

Dependent Variable: The logarithm of maize yield (kg/acre)

	(1)	(2)
Registration into NSFP	0.07	0.06
	(0.13)	(0.12)
Constant	6.94***	7.03***
	(0.03)	(0.19)
Control Variables	No	Yes
Household Fixed Effect	No	No
Year Fixed Effect	No	No
Number of observations	550	550

Note: The dependent variable is the logarithm of yield (kg/acre). In columns 2, we control the household-specific control variables, including gender, education, age, dummy variables for the use of organic matter, irrigation, crop insurance, credit take-up, and take-up of the county government subsidy. Enumeration area (cluster)-level clustered standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: Impact of the NFSP on maize yield - Registered sub sample

	2SLS/IV estimates	
	(1)	(2)
Log total fertilizer subsidy (kg/acre)	0.14*	0.16**
	(0.08)	(0.08)
First Stage IV Regression		
	1.88***	1.78***
Phone SMS notification	(0.38)	(0.38)
F-test for excluded instruments:	24.51	21.45
Prob > F	(0.00)	(0.00)
Control Variables	No	Yes
Household Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Number of observations	958	958

Note: The dependent variable is the logarithm of yield (kg/acre). In column 2, we control the household-specific control variables, including gender, education, age, dummy variables for the use of organic matter, irrigation, crop insurance, credit take-up, and take-up of the county government subsidy. Enumeration area (cluster)-level clustered standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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