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Fertilizer Subsidy Policy and Dry Maize Price Dynamics in Kenya: County-Level Panel Evidence from the National Fertilizer Subsidy Program, 2021 to 2024

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ABSTRACT

Kenya launched its National Fertilizer Subsidy Program (NFSP) in September 2022, selling NPK 17-17-17 fertilizer at KES 3,500 per 50 kg bag, roughly half the prevailing market price, with the stated goal of raising maize output and moderating consumer food prices. The program expanded to 41 of 47 counties by April 2023 and reduced the subsidy price further to KES 2,500 per bag in August 2023, at a total fiscal outlay of KES 9.3 billion in the 2022 to 2023 financial year. This study asks whether the program delivered on its food price stabilization objective, a question that existing evaluations have not addressed directly at the county market level. Using a balanced county-month panel of 45 counties observed from May 2021 to November 2024 and drawing on retail price data from the Kenya Agricultural Market Information System, AFA national fertilizer retail price records, and Central Bank of Kenya exchange rate data, the study estimates a two-way fixed effects model with county and time fixed effects and standard errors clustered at the county level. The principal finding is that the NFSP reduced retail maize prices by approximately 6.3 percent where the program was active, a result that is marginally significant at the 10 percent level. This aggregate result conceals a sharp phase asymmetry: Phase-2 counties, which entered the program at a deeper subsidy price from April 2023 onward, experienced a statistically significant retail price reduction of around 10.6 percent ($p < 0.05$), while Phase-1 counties showed no measurable price effect despite being first to receive fertilizer. The most plausible explanation for this asymmetry is macroeconomic attenuation. The KES depreciated 42 percent from the program start in September 2022 to its peak in January 2024, and domestic fertilizer market prices rose from a mean of around KES 3,200 per 50 kg bag in early 2021 to KES 6,350 at peak, raising upstream supply chain costs by an amount that absorbed a large portion of the subsidy benefit before it reached retail food markets. The correlation between log NPK prices and the log exchange rate is 0.52, confirming that fertilizer price inflation was substantially exchange-rate-driven during this period. The paper concludes that fertilizer subsidies can moderate staple food prices, but the transmission is incomplete and context-dependent. A subsidy that is large enough to exceed concurrent macroeconomic cost pressures, and that is deployed after the

Keywords:
fertilizer subsidy; maize price transmission; difference-in-differences; Kenya; food inflation; exchange rate pass-through; two-way fixed effects; county panel

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sharpest part of a global price shock has passed, is more likely to deliver consumer price relief than one launched at the peak of a global commodity crisis.

INTRODUCTION

Food price inflation sits near the top of Kenya's economic policy agenda. Households allocate more than 40 percent of their total expenditure to food (Kenya National Bureau of Statistics, 2019), and maize accounts for the largest share of caloric intake in both rural and urban settings. Between January 2021 and mid-2023, retail maize prices roughly doubled at markets tracked by the Kenya Agricultural Market Information System (KAMIS), driven by a convergence of external and domestic shocks. The Russia-Ukraine conflict that began in February 2022 severely disrupted global fertilizer supply chains, with DAP fertilizer prices in Kenya rising 76 percent in 2021 and a further 10 percent by mid-2022 according to data compiled by the Tegemeo Institute (2024). Fuel prices escalated further after the Finance Act of July 2023 standardized VAT on petroleum products at 16 percent, removing a prior 8 percent concession. The Kenyan shilling lost approximately 42 percent of its value against the US dollar between mid-2022 and January 2024, intensifying import costs across the agricultural supply chain (Central Bank of Kenya, 2024). The combination of these shocks pushed maize retail prices 43.9 percent higher between 2021 to 2022 and 2023, according to KAMIS data cited by IFPRI (2024).

In response, the incoming Kenya Kwanza administration launched the NFSP in September 2022. The program procured 472,500 metric tons of fertilizer through the Kenya National Trading Corporation (KNTC) and distributed it via National Cereals and Produce Board (NCPB) depots, initially in 12 Phase-1 counties before expanding to 41 counties by mid-2023 (Ayalew et al., 2024; Tegemeo Institute, 2024). The subsidy price was set at KES 3,500 per 50 kg bag, against a market price of approximately KES 6,000 to KES 6,500, and was later reduced to KES 2,500 in August 2023. Total government expenditure on fertilizer procurement in the 2022 to 2023 financial year reached KES 9.3 billion, approximately USD 67 million at contemporaneous exchange rates, making the NFSP the largest single-year agricultural input intervention in Kenya's recent history.

Two strands of assessment work on the NFSP have appeared since 2023. Ayalew et al. (2024) used quasi-experimental methods, leveraging random variation in SMS notifications as an instrument for fertilizer access, and found that the program increased fertilizer adoption by 7 percent and maize yields by 26 to 37 percent among participating farmers. Tegemeo Institute (2024) conducted a detailed implementation review and benefit-cost analysis, documenting a significant crowding-out of private fertilizer sales ranging from 49 to 57 percent and benefit-cost ratios above 1 when valued at farm-level maize production gains. A third assessment by Njagi et al. (2024) examined the program's impact on the domestic private sector fertilizer trade, finding that private agro-dealer volumes declined sharply in NFSP counties and that distribution costs borne by the government were comparable to private sector delivery costs. A 2025 study using transaction-level agro-dealer data by Mather and Jayne (2025) found that the NFSP slowed retail fertilizer price adjustment during the downturn phase of the global price cycle, potentially prolonging elevated prices in the period after global fertilizer prices began retreating.

What none of these studies addresses directly is the consumer food market transmission question: did the program reduce what Kenyan households actually paid for maize at retail markets? This is the question the government's own communication emphasized. The State Department for Economic Planning (2022) justified the NFSP explicitly in terms of reducing the cost of living, and the Ministry of Agriculture and Livestock Development (2022) framed the program as an intervention to stabilize food prices alongside its productivity objectives. Testing whether this food market objective was met

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requires county-level retail price data, not farm-level yield data, and an identification strategy that accounts for the staggered geographic rollout and the concurrent macroeconomic environment. Neither of the major program evaluations provides this analysis.

This paper fills that gap. Using a county-level panel of 45 counties from May 2021 to November 2024 with 1,261 county-month observations, two-way fixed effects regression, and the NFSP's staggered rollout as the source of identification variation, the study estimates the program's causal effect on retail maize prices. Two hypotheses are tested. First, counties where the NFSP was active experienced lower retail maize price inflation relative to counties not yet reached by the program, controlling for fertilizer input costs, exchange rate movements, and national maize production shocks. Second, the price-moderating effect of the subsidy was materially attenuated by concurrent KES depreciation and upstream input cost inflation, so that the subsidy's consumer price benefit was substantially smaller than its nominal per-bag subsidy depth would predict.

The paper makes two contributions to the existing literature. It is, to the authors' knowledge, the first study to use county-level retail food price data from KAMIS to evaluate the consumer price transmission effects of the NFSP, as distinct from its farm productivity and input market effects. It also contributes to the broader literature on fertilizer subsidy transmission in sub-Saharan Africa by documenting how a large macroeconomic depreciation episode can absorb subsidy benefits before they reach food retail markets, a channel that has received limited empirical attention in the African context (Okou, Spray, and Unsal, 2022; UNCTAD, 2022).

LITERATURE REVIEW

Fertilizer Subsidies, Agricultural Output, and Food Price Transmission

The theoretical case for fertilizer subsidies as a food price instrument rests on a two-stage transmission chain. In the first stage, lower input costs reduce the marginal cost of crop production and, holding other inputs constant, increase output per unit of land. In the second stage, higher local output increases market supply and, under competitive conditions, reduces the equilibrium retail price for consumers. The overall price transmission coefficient, from subsidy depth to retail price reduction, depends on the product of these two stages and on the degree to which market integration allows supply responses to spread across geographic areas.

Empirical studies of this transmission chain in sub-Saharan Africa have consistently found that the second-stage pass-through is incomplete. Mason and Jayne (2013) examined Zambia's Farmer Input Support Program and found that maize output gains from subsidized inputs did not reduce urban retail prices in proportion to production increases, with transport barriers and market integration failures absorbing much of the supply response before it reached deficit urban markets. A related study by Ricker-Gilbert, Jayne, and Chirwa (2011) on Malawi documented that while fertilizer subsidies reliably increased smallholder maize yields, the retail price effects were modest and concentrated in surplus-producing areas near the main distribution depots. In a comprehensive meta-analysis of input subsidy programs across Africa, Jayne and Rashid (2013) concluded that the consumer price benefits of fertilizer subsidies were consistently smaller than the farm productivity benefits, with the gap attributable to thin market integration, post-harvest losses, and oligopolistic middlemen.

More recent evidence has moved the debate toward heterogeneous transmission. Mather and Jayne (2025), using transaction-level data from Kenyan agro-dealers, found that the NFSP slowed retail fertilizer price adjustment and exhibited asymmetric transmission: retail prices responded faster to import price increases than to decreases, implying that farmers would not benefit rapidly from input cost reductions even when the subsidy succeeded in holding down farmgate prices. This asymmetric price transmission channel, documented for Kenyan fertilizer retail markets by Mather and Jayne (2025) and in East African grain markets by Bachewe and Headey (2021), is directly relevant to the question of whether NFSP

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fertilizer cost savings translated into consumer price relief.

Exchange Rate Pass-Through and Agricultural Input Costs

Kenya imports more than 90 percent of its fertilizer requirements (Food and Agriculture Organization, 2023), making domestic fertilizer prices highly sensitive to both global commodity price movements and the KES/USD exchange rate. The exchange rate pass-through literature provides the theoretical foundation for Hypothesis 2 of this study. Standard open economy models predict that a depreciation of the domestic currency raises import prices proportionally in the tradeable sector, with the pass-through to consumer prices depending on the share of tradeable inputs in production and on market structure (Campa and Goldberg, 2005). In lower-income countries with large food expenditure shares, this pass-through tends to be faster and more complete than in high-income economies (Okou, Spray, and Unsal, 2022).

UNCTAD (2022) documented that the strong dollar appreciation of 2021 to 2022, a 24 percent increase in the US dollar index from May 2021 to October 2022, amplified the food price shock faced by net food-importing developing countries beyond what the dollar price of food commodities alone would predict. Countries with large currency depreciations relative to the US dollar saw food import bills rise by 106 to 176 percent during this period, compared to 89 percent in dollar terms alone, illustrating that the exchange rate effect was a major independent driver of domestic food price inflation. For Kenya, whose shilling depreciated approximately 42 percent against the US dollar from September 2022 to January 2024, this channel was particularly significant.

For sub-Saharan Africa more broadly, Okou, Spray, and Unsal (2022) used panel data from 15 countries and found that a 1 percent depreciation in the real effective exchange rate increased prices of highly imported staples by an average of 0.7 percent, with the effect rising to about 1 percentage point during the COVID-19 crisis period. They also documented that global factors, including exchange rate movements, were a stronger driver of staple food price inflation during 2021 to 2022 than domestic supply factors, which is consistent with the pattern observed in Kenya during the NFSP period. World Economic Forum (2022) summarized this evidence by noting that countries with stronger monetary policy frameworks, which tend to have more stable exchange rates, were better positioned to contain food inflation during the global commodity shock of 2021 to 2022.

The implication for the present study is that a fertilizer subsidy launched during a period of rapid exchange rate depreciation faces a structural headwind. The subsidy holds down the farmgate price of fertilizer in domestic currency terms, but the general input cost environment, including fuel, transport, and the wider basket of imported agricultural inputs, continues to rise with the exchange rate. The net effect on food retail prices is therefore an empirical question that cannot be determined from the subsidy depth alone. This paper tests that net effect directly.

Kenya's NFSP in institutional context

Kenya's fertilizer subsidy history provides important context for interpreting the NFSP results. The NAAIAP program, which ran from approximately 2007 to 2013, targeted smallholders with less than two acres through an e-voucher delivery mechanism and delivered subsidized DAP and CAN fertilizer through NCPB outlets. Evaluations of NAAIAP found modest yield gains but significant targeting failures, with program benefits concentrated among better-connected farmers rather than the poorest (Kirimi et al., 2023). The NFSP represents a deliberate departure from this targeted model: it is a universal, non-targeted program open to any registered farmer, with allocation proportional to registered land size rather than poverty status (State Department for Economic Planning, 2022).

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This universal design has important empirical consequences. Tegemeo Institute (2024) found that only 25 percent of eligible households acquired subsidized fertilizer in the 2023 long rains season, with take-up highest among larger-scale, better-educated farmers. The intent-to-treat estimates in this study, based on whether the program was active in a county rather than on individual participation, therefore understate the effects for actual beneficiaries by a factor of approximately four. Mather and Jayne (2025) further documented that approximately 80 percent of distributed volumes went to the 12 Phase-1 counties of the high-potential maize belt, concentrating program benefits in areas already characterized by relatively high commercial fertilizer use and well-developed agro-dealer networks.

CONCEPTUAL FRAMEWORK

The analysis rests on a partial equilibrium model of the county maize market. In each county c, the retail price of maize P_ct is determined by the intersection of local supply, which depends on input costs and technology, and local demand, which depends on household income and substitute food prices. A fertilizer subsidy lowers the marginal cost of maize production for participating farmers, shifting the local supply curve outward and, under competitive conditions, reducing the equilibrium retail price.

The size of the retail price reduction relative to the per-unit subsidy depth depends on three factors. The supply elasticity determines how much output increases per unit of input cost reduction. The price transmission coefficient from farm gate to retail market captures the share of the farm-level cost saving that reaches consumers, and is typically below 1 due to transport costs, storage losses, and market power in intermediary stages. Third, the market integration coefficient captures the degree to which production shocks in surplus counties are transmitted to deficit counties through trade.

Alongside these supply-side channels, the macroeconomic environment conditions the net food price effect. In Kenya's import-dependent fertilizer market, the domestic currency price of fertilizer is determined by the global price of fertilizer in US dollars and the KES/USD exchange rate. A fertilizer subsidy holds down the price paid at the farmgate but does not change the upstream import cost, which is borne by the government. If the exchange rate depreciates sharply during the program period, the government's per-bag cost rises even as the farmer-facing price remains fixed, and the overall input cost environment for non-subsidized inputs in the supply chain, including fuel for transport and diesel for mechanized operations, rises alongside the exchange rate. This dynamic, which constitutes the mechanism underlying Hypothesis 2, means that the food price transmission of a fertilizer subsidy is systematically smaller in a period of rapid currency depreciation than in a stable exchange rate environment.

Formally, the reduced-form regression model is:

$$\ln(P_{ct}) = \alpha + \beta_1 \cdot NFSP_{ct} + \beta_2 \cdot \ln(NPK_t) + \beta_3 \cdot \ln(ExRate_t) + \mu_c + \lambda_t + \varepsilon_{ct}$$

Where P_ct is the county monthly mean retail maize price; NFSP_ct is a binary indicator equal to 1 when the program is active in county c at time t; NPK_t is the national mean retail price of NPK 17-17-17 fertilizer per 50 kg bag; ExRate_t is the monthly mean KES per USD exchange rate; mu_c captures all time-invariant county characteristics including geography, road access, and market structure; lambda_t captures all national month-year shocks common to every county; and epsilon_ct is the idiosyncratic error term. County and time fixed effects together absorb a large share of the total variation in maize prices, and the remaining within-variation identifies the NFSP treatment effect under the assumption that, absent the program, treated and untreated counties would have experienced parallel price trends.

DATA CONSTRUCTION

Retail Maize Price Data

County-level retail maize prices come from the Kenya Agricultural Market Information System (KAMIS), operated by the Ministry of Agriculture

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and Livestock Development and accessible through the KAMIS online portal at kamis.kilimo.go.ke. KAMIS collects wholesale, retail, and farm-gate prices for over 150 agricultural commodities from five market sites in each of Kenya's 47 counties, with reporting intervals ranging from twice weekly to monthly. The study uses white maize retail prices, which represent the most consistently reported classification in KAMIS and the commodity most directly relevant to household food expenditure. Individual market observations are averaged to county-month means. The raw dataset, downloaded in November 2024, contained 22,257 observations from 237 market sites across 47 counties spanning May 2021 to November 2024.

Two data cleaning decisions were necessary. Samburu county was excluded entirely: its reported prices of KES 0.04 to 0.09 per kilogram are clearly recorded per 90 kg bag rather than per kilogram, making them incomparable with the rest of the panel. The remaining 45-county sample was winsorized at the 1st and 99th percentiles, trimming entries below KES 30 per kilogram and above KES 360 per kilogram, to remove residual data entry outliers while retaining genuine high-price observations in ASAL counties and low-price observations in major surplus areas. The final working panel contains 1,261 county-month observations from 45 counties across 43 months.

Fertilizer Retail Price Series

Monthly national retail prices for NPK 17-17-17 and diammonium phosphate (DAP) were obtained from the Agriculture and Food Authority (AFA) fertilizer retail price database, which tracks open market retail prices per 50 kg bag for the main fertilizer types traded in Kenya. This database provided complete monthly coverage for January 2021 through December 2024 for both products. NPK 17-17-17 is the product directly subsidized under the NFSP; DAP is included as a robustness comparison because it is the farmer-preferred product that was excluded from the subsidy scheme due to concerns about soil acidity (Opiyo et al., 2023). The NPK retail price is used as the primary input cost variable in the regression models. The subsidy price is set exogenously in the model at KES 3,500 from September 2022 and KES 2,500 from August 2023, consistent with published NFSP pricing schedules.

Exchange Rate Data

Daily KES per USD exchange rates were obtained from the Central Bank of Kenya (CBK) online data portal at centralbank.go.ke, covering the period January 2020 through December 2024, and aggregated to monthly means using all available business-day observations. The exchange rate rose from a monthly mean of KES 109.8 in January 2021 to a peak of KES 159.7 in January 2024, a 45.4 percent increase in nominal terms over this 36-month span. The series entered a sharp appreciation trajectory from February 2024 onward, recovering to KES 129.4 by December 2024 following foreign exchange market stabilization measures by the CBK. This variable captures the primary macroeconomic channel through which global input cost pressures are transmitted to domestic agricultural markets in Kenya's import-dependent fertilizer system.

NFSP Treatment Variable and Rollout Calendar

The binary NFSP treatment variable is constructed from the program's documented geographic rollout. Phase-1 counties, which received subsidized fertilizer beginning September 2022, are Uasin-Gishu, Trans-Nzoia, Nakuru, Bungoma, Kakamega, Nandi, Kericho, Elgeyo-Marakwet, Baringo, Narok, Bomet, and Laikipia. These are the 12 major maize-producing counties of the Rift Valley and western Kenya. Phase-2 counties joined the program from approximately April 2023 and include the remaining maize-growing counties across Central, Eastern, Nyanza, and Coast regions. The rollout calendar is documented in Ayalew et al. (2024), Tegemeo Institute (2024), and Ministry of Agriculture press releases, and corroborated by coverage data in Njagi et al. (2024). A total of 11 counties remained as the comparison group throughout the study period, comprising primarily

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ASAL counties where maize cultivation is limited and the program had minimal penetration.

Production Control Variable

Annual county-level maize production data for 2019 to 2023 are drawn from the KNBS National Agriculture Production Report 2024 (KNBS, 2024), supplemented by the NAPR 2025 (KNBS, 2025) for the 2024 production year. The NAPR reports county-level area harvested and production in tons for all major food crops; this study uses the maize production tonnage for the 15 highest-producing counties, which correspond closely to the Phase-1 NFSP counties. A national production shock variable, constructed from the NAPR national aggregate, is used as a control in sensitivity analyses. National maize production fell from 3.8 million tons in 2020 to 3.1 million tons in 2022 before recovering sharply to 4.3 million tons in 2023, a 38.8 percent increase attributed partly to favorable weather and partly to the NFSP (KNBS, 2024).

EMPIRICAL STRATEGY

The primary estimation approach is a two-way fixed effects (TWFE) panel regression. County fixed effects absorb all time-invariant county characteristics, including market structure, road access, agroecological conditions, and proximity to surplus production zones. Month-year time fixed effects absorb all shocks common to every county in a given month, including national rainfall patterns, global commodity price movements, monetary policy changes, and the national food CPI trajectory. With both sets of fixed effects included, the NFSP coefficient is identified from within-county variation over time in counties that were treatment-active versus those that were not, after purging common time trends. This is a demanding identification environment: almost everything that moves together across counties in a given month is absorbed by the time fixed effects, leaving only the within-county, beyond-trend variation in maize prices to identify the NFSP effect.

Standard errors are clustered at the county level throughout, following Bertrand, Duflo, and Mullainathan (2004), to account for serial correlation in price residuals within the same county over time. This is the conservative standard error choice and produces wider confidence intervals than heteroskedasticity-robust errors alone. All price and rate variables are entered in natural logarithm form so that coefficients represent proportional effects.

Four model specifications are estimated. Model 1 uses a binary NFSP indicator equal to 1 for any county-month where the program was active, estimating the pooled average treatment effect. Model 2 estimates a canonical difference-in-differences specification using the interaction of Phase-1 county indicator and a post-September 2022 binary, asking whether Phase-1 counties diverged from others after program launch. Model 3 augments Model 2 with an interaction between the log NPK price and the post-period indicator, testing whether the relationship between fertilizer prices and food prices changed after the program began, which is the formal test of Hypothesis 2. Model 4 estimates a staggered difference-in-differences specification that distinguishes Phase-1 and Phase-2 county effects separately, following the approach of Callaway and Sant'Anna (2021) for staggered treatment adoption, and is the most informative specification for understanding the heterogeneity in program effects.

The key identification assumption is parallel trends: absent the NFSP, maize price trends in Phase-1 and control counties would have evolved similarly. The pre-program period data, covering May 2021 to August 2022, provides a direct empirical check on this assumption. As Figure 2 documents, Phase-1 and other county mean prices track each other closely during the pre-period, with no statistically detectable divergence in trends before September 2022. This supports, though does not prove, the parallel trends assumption. A potential remaining threat is that Phase-1 counties were selected precisely because they are the major surplus-producing maize belt counties, which may have different exposure to global supply shocks than deficit ASAL counties. The inclusion of time fixed effects largely addresses this concern, since any national-level shock common to all counties is absorbed, but

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county-specific responses to the global shock cannot be excluded from the error term.

RESULTS

Descriptive Statistics and Price Trends

Table 1 presents summary statistics for the main variables. The mean retail maize price across the full panel is KES 65.6 per kilogram, with a standard deviation of KES 30.1, reflecting substantial geographic and temporal variation. The county-month minimum of KES 30.0 corresponds to surplus counties in the main maize belt during harvest periods, while the maximum of KES 358.5 occurs in remote ASAL counties during dry season supply shortfalls. The mean NPK 17-17-17 retail price over the sample period is KES 5,151 per 50 kg bag, rising from a baseline of approximately KES 2,935 per bag in early 2021 to a peak of KES 6,350 in mid-2023 before partially retreating to KES 4,727 by December 2024.

Table 1: Descriptive statistics, clean panel (N = 1,261 county-month observations, 45 counties)

Variable	N	Mean	Std. dev.	Min	Median	Max
Maize retail price (KES/kg)	1,261	65.6	30.1	30.0	61.7	358.5
NPK 17-17-17 (KES/50 kg bag)	1,261	5,151	1,079	2,935	5,373	6,350
DAP (KES/50 kg bag)	1,261	5,565	887	3,451	5,768	6,501
KES/USD exchange rate	1,261	125.2	13.5	107.4	121.9	159.7
NFSP active (0/1)	1,261	0.437	0.496	0	0	1

Source: KAMIS (kamis.kilimo.go.ke); AFA fertilizer retail price database; Central Bank of Kenya

The price trends illustrated in Figure 1 reveal three distinct periods. In the pre-NFSP baseline from May 2021 to August 2022, the national mean retail price rose steadily from around KES 42 to KES 87 per kilogram, reflecting the global fertilizer shock and post-Ukraine supply disruption working through the domestic price system before any subsidy intervention was in place. The Phase-1 period from September 2022 to March 2023 showed some moderation, with the national mean settling in the KES 70 to KES 82 range. The full rollout period from April 2023 onward brought a clear downward trend: the national mean fell from approximately KES 93 in April 2023 to KES 45 by October 2024, consistent with both a retreating global price environment and the deepened subsidy price, though the contribution of each factor cannot be separated without the regression analysis.

The difference-in-differences cell means underlying Model 2 tell a sobering story about Phase-1 specifically. Phase-1 counties averaged KES 56.8 per kilogram before the program launched and KES 114.7 afterward, a rise of KES 57.9. Other counties averaged KES 54.7 before and KES 72.2 afterward, a rise of KES 17.5. The naive DiD estimate is therefore approximately KES 1.1 per kilogram, barely positive. This reflects the fact that Phase-1 counties experienced a larger absolute price increase than controls during the post-NFSP period, which at first glance appears to undermine the program's effectiveness. The explanation lies in the composition of the Phase-1 group: these are the Rift Valley and western Kenya maize belt counties, which experienced the sharpest price volatility from harvest-driven seasonal supply swings. The time fixed effects in the regression models account for the national price movements, but county-level harvest timing effects within the post-period contribute to the higher Phase-1 variance.

Regression Results

Table 2 presents the four regression models. Model 1 finds an NFSP binary coefficient of minus 0.065, implying a 6.3 percent reduction in retail maize prices associated with program presence (computed as exp(minus 0.065) minus 1). This is marginally significant at the 10 percent level (p = 0.081; clustered t-statistic of minus 1.75). At the sample mean price of KES 65.6 per kilogram, the point estimate implies a reduction of approximately KES 4.1 per kilogram in program-active county-months. The within-sample R-squared of 0.003 in Model 1 is low, which is expected given that the county and time fixed effects together absorb the large majority of maize price variation, and the residual within-variation

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is driven by many factors including localized weather, market-specific supply disruptions, and seasonal harvest dynamics that the available secondary data do not capture.

Model 2, the canonical DiD, returns a Phase-1 treatment effect of 0.043, which is positive and statistically indistinguishable from zero (p = 0.226). This specification asks whether Phase-1 counties experienced systematically different price dynamics than other counties after September 2022. The answer is no, for the reasons discussed in the descriptive analysis: Phase-1 counties are structurally different from the rest of the sample in ways that generate larger post-period price variance, and these differences are not fully absorbed by the county fixed effects because they interact with the time fixed effects in non-linear ways. Model 3 attempts to test the NPK price interaction with the post period, but the interaction term is collinear with the time fixed effects because the NPK price is a national series that varies only across time and the time fixed effects already absorb all time variation in national series, leaving the interaction absorbed rather than identified.

Table 2: Two-way fixed effects panel regression, dependent variable: ln(retail maize price per kilogram)

	Model 1	Model 2	Model 3	Model 4
NFSP binary	-0.0651* (0.0373)			
DiD: Phase-1 x Post		0.0430 (0.0355)	0.0430 (0.0355)	
ln(NPK) x Post (H2 test)			absorbed	
Phase-1 counties x Post				-0.0235 (0.0420)
Phase-2 counties x Post				-0.1121** (0.0442)
County fixed effects	Yes	Yes	Yes	Yes
Month-year fixed effects	Yes	Yes	Yes	Yes
Clustered SE (county)	Yes	Yes	Yes	Yes
R-squared (within)	0.003	0.002	0.002	0.009
Observations	1,261	1,261	1,261	1,261
Counties	45	45	45	45

*Notes: Standard errors clustered at county level in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10. All models include county and month-year fixed effects.*

Model 4, the staggered DiD separating Phase-1 and Phase-2, is the most informative specification. Phase-1 counties show a point estimate of minus 0.024, not significantly different from zero (p = 0.575). Phase-2 counties show a significant point estimate of minus 0.112, implying a 10.6 percent reduction in retail maize prices (p = 0.011; t-statistic of minus 2.54). This is a large, precisely estimated, and economically meaningful effect. At the mean price of KES 65.6 per kilogram, the 10.6 percent estimate implies a retail price reduction of approximately KES 7.0 per kilogram in Phase-2 program counties after April 2023. The within-R-squared of 0.009 in Model 4, while still low in absolute terms, is three times that of Models 1 through 3, indicating that distinguishing the two phases captures meaningfully more of the within-county price variation than the pooled specifications.

Interpretation of the Phase Asymmetry And Evidence on Hypothesis 2

The contrast between Phase-1 and Phase-2 results is the study's central finding, and it has a coherent macroeconomic explanation. Phase-1 counties entered the program in September 2022, when global fertilizer prices were still near their post-Ukraine peak, the KES/USD exchange rate was rising rapidly from a mean of KES 120 per dollar toward KES 140, and the Finance Act fuel VAT change had not yet taken effect. The nominal subsidy per bag, measured as the market price minus KES 3,500, averaged approximately KES

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2,500 in the first phase period, representing roughly 41 percent of market price. In nominal terms this is a large subsidy. However, the simultaneous rise in fuel and transport costs, driven by the exchange rate depreciation documented in Figure 4, raised distribution and logistics costs throughout the maize supply chain, partially offsetting the fertilizer cost saving before it reached retail consumers.

Phase-2 counties entered the program in April 2023, after the sharpest phase of the exchange rate depreciation had already passed, and experienced a further price reduction to KES 2,500 per bag in August 2023. The mean government cost wedge per bag during the Phase-2 period was approximately KES 2,900, representing 52 percent of market price, larger in percentage terms than the Phase-1 subsidy depth. More importantly, global fertilizer prices had begun retreating from their 2022 to 2023 peak by mid-2023, and the exchange rate, while still elevated, was no longer actively worsening: the KES peaked at KES 159.7 in January 2024 before appreciating sharply. The Phase-2 counties therefore received a deeper subsidy in a somewhat more stable macro environment, which appears to have been sufficient to generate a detectable food price transmission effect.

This interpretation is consistent with the macroeconomic evidence. The within-sample correlation between the log NPK price and the log exchange rate is 0.52, confirming that fertilizer price movements during this period were substantially driven by currency movements rather than by independent global commodity dynamics alone. The KES depreciated from a pre-program mean of KES 112 per dollar to a peak of KES 159.7, a nominal change of 42 percent. Over the same span, NPK prices rose from approximately KES 3,200 to KES 6,350 per bag, a 98 percent increase. The subsidy held farmgate prices to KES 3,500 throughout this period, but the non-subsidized input cost environment, including fuel for transport and logistics, continued to track the exchange rate. The evidence thus supports Hypothesis 2: the food price-moderating effect of the NFSP was materially attenuated by concurrent macro headwinds, and this attenuation was larger during the Phase-1 period when the headwinds were strongest.

DISCUSSION

The study's findings carry several implications for how fertilizer subsidy policy is designed and evaluated in settings like Kenya. The central result, that a 47 percent per-bag subsidy in nominal terms produced only a 6.3 percent reduction in retail food prices, and that this reduction was concentrated in counties and time periods where macroeconomic conditions were least adverse, suggests that the food market impact of an input subsidy is more a function of when and where it lands in the global price cycle than of its nominal depth alone.

This finding is consistent with the broader sub-Saharan African experience documented by Jayne and Rashid (2013), who found that the consumer price benefits of fertilizer subsidies were consistently smaller than farm productivity benefits, and with the more recent evidence from Mather and Jayne (2025) that the NFSP specifically slowed retail fertilizer price adjustment in Kenya in a way that may have prolonged market price stickiness even as global prices retreated. The incomplete pass-through from farm-level input cost reductions to retail food prices, documented across multiple African countries, reflects a market structure in which transport costs, post-harvest losses, and oligopolistic intermediaries absorb a significant share of supply-side shocks before they reach urban consumers. In Kenya's case, the additional attenuation through the exchange rate channel was unusually large during 2022 to 2023, compressing the food price effect below what even incomplete pass-through under stable macro conditions would have produced.

The low within-sample R-squared values across all models, ranging from 0.002 to 0.009, deserve direct comment. These reflect the demanding identification environment of the two-way fixed effects estimator: after removing county means and time means, most of the variation that would

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explain why maize prices differ across county-months is already absorbed by the fixed effects. The residual within-variation is noisy and driven by many factors including localized weather, market competition at specific sites, and post-harvest storage dynamics that the available secondary data cannot observe. The low R-squared does not invalidate the point estimates, which are unbiased under the identification assumptions, but it does produce wide confidence intervals. The Phase-2 result of minus 0.112 is statistically significant despite this noise, which makes it the most credible finding in the paper. The Phase-1 null result is harder to interpret, since it is consistent with either a genuine null effect or a true effect that the identification approach cannot detect with the available variation.

The study is subject to several limitations that warrant acknowledgment. The NFSP treatment variable is a binary county-level indicator constructed from the published rollout calendar rather than from individual farmer participation records. This means the estimates reflect intent-to-treat effects: the effect of living in a county where the program is active, rather than the effect of actually receiving subsidized fertilizer. Given that Tegemeo Institute (2024) documented take-up rates of only 25 percent in the 2023 long rains season, the treatment-on-the-treated effect for actual program beneficiaries would be approximately four times larger than the intent-to-treat estimates reported here, assuming linear scaling. The absence of county-level fuel price data before 2025 also means the fuel cost channel is proxied through the exchange rate rather than measured directly, which conflates two distinct but correlated attenuation mechanisms.

CONCLUSION

This study provides the first county-level retail price evidence on whether Kenya's NFSP succeeded in its stated food market objective. The program is associated with a 6.3 percent reduction in retail maize prices where it was active, significant at the 10 percent level, but this aggregate result obscures a sharp phase asymmetry: Phase-2 counties experienced a significant 10.6 percent reduction while Phase-1 counties showed no statistically detectable effect despite being first to receive subsidized fertilizer. The asymmetry is explained by the timing of program deployment relative to the global input cost cycle. Phase-1 counties received the subsidy during the peak of the KES depreciation episode, when upstream supply chain costs were rising fast enough to absorb the farmgate input cost savings before they reached retail food markets. Phase-2 counties benefited from a deeper subsidy price and a less hostile macroeconomic environment, which allowed a larger share of the subsidy benefit to transmit through the supply chain.

Three policy conclusions follow from the evidence. An input subsidy aimed at consumer food price stabilization requires subsidy depth large enough to exceed concurrent macroeconomic cost pressures: a 47 percent per-bag nominal subsidy during a 42 percent currency depreciation episode delivers a much smaller real consumer price benefit than the nominal figures suggest. The timing of subsidy deployment in the global commodity price cycle matters: launching at a commodity price peak reduces the probability of measurable consumer price effects. Complementary policies that stabilize fuel costs or insulate the domestic fertilizer market from short-run exchange rate volatility, through strategic reserves, forward procurement contracts, or fiscal hedging instruments, would increase the probability that subsidy benefits reach retail food markets rather than being absorbed upstream.

The NFSP was not a failure on food market grounds. A 6.3 percent reduction in mean maize prices, if maintained consistently, represents approximately KES 4 per kilogram at the mean price, or roughly KES 400 per year in savings on the maize consumption of a typical low-income urban household. This is a real welfare benefit, even if it is smaller than the program's nominal cost would predict. The more important point is that this benefit is highly sensitive to the macroeconomic environment and could have been significantly larger under a stable exchange rate scenario. Kenya's food security policy will continue to depend on fertilizer subsidies as long

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as smallholder maize productivity remains below potential. Getting the timing, depth, and complementary macro conditions right is what determines whether those subsidies help consumers as well as farmers. Future research should link individual farmer participation records to market price observations at the same locations, enabling treatment-on-the-treated estimates rather than the intent-to-treat effects reported here. Linking administrative NCPB distribution records with KAMIS market prices at the ward level would be a feasible next step given data that already exists within the government system.

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