Causes and Consequences of the 2021/22 Fertilizer Price Spike on sub-Saharan Africa.

Lessons Learned and Implications for Future Actions

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1. Foreword

Sustain Africa was founded in 2022 as a crisis response programme aimed at ensuring fertilizer availability and affordability to farmers most in need as the Russia / Ukraine war drove a steep rise in International fertilizer prices. The concern of Sustain Africa Board member organisations was that a shortfall of 3.9 million MT of fertilizer in Sub-Saharan Africa – 35% of supply - would lead to worsening food security on the continent[1].

Over two years, Sustain Africa has mobilized 175,000 MT of fertilizer, directly benefitting two million smallholder farmers in seven vulnerable countries, generating rebates from fertilizer suppliers of just over USD 24 million and leveraging USD 20 million in funding from the Bill and Melinda Gates Foundation (BMGF) and Rabobank.

As International fertilizer prices began to fall, it was apparent that national prices were not declining at the same rate, or at all. Indeed, in some countries, for some products, prices continued to rise throughout 2023. In response, and at the request of the Sustain Africa Board, Sustain Africa launched a learning agenda, generously funded by the UK Government's Foreign, Commonwealth & Development Office (FCDO) and the United States Agency for International Development (USAID). The aim of the learning agenda has been to provide evidence-based recommendations to governments, donors, the private sector and other stakeholders on how to respond effectively to an international fertilizer price crisis and how to build longer-term resilience in fertilizer markets to enable them to endure shocks without the need for sudden shifts in policy that might unintentionally damage commercial fertilizer supply chains and weaken their performance for many years into the future to the potential detriment of African farmers.

Sustain Africa focuses on developing and coordinating solutions in three focus areas: crisis response; fertilizer soil health and; food systems. Sustain Africa is not a policy advocacy group. The recommendations in the report reflect the findings and analysis of the authors, not the opinion of the Sustain Africa Partners.

However, as governments, multilateral funders and donors focus on national responses to the recently adopted Africa Fertilizer and Soil Health Action Plan, it is critical that stakeholders review and assess which measures will generate most return on finite agricultural budgets and external funding streams, and which are implementable in the national context. We hope this work will add value to the existing evidence base available to stakeholders in this endeavour.

Our sincere thanks go to our funding partners, our external Advisory Board members who generously gave their time to review and critique the report, and in particular the research team for their considerable efforts in data gathering and conducting the modelling, analysis and reporting.

Best wishes,

Ben Valk
Executive Director, Sustain Africa

[1] IFDC reports the shortfall was in fact 27%

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4. Executive Summary

The rapid increase in inorganic fertilizer prices in 2021 and 2022 was a major shock to global agricultural and food markets. This price spike was initially caused by disruptions to global supply chains as a result of the COVID-19 pandemic. Russia's invasion of Ukraine in early 2022 put additional upward pressure on inorganic fertilizer prices. After peaking in mid-2022, the world prices of inorganic fertilizers declined quickly and were back to pre-2021 levels by the end of 2023. Thus, the global fertilizer industry adjusted their production and sourcing so the effect in global markets was relatively short-lived. However, sub-Saharan Africa (SSA) faced a much longer and more pronounced fertilizer price spike. Specifically, fertilizer prices in SSA rose with the world price in 2021 but decoupled from the world price after that. Prices in SSA stayed higher for longer and still had not returned to their previous levels in most countries as of mid-2024. Since a significant share of SSA's population earns the majority of their income from crop farming and inorganic fertilizer is a key input into the production of those crops, the prolonged fertilizer price spike and decoupling from the world price has major implications for millions of smallholder farmers in the region. This is true for both farmers who use inorganic fertilizer and those who would use fertilizer if the economic conditions were more favorable.

The first objective of this study was to document the changes in local fertilizer prices and the difference between local fertilizer prices and the world price (known as the price wedge) during the global fertilizer price spike of 2021/22. We estimated which factors impacted the fertilizer prices and the price wedge in six focus countries in our analysis: Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia. These countries collectively cover the range of sub-Saharan African regions, representing East, West, and Southern Africa. There is also a wide range of economic representation from among Africa's poorest to wealthiest nations. In each of these countries, both monthly fertilizer price data between 2010-2023 and smallholder farm household panel data on fertilizer use over time were available. We used monthly urea price data from AfricaFertilizer.org to estimate factors that helped to explain the monthly price of urea in each and the price wedge between 2010 and 2023. We focused our analysis on urea as the representative fertilizer for the price analysis, because it is a standard product consisting of 46% nitrogen that is widely traded and consumed globally and in SSA.

The Most important factors that affected local urea prices across countries

1. Government corruption affected urea prices: when the World Bank's indicator variable Control of Corruption increased, the price of urea decreased. On average a one standard deviation increase in the control of corruption index, which meant that the country did more to reduce corruption, led to an approximate 3.0% decrease in urea prices in that country.

2. Macroeconomic conditions affected urea prices:

i. Real interest rates were positively associated with the price of urea. A 1% increase in rates was associated with a 0.04% increase in urea prices, which highlights how financing costs get embedded into fertilizer prices farmers pay.

ii. GDP growth was associated with lower urea prices. On average, a 10% increase in GDP lowered urea prices by 3.9% in LCU terms. This suggests that the efficiency benefits that come along with greater economic development result in lower fertilizer prices for farmers.

iii. A one percentage point depreciation in the local currency relative to the dollar was associated with a 0.34% increase in the price of urea on average. This relationship is expected since a weakening currency against the dollar should make imported goods like fertilizer more expensive in local currency terms.

3. Increased demand for fertilizer

i. A 10% increase in monthly urea imports is associated with a 0.3% increase in price on average. The positive relationship between imports and price was indicative of demand for fertilizer driving its price up.

ii. Similarly, a 10% increase in the annual share of private sector sales was associated with an increase in the urea price of .6% on average, a modest effect.

iii. Finally, a 10% increase in the number of firms importing fertilizer was associated with a 1.4% increase in the urea price on average

Note that in the case of all three variables, we could also expect that increased sales reflects greater competition that should drive prices down. This was not what was observed however.

4. Increased Demand from Maize: Local maize prices in the previous month were positively associated with fertilizer prices in the current month. A 10% increase in the previous month's maize prices was associated with a 2.2% increase in urea prices on average. This result indicated that anticipated demand for fertilizer due to more valuable maize output put upward pressure on local urea prices.

5. Global and Local Cost Factors Impacted Urea Prices: World urea, and world natural gas prices were positively associated with local urea prices. Natural gas prices are a major input into urea production, so it would be expected than when these prices go up, local fertilizer prices also rise. A 10% increase in world urea prices and world gas prices was associated with in an increase of 3.2% and 2.1% in local urea prices, respectively.

Factors affecting the urea price wedge (the difference between global and local fertilizer prices)

1. Financing Costs Important in the Wedge: Higher interest rates were associated with a higher wedge, illustrating how the costs of financing business operations are embedded into the local costs of fertilizer that farmers face. A 1% increase in the real interest rate was associated with a 0.8% increase in in the wedge.

2. Increased demand for fertilizer: As in the local price model, the number of firms importing fertilizer was associated with an increase in urea prices: A 1% increase was associated with a 1.80% increase in the price wedge on average.

3. Local Diesel Prices Significantly Affected the Price Wedge: Since local diesel prices are largely influenced by the global energy market and countries rely on diesel to transport fertilizer around the country, the price wedge is influenced by diesel prices and this connection will be difficult for countries to overcome. A 1% increase in diesel price was associated with a 0.77% increase in local urea prices on average.

4. Contrary to expectations, the world natural gas price was significant and negative in the price wedge. This could be expected to be insignificant as the gas price is already reflected in the world price of urea. It is possible that this result was driven by the difference in the timing of when natural gas prices impact the world price compared to when it impacts local prices, making the contemporaneous relationship a spurious one.

The second objective was to assess how governments, donors, and other multi-lateral organizations in the six countries responded to the price spike. We estimated the impact subsidies had on commercial fertilizer prices, and how effective national fertilizer policies were at increasing fertilizer use among smallholder farmers.

Our third objective was to evaluate the profitability of fertilizer use for farmers during this period of abnormally high fertilizer prices in the six countries. We did this using data collected on smallholder farm households over the past decade. We wanted to understand whether commercial fertilizer use remained profitable for farmers both under more typical periods as well as during this recent period of abnormally high fertilizer prices. To our knowledge, this was the first report to 1) analyze the factors that affected fertilizer prices in African countries during the recent price spikes, 2) to estimate the impacts of the price spike on smallholder farmers' fertilizer profitability and 3) calculate the returns to government fertilizer subsidy programs, using fertilizer and maize prices before and during the price spike period. Since fertilizer subsidies were the major policy tool governments used to respond to high prices during the spike, understanding the returns to these programs is essential for evidence-based policymaking.

The intended audience for this report is governments, donor organizations, and private sector actors, along with research and academic institutions. In learning more about the causes and consequences of the 2021-2023 price spikes in SSA, stakeholders can consider our recommendations and take action that may make the fertilizer sector more resilient and better prepared for future fertilizer market shocks.

I. Key Findings

The findings below are clustered under four key themes.

i. The most important factors that affected urea prices and the price wedge (local urea price – world urea price) across countries.

We ran a cross-country panel regression model of factors affecting 1) monthly urea prices in nominal local currency terms and 2) the monthly price wedge (i.e. the difference between local urea prices and the world price of urea) in our six focus countries of Ghana, Kenya, Malawi, Nigeria, Tanzania and Ghana between 2010 and 2023. The model and its results are discussed in detail in Section IV. The main findings are as follows:

1. Government corruption affected urea prices: when the World Bank's indicator variable Control of Corruption increased, the price of urea decreased. On average a one standard deviation increase in the control of corruption index, which meant that the country did more to reduce corruption, led to an approximate 3.0% decrease in urea prices in that country.

2. Macroeconomic conditions affected urea prices:
    i. Real interest rates were positively associated with the price of urea. A 1% increase in rates was associated with a 0.04% increase in urea prices, which highlights how financing costs get embedded into fertilizer prices farmers pay.
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difference in the timing of when natural gas prices impact the world price compared to when it impacts local prices, making the contemporaneous relationship a spurious one.

ii. Findings on the fertilizer market before, during and after the price spikes

1. Sub-Saharan Africa (SSA) is a small but growing market for fertilizer imports. However, since SSA only consumes about 3% of the world's total inorganic fertilizer, serving the region is not a priority for the large fertilizer companies who view the region as a tertiary market. These companies are happy to respond to a tender from the region but during the fertilizer price spikes of 2021/22, they were attracted by larger and therefore more lucrative markets elsewhere in the world. Thus, they did not immediately respond to potential opportunities created by rising fertilizer prices in SSA, because fertilizer prices were also rising in other regions of the world that demanded higher volumes of fertilizer. Even fertilizer producing countries in the region, like Nigeria, focused on producing fertilizer to export to other regions of the world during the price spike for the same reasons.

2. Three of the six focus countries, Nigeria, Tanzania and Zambia, produce inorganic fertilizer. Nigeria is the only major producer of the countries that we analysed and the only significant fertilizer exporter in SSA.
    a. Nigeria's investment in fertilizer production began before the fertilizer price spike with support from the Nigerian government, the African Development Bank (AfDB), and agreements with the government of Morocco through the Presidential Fertilizer Initiative. The program imports phosphate for blending from Morocco with Nigeria's abundant supply of nitrogen. Several public-private partnerships were developed as a result of these investments, including Indorama's Eleme Fertilizer production plant. This support helped Nigeria move from a net importer of fertilizer to a major producer and exporter of fertilizer within ten years.
    b. Most of Nigeria's fertilizer production was exported during the price spike. Much of it went to Brazil and the E.U. Very little of it was exported to neighboring countries. Nigeria has a quota requirement that a certain amount of domestic fertilizer must be held back for domestic consumption. However, in aggregate Nigerian farmers have purchased less fertilizer than the quota in recent years. This is presumably due to the price of fertilizer being high. Thus, even with increased production, and an export quota, Nigerian farmers experienced fertilizer price increases and decreased fertilizer availability during the price spike just like farmers in other countries did.
    c. Zambia is not a major fertilizer producer. However, in response to the recent price spikes and the Kwacha's depreciation against the dollar the country has recently moved to enhance domestic fertilizer production. To that end, United Capital Fertilizer (UCF) recently announced a USD 1 billion investment in fertilizer plant capacity to produce 80% of the country's urea demand and 60% of its Compound D demand, all of which are currently imported. The raw materials: coal, and phosphate are expected to be sourced from Zambia's southern province.
    d. Tanzania produces some inorganic fertilizer but it lacks the raw materials to produce more than 10% of the fertilizer that is required for domestic consumption. The rest is met through imports.
    e. Ghana does not produce inorganic fertilizer but the country produces some organic fertilizer and lime. In 2018 Ghana announced a USD 2 billion investment to produce inorganic fertilizer from natural gas. However, inorganic fertilizer production has yet to begin in the country.

3. Beyond manufacturing, the fertilizer sector is generally highly concentrated and pyramid-shaped across the six focus countries with few firms controlling much of the fertilizer importing, blending, and wholesaling.
   i. The number of primary importers in Tanzania grew from 7 in 2014, to 12 in 2019 to 30 in 2022 to 32 in 2023.
   ii. Ghana, Nigeria, Kenya, Malawi, and Zambia currently have 15 or fewer primary importers controlling 90% of the imports.
      a. By policy design, Nigeria only has one fertilizer importer, the government-run PFI NPK which is responsible for all fertilizer raw material imports into the country.
   iii. Over the past 10 years, including during the fertilizer price spike, there have been slight increases in the number of firms blending and wholesaling 90% of the fertilizer in Kenya, Nigeria, Zambia, and Tanzania. There has been little to no change in these numbers in Malawi and Ghana.
   iv. At the base of the pyramid, the fertilizer retail sector is highly competitive in four of the six countries of focus, (Ghana, Kenya, Nigeria, and Zambia). The retail sector is highly concentrated and not competitive in Malawi and Tanzania.
      a. Kenya, Nigeria, Ghana, and Zambia have highly competitive retail fertilizer sectors with hundreds or thousands of retailers controlling 90% of the fertilizer market there.
      b. Conversely, the fertilizer retail markets in Tanzania and Malawi have been highly concentrated, with a few large firms controlling 90% of the fertilizer that is retailed there. These large firms import fertilizer directly from international markets and sell it at their various retail shops across the country. Many smaller-scale independent agro-dealers also operate in these markets. Their sales volumes are low, and they buy fertilizer from larger-scale companies and re-sell it at their retail shops. These shops are often located in more rural areas, and though they sell a relatively small volume of fertilizer they help make fertilizer more accessible to farmers in remote areas.
      c. Tanzania only had seven firms in 2014 controlling 90% of fertilizer retailing in the country. This rose to 12 in 2019, 32 in 2022 and 34 in 2023. Malawi had six firms controlling 90% of the fertilizer retailing in 2014, 20 in 2019, 15 in 2022 and 15 in 2023. Thus, competition in retail increased over the past 10 years in Tanzania and Malawi, but it was still much more concentrated than the other countries in our analysis.

4. Key Informant Interviews indicated that fertilizer retail/distribution margins are low within countries (2-5%) for private-sector agro-dealers. If governments increase their control of fertilizer distribution without engaging the private sector, some agro-dealers, especially small ones, go out of business.
   i. Prior to the price spikes and increases in government subsidies, many agro-dealers entered the Kenyan market. However, many were seasonal players. This suggests that the market was competitive with low barriers to entry.
   ii. Malawi showed a similar pattern to Kenya, where the number and distribution of private retailers has been a function of the government’s decisions on how to distribute fertilizers for the subsidy (i.e. Whether or not to allow the private sector to sell subsidized fertilizer to farmers).
      a. After the spikes, the subsidy program in Malawi used only a few large companies to retail fertilizer to farmers. This decision led to a decline in small-scale independent private retailers (note: that we do not have quantifiable data on the exact extent of this decline). The decline reduced farmers' access to commercial fertilizers.
   iii. When agro-dealers face low margins or are unable to sell much fertilizer (e.g., due to direct government distribution) they often broaden the goods they sell (e.g.,

seeds, pesticides and equipment) and in some cases expand their crop trading businesses or become general retail shops selling home goods (e.g., groceries, candles, lights, etc.)

a. Respondents in our qualitative interviews suggested that agro-dealers would quickly re-enter fertilizer retail markets if the subsidy program changed.

5. Our key informant interviews indicated that there are many challenges associated with moving fertilizer in SSA.
   i. Obtaining loans to finance bulk fertilizer purchases is important in the cost build-up of fertilizer in Africa. Fertilizer must be financed several times including at first purchase (often in the Middle East); then at the port where it is needed to pay for unloading and storing fertilizer.
   ii. It can take up to a month for fertilizer to be ready for transport out of the port so costs can accumulate if the importing port is slow.
   iii. Other costs include transporting into the country, (e.g. from Beira port in Mozambique to Malawi), and then distribution within a country (e.g. moving fertilizer from where it crosses the border in southern Malawi to wholesalers and retailers across the country).
   iv. Last mile of delivery costs can be greater than half of the total transport costs from port to farmer. When fertilizer distribution is financed, slow delivery adds to the final cost because the interest on the loan accumulates.

iii. Findings on government policies before, during, and after the price spike

1. Governments in all six focus countries had been subsidizing fertilizer and other inputs for farmers in the decade prior to the input price spike of 2021/22. Many were targeted programs that distributed fertilizer to farmers who met certain characteristics. However, for various reasons including budgetary pressure, concerns about corruption and mismanagement, and the desire to do something different, Malawi, Nigeria, Tanzania, and Kenya scaled down the size and scope of their subsidy programs in the second half of the 2010's. Ghana and Zambia maintained large direct fertilizer subsidy programs for farmers.

2. As mentioned previously, SSA is not a major fertilizer market, making up just three percent of global consumption. As a result, international fertilizer companies were focused on other markets during the price spike. Thus, they were slow to bring additional fertilizer to SSA even though prices were rising in the region.

3. In general, the governments in our six focus countries were slow to respond to the rising prices that started in 2021.
   i. They "waited/waited/waited" to see what would happen in the markets. Meanwhile, prices continued to rise before action was taken.
   ii. Late and unclear responses to the price spike by governments, coupled with an influx of donor money from the World Bank and African Development Bank likely worsened the price spike.
      a. For example, Nigeria's policy to prevent imports of nitrogen fertilizer and blended fertilizer was implemented in 2018 to support domestic fertilizer production. However, it likely had the unintended consequence of decoupling local fertilizer prices from world prices and made the price spike in that country more pronounced (i.e. higher) and longer lasting than if the country had been willing to import cheaper fertilizer from elsewhere in the world.

ii. Another example was Kenya. The country is widely regarded to have had one of the most dynamic input supply chains in SSA (Ariga and Jayne 2011). Before the price spike the country had a relatively progressive, "smart-subsidy" program, the National Value Chain Support Programme (NVSP). It targeted small-scale producers, used an e-voucher, and inputs were redeemed through the private sector. In response to the rapid rise in fertilizer prices in 2022, the new government in Kenya introduced a wider-scale, untargeted National Fertilizer Subsidy Programme (NFSP) that distributed fertilizer through government-run depots. The private sector was excluded and many small-scale farmers who did not live near government depots were unable to access subsidized fertilizer because the distances and cost to transport it were too great.

4. Our key informant interviews with fertilizer industry actors revealed that government engagement in the market was by far the most often cited 'critical threat' to their business. Government engagement usually took the form of (1) subsidy programs, and/or (2) bulk procurement, where the government gives importing rights to one or two firms. Other firms place orders with the chosen firm for bulk importing. In theory this should allow firms to take advantages of economies of scale and import fertilizer at a lower price. Some of these savings should be passed back to farmers. Concerns about government subsidy programs was supported by a recent study on Kenya's input subsidy program (Opiyo et al. 2023). They found that private agro-dealers fertilizer sales were reduced in 2023, after they were excluded from the government run subsidy program that was scaled up in response to the price spike (see the Kenya country report for more details).

5. Subsidizing fertilizer is a powerful tool that has the potential to quickly increase fertilizer use. However, there are numerous concerns and consequences associated with subsidizing fertilizer. These include:
   i. Subsidy programs that do not involve the private sector disadvantage private fertilizer markets in many areas and cause widespread disruptions.
   ii. Even if the government is 'transparent' about the fertilizer subsidy program plans (e.g., releases info on quantities, types, and locations of fertilizer subsidies), they are often late and what is distributed is different than what is stated in plans.
   iii. The private sector often has to wait until subsidy procurement and deliveries happen in order to understand what the potential market gaps are for the private sector to try to fill.
   iv. Subsidy programs crowd-out (i.e. displace) commercial fertilizer sales (discussed below).
   v. Other disruptions – (e.g. late delivery to agro-dealers). These challenges are less well documented.
   vi. Unlevel playing field: even if subsidy programs include one or two private sector firms to distribute subsidized fertilizer on behalf of governments, this can give substantial advantages to these firms in their commercial sales and make it difficult for other private firms to compete. This sometimes results in the exit of firms from the market and leads to a more concentrated fertilizer wholesaling and retailing sector.

6. Challenges with bulk procurement include
   i. Bulkiness of fertilizer orders and generally low demand leads to difficult logistics and governments try to alleviate this with 'bulk' procurement systems.
   ii. It is potentially cost-effective to order an entire boatload of fertilizer at one time. This can lower the fixed cost of procuring fertilizer. But this requires the government to coordinate procurement because individual importers are unlikely to:
      a. Finance such a large shipment.

b. Be able to sell a full shipment themselves. The Nigerian, Kenyan, and Tanzanian governments do this on behalf of the private sector, then rely on the private sector to distribute to retailers.

iii. Bulk procurement often leads to tenders given to a single company. This was by design during the bulk procurement program that ran in Tanzania from 2017-2022. However, the private sector would prefer for multiple companies to be able to distribute fertilizer and for the government to be transparent about the tender and distribution process.

iv. Malawian and Zambian governments directly import subsidized fertilizer themselves. Given the inefficiencies in government procurement and the high cost of distributing fertilizer in landlocked Africa, these systems have meant that farmers get their subsidized fertilizer later in the planting season than when fertilizer is distributed through the private sector (Arias-Granada and Ricker-Gilbert 2024).

v. In theory, bulk procurement can reduce the costs of importing a given quantity of imported fertilizer by coordinating many firms' imports onto one large ship. But practical difficulties can outweigh these cost advantages, (e.g., if the process is not fully transparent, the government may contract with a single company to their mutual advantage and then charge fertilizer companies more than they would have paid if they had arranged fertilizer imports on their own).

7. Both subsidies and bulk procurement lead to huge uncertainties and high risk for private fertilizer companies

   i. Importing fertilizers without good knowledge of the government's plans for the subsidy program is a huge risk, as suppliers could be left storing a lot of valuable fertilizer. This leads to cash flow challenges and storage costs.
   ii. The larger the procurement the greater the risk to companies of late payment by government. It is harder for governments to come up with the money to pay back suppliers on larger orders.
   iii. Our key informants indicated that even though fertilizers do not expire, farmers perceive fertilizer that looks "old" as lower quality and do not want to buy or use it.
   iv. The private sector often has to wait to observe government subsidies procurement/delivery/implementation before taking on the risk of importing. This often creates delays across the supply chain.
   v. The risk of governments cancelling tenders that have been issued is another risk for the private sector to engage in subsidy programs.
   vi. Even if the private sector participates in subsidy programs and delivers fertilizer to farmers there is a risk of non-repayment or late repayment by governments. Late repayment by government to the private sector has been reported in the current fertilizer support programs in Ghana, Kenya, and Tanzania.

8. We used data on the cost of fertilizer subsidy programs in Ghana, Kenya, Malawi and Zambia over the past 10 years to compare the benefits relative to the costs of the programs. Benefits were measured as the value of maize produced nationally from the subsidy program; costs were measured as the cost of the subsidy program to government and farmers (based on the reduced amount they paid for subsidized fertilizers). Nigeria scaled down its direct subsidy to farmers in 2016, and Tanzania ended direct subsidies in 2017. As a result, there was no subsidy program to evaluate the benefits and costs in either country during recent years. We found that Malawi and Zambia did not break even on their subsidy program in any of the years of the analysis. This meant that the costs of their subsidy programs were higher than the benefits to the economy in terms of incremental maize produced from the subsidized fertilizer. This was due to low maize-to-fertilizer response rates and the high costs of the government procuring fertilizer. Kenya obtained a marginally positive return on its fertilizer subsidy

program, but the subsidy program barely broke even during 2022/23 when the high costs of procuring huge quantities of fertilizer outweighed the benefits to the economy from incremental fertilizer use. Ghana generated a positive return to its fertilizer subsidy program in the years we analyzed because of a low cost of fertilizer relative to the price of maize and a relatively high maize-to-fertilizer use rate among Ghanaian farmers on average, compared to other countries.

i. This benefit/cost analysis did not include potential effects that the subsidy programs had on a more concentrated commercial market structure and resulting effects on farmers' access to commercial fertilizers.
ii. It should be noted that even though the government lost money on fertilizer subsidies in Malawi, and Zambia, the small proportion of farmers who were fortunate enough to acquire subsidized fertilizer obtained a positive return from it at the lower subsidized price. However, the program operated at an overall a loss to the economy in both countries.
iii. When fertilizer was valued at commercial prices, we found that it was not profitable on average for farmers in Malawi and Zambia. This was due to unfavorable fertilizer/maize price ratios and low maize-to-fertilizer response rates (a measure of how many kilograms of maize were obtained from a kilogram of fertilizer). We found that on average fertilizer use was profitable in the coastal countries in our analysis. This occurred because the maize-to-fertilizer response ratios were a bit higher suggesting that farmers used fertilizer more efficiently, and fertilizer was priced relatively low compared to the price of maize due to lower transport costs. That being said there is room for improvement in fertilizer profitability in all six countries that we analyzed. These improvements come from more efficient and competitive fertilizer and output markets and improving fertilizer use efficiency among smallholder farmers. We offer ways to make improvements in the overall recommendations section and in the specific recommendations section in each country report.

iv. Findings on fertilizer demand and farm profits before, during and after the price spikes.

1. We found evidence from smallholder household survey data that farmers' use of non-subsidized commercially-priced inorganic fertilizer bought from the private sector has generally risen over time. However, in virtually all of the countries of focus, farm household-level data indicated that fertilizer use was below the 2006 Abuja declaration's goal of a 50-kilogram of nutrients per hectare average (see the country-specific reports for details).
   i. Only Zambia achieved this goal, and it was in large part due to a very big fertilizer subsidy program.
   ii. In all six countries fewer than 50% of households purchased any commercial fertilizer in most years over the previous decade. Malawi was the only country where more than half the smallholder households sampled purchased fertilizer at commercial prices in any year over the past decade (53% in 2018/19). In general, farmers purchased more fertilizer at commercial prices from private sector agro-dealers when fertilizer prices and the amount of subsidized fertilizer distributed both went down.

2. We also found that subsidized fertilizer crowded-out (displaced) a significant amount of commercial fertilizer sales in five of the six focus countries over the past decade (Ghana, Kenya, Malawi, Nigeria, Zambia). We found no statistically significant crowding-out effect of Tanzania's relatively small subsidy program during the previous decade. Crowding-out of commercial fertilizer by subsidized fertilizer reduces the total amount of new fertilizer

that subsidy programs add to farmers' fields. In doing so, crowding-out also lowers the benefit-cost ratio of input subsidy programs and the returns they generate for farmers.

3. Our analysis of the previous literature indicated that the returns to using fertilizer on maize yields were low on average as measured through household survey data collected on smallholder farmers in the decade before the fertilizer price spike of 2021/22. On average, we found that the maize-to-fertilizer response rate was under 2.0 in Malawi, under 3.0 in Nigeria and Zambia, under 3.5 in Tanzania, and slightly better at between 5.5 and 6.0 in Ghana and Kenya. The response rates we used came from farmer-reported surveys and were significantly lower than they were on experiment stations and on-farm, researcher-managed trials. For example, the literature review by Chapoto et al. (2023) found that experiment station maize-to-fertilizer response rates in Malawi were 14.3, and they were 7.75 on researcher-managed trials on Malawian farmers' fields. Low maize-to-fertilizer response rates meant that both yields and yield response to fertilizer application were below their potential and this undermined the profitability of fertilizer use and returns to fertilizer subsidy programs.
    i. Various factors contributed to low maize to fertilizer response rates on smallholder farmers' fields in SSA. These included a 1) lack of access to quality extension or other sources of accurate information about soil fertility management and proper fertilizer application. 2) farmers often receive generic fertilizer recommendations that do not match the conditions in their fields, 3) no way to deal with poor soil fertility that has been caused by low awareness and low adoption of a) integrated soil fertility management practices, b) slow adaptation of international technical innovation to the highly varying conditions of SSA, c) variable weather including high temperatures and inconsistent rainfall, and limited access to irrigation to adapt to inconsistent rainfall, d) limited labor availability, e) limited access to labor-saving production technologies, f) insecure land tenure, and g) limited access to output markets that pay a remunerative price that would incentivize farmers to use fertilizer more efficiently. There are also anecdotal reports of adulterated fertilizer being sold to farmers. This undermines both fertilizer profitability and farmers' confidence in the benefits of the input.

4. The price ratio of fertilizer to maize is a major determinant of fertilizer profitability. This is known as the input/output price ratio, A lower ratio means that fertilizer is more profitable, as the price of fertilizer is going down (i.e. the numerator in the ratio getting smaller) or the maize price is going up (i.e. the denominator is getting bigger). We found that in most countries the input/output price ratio was trending down before the 2021/22 price spike. The ratio increased during the spike, but it was muted in Nigeria and came down quickly in Kenya because maize prices rose along with fertilizer prices during the spike. In those countries, maize prices stayed higher longer than fertilizer prices did, causing the ratio to decline. High maize prices were good for surplus-producing farmers in these countries, but bad for urban and rural net maize-consuming households.
    i. The two landlocked countries in our analysis (Malawi and Zambia) had much higher fertilizer/maize price ratios than the coastal countries (Ghana, Kenya, Nigeria and Tanzania). This was due to the high costs associated with transporting fertilizer in both countries. It meant that fertilizer was less profitable relative to maize in Malawi and Zambia compared to the other focus countries. For example, Zambia had a fertilizer/maize price ratio of about 2.5 in 2020 before the fertilizer price spike, but it shot up to nearly 7.0 in 2021 and 2022 during the spike. As a result, the average farmer went from needing to obtain just 2.5 kilograms of maize from a kilogram of fertilizer to break even to over 7.0 kilograms of maize per kilogram of fertilizer to break even.

EXCURS: Food aid or fertilizer support: Which is most effective during a food security crisis?

The issues raised above related to fertilizer access and fertilizer use efficiency raise the question of whether it is better to subsidize fertilizer or provide food aid during a crisis like the fertilizer price spike of 2021/22. Our analysis provided clear evidence that the landlocked countries of Malawi and Zambia have not obtained a positive return from subsidizing fertilizer for their smallholder farmers. Both countries have had large subsidy programs for many decades and fertilizer use efficiency is still low among farmers. Low fertilizer use efficiency undermines both the profitability of fertilizer for farmers and the cost-effectiveness of importing and distributing subsidized fertilizer. For the average farmer in both countries, money for subsidized fertilizer could be spent more effectively, including cash and/or food transfers during a crisis. If the governments of Malawi and Zambia want to invest in smallholder maize production, they need to help farmers increase their fertilizer use efficiency so that they obtain more maize from a kilogram of fertilizer. This involves shifting resources towards improving soil fertility, climate change adaptation, encouraging the adoption of improved maize varieties, and, perhaps most importantly, providing extension services to support farmers in using fertilizer correctly.

The other four countries in our analysis (Ghana, Kenya, Nigeria and Tanzania) did somewhat better in terms of fertilizer profitability and returns to subsidized fertilizer. However, the challenge with attempting to scale up a large subsidy program during a crisis like the one in 2021/22 is that it is hard to implement correctly. Kenya is an example of a hastily implemented program that had many problems. First, the private sector was excluded from the 2022/23 subsidy program, which could have negative longer-term consequences. Second, our analysis revealed that wealthier farmers benefited more from Kenya's large, untargeted subsidy than poorer farmers did. The wealthier farmers likely already had the cash to buy fertilizer at commercial prices and they probably obtained higher profits when they sold their maize at a high market price.

It should be noted that food aid and cash transfers can also be hastily implemented and poorly executed, thus suffering from some of the same issues as fertilizer subsidies. Ultimately, the relative costs and benefits of each option (subsidy or food aid) will depend on how either programme is designed and implemented. A well-designed policy response to improve farmers' access to fertilizers in crisis years may partially involve subsidies but it should also involve investments that can be taken now to increase agricultural productivity so that farmers can use fertilizer more profitability and do not need to rely on subsidies during a price spike.

Similarly, a food aid programme can be well designed to provide additional benefits, for example by involving local procurement in areas where supplies are high enough to support local farmers and avoid depressing local food prices by importing food from abroad.

II. Key Recommendations.

The overall goal of stakeholders involved in the fertilizer sector in sub-Saharan Africa should be to make use of the input more profitable along the entire supply chain from fertilizer producers to farmers who are the end users. Once fertilizer use is profitable, subsidies are no longer required and governments can focus agriculture budget spend on further increasing yields, for example by scaling extension services and research and development, both of which have been shown to deliver greater return on investment (Aragie et al. 2019). With that in mind, we make the following recommendations, based on the results of our report.

1. The most important step governments can take today that will make the fertilizer supply chains more resilient to future price spikes is to prioritize improving agricultural productivity. This means helping farmers increase their fertilizer use efficiency (ie: getting more maize and other staple crops from a kilogram of fertilizer). Increased fertilizer use efficiency will lead to increased profits. In turn, this will incentivize farmers to continue buying fertilizer when fertilizer prices rise. When fertilizer prices rise, the price of outputs like maize, and rice do as well. This potentially allows fertilizer to remain profitable even when its prices increase. However, farmers in all of our focus countries need to get more output from a kilogram of fertilizer so that the returns to the input are high enough to cover its increased cost during a spike.

2. Governments need to support farmers with complementary inputs such as increased access to quality public sector and private sector extension and advisory services. Farmers also need training on soil fertility management, erosion control, climate change adaption, water management, the use of appropriate fertilizer blends, and proper timing of fertilizer application. The need for liming should also be investigated and supported where it would prove effective. Improving soil fertility is essential, but it takes time for farmers or the government to see a return on their investment, so governments and donors need to make consistent and clear investments now.

3. Emphasis should either be placed on helping farmers diversify away from maize to other crops or move out of agriculture into other livelihood activities. Maize production is ubiquitous in smallholder communities in most of our focus countries, and fertilizer use efficiency on maize is below its agronomic potential across the region. The emphasis on maize is largely driven by the colonial history of many countries and is buttressed by prevailing policies. The centrality of maize is not, however, immutable.
   i. The over-emphasis on maize leads to both a lack of diversified markets and lack of diversified diets.
   ii. Diversification does not necessarily mean moving away from maize during the maize season, but could simply mean cultivating winter season crops (e.g. vegetables).

4. Donors and multilateral organizations should be proactive, by urgently implementing programs that help smallholder African farmers diversify their income and increase maize productivity. Doing so will make people more resilient to the next fertilizer price spike. This will be more effective than the reactive approach of attempting to make fertilizer cheaper that many took during the 2021/22 fertilizer price spike.

5. Another way to help farmers use fertilizer more profitability is to lower its cost at the "last-mile" of the supply chain. Many countries have highly concentrated fertilizer sectors with few if any actors engaging in production, blending, importing and wholesaling. Creating a facilitating environment where more companies can enter the market should lead to new and more effective blends of fertilizer and lower prices for farmers. The bulk procurement programs in countries like Ghana, Nigeria, and Tanzania were sound in principle because they attempted to reduce the number of actors in the supply-chain and achieve economies

of scale, thus lowering prices for farmers. However, poor implementation meant the potential benefits weren't realized. Furthermore, giving import licenses to a small number of companies with the government controlling the process was inefficient and led to higher prices and late delivery. Procurement for both government and private fertilizer tenders should be open and transparent to promote innovation and competition, for the ultimate benefit of smallholder farmers obtaining better quality fertilizer at lower prices.

i. Each country is different so the optimal number of firms at each point in the supply chain will differ over time and space. The government should focus on making the market transparent, enforcing fertilizer quality standards, and not showing favoritism to specific actors that give them an advantage against legitimate competition.

6. At the same time, private sector actors in the fertilizer supply chain need to show governments that they are reliable/consistent partners that can deliver fertilizer to farmers when and where it is needed. Lack of trust in the private sector to meet smallholders' needs is often one of the reasons that governments use to justify fertilizer subsidies that are distributed through government rather than private channels.
   i. The fertilizer sector needs to make efforts to engage with the government through a national fertilizer association so the two channels can coordinate their efforts with one another. This entails regular meetings and clear and honest communication so that each side is aware of and trusts what the other will do.
   ii. All communication between private fertilizer companies and representatives of the government (written, verbal, or any other type of communication) should be conducted through the national fertilizer industry association, discouraging informal individual firm interactions with representatives of government. All association communications with public sector representatives should be declared, with a record of the communication being available to all association members. Direct communication between representatives of private companies and government that might benefit a particular company at the expense of other companies should be dissuaded or sanctioned. A transparent approach will encourage a more level playing field and competitive fertilizer industry.
   iii. Large fertilizer importing companies should recognize that SSA is a small but growing market that deserves investment and priority. Investments made today should pay off as populations and incomes continue to rise in aggregate on the continent in the coming decades.

7. Rapidly increasing fertilizer prices are a major problem for African farmers and governments and donors will feel the need to respond accordingly. Subsidizing fertilizer is a powerful tool that can decrease the price of fertilizer for farmers and potentially increase fertilizer use quickly during a price spike. However, it can have many unintended consequences that can affect the market, harming farmers and agro-dealers for many years. Therefore, if governments want to implement an effective fertilizer subsidy program during a price crisis, they should take the following steps.
   i. Clearly and effectively communicate their planned fertilizer policies in a timely manner,
   ii. Subsidies should be time-limited in duration according to the conditions of the crisis;
   iii. Subsidies should operate through the private sector. Doing so capitalizes on commercial suppliers' fertilizer distribution networks that are often more efficient than government networks. It also incentivizes commercial suppliers to stay in the market.
   iv. Use e-vouchers and electronic registration to ensure transparency and accountability;
   v. Target subsidies towards a sub-set of farmers that have the land and labor to use fertilizer efficiently but lack the cash to purchase fertilizer during a price crisis. It should be noted that maintaining up-to-date farmer registries is essential for effective farmer targeting.
   vi. Limited resource households would likely be better served by a cash transfer and/or food aid in a fertilizer price crisis. These households generally lack the land and labor

necessary to use subsidized fertilizer effectively. Wealthier households do not need a fertilizer subsidy and are normally the ones who disproportionately benefit from untargeted fertilizer programs that are open to everyone.

8. In our model, countries that did more to control corruption had lower urea prices. This variable is defined by the World Bank as “captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.” In addition, GDP growth was associated with lower fertilizer prices. This points to the importance of focusing on cleaning up corruption and promoting investments that lead to broad economic growth as important measures to make fertilizer markets more efficient. Increasing the traceability of subsidized fertilizer is one way that governments can increase accountability and reduce corruption in the value chain.

9. If governments are going to subsidize fertilizer it would be less detrimental to the commercial market and to long-term market development if the quantity and targets of subsidies were based on clear and predictable guidelines. Our model found that fertilizer prices were lower in a presidential election year. This is consistent with previous research that notes fertilizer subsidies have been used in Africa to gain political patronage in the past (Banful 2011; Mason and Ricker-Gilbert 2013). The main problem of an ostensibly economic program becoming overtly politicized is the effect it has on the incentives of private investors. Specifically, *ad hoc* policy changes that are dictated by the direction of prevailing political winds are difficult to predict, which imposes a risk to would-be investors.

10. Producing fertilizer has the potential to benefit the economy. However, it should be an option that is only available to countries with sources of key commodities required for fertilizer production. Subsidizing fertilizer production does not necessarily translate to lower fertilizer prices and better fertilizer availability for smallholder farmers. Producers with access to global markets will sell in countries where they can secure the highest prices and sales volumes. As we have seen in Nigeria, producers have historically exported most of their stock meaning the potential of lower prices to domestic farmers is not fully realized, even with an export quota in place. Zambia is planning to invest $1.0 billion in fertilizer production and Ghana has plans to develop fertilizer production, using proven natural gas reserves.

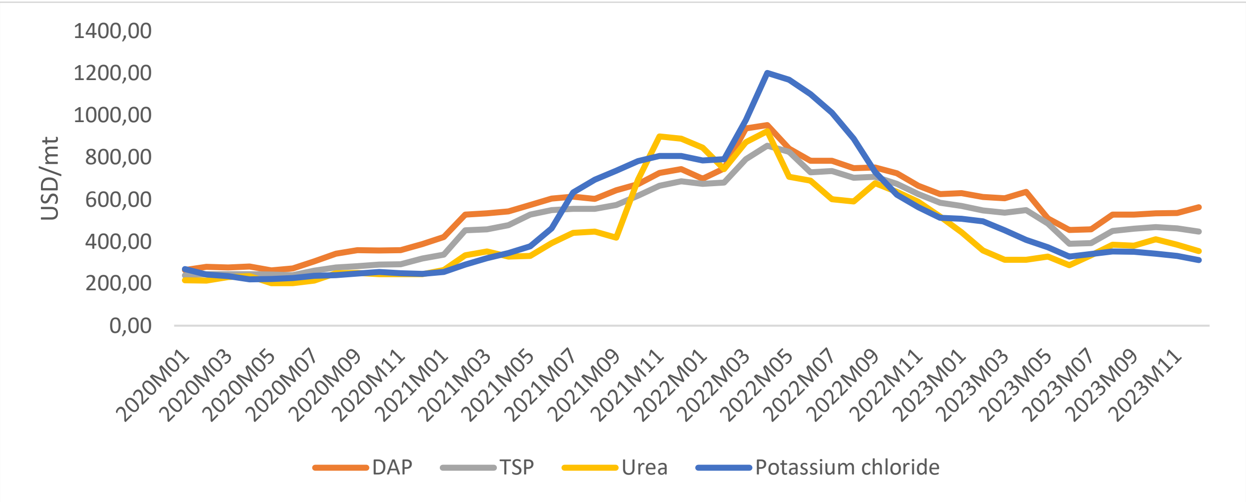
    i. Thus, domestication on its own is not a barrier to global market shocks, and thus policymakers will need to evaluate how local farmers benefit from increased domestic production to determine whether supporting such transitions are cost-effective. Furthermore, if support is given, for example in the form of government-funded subsidies to local producers, it may be incumbent upon the same policies to ensure local farmers have access to domestically produced fertilizer by designated predetermined amounts and prices for local consumption.

III. Introduction

International fertilizer prices increased and then decreased substantially between 2020 and 2024. The initial global drivers of the increase were disruptions in the global supply chain caused by COVID-19. As a result, China and Russia, two of the largest fertilizer exporters, imposed restrictions on their exports. These restrictions also came at the same time that international coal and natural gas prices, key inputs in the production of fertilizer, were rising. Fertilizer prices increased further in early 2022, due to the fallout from the Ukraine crisis. Russia and Ukraine are major fertilizer exporters, and Russia's invasion of Ukraine greatly reduced the global fertilizer supply during the initial months of the war.

Though the initial fertilizer price spike was pronounced on the world market, fertilizer prices declined in 2023 in USD terms back to their pre-spike levels, as global markets adjusted to the dynamics of the Russia-Ukraine war. Figure 1 illustrates this trend across fertilizer blends. For example, nominal global urea prices stood at $215 per metric ton (MT) in January 2020. The nominal global urea price rose to a high of $ 925 per MT in March of 2022 (nearly a 330% increase), before retreating to $ 354/MT in December of 2023. Other blends, including diammonium phosphate (DAP), Triple superphosphate (TSP), and potassium chloride followed a similar pattern. Given the importance of inorganic fertilizer as a crucial input in the production of staple and cash crops around the world, understanding the implications of the price spike in fertilizer prices cannot be understated.

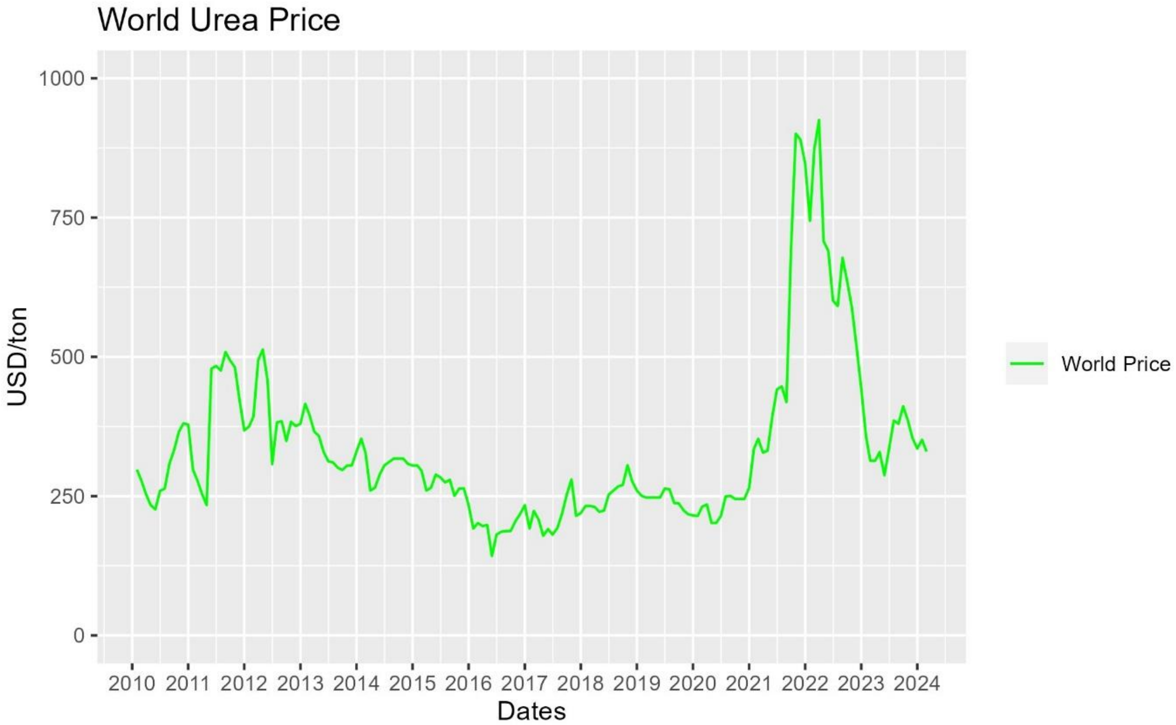
Figure 1:Monthly Global Fertilizer Prices (2020-2023)



Source: World Bank Commodity Price Data (The Pink Sheet), Accessed 8 January 2024.

Figure 2 shows the world price of urea in nominal USD terms from 2010-2023. Urea is the main fertilizer blend analysed in this report because it is a common type of fertilizer, comprised of 46% nitrogen, that is used widely across the world so its price can be compared easily across the six focus countries in our study. In addition, prices in this report are analysed in nominal terms as they represent the price that farmers paid for fertilizer at the time of purchase. The nominal value of urea in Figure 2 indicates that globally the urea price spike of 2021/22 was over by 2023 in nominal terms (and real terms as well). The global urea price returned close to its pre-spike level by the end of the year.

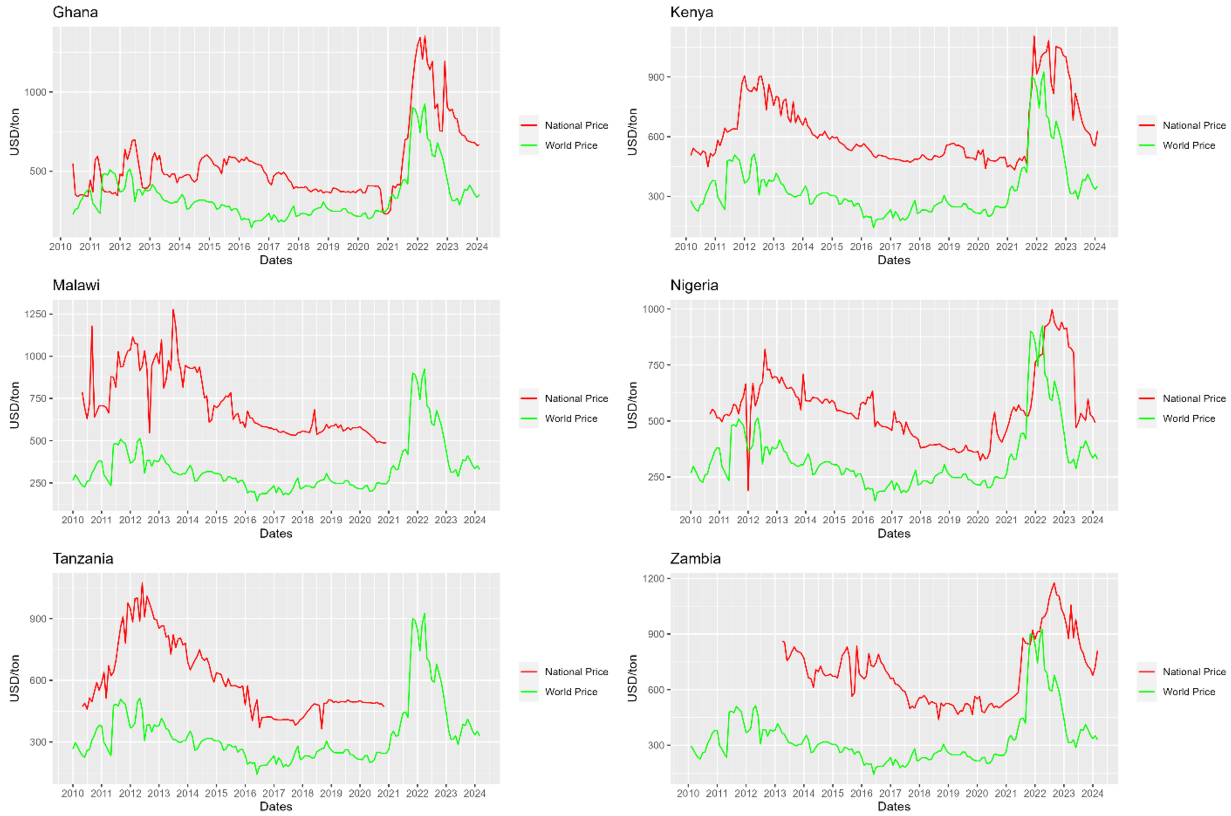
Figure 2: World price of urea in nominal USD (2010 – 2023)



Source: World Bank Pink Sheets. Urea prices were reported for F.O.B. in the Black Sea before 2022 and in the Middle East since.

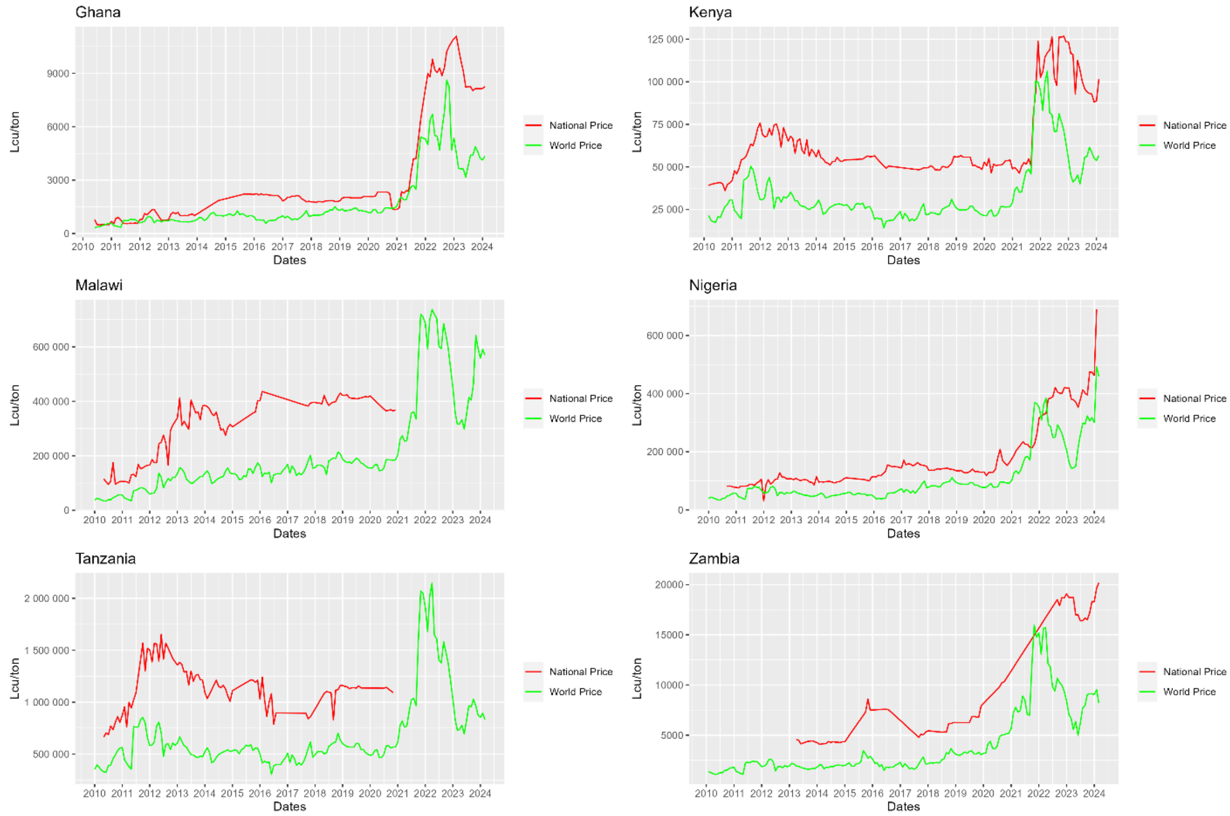
However, Figure 3 reveals that the price spike did not end in 2023 in the six countries of SSA that were the focus of our study (Ghana, Kenya, Malawi, Nigeria, Tanzania and Zambia). When denominating global and local prices in nominal USD, we see that local prices started falling back toward their pre-crisis levels, but only partially (Figure 3). However, when comparing the global and national price of urea in local currency units (LCU), a very different picture emerges. The story shown for most countries in Figure 4 is that: 1) urea prices climbed higher and stayed higher for a much longer period than the world price did during the spike in the four countries where we have retail fertilizer price data after 2020; and 2) at the end of 2023 urea prices were still higher than the world price in the four countries where we have retail fertilizer data after 2020. Thus, the urea price spike has continued into 2024 in the focus countries. This is the case when urea is denominated in USD but especially so when denominated in the LCU which is what farmers actually paid for the input.

Figure 3: Urea Prices in Six Focus Countries Compared to the World Price in USD per Metric Ton (2010-2023).



Notes: Local urea prices (US$/Ton) are an average of monthly prices available from AfricaFertilizer.org; World price is from the World Bank Pink Sheets. The difference between the local price and the world price is the *price wedge*. Local prices not available for Tanzania or Malawi from 2021

Figure 4: Urea Prices in Six Focus Countries Compared to the World Price in Local Currency Units (LCU) per Metric Ton (2010-2023).



Notes: Local urea prices (LCU/Ton) are an average of monthly prices available from AfricaFertilizer.org; World price is from the World Bank Pink Sheets. The difference between the local price and the world price is the *price wedge*. Prices were converted between USD and local currencies using official central bank exchange rates.

The large spatial and temporal variation across countries in SSA before, during, and after the 2021/22 fertilizer price spike motivates the current report. We seek to answer the following questions: What factors contributed to the variation in fertilizer prices across countries and over time? How much of this variation in fertilizer prices was related to differences in 1) market structure, including competition in manufacturing, importing, blending, and retailing sectors; 2) government corruption and political influence, 4) financial risk for input suppliers and farmers, 5) and macro-economic factors like exchange rates, consumer prices, diesel prices, natural gas prices, and GDP growth.

Developing effective strategies to manage and mitigate the impacts of the next inevitable fertilizer price spike like the one in 2021/22 is essential for the incomes, food security, and welfare of millions of people in sub-Saharan Africa. The first objective is to document what the change in the fertilizer price wedge during the global fertilizer price spike of 2021/22 meant for the six focus countries in our analysis; Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia. These countries collectively cover the range of sub-Saharan African regions, representing East, West, and Southern Africa. There is also a wide range of economic representation from among Africa's poorest to wealthiest nations. In each of these countries, both monthly fertilizer price data and smallholder farm household panel data on fertilizer use over time were available. We used monthly urea price data from AfricaFertilizer.org to estimate factors that helped to explain the monthly price of urea in each and the price wedge (i.e. the difference between the local price of urea in each country and the world price) between 2010 and 2023. Second, we assessed how governments, donors, and other multi-lateral organizations in the six countries responded to the price spike. Since subsidizing fertilizer for farmers was the major policy response in Ghana, Kenya, Malawi and Zambia, we estimated the impact of subsidies on commercial fertilizer demand, and how effective each country's fertilizer policy was at increasing fertilizer use among smallholder farmers. Third, we estimated the profitability of fertilizer use for farmers in the six countries using data collected on smallholder farm households over the past decade in each of those countries. To our knowledge, this is the first report to analyse the factors that affected the recent fertilizer price spikes in SSA and estimate the impacts of the price spike on fertilizer profitability for smallholder farmers and the returns to government fertilizer subsidy programs. Our analysis combines state-of-the-art econometric models, fertilizer and farm profitability analyses, reviews of fertilizer policy, and in-depth analysis of fertilizer market structures to develop information and tools that can be used by donors, African governments, academics, NGOs, academics and other stakeholders to prepare for and respond to the next fertilizer price spike.

We derive policy actions for the short-run and longer run, recognizing that steps can be taken today to make fertilizer supply chains more resilient to future shocks and for fertilizer to remain profitable and accessible for smallholder farmers during a shock or crisis. The rest of this report is organized as follows: The next section presents the methodology and data we used to conduct the analysis in this report. We then discuss key results. This is followed by country reports for Ghana, Kenya, Malawi, Nigeria, Tanzania and Zambia. The country reports include detailed analysis, results, and recommendations for each country. We end with study limitations and conclusions.

IV. Methodology and Data

This section discusses the methods and data that we used to complete the objectives of this report. We first discuss the methods related to the cross-country models of urea prices and the urea price wedge. We use logged urea prices as the dependent variable in the urea price level model, and the inverse hyperbolic sine (denoted asinh) of the price wedge in the wedge model because these transformations, along with using logs of explanatory variables, will allow us to interpret the regression coefficients as elasticities (e.g., a percent change in x is associated with a percent change in y). Second, we discuss the methods used to estimate fertilizer demand, maize-to-fertilizer response rates (the amount of maize farmers obtain from a kilogram of fertilizer), and returns to fertilizer use at both subsidized and commercial fertilizer prices. We give the basic details of these models here. More details and the full model specifications are located in Appendix 1.

i. Model of Factors Affecting Fertilizer Prices and the Price Wedge

i. Cross-country model

We employed a panel linear model with individual country and year fixed effects to estimate the relationship between local urea prices and the urea local-global price wedge and various explanatory variables across time. Panel regression models allow for the average effect of each factor to be estimated across many individual countries. Panel models are advantageous in that they smooth out noisy relationships that can be difficult to measure country by country. We have monthly urea price data from AfricaFertlizer.org (with some gaps) between 2010-2023 for Nigeria, Ghana, and Kenya. We have the same data between 2014-2023 for Zambia and from 2010-2020 for Malawi and Tanzania. As a result, we ran an unbalanced panel model that uses the available data from each country for the analysis.

We expect the sign of variables (i.e an indication of whether the variable pushes the price or the price wedge up or down) in the wedge model to be the same as in the local price level model, since local demand (or cost) factors that push up (or push down) local prices should also be pushing the wedge in the same direction. Similarly, we would expect global demand and supply factors that push up the world price to pass through at least partially to the local market.

However, we recognize that it may be more difficult to detect elements that impact the urea price wedge compared to detecting elements that impact the urea price level since the construction of the price wedge means that the variable has less variation than the price level. Therefore, we expect that the variables will have the same sign as the price level model, but we will likely find fewer variables significant.

ii. Country-Specific Models

We also provided country-by-country estimates of the local price and wedge models so that if there were any striking differences in responses across countries, we could uncover those with the country-specific models.

iii. Explanatory Variables

We chose the explanatory variables for this analysis that we believed would affect the price of urea and the a price wedge in our focus countries. These variables were constructed from data that came from various sources including AFAP, Afriqom, World Bank, IMF, country central banks, and FAO. The variables we collected and incorporated into model results are explained below.

Control of Corruption: We hypothesize that a well-functioning government with low markers of corruption would have been able to better react to the global shock in fertilizer prices. Therefore, we expect the sign on this variable to be negative in both the price level and the price wedge models and this is the case in both models and is statistically significant in the local price model. As a measure of corruption, we used the World Bank's Control of Corruption Index. The index "captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests." This index runs from -2.5 to 2.5. More information about the Control of Corruption index is available here.

Election Year: Since incumbent governments or candidates for upcoming elections may promise supportive policies to farmers, we included two variables related to elections in the country. We had one dummy variable during election years and another dummy variable for one year after election years, and we expect the sign of these variables will be negative in the price level and wedge models. However, this did not turn out to be the case. Election years were correlated with price increases in both models, and this was statistically significant in the local price model. In the price wedge model, the sign for one year after election years was positive but was not statistically significant. Information on election years was obtained from the Electoral Institute for Sustainable Democracy in Africa.

Log of Forex Reserves: We included the log of forex reserves, since most countries are dependent on imports of fertilizer, which in turn require sufficient hard currency because imports are paid in USD. Low levels of forex reserve may correlate to difficulties importing fertilizer, which would limit local supply. Therefore, we expect that this variable will be negative in both the price level and wedge models (i.e. a greater stock of forex reserves drives down prices). This was the case in the wedge model but not the local price model but the result was not statistically significant for either. Forex reserves were obtained from the International Monetary Fund.

Log of Real Interest Rates: We included the log of the country's real interest rate because costs of financing are an important part of both demand and supply of fertilizer in the six countries considered in this report. Interest rates were obtained from the IMF and Trading Economics (Ghana). Since financing is a component of cost in fertilizer production and import, we expect the sign on this variable to be positive in both the price level and wedge model. This is the case in the price wedge model but not in the local price model but in neither case were the values statistically significant.

Log of GDP: We included the log of the country's gross domestic product, as more developed countries would be expected to have better industrial infrastructure that would make the fertilizer supply chain more efficient and correlate to lower prices. We therefore expect a negative coefficient in the price level and wedge model which is the case in both models and is statistically significant in both models. GDP was obtained from World Bank Pink Sheets.

First Difference of Local Logged Consumer Price Index (CPI): To control for the general level of inflation in the country we include the local CPI, which we obtain from the World Bank. We used the first difference of logged CPI instead of log CPI itself because log CPI was not stable or consistent over time, something we need for statistical validity. We would expect higher percent changes in CPI to be correlated with higher price levels and a higher price wedge, so we expect the coefficient to be positive on this variable in both models. However, this is not the case in either model, as the values are not statistically significant.

First Difference of Local Currency Exchange (LCU) Rate with the US Dollar: Most countries in SSA import all or a significant portion of their fertilizer needs. Imports are largely paid in dollars, but retail sales are in local currency, hence countries are exposed to changes in exchange rates. We used the first difference of logged exchange rate because exchange rates were non-stationary, meaning that their values were not stable over time, something we need for statistical validity. We obtained exchange rates from Yahoo Finance. We expect that appreciation of the LCU in relation to the dollar will be associated negatively with fertilizer price level and wedge since a stronger currency should make imported goods like fertilizer cheaper in local currency terms. This is the case in both models, and is statistically significant in the local price model.

Number of Firms Importing Fertilizer: This indicator tracks the number of primary importers who brought in fertilizer from the international market in the country by year. This information was provided by Afriqom for 2013-2022. Since importing fertilizer is a highly logistical business with substantial economies of scale, we expect that countries that have a smaller number of private firms importing can create efficiencies that result in lower prices. Such a result would be consistent with an industry where a smaller number of larger firms build out infrastructure that saves on cost of importing and distribution. It is possible, though, that since a large number of firms indicate healthy competition, that should put downward pressure on prices, and hence we could see a negative coefficient on this variable. We see a statistically significant positive sign (i.e. more firms is correlated with a higher price wedge) in both models.

Monthly Urea Imports: Log of imports of urea fertilizer by month.[2] These data were available between 2013-2022, through Afriqom. We hypothesized that this variable may be either of positive or negative in sign. If high imports are driven by government's effort to increase supply and lower prices, we should see a negative sign on this variable in the price level and wedge model. Conversely, if high imports are the result of high demand from the private sector, then high imports will be associated with higher prices and a positive coefficient on this variable in

[2] We used monthly DAP imports in the Kenya DAP model and monthly NPK 10-10-10 imports in the Nigeria NPK model.

the price and wedge model. Results from the cross-country urea price model indicated that the variable was statistically significant and a negative. It was not statistically significant in the price wedge model.

Annual Share of Private Sector Sales: Share of private sector sales of fertilizer (from the total of private sector and government sales) in the country. This information was provided by Afriqom. A high *Annual Share of Private Sector Sales* could be associated with healthy competition among suppliers, which should lead to lower urea prices. However, a high *Annual Share of Private Sector Sales* could also be associated with a high demand for fertilizer from farmers which could increase prices. These two effects would pull price in opposite directions, so before running the model we cannot determine which will be more powerful. The sign is positive (i.e. correlated with higher prices) in both models but is only statistically significant in the local price model.

Log of Lagged Local Maize Price: Since the value of fertilizer ultimately depends on improved crop yields, fertilizer price should be positively correlated to maize price, and result in a positive coefficient in the price level and wedge model. We hypothesize that a higher maize price in the previous month would increase anticipated demand for fertilizer, because if maize is worth more fertilizer should be in higher demand. We used the one-month lag of log prices in LCU to avoid contemporaneous correlation. Local maize prices were obtained from FAO.

Log of Local Diesel Price: Fuel is an important component of the cost of transporting fertilizer from producers (often abroad) to farmers in rural regions so we expect a positive coefficient on this variable in both the price level and wedge models and indeed, the sign is positive and statistically significant in both models. We obtain local diesel prices in LCU from GlobalPetrolPrices.com.

Log of World Urea Price: The world price is expected to be one of the most important drivers of the local price of fertilizer. We expect a positive coefficient on this variable and indeed, the sign is positive and statistically significant. We obtain the world price of urea in USD from the World Bank Pink Sheets and convert this price to LCU for our analysis.

Log of World Natural Gas Price: Since natural gas is the most important input in the production of synthetic urea fertilizer, we included the world price of natural gas, converted to LCU. We expect this variable to be positive in both the price level and wedge models. We obtained world natural gas prices in USD from the World Bank Pink Sheets.

ii. Methodology for estimating commercial fertilizer demand, fertilizer use efficiency profitability of fertilizer use, and returns to fertilizer subsidies.

i. Model of commercial fertilizer demand

We used smallholder panel survey data over around 10 years from each of our six focus countries to individually estimate the factors that affect demand for commercial fertilizer. Details of the datasets used in the analysis are available in the individual country reports. The number of farm households used in each of the six countries ranged from several hundred in each survey year to several thousand in each year.

ii. Model of maize yield response to fertilizer.

Next, we use estimates of maize-to-fertilizer response rate (i.e. the amount of maize farmers get from a kilogram of fertilizer) taken from previous studies to understand fertilizer use efficiency. We used estimates on fertilizer use efficiency from Chapoto et al. (2023) for Kenya, Nigeria, Tanzania and Zambia. We used estimates from Shah et al. (2024) for Malawi, and from Adzawla et al. (2021) for Ghana.

iii. Fertilizer profitability

Per Chapoto et al. (2023) many factors affect crop yield and these are highly variable by location and soil type. They are also affected by farmer management practices including crop rotation and intercropping patterns, use of organic manure, weed management etc. In the current analysis, we estimate fertilizer profitability based on yield response rates that were calculated on farmer-managed fields, as they were the most likely to represent the true on-farm yield results that farmers obtain.

Fertilizer profitability is calculated by the Marginal Value Cost Ratio (MVCR) which represents the extent to which farm income will increase if the rate of nitrogen application increases. MVCR is expressed as follows:

$$MVCR = \frac{\{\text{incremental maize output (kilograms of maize/kilograms of fertilizer) * maize price/kilogram}\}}{\text{price of fertilizer per kilogram.}}$$

Generally, an MVCR that is greater than one suggests that using fertilizer generated a positive/profitable return for farmers. A ratio equal to one is break-even, indicating that the farmer made zero profits using fertilizer, and a ratio less than one is a loss. However, whether or not fertilizer is likely to be profitable depends on outcomes that are uncertain when fertilizer decisions are made, as well as costs associated with the use of fertilizer that are unknown to the researcher. The types of risks that farmers face when using fertilizer at planting to increase staple crop yields at harvest include the chance of low yields due to adverse weather, and output prices at harvest being lower than expected. In the face of these uncertainties and unobserved costs, an MVCR of at least 2.0 (meaning a risk premium of one) has been recommended in the literature to be required in order for fertilizer to be profitable (Xu et al., 2009; Sauer and Tchale, 2009; Sheahan et al. 2013). We discuss the implications of our results when profitability is assumed to be obtained with an MVCR of 1.0 and 2.0.

iv. Returns to fertilizer subsidy programs

We use fertilizer cost data to estimate the returns to fertilizer subsidy programs in Ghana, Kenya, Malawi, and Zambia before and during the recent fertilizer price spike. Each of these four countries had programs that directly distributed fertilizer to farmers, so we can compare the cost of implementing these programs with their benefits. Nigeria scaled down its direct subsidy to farmers in 2016, and Tanzania ended direct subsidies in 2017. As a result, there was no subsidy program to evaluate the benefits and costs in either country during recent years. Tanzania moved to support fertilizer imports in 2017, and Nigeria began subsidizing fertilizer production after scaling down direct subsidies. We do not know how much money the Tanzanian or Nigerian governments spent on these programs, and since there was no direct fertilizer subsidy to farmers there is no way to know how much new fertilizer was added to farmers fields as a result of government support for fertilizer imports and fertilizer production.

In the four countries with direct fertilizer subsidy programs for farmers, we estimated the benefits of the program in each country as the value of incremental maize output that the program generated. The incremental maize output was calculated by taking the quantity of subsidized fertilizer distributed by the subsidy program. Then, based on our estimates, the quantity of fertilizer at commercial prices that was crowded out (displaced) or crowded in (incentivized) by the subsidy program was added or subtracted from the amount of fertilizer that the subsidy distributed. considered an estimated amount of subsidized fertilizer from the amount distributed to account for the diversion of subsidized fertilizer due to corruption and side-selling, following Jayne et al. (2013). For example, if a government distributed 100,000 MT of fertilizer and the crowding out rate was 25% and the diversion rate was 15%, then the amount of incremental fertilizer that was applied to farmers' fields as a result of the subsidy program was estimated as follows: *government fertilizer distributed x {(1+crowding out rate) x (1+diversion rate)} = 100,000*{(1-0.25) x (1-0.15)} = 63,750 incremental MT of fertilizer added to farmers' fields by the subsidy program*. Our estimate of incremental fertilizer use was then multiplied by the maize-to-fertilizer response rates found in the literature. This provided us with an estimate of the incremental quantity of maize output from the fertilizer subsidy. We then multiplied that output by the retail or wholesale price of maize at harvest, obtained from FAOSTAT. We lowered retail maize prices by 20% and wholesale price by 8% to get an estimated farmgate maize price. This price was used to calculate the full benefit of the subsidy, measured as the value of incremental maize production. We then divided that benefit by the cost of the subsidy. This includes the cost to the government of implementing the subsidy program, plus the costs that farmers incurred when they redeemed fertilizer at the subsidized price. This gave us the benefit-cost ratio (BCR) of the subsidy. Just as with the MVCR calculation, a BCR of 1.0 is the break-even point, so a BCR less than 1.0 denotes an economic loss. Under the assumption of risk, 2.0 can be considered break-even for the economy as a whole from subsidized fertilizer. We also considered the private returns to farmers who benefit from receiving subsidized fertilizer at a reduced price. Taken together the MVCR and the BCR tell us about the return on government subsidy programs, the profitability of fertilizer use for farmers who buy or receive subsidized fertilizer, and finally the profitability of fertilizer use for farmers who buy it on the commercial market. It should be noted that we only calculated average MVCRs and BCRs. This does not necessarily mean that the returns to fertilizer use were profitable for all or even most farmers or that the returns to subsidized fertilizer were positive for everyone.

In both the MVCR and BCR calculations, we measured the benefits of total fertilizer use, rather than just the benefit to using nitrogen. This allowed us to compare the benefits to the cost of using urea on a standardized per kilogram basis. This is a simplification as farmers use other fertilizers besides urea, but urea is 46% nitrogen, and nitrogen is usually the limiting nutrient in African soils (Snapp et al. 2014).

We also estimated an average MVCR and BCR assuming that the maize-to-fertilizer response rate was linear. While this was also a simplification as response rates must decline after a certain level of fertilizer use. However, response rates have often been found to be linear at the levels of fertilizer that most African smallholders applied it.

V. Results

This section discusses the main findings of the report. The results section follows the same structure as the methods section by first discussing the descriptive statistics of the variables in the urea price and price wedge models. Then we discuss the findings for the cross-country models of urea prices and the urea price wedge. Next, we discuss the main findings on market structure. This is followed by the main findings on fertilizer policies before, during, and after the 2021/22 price spikes. Finally, we discuss the results for our estimates of fertilizer demand, crowding in/out of commercial fertilizer by subsidized fertilizer, maize-to-fertilizer response rates, and returns to fertilizer use at both subsidized and commercial fertilizer prices. The individual country reports in section VI have much more detailed results for each individual country.

i. Findings from the Model of Factors Affecting Fertilizer Prices and the Price Wedge

Table 1 shows descriptive statistics for all the variables used in the cross-country and country-level models of factors affecting fertilizer prices and the price wedge between 2010 and 2022. The table indicates that the unsubsidized/commercial price of urea was highest on average over time in Kenya, Malawi, and Zambia. It was the lowest in terms of USD in Ghana, Tanzania, and Nigeria. It is important to note that, as mentioned earlier, we lack fertilizer price data after 2020 for Tanzania and Malawi. Thus, the average fertilizer price in these countries was likely higher than what is reported in Table 1, because we did not have information covering the recent urea price spike in those countries.

The corruption control index variable indicated that all six countries had a level of corruption that was less than the median value of zero. This suggested that they all had room for improvement when it came to cleaning up corruption. Nigeria had the lowest level of corruption control (i.e. the highest level of corruption), followed by Kenya. Ghana had the highest level of corruption control among the six focus countries but was still below the median.

Nigeria had the highest average foreign currency reserve and the lowest average interest rate, while Malawi had the lowest foreign currency reserve and Ghana had the highest interest rate. GDP was also, not surprisingly, highest on average in Nigeria, while it was the smallest in Malawi. This makes sense given the relative size of their economies.

CPI movements and exchange rate movements were included in the model in first difference form and showed little variation across countries over time.

The average number of firms importing any fertilizer into a country per year was compiled by Afriqom. It indicated that Zambia had the highest number of firms importing fertilizer annually at over 37 on average. Tanzania was the lowest with only about 11.5 firms importing fertilizer in any given year on average. The low numbers in Tanzania were not surprising given the government's use of bulk procurement since 2017, which awarded fertilizer tenders to one firm.

Monthly urea imports according to Afriqom varied widely, with Nigeria the highest at over 38,000 MT. The lowest was Ghana at just over 8,000 MT. Per Afriqom, the share of fertilizer imports procured by the private sector, rather than the government, was 1.00 in Nigeria and Tanzania. Neither of these countries has had a substantial direct subsidy to farmers since 2017, and even when they directly subsidized fertilizer to farmers, fertilizer imports were managed by private companies. Conversely, the share of private sector sales was lowest at 0.53 in Malawi, which maintained a large fertilizer subsidy program throughout the years of our analysis, and the government parastatal SFFRFM managed fertilizer procurement for the program.

Farmgate maize prices were the lowest in Zambia at 163/MT and in Malawi at USD 195/MT on average. This is not surprising, given both countries' landlocked positions, and poor infrastructure, which leads to highs costs of moving maize around the country. This ultimately results in low farmgate prices for smallholder farmers in remote areas who have few options for selling their maize a remunerative prices (Sitko and Jayne 2014). Farmgate maize prices were highest in Ghana at USD 373/MT and Nigeria at USD 349/MT.

Diesel prices were the lowest in Ghana Kenya and Tanzania. This makes sense as both are coastal countries with direct access by ocean to the Middle East. Conversely, diesel prices were highest on average in landlocked Malawi. World natural gas prices were the same on average across countries. The only variation in the numbers in Table 1 was due to the different number of months for which we had urea price data to analyse in different countries.

Table 1: Summary Statistics: Mean and Standard Deviation of Variables

Variable	Units	Ghana	Kenya	Malawi	Nigeria	Tanzania	Zambia
Local Urea Price (MT)	Local Currency	2,848	62,821	326,863	167,346	1,111,484	8,982
		(2,828)	(22,006)	(104,480)	(101,762)	(205,201)	(4,832)
	USD	540.43	626.34	716.68	553.98	600.59	694.17
		(223.71)	(165.42)	(188.95)	(151.74)	(176.37)	(174.16)
Price Wedge	Local Currency	864	27,000	196,775	52,461	579,126	3,917
		(916)	(9,606)	(71,089)	(39,865)	(164,258)	(1,754)
	USD	186.81	283.91	430.47	208.49	314.06	353.90
		(140.83)	(103.71)	(145.02)	(126.79)	(121.23)	(132.86)
Corruption Control	WB Index (-2.5, 2.5)	-0.13	-0.92	-0.64	-1.13	-0.59	-0.55
		(0.07)	(0.10)	(0.15)	(0.07)	(0.14)	(0.16)
Forex Reserves	USD	6.06B	7.28B	553M	36.76B	4.58B	2.30B
		(1.27)	(1.54)	(217.00)	(5.28)	(618.00)	(669.00)
Real Interest Rate	Annualized %	17.87	7.82	17.21	6.40	8.80	2.14
		(3.96)	(2.01)	(5.16)	(3.74)	(4.08)	(3.00)
GDP	Million USD	61,739	79,176	8,409	452,546	50,340	23,848
		(9,663)	(22,232)	(1,808)	(53,223)	(10,195)	(3,238)
CPI Movements	$CPI_t - CPI_{t-1}$	0.01	0.01	0.01	0.01	0.01	0.01
		(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.01)
Exchange Rate Movements	$ER_t - ER_{t-1}$	0.01	-	0.01	0.01	-	0.01
		(0.06)	(0.02)	(0.07)	(0.05)	(0.02)	(0.07)
Num Firms Importing Fert	Count	25.07	11.61	16.31	17.97	11.49	37.54
		(6.34)	(2.52)	(3.50)	(4.98)	(2.86)	(7.77)
Monthly Urea Imports	MT	8,150	36,473	20,415	38,360	34,375	13,612
		(9,363)	(23,693)	(26,312)	(29,535)	(26,403)	(4,387)
Share Private Sector Sales	Annual Share	0.70	0.68	0.53	1.00	1.00	0.60
		(0.29)	(0.24)	(0.25)	(-)	(-)	(0.19)
Local Maize Price (MT)	Local Currency	1,674	38,138	99,413	119,583	506,056	2,053
		(1,145)	(14,203)	(56,567)	(79,445)	(150,727)	(1,022)
	USD	373.79	344.33	194.58	349.27	264.76	162.96
		(87.43)	(85.73)	(54.54)	(98.92)	(69.24)	(38.63)
Local Diesel Price (Litre)	Local Currency	6.31	108.35	804.86	184.95	1,956.38	14.76
		(4.22)	(30.13)	(75.13)	(118.99)	(217.28)	(6.33)
	USD	1.02	1.01	1.31	0.47	0.93	1.11
		(0.23)	(0.17)	(0.35)	(0.1)	(0.15)	(0.27)
World Urea Price* (MT)	USD	335.10	333.54	286.21	336.83	286.53	322.23
		(156.97)	(155.84)	(80.87)	(158.07)	(81.10)	(170.71)
World Nat Gas Price (MMBtu)	USD	102.25	102.12	82.70	102.27	82.85	102.04
		(64.68)	(64.05)	(24.25)	(65.34)	(24.29)	(73.45)
Number of observations		136	148	118	137	124	116

Note: First row is the mean, and standard deviations are in parentheses. *World Urea Price and World Natural Gas price have different means in the country columns because the country series have different lengths and we present the mean and standard deviation over the time periods available for each series.

ii. Results by Variable for Price Level Cross Country Model in Local Currency Units (LCU)

Figure 5 presents the box and whiskers plot of factors that affected the price of urea across the six countries of analysis (Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia) between 2010 and 2023. Figure 6 presents the same for the price wedge. Both of these figures came from a cross-country panel regression model of 881 monthly observations of nominal urea prices collected by AfricaFertilizer.org. The wedge was the difference between the urea price in local currency units (LCU) in each country and the world price converted from USD to LCU based on the USD price given in the World Bank Pink Sheets. The urea price and the wedge were regressed against the set of factors we discussed in the previous section, that we hypothesized would have affected them. The variables were presented in the figures in the order of our assessment of how much control governments potentially have over each of them. For example, they have the most control over corruption, and the least control over world natural gas prices.

The figures show variables that were statistically significant at the 5% significance level in red with variables that were not statistically significant in black. The triangles and circles represent the coefficient estimate in the panel regression model, and the whiskers show the 95% confidence interval around the coefficient estimates – allowing us to visually assess how precisely we can measure each variable's relationship to fertilizer price level/wedge.

We begin by discussing Figure 5 which estimated the factors that affected urea prices measured in local currency units (LCU) across our six focus countries of Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia between 2010-2023. Our discussion focuses on the explanatory variables that were statistically significant in the model. We present and discuss the factors that governments are most likely to be able to control first (e.g. control of corruption), and then progressively more to those for which they have less control (e.g. world price of urea). First, the World Bank's *Control of Corruption index* was statistically significant and negative in the model of urea prices. Our results indicated that an increase in the *Control of Corruption index* by one standard deviation resulted in a 3.0% decline in the price of urea in LCU (.11 is the standard deviation of Control of Corruption across the 6 countries and over the sample period).[3] This result was in line with our expectations and indicated that if actions can be taken to clean up corruption there is less value that leaks from the market, resulting in lower prices for farmers.

Regarding the election variables, we originally hypothesized that incumbents and challengers have incentive to deliver lower fertilizer prices to farmers (in the case of the incumbents) or promise lower fertilizer prices after election (in the case of the incumbent or the challenger). Therefore, we expected that our variables *One Yr After Election* and *Election Yr* would be negative and significant. We found that One Yr After Election was not significant and *Election Yr* was actually positive and significant. While this was contradictory to our expectation, the effect size is very small with election years associated with an estimated .03% higher urea price. We concluded this was probably driven by a spurious correlation of election years with modest price increases in some countries.

Log Real Interest Rate was positively associated with urea price. A 1% increase in real interest rates was associated with a .04% increase in the price of urea. This highlights the importance of financing costs and how these can get passed through to retail prices and add costs to farmers.

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[3] Since the model in log linear in Control of Corruption index, the percent impact of a one standard deviation increase in the variable is (exp(-.27*.11)-1)*100, where -.27 is our estimated coefficient and .11 is the standard deviation of the Control of Corruption Index across countries and over time.

The next significant variable in the price level regression was *Log GDP*. We find that a 1% increase in GDP is associated with a -0.39% decrease in urea price in LCU. We were unsure of the expected sign on this variable because higher GDP could be associated with strong demand in general and for fertilizer in particular, which would suggest a positive relationship. However, higher GDP also tends to be associated with a more developed economy with better infrastructure that can provide logistical efficiencies that may be negatively associated with price. Our result suggested that the efficiency gains that come along with greater economic development benefited farmers in the form of lower fertilizer prices.

Our next statistically significant variable was a negative relationship *between Exchange Rate Movement* and urea price in Local Currency Units (LCU). A one percentage point depreciation in the local currency relative to the dollar was associated with a 0.34% increase in the price of urea on average. This relationship is what we expect since a weakening currency against the dollar should make imported goods like fertilizer more expensive in local currency terms.

Next, we found that the *Number of Firms Importing Fert* in a year was positively associated with urea prices in LCU. A 1% increase in the number of primary firms[4] importing fertilizer was associated with a 0.14% increase in the price of urea in LCU on average. Since importing fertilizer is a highly logistical business with substantial economies of scale, we found that countries that had a smaller number of private firms were able to create enough efficiencies that we saw lower prices. We recognized the possibility that the relationship could have been positive, reflecting the fact that competition among importers could result in lower prices. However, our results were consistent with an industry that exhibits significant economies of scale. Larger import volumes can lower importing and distribution costs. However, the effect was fairly modest – reducing the number of firms by 50% would only result in a decrease in urea price of 7%.

Monthly Urea Imports were statistically significant and positive, with a 10% increase in monthly urea imports associated with a 0.3% increase in price on average. The positive relationship between imports and price was indicative of demand for fertilizer driving its price up. However, if the importation was driven by government efforts to increase local supply, we would expect higher imports to be associated with lower local urea prices.

We found a positive and significant relationship between *Annual Share of Private Sector Sales* (of total sales by private sector and government) and urea price in LCU. A 10% increase in the *Annual Share of Private Sector Sales* was associated with an increase in the urea price of .6% on average, a modest effect. We did not have a confident prediction on the sign. A high *Annual Share of Private Sector Sales* should be associated with healthy competition among suppliers, which should have a dampening effect on prices. However, a high *Annual Share of Private Sector Sales* can also be associated with a high demand for fertilizer from farmers, which more easily supports a robust private sector of fertilizer supply.

Local Maize Price in the prior month was positively associated with local urea price in LCU. A 10% increase in lagged maize price was associated with a 2.2% increase in the local urea price on average in the model. We hypothesized that a higher maize price would increase the anticipated demand for fertilizer, thus leading to higher prices.

We found *World Urea Price* was positively associated with local urea prices. A 10% increase in world urea price (that has been converted to LCU) was associated with a 3.2% increase in local urea prices on average. Although we expected this variable to have a positive sign, it is surprising that there is not more of a complete passthrough from world prices to local prices. This likely reflects the fact that complex supply chains between the world market and local markets, causes delay in price passthrough and reduce contemporaneous correlation.

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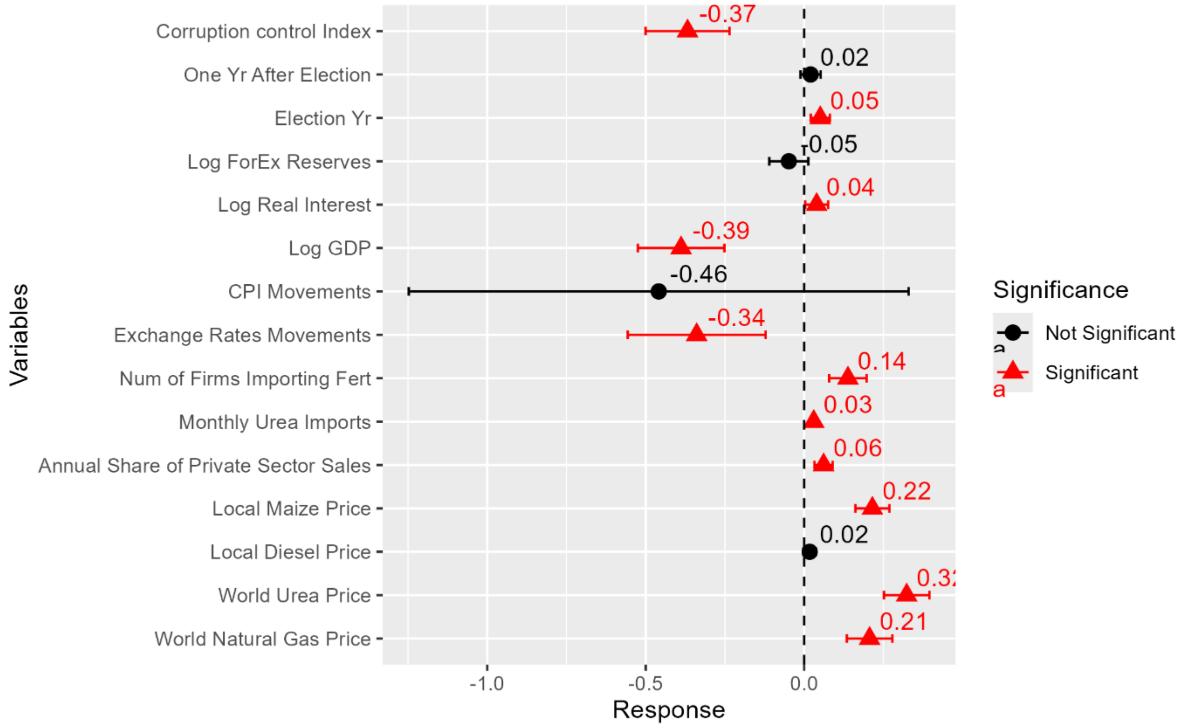
[4] Primary importers are those that place bulk orders for transport of fertilizer. Most countries have a network of secondary importers who buy from the primary importers.

Similarly, we found the *World Natural Gas Price* (that has been converted to LCU) was positively associated with local urea prices. A 10% increase in the *World Natural Gas Price* was associated with a 0.21% increase in local urea prices on average. This was expected since natural gas is a major input cost to urea production. Also, it makes sense that the pass through is smaller than the pass through we found for *World Urea Price,* since World Urea Price also is impacted by *World Natural Gas Price.*

Figure 5: Factors affecting urea prices across six countries from 2010-2023 in LCU/MT

Dependent variable: log of nominal urea price in LCU



Notes: Results are from a cross-country panel regression model of 881 monthly observations of nominal urea prices in Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia denominated in LCU from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into LCU to correspond to the impacts in local markets. Models include year and country fixed effects.

iii. Results by Variable for Price Wedge Cross Country Model in LCU

Next, we discuss figure 6 and the Price Wedge Cross Country Model in LCU. We kept all local prices in LCU and converted all world prices to LCU. Therefore, the wedge represents the reality of local importers converting local currency to dollars to procure fertilizer on the world market and the fact that farmers buy fertilizer in local currency. Overall, our expectations for signs of variables in the wedge model were the same as in the price level model, as discussed in the previous section, since local demand (or cost) factors that push up (or push down) local prices should also push the wedge in the same direction. Similarly, as there are global demand and supply factors pushing up the world price, we would expect these impacts to pass through at least partially to the local market.

However, we recognize that it may be more difficult to detect elements that impact the wedge compared to detecting elements that impact the price level since the construction of the price wedge means that the variable has less variation than the price level. Therefore, our expectation is that the variables will have the same sign as the price level model, but we will likely find fewer variables significant. Indeed, we found 11 out of 15 variables statistically significant in the price level model, but only 4 out of 14 significant in the wedge model.

We found *Log Real Interest Rate* was positively associated with the urea price wedge. A 1% increase in the real interest rate was associated with a 0.8% increase in in the wedge, highlighting the importance of financing costs to the wedge farmers face.

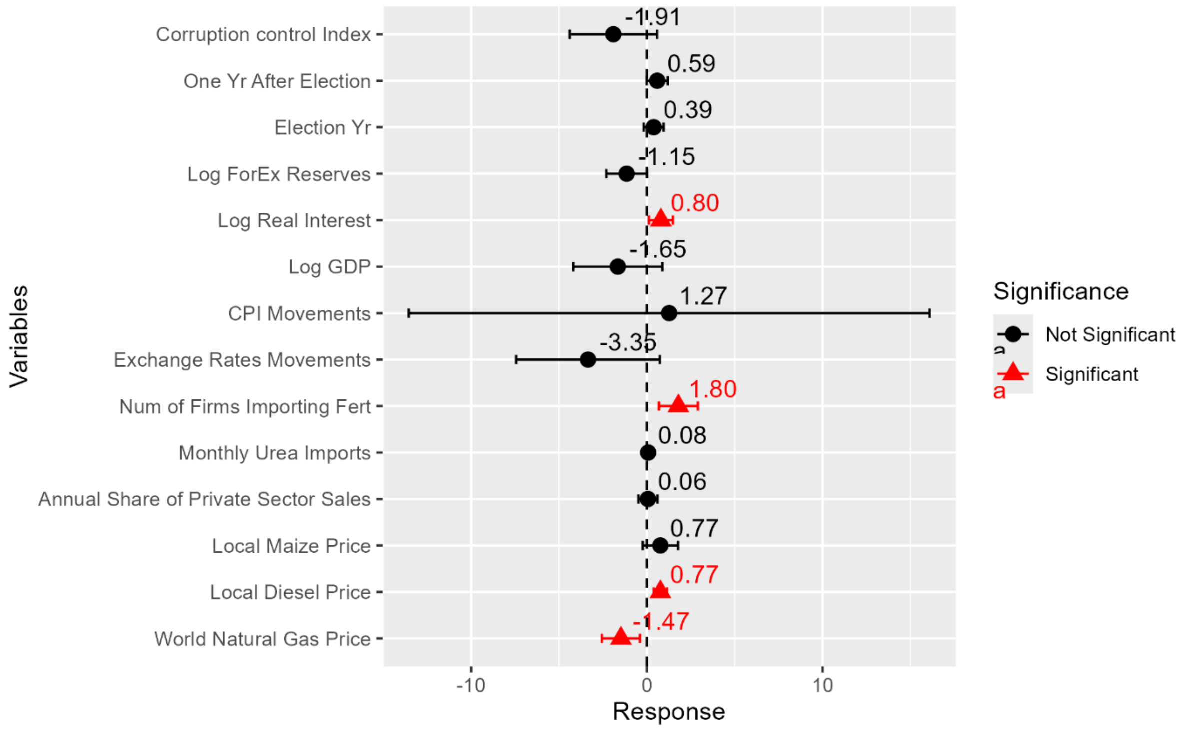
Number of Firms Importing Fertilizer was also positive and significant in the wedge equation, further highlighting that there are likely economies of scale in the logistics of importing and moving fertilizer around the country. A small number of larger private firms can better invest in the capital required to efficiently move fertilizer where it is needed, thereby reducing the spread between local and world prices these firms need to make a profit. We found that a 1% increase in the *Number of Firms Importing Fertilizer* was associated with a 1.80% increase in the price wedge on average.

Local Diesel Price was positive and significant in the price wedge with a 1% increase in diesel price being associated with a 0.77% increase in local urea prices on average. Again, since diesel is a main cost in the transport of urea, we expected this variable to be significant in the price wedge.

Finally, *World Natural Gas Price* (converted to LCU) was significant and negative in the wedge equation. This was the only result in either the price level or the price wedge regression that was truly unexpected. We expected natural gas price to be positive or not significant since it is a major input cost to urea world-wide. It would have made sense if it had been insignificant because increases in cost factors should be reflected in the world price itself, which is already in the spread. It is possible that the world natural gas price was built into the world price of urea. It is also possible that this result was driven by the difference in the timing of when natural gas prices impact the world price compared to when it impacts local prices, making the contemporaneous relationship a spurious one. More exploration is needed on this issue.

Figure 6: Factors affecting urea price wedge across six countries from 2010-2023 in LCU/MT

Dependent variable: urea price wedge asinh(nominal urea price in LCU – world price in LCU)



Notes: Results are from a cross-country panel regression model of 881 monthly observations of nominal urea price wedges in Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia. The price wedge is calculated as the price of urea in LCU in each country obtained from AfricaFertilizer.org minus the world price of urea obtained from the World Bank Pink Sheets converted to LCU. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into LCU to correspond to the impacts in local markets. Models include year and country fixed effects.

iv. Findings from fertilizer demand models

Figure 7 shows the crowding-out estimates for each of the six focus countries. The crowding out estimate tells us how much commercial fertilizer was displaced when farmers acquire subsidized fertilizer. This affects how much new fertilizer ends up on farmers' fields and affects the cost-effectiveness of fertilizer subsidy programs. The results from Figure 7 show that subsidized fertilizer crowded out (displaced) a significant amount of commercial fertilizer in five of the six focus countries over the past decade (Malawi, Ghana, Zambia, Kenya, and Nigeria). We found no statistically significant crowding-out effect of Tanzania's relatively small subsidy program during the previous decade. The highest average crowding-out rate was 40% in Nigeria. This meant that every 100 additional kilograms of subsidized fertilizer distributed to farmers in Nigeria only added 60 new kilograms to total fertilizer use because 40 kilograms were just displaced commercial fertilizer purchases by farmers. These crowding-out estimates and their implications for fertilizer policy are discussed in more detail in the individual country reports.

Figure 7: Crowding out of commercial fertilizer by subsidized fertilizer in each of the six focus countries.

Kenya

Category	Average Crowding out
Overall	-0.22
I. Year	
-	-
-	-
-	-
-	-
II. Area cultivated	
Less than 2 Acres	-0.21
Between 2 and 5 Acres	-0.22
Greater than 5 Acres	-0.27
III. Asset Quintile	
POOREST 20%	-0.20
20 - 40%tile	-0.20
40 - 60%tile	-0.21
60 - 80%tile	-0.22
RICHEST 20%	-0.27

Malawi

Category	Average Crowding out	Category Average
Overall	-0.27	-
I. Year		
2009/10	-0.29	-
2012/13	-0.27	-
2015/16	-0.26	-
2018/19	-0.26	-
II. Area cultivated		Acres
SMALLEST 20%	-0.19	0.44
20 - 40%tile	-0.21	0.92
40 - 60%tile	-0.22	1.41
60 - 80%tile	-0.27	2.13
LARGEST 20%	-0.44	4.19
III. Asset Quintile		US $
POOREST 20%	-0.21	0.75
20 - 40%tile	-0.23	9.27
40 - 60%tile	-0.24	36.24
60 - 80%tile	-0.28	79.30
RICHEST 20%	-0.36	668.98

Nigeria

Category	Average Crowding out	Category Average
Overall	-0.40	-
I. Year		
2010	-0.36	-
2012	-0.46	-
2015	-0.32	-
2018	-0.48	-
III. Landholding		Hectares
SMALLEST 20%	-0.30	0.1
20 - 40%tile	-0.34	0.4
40 - 60%tile	-0.43	0.8
60 - 80%tile	-0.45	1.5
LARGEST 20%	-0.51	4.1
III. Asset Quintile		'000 Naira
POOREST 20%	-0.33	13
20 - 40%tile	-0.40	38
40 - 60%tile	-0.38	76
60 - 80%tile	-0.46	140
RICHEST 20%	-0.43	484

Zambia

Category	Average crowd-out	P-value	Category average
Overall	-0.13	(0.000)	
Year			
2010/11	-0.05	(0.00)	
2013/14	-0.31	(0.00)	
2017/18	-0.38	(0.00)	
Area cultivated			Ha/HH
SMALLEST20%	-0.16	(0.12)	0.49
20 - 40%	-0.86	(0.01)	1.52
40-60%	-0.08	(0.04)	2.55
60 - 80%	-0.21	(0.00)	4.309
Largest 20%	-0.15	(0.00)	14.29
Asset quintile			USD/HH
POOREST20%	-0.11	(0.02)	40
20 - 40%	-0.01	(0.03)	236
40-60%	-0.29	(0.07)	1,280
60 - 80%	-0.10	(0.00)	1,910
richest 20%	-0.15	(0.00)	2,275

Tanzania

Category	Average Crowding out	P-value	Category Average
Overall	-0.08	(0.11)	-
Year			
2010/11	-0.05	(0.18)	-
2012/13	-0.08	(0.24)	-
2014/15	-0.09	(0.13)	-
2020/21	-0.09	(0.16)	-
Landholding			Hectares
SMALLEST20%	-0.06	(0.22)	0.3
20 - 40%tile	-0.06	(0.25)	0.7
40 - 60%tile	-0.11	(0.14)	1.2
60 - 80%tile	-0.07	(0.23)	2.3
LARGEST20%	-0.10	(0.14)	5.8
AssetQuintile			'000 Shillings
POOREST20%	-0.04	(0.11)	59
20 - 40%tile	-0.05	(0.17)	361
40 - 60%tile	-0.05	(0.22)	1,378
60 - 80%tile	-0.10	(0.16)	4,664
RICHEST20%	-0.15	(0.17)	30,474

Ghana

Category	Average crowding out	P-value
Overall	-0.067	(<0.10)
Area cultivated		
SMALLEST		
0/2 ha of Landholding	-0.380***	(<0.01)
2/5 ha of Landholding	-0.111**	(<0.05)
5/10 ha of Landholding	-0.248	(>0.10)
10 ha and above of Landholding	-0.379	(>0.10)
AssetQuintile		
Poorest		
0 - 20%	-0.24	(>0.10)
20 - 40%tile	-4.797*	(<0.10)
40 - 60%tile	-0.063	(>0.10)
60 - 80%tile	0.071**	(<0.10)
80 - 100%tile	-0.153**	(<0.05)

v. Findings from Maize Response to Fertilizer Estimates

Table 2 shows the results of our literature review on the average maize-to-fertilizer response rates in the six focus countries. This tells us how much maize a farmer obtained from an additional kilogram of fertilizer on average. We show the results in nitrogen equivalents, which is how they were reported in Chapoto et al. (2023). We also divide by three as a rough estimate to translate nitrogen use to total fertilizer use. This division is a rule of thumb based on fertilizers' average nutrient content relative to filler. This allows us to compare the maize-to-fertilizer response rates to the fertilizer's cost on a per kilogram of fertilizer basis. Our analysis of the previous literature indicated that the maize-to-fertilizer response rates on smallholders' fields were low on average as measured through household survey data. The literature indicates that the maize-to-fertilizer response rate was under 2.0 in Malawi on average (meaning that a farmer obtained 2.0 kilograms of maize per kilogram of fertilizer applied), under 3.0 in Nigeria and Zambia, under 3.5 in Tanzania and slightly better at between 5.5 and 6.0 in Ghana and Kenya on average. All of these low average maize-to-fertilizer response rates on smallholders' fields meant that yields were below their agronomic potential. For example, the literature review by Chapoto et al. (2023) found that experiment station maize-to-fertilizer response rates in Malawi were 14.3, and they were 7.75 on researcher-managed trials in Malawian farmers' fields. Low maize-to-fertilizer response rates on fields managed by smallholders under their "real world" conditions, undermined the profitability of using fertilizer and the returns to fertilizer subsidy programs.

It is well documented that various factors contribute to low maize-to-fertilizer response rates on smallholder farmers' fields in SSA. These include poor soil fertility, and lack of access to effective extension that can provide information, technologies and improved practices that can help farmers effectively manage and improve soil fertility. In addition, variable weather including high temperatures and inconsistent rainfall, along with lack of access to irrigation and drought resistant seeds that can help to mitigate the effects of inconsistent rainfall are a major challenge to improving maize-to-fertilizer response rates. Further, many farmers have limited labor available, and lack access to labor-saving production technologies. This along with having limited access to output markets that pay a remunerative price for the crops that smallholders produce, reduce their incentives to use fertilizer more efficiently.

Table 2: Maize-to-nitrogen and maize-to-fertilizer response rates in six focus countries

Country	(1) (kg maize/ Kg Nitrogen)	(2) Fertilizer (kg maize / kg total fertilizer)
Nigeria	7.67	2.5
Ghana	16.5	5.5
Kenya	17.05	5.68
Tanzania	9.97	3.32
Malawi	5.52	1.82
Zambia	8.90	2.94

Notes: maize-to-fertilizer response rate estimates for Nigeria, Kenya, Tanzania and Zambia from Chapoto et al. (2023) table 1; maize-to-fertilizer response rate estimates for Malawi from Shah (2024); maize-to-fertilizer response rate estimates for Ghana from Adzawla et al. (2021); maize-to-nitrogen response rate estimates in column 1 converted to maize-to-fertilizer response rate estimates in column 1 by dividing maize-to-nitrogen response rate estimates by three.

vi. Findings on Benefit-cost ratios for fertilizer subsidy programs and Marginal value cost-ratios of fertilizer at subsidized and commercial prices

Table 3 shows the benefit-cost ratios (BCR) for fertilizer subsidy programs and the Marginal Value Cost Ratios (MVCRs) of fertilizer for farmers when they acquire it at subsidized and commercial prices. As mentioned in the previous section, an MVCR that is greater than one indicates that using fertilizer generated a positive and profitable return for farmers. A ratio equal to one is break-even, meaning that the farmer made no profits and a ratio less than one is a loss. However, whether or not fertilizer is likely to be profitable depends on outcomes that are uncertain when fertilizer decisions are made, as well as costs associated with the use of fertilizer that are unknown to the researcher. The types of risks that farmers face when using fertilizer at planting to increase staple crop yields at harvest include the chance of low yields due to adverse weather, and output prices at harvest being lower than expected. In the face of these uncertainties and unobserved costs, an MVCR of at least 2.0 (meaning a risk premium of one) has been recommended in the literature to be required in order for fertilizer to be profitable (Xu et al., 2009; Sauer and Tchale, 2009; Sheahan et al. 2013).

This also applies to the BCR for fertilizer subsidy programs. A BCR of a subsidy program equal to 1.0 means that the economy broke even on it, essentially that the program was equal to giving farmers cash. A BCR greater than 1.0 indicates a gain for the economy from the subsidy program, while, a BCR <1.0 indicates a loss for the economy. Again, a break-even BCR of 1.0 assumes zero transaction costs for implementing the subsidy program. Thus 2.0 may be a better break-even point for subsidies as a rule of thumb.

As mentioned earlier, we had data on costs for fertilizer subsidy programs in Ghana, Kenya, Malawi, and Zambia in recent years that we used to compare to the benefits of subsidy programs in those countries. Nigeria and Tanzania have not had direct input subsidies to farmers since 2016 and 2017 respectively. Since that time Nigeria focused on subsidizing fertilizer production, while Tanzania's fertilizer policy focused on supporting fertilizer imports through bulk procurement. Thus, we did not have a way to measure the direct benefits and costs of fertilizer subsidies in either country.

Results from Row 1 of each country's panel in Table 3 show the financial BCR for their subsidy program. They indicate that the landlocked countries of Malawi and Zambia did not break even on their subsidy program in any of the years of the analysis. This was due to crowding out of commercial fertilizer by the subsidy, low maize-to-fertilizer response rates, and the high costs of the government procuring fertilizer, partly given the high transportation costs of importing fertilizer into these countries. It also helps to explain Zambia's interest in producing its own fertilizers domestically. Kenya obtained a marginally positive return to their subsidy program with a BCR of 1.29 in 2022/23. In that year the high costs of procuring huge quantities of fertilizer lowered the benefits to the economy from incremental fertilizer use. Ghana generated a positive return to its fertilizer subsidy program in the years analyzed because of a favorable cost of fertilizer relative to the price of maize and a relatively efficient maize-to-fertilizer use rate among Ghanaian farmers on average.

The MVCR of fertilizer was found to be profitable in all four countries in all years for the few farmers in each country who were fortunate enough to acquire subsidized fertilizer at below the market price. This is not surprising because subsidy programs across these countries offer selected farmers fertilizer at a discount of between 40 to 90% of the commercial price. It is important to note that this result is different than the financial BCR from the subsidy programs because it only considers the costs that farmers pay to redeem subsidized fertilizer and not the full cost incurred by the government of implementing the program.

Conversely, when fertilizer was valued at commercial prices, we found that it was not profitable on average for farmers in Malawi and Zambia. This was also due to unfavorable fertilizer/maize price ratios and low maize-to-fertilizer response rates that drove down the financial BCR for the country's subsidy program. The MVCR for fertilizer was profitable in Nigeria and Tanzania when it was valued at its commercial price and when we considered a profitability benchmark of 1.0. However, it was not profitable using a risk-adjusted MVCR benchmark of 2.0 in any of the years we analyzed other than 2018/19 in Nigeria and 2023/24 in Tanzania when the MVCR was greater than 2.0 in both countries.

We found that on average fertilizer use was profitable when it was valued at its commercial price in Ghana, and Kenya, using the 2.0 MVCR benchmark. Ghana and Kenya had higher MVCRs for commercially priced fertilizer than other countries in our analysis did, because the maize-to-fertilizer response rates were a bit higher, and fertilizer was priced relatively low compared to the price of maize in those countries. That being said there is room for improvement in maize-to-fertilizer response rates and fertilizer profitability in all six countries that we analyzed. These improvements come from more efficient and competitive fertilizer and output markets and improving fertilizer use efficiency to raise maize-to-fertilizer response rates among smallholder farmers. We offer ways to make improvements in the overall recommendations section and the specific recommendations section in each country report.

Table 3: Benefit-Cost Ratio (BCR) of Fertilizer Subsidy Programs, and Marginal Value Cost Ratio (MVCR) of Fertilizer at Subsidized and Commercial Prices across countries.

I. Ghana (Using maize prices in Accra/Southern)

	Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
1	Financial BCR of Subsidy program	2.69	2.17	2.40	2.94	-	-
2	MVCR of Fertilizer at subsidized price	7.54	5.37	5.95	6.30	-	-
3	MVCR of Fertilizer at commercial price	4.02	3.45	3.79	4.46	1.69	1.86

II. Kenya (Using maize prices in Nairobi/Central)

	Year	**2012/13**	**2013/14**	**2016/17**	**2019/20**	**2021/22**	**2022/23**
1	Financial BCR of Subsidy program	3.34	1.55	4.17	1.17	-	1.29
2	MVCR of Fertilizer at subsidized price	13.42	6.23	16.77	4.69	-	3.44
3	MVCR of Fertilizer at commercial price	2.97	2.61	3.27	3.14	2.26	2.23

III. Malawi (Using maize prices in Lilongwe / Central)

	Year	**2010/11**	**2012/13**	**2015/16**	**2018/19**	**2021/22**	**2022/23**
1	Financial BCR of Subsidy program	0.17	0.28	0.13	0.22	0.27	0.42
2	MVCR of Fertilizer at subsidized price	4.43	12.96	2.56	1.59	1.75	4.75
3	MVCR of Fertilizer at commercial price	0.31	0.57	0.56	0.51	0.37	0.41

IV. Nigeria (Using maize prices in Lagos / Southwestern)

	Year	**2010/11**	**2012/13**	**2015/16**	**2018/19**	**2021/22**	**2022/23**
1	Financial BCR of Subsidy program	-	-	-	-	-	-
2	MVCR of Fertilizer at subsidized price	-	-	-	-	-	-
3	MVCR of Fertilizer at commercial price	1.76	1.85	1.90	2.22	1.76	1.54

V. Tanzania (Using national-level maize and fertilizer prices)

	Year	2010/11	2012/13	2014/15	2018/19	2021/22	2022/23	2023/24
1	Financial BCR of Subsidy program	-	-	-	-	-	-	-
2	MVCR of Fertilizer at subsidized price	-	-	-	-	-	-	-
3	MVCR of Fertilizer at commercial price	1.55	1.14	1.44	1.37	1.69	1.07	2.26

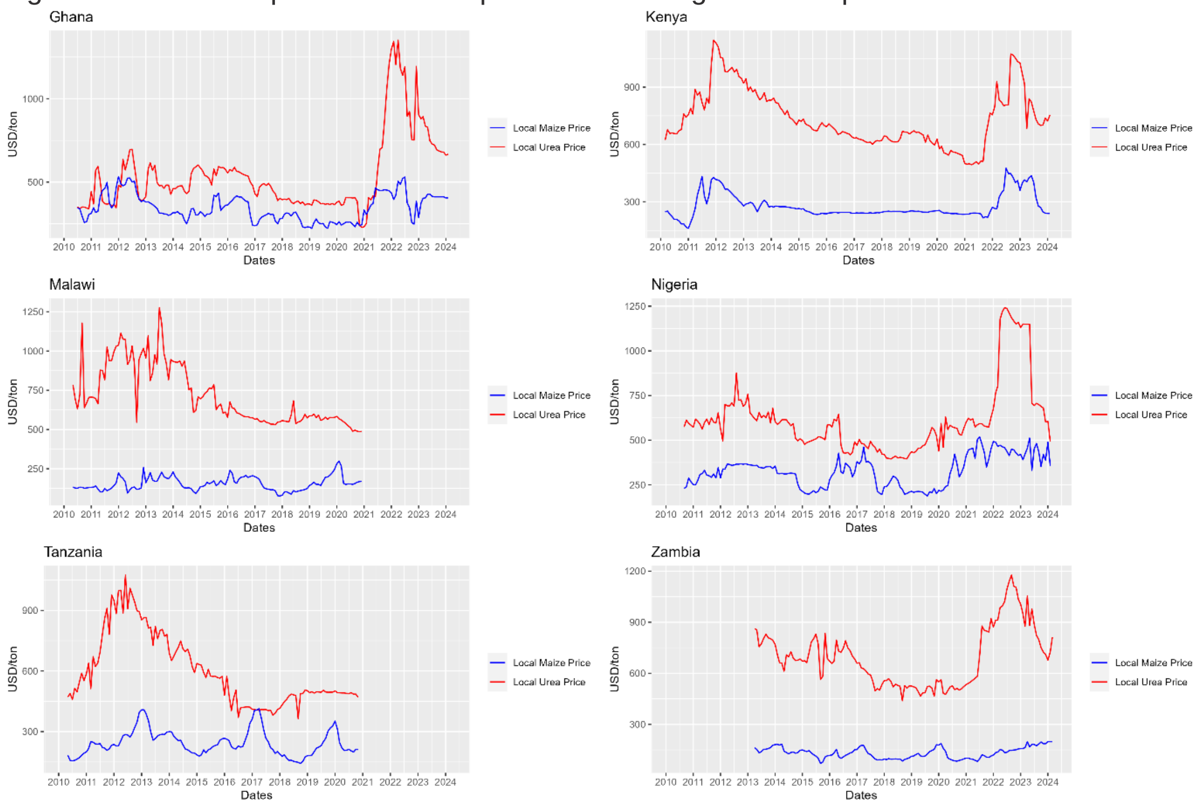
VI. Zambia (Using national-level maize and fertilizer prices)

	Year	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
1	Financial BCR of Subsidy program	0.18	0.40	0.56	0.89	0.28	0.51
2	MVCR of Fertilizer at subsidized price	7.40	8.89	6.46	7.79	7.52	5.98
3	MVCR of Fertilizer at commercial price	0.63	0.82	0.59	0.72	0.69	0.64

vii. Relationship between maize and fertilizer prices in net-importing and net-exporting countries.

Figure 8 shows the relationship between urea and farmgate maize prices across our six focus countries. We discuss them for the two countries in our analysis that are generally net maize-exporting countries (Zambia and Tanzania) and those that were generally net-maize importing countries (Ghana, Kenya, Malawi, and Nigeria) between 2010-2023. The result suggested that there was no clear differentiated pattern between urea prices and maize prices among the net maize importing and net maize exporting countries. Before the 2021/22 price spike, urea and maize prices moved together among the six countries. The reason was likely that at the national level, urea and maize prices were fairly well integrated as moderate shocks to urea or maize prices would propagate from one market to the other. This is because farmer demand for urea is derived from how much more profit maize farmers expect to make from urea application, and maize supply is impacted by input costs like urea. As a result, the prices followed similar trends. However, during the price spikes, urea prices increased more than maize prices in all four countries for which we had data after 2020. This was the case in Zambia, a maize exporter, and in Ghana, Kenya, and Nigeria, which are generally maize importers. The price of urea even rose more than the price of maize in urea-producing Nigeria. The increase in world urea price likely explained why Nigeria exported a significant amount of the fertilizer it produced in 2021 and 2022 in an effort to capture higher prices on the international market. Furthermore, the fact that maize is produced domestically in the six focus countries, while urea is imported in five of the six countries from outside the region likely explains the decoupling of maize and urea prices during the fertilizer price spike of 2021/22.

Figure 8: Relationship between urea prices and farm-gate maize prices in six focus countries.



VI. Individual Country Reports

i. Ghana Country Report

1. Main Findings for Ghana

1. The fertilizer supply chain in Ghana is highly concentrated in manufacturing, importing, blending, and wholesaling. There are currently six companies that produce organic fertilizer. This increased from two in 2014. In addition, there is one company that manufactures lime. However, domestic fertilizer production in Ghana makes up a small fraction of consumption, so the country imports the vast majority of fertilizer that it uses. Three primary importing companies controlled 90% of imports in 2014. This increased to 10 in 2019 and stayed at 10 in 2022 but decreased to six in 2023, likely because of issues with the government's subsidy program implementation (discussed below). There have been between three and seven blending operations in different years over the past decade. However, blended fertilizers are produced for use on cocoa and most of the fertilizer that is used on cereal crops is already blended/finished when it arrives. The fertilizer retail sector is much more competitive and has hundreds of companies selling fertilizer. There are also many more secondary importers supplying hub agro-dealers (wholesalers). In 2018, the government announced plans to explore national fertilizer production, combining natural gas from Ghana and phosphate from Morocco. This production has yet to be realized.

2. The nominal price of urea in Ghana trended downward in USD terms in the years before the fertilizer price spike suggesting that the fertilizer market was becoming more efficient. However, the price of urea rose rapidly as the world price rose in early 2021 and into 2022. The world price of urea peaked at around USD 925/MT in March 2022, but the price in Ghana continued to rise, reaching a high of around USD 1,350/MT near the end of that year. The world price of urea dropped to an average of USD 375 in the second half of 2023, but the local price in Ghana in USD stayed higher for longer and only reached a low of around USD 700/MT at the end of 2023. The wedge between the local price and the world price of urea of over USD 300/MT at the end of 2023 was higher than the wedge at any time in the decade before the price spike. The urea price spike in Ghana was even higher when the fertilizer was valued in Cedi than when it was valued in USD, because of the currency's significant depreciation against the USD. As a result, the price of urea reduced even less when it was valued in Cedi than it did when it was valued in USD as the world price of urea declined throughout 2022 and into 2023. The depreciating Cedi has made it extremely difficult for Ghanian farmers to purchase fertilizer at commercial price over the past several years.

3. Related to point 2) above, our analysis of monthly urea prices between 2010 and 2023 in Ghana indicated that several key factors affected the price of urea:
   a. The price of urea was negatively related to the *Control of Corruption Index*. Cleaning up corruption can help to remove waste from the system and lower prices of fertilizer for farmers.
   b. Robust demand in the economy (as measured by GDP) and robust demand for fertilizer (as measured by Annual Share of Private Sector Sales) and expected demand from the one-month lag of maize prices were associated with higher fertilizer prices in our model. This is expected, and a result of a well-functioning private market.
   c. Similarly, diesel fuel was positively related to urea prices in Ghana, reflecting the role it plays as a cost required to transport fertilizer around the country.

4. Ghana has subsidized fertilizer for smallholder farmers every year since 2008. We note the following about Ghana's subsidy program since that time.
    a. In 2008 the Government re-introduced fertilizer subsidies to farmers in the form of region-specific and fertilizer-specific coupons distributed by the Ministry of Food and Agriculture (MOFA) through its District Directorates and extension officers.
    b. In 2009, Ghana imported and utilized 218,000 tons of fertilizer products. Subsidized fertilizer imports increased again in 2011, but declined in 2012 and 2013, leading to a break in 2014 when the government did not provide subsidized fertilizer. This was despite budgetary statements indicating an intention to distribute 180,000 MT of subsidized fertilizer that year. The quantity distributed in 2015 amounted to 89,201 MT, which was less than half (50%) of the promised subsidized fertilizer quantity at the program's launch. Similarly, in 2016, the total quantity of subsidized fertilizer distributed was 134,227 MT, representing 74.57% of the annual target. The government's inability to reach its targets was likely due to inefficiencies in fertilizer procurement and distribution, along with an overly optimistic assessment of how much fertilizer they could procure.
    c. In 2016, Ghana utilized an electronic voucher system, known as the E-subsidy platform, for subsidy management. Although the free registration of farmers onto the MoFA e-platform was scheduled to begin in April 2016, this electronic system, heralded as a move by MoFA to enhance targeting, efficiency, and transparency in subsidy management, ultimately did not become operational.
    d. In 2017 the FSP was repackaged as the Planting for Food and Jobs Programme (PFJ). In addition to subsidized fertilizer the PFJ tried to promote technology adoption, such as improved seeds and fertilizers, by offering incentives and tailored training to farmers, while facilitating market access through the extensive use of information and communication technology.
        i. A unique provision was introduced within the PFJ's fertilizer subsidy program to incentivize fertilizer uptake, particularly among smallholder farmers with limited incomes and resources for agricultural inputs. Eligible farmers received a 50% subsidy, enabling them to pay 25% of the fertilizer price upfront, with the remaining 25% due after harvest.
        ii. Unfortunately, in 2022 the PFJ was only able to register one company to deliver subsidized fertilizer so the subsidy was not operational.
    e. In 2023, the country implemented the Planting for Food and Jobs Phase II (PFJ 2.0)
        i. According to the Ministry of Food and Agriculture (MoFA) website, the PFJ 2.0 is a five-year program guided by four core principles: a private sector focus, a supply chain approach, market-driven strategies, and inclusivity. These principles underpin the program's strategy to accelerate modernization and enhance competitiveness within the agricultural sector.
        ii. There have been issues with the implementation and roll-out of PFJ 2.0 For example, the program works with output aggregation companies rather than agro-dealers. The goal is for aggregators to offer fertilizer, seed, and extension to farmers on credit with repayment at harvest for the output that farmers sell them. The government has offered a repayment guarantee, but it is not clear that the government has money for the guarantee.
            1. The program has not been piloted but is being evaluated as it rolls out. There are concerns that agro-dealers are not included in the program and there have been reports of farmers side-selling the fertilizer that they acquired under the program.

5. We found that on average, Ghana's subsidy program in 2009/10 crowded out (displaced) about 7% of commercial fertilizer during that year. This meant that 100 kilograms of subsidized fertilizer added 93 kilograms to total fertilizer use, because the remaining seven kilograms were displaced/crowded out commercial fertilizer. Crowding out has

implications for the efficiency of fertilizer use and it reduces the benefits of fertilizer subsidy programs relative to their costs. However, it should be noted that the crowding-out estimate in Ghana was significantly lower than all of our other focus countries besides Tanzania. For example, the average crowding out rate in Nigeria was 44% on average.

6. As a coastal country, Ghana has a relatively favorable position to import fertilizer at a competitive price compared to landlocked countries. The port of Tema is a large and efficient terminal that can handle large shipments of fertilizer and other goods. There have been challenges with the port's competitiveness in recent years as the government has increased import duties to raise revenue. Our analysis found that the farmgate price of maize was favorably high compared to the retail price of fertilizer for smallholder farmers in Ghana. This meant that on average, Ghanian farmers generated more incremental income from their maize production than they spent on fertilizer to produce it. In addition, several recent studies suggested that farmers in Ghana who actually used fertilizer on maize, were able to use the input relatively efficiently (Adzawala et al. 2021; Ragasa and Chapoto et al. 2017). Our analysis used an average maize-to-fertilizer response rate of 5.5 kilograms of maize per kilogram of fertilizer found in Adzawala et al. (2021). This was significantly better than the 3.0 average return in Zambia, and the 2.5 average return in Nigeria.

7. Related to the favorable fertilizer-to-maize price relationship and the maize-to-fertilizer response rate in Ghana, we found that on average inorganic fertilizer was profitable in Ghana when it was valued at its commercial price. We estimated that the average Ghanian farmer obtained a return between 45-435% using fertilizer between 2016-2023. This was consistent with other studies from Ghana including Ragasa and Chapoto (2017).

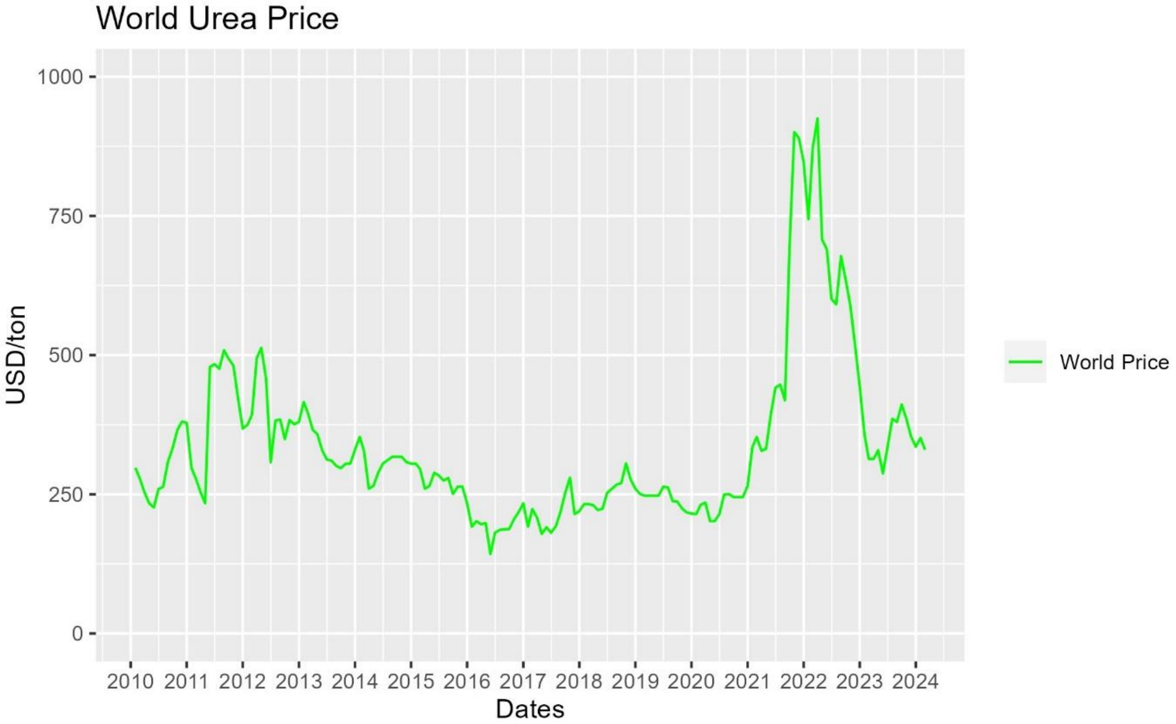
8. Even though fertilizer was found to be profitable on average in Ghana, fertilizer use has remained relatively low in terms of both the percentage of farmers using fertilizer, and the amount used. We found in 2009/10 that only 10% of Ghanian farmers used fertilizer. This was significantly below the Abuja declaration goal of 50 kilograms of fertilizer per hectare on average in the region. Adzawala et al. (2021) found that institutional inputs that facilitate fertilizer use among farmers such as credit and access to extension (training and technical assistance) were low among farmers in Ghana. They also found that poverty status, lack of available labor, and perceptions of low soil fertility limited fertilizer use among farmers in their sample. Ragasa and Chapoto (2021) found that lack of access to modern seed varieties, mechanization, and hired labor were major constraints to fertilizer use. Furthermore, Adzawala et al. found that using integrated agronomic practices, such as organic manure, and intercropping maize with legumes was low among farmers in their sample. These practices are important for the efficient use of fertilizer among smallholder farmers and can increase yields.

2. Introduction

International fertilizer prices increased and then decreased substantially between 2020 and 2024. The initial global drivers of the increase were disruptions in the global supply chain caused by COVID-19. As a result, China and Russia, two of the largest fertilizer exporters, imposed restrictions on their exports. These restrictions also came at the same time that international coal and natural gas prices, key inputs in the production of fertilizer, were rising. Fertilizer prices increased further in early 2022, due to the fallout from the Ukraine crisis. Russia and Ukraine are major fertilizer exporters, and Russia’s invasion of Ukraine greatly reduced the global fertilizer supply during the initial months of the war. At the same time that fertilizer prices increased, prices of staple foods increased as well. This increase in input and output prices had important implications for smallholder farmers, small-scale traders, and consumers in Ghana as it did in many other countries of sub-Saharan Africa (SSA). This is not surprising because Ghana imports virtually all its fertilizers from the international market. Figure G.1 shows the world price of urea, between 2010 and 2024 in nominal USD per metric ton (MT). The figure shows that prior to the price spike of 2021/22, the price of urea had declined from a high of about USD 500/MT in 2013 to a low of about USD 250/MT in 2020 before the spike began. The world price of urea then spiked beginning in early 2021 reaching a high of USD 925 in March of 2022. The price then dropped during the remainder of 2022 before reaching a monthly average of $375/MT in the second half of 2023.

This report analyses global and national-level urea prices because urea is a consistent type of fertilizer (46% nitrogen) that is traded and used globally. Doing so allows us to make cross-country comparisons. Subsequent figures and analyses compare the price of urea in Ghana with the world price. The difference between the local price, and the world price is called the price wedge. Understanding the factors that affected the fertilizer price wedge before, during, and after the fertilizer price spike of 2021/22 in Ghana is important for developing policies, programs, and strategies to mitigate the effects of future shocks.

Figure G.1: World price of urea in nominal USD (2010 – 2023)



Source: World Bank Pink Sheets. Urea prices were reported for F.O.B. in the Black Sea before 2022 and in the Middle East since.

3. Objectives

This report has several main objectives. The first is to analyse and document what the change in the fertilizer price wedge during the global fertilizer price spike of 2021/22 meant for Ghana. We estimated which factors explained the local price of urea and the price wedge in the country between 2010-2022. Second, we assessed how the government, donors, and other multi-lateral organizations in Ghana responded to the price spike. Since subsidizing fertilizer was the major policy response of the Ghanian government to the price spike, we estimated the impact of fertilizer subsidies on commercial fertilizer demand, and how effective fertilizer policy was at increasing fertilizer use among smallholder farmers. Third, we estimated the profitability of fertilizer use for farmers in Ghana using data on smallholder farm household data in the country collected by the Institute of Statistical Social and Economic Research (ISSER) and Yale University that was collected in the 2009/10, 2013/14, and 2017/18 seasons.[5] Fourth, we analysed the return on the government subsidy expenditure to see if subsidising fertilizer was a good use of agricultural budget. Finally, based on these analyses we made recommendations that the Government of Ghana, donors, and the private sector can take to increase the returns to fertilizer use among farmers. Ultimately this will help to make the fertilizer sector more resilient and better prepared for the next time fertilizer prices rise drastically.

4. Methodology

The study applied the following methodology: 1) a qualitative and quantitative econometric analysis of the factors that affected the fertilizer price wedge before during and after the fertilizer price spike in Ghana, 2) a review of the fertilizer market structure that was conducted by key informant interviews with important actors in the fertilizer sector, and review of relevant background documents 3) a scoping review of the literature and available databases on fertilizer subsidy policies in Ghana and fertilizer prices, both global and national, before, during and after the fertilizer price spikes of 2021/22. 4) an analysis of the farmer survey conducted by ISSER/Yale. Using these data we analysed fertilizer demand, including i) how Ghana's fertilizer subsidy program affected demand for commercial fertilizer for both the average household and along the distribution of assets and landholding, ii) how fertilizer purchasing behavior over time was associated with farm household characteristics, iii) how fertilizer profitability was affected by the price spike and the benefit-cost analysis of subsidizing fertilizer was impacted by rising fertilizer and maize prices during the price spike.

5. Results and Discussion

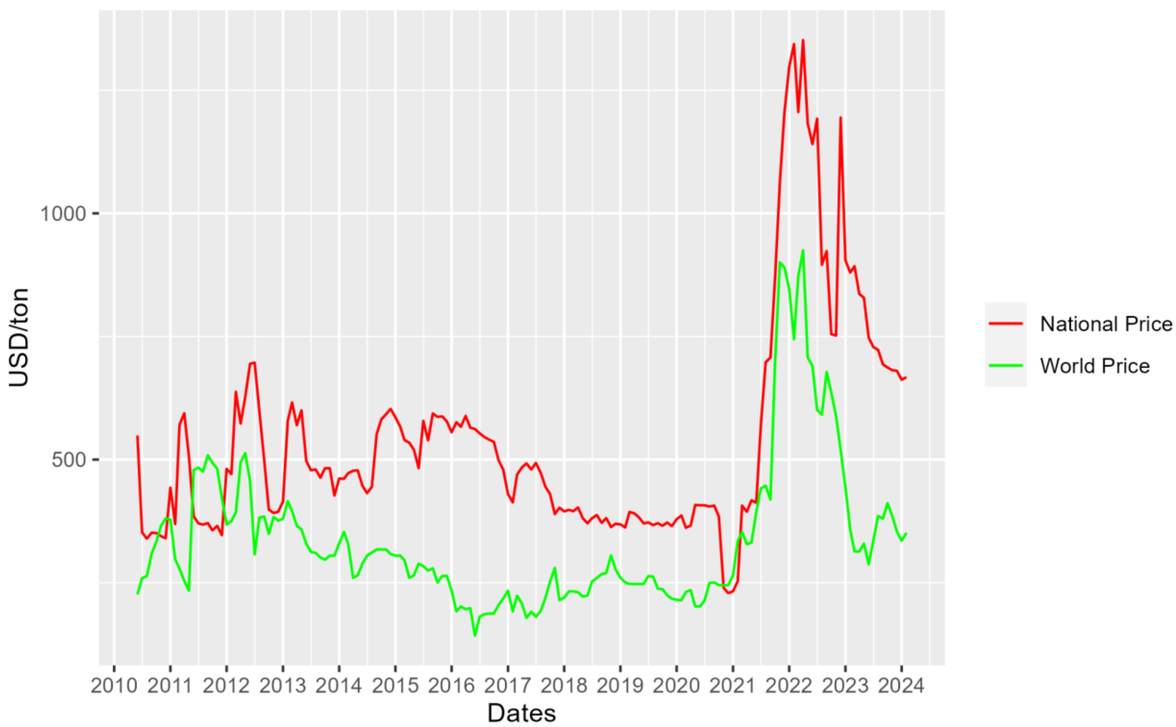
i) The fertilizer price wedge in Ghana

Figure G.2 shows the nominal price of urea in Ghana between July 2010 and December 2023 in USD in red and how it compares to the world price of urea in green. The figure indicated that the price of urea in Ghana was always above the world price before the price spike of 2021/22. This is not surprising, given Ghana's position as a fertilizer importer. However, urea prices in Ghana trended downward during that pre-spike period, meaning that the wedge got smaller Prices went from a high close to USD 700/MT in 2012 to under USD 400/MT at the end of 2020. This suggests that fertilizer use was becoming more profitable for farmers during that period, in US dollar terms, before the price spike.

The local urea price rose at roughly the same time that the world price did in Ghana starting in 2021. There was a brief period at the end of 2020 and the start of 2021 where the wedge was negative but the two prices rose in tandem throughout 2021. The big difference between the urea price in Ghana and the world price came in early 2022; as the world price peaked at about USD 925/MT, the price in Ghana continued to rise. It reached a high of around USD 1,350/MT near the end of that year. The world price of urea dropped to an average of USD 375 in the second half of 2023, but the local price in Ghana stayed higher for longer and only reached a low of around USD 680/MT at the end of 2023. The decline in urea price in Ghana from its peak at the end of 2021 to the end of 2023 was 48%, but in relative terms, the price of urea in Ghana remained high compared to the world price. By the end of 2023, the wedge between the price of urea in Ghana and the world price was $325/MT, and the world price was $680/MT, making the price in Ghana 92% higher than the world price

Figure G.2: Retail prices of Urea in Ghana and the world price in USD/MT (2010-2023)

[5] Most of the analysis focuses on the 2009/10 data as later rounds did not clearly differentiate subsidized from commercial fertilizer acquisition.



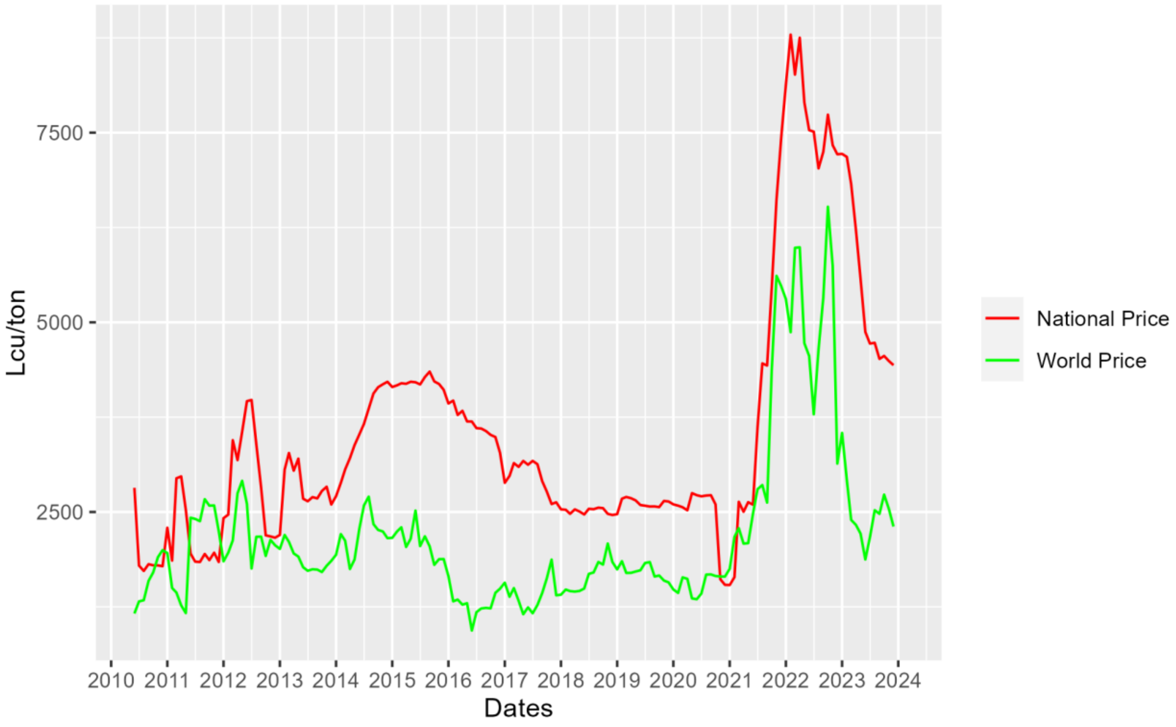
Notes: Price Wedge = Local urea price (US$/Ton) – World Price (US$/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Ghana began in 2010.

Figure G.3 presents the same relationship between the price of urea in Ghana and the world price, but this time both price series were measured in nominal local Ghana Cedi. When urea was denominated in Cedi the price of urea and the price wedge was much more volatile than it was when the price was denominated in USD. In Figure 3 the price of urea was close to Cedi 4,000/MT in 2015 but dropped to about Cedi 1,300/MT at the end of 2020 just before the price spike. The price of urea in Ghana began to rise sharply in early 2021, at the same time the world price rose.

Just as when urea was USD denominated, in early 2021, the world price of urea was higher than the price in Ghana for a brief period. This caused the price wedge to go negative. However, the world price and the Ghanaian price of urea both rose sharply in 2021 when the commodity was valued in Cedis. The world price of urea valued in Cedis stayed high in 2021 and 2022, then dropped quickly, reaching a low of about Cedi 2,500/MT by the end of 2023. Conversely, the local price of urea in Ghana remained high, peaking at about Cedi 10,000/MT in early 2022. It dropped slightly but remained high throughout 2022, and then dropped to about Cedi 4,500/MT by the end of 2023. This was equivalent to a 55% decline. By the end of 2023, the price wedge in Ghana was about Cedi 2,000/MT, meaning that the urea price in Cedi was about 80% higher than the world price at that time. The next section conducts a quantitative analysis to estimate the factors that affected urea prices and the price wedge in Ghana.

The next sub-section discusses the results of our quantitative results on factors that affect the price of urea and the price wedge in Ghana.

Figure G.3: Retail prices of Urea in Ghana and the world price in Cedis/MT (2010-2023)



Notes: Price Wedge = Local urea price (Cedi/Ton) – World Price (Cedi/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Ghana began in 2010.

ii) Quantitative analysis of factors affecting the fertilizer price wedge over time in Ghana

Results by Variable for Price Level Model in Cedi

Figure G.4 presents the box and whiskers plot for the factors that affected the price of urea in Ghana between 2010 and 2023. Figure G.5 presents the same for the price wedge. Both of these figures were based on a time series regression of monthly urea price collected by AfricaFertilizer.org. The wedge is the difference between the urea price in Ghana and the world price based on the World Bank Pink Sheets both in cedi. The urea price and the wedge were regressed against a set of factors that were hypothesized to affect them; the factors were the same ones used in the cross-country panel model.

Results of our model indicated that the *Corruption Control Index* was significantly negative, suggesting that an increase in the control of corruption by one standard deviation results in a 5.96% decrease in urea prices on. This indicates that reducing corruption could lead to lower fertilizer prices by minimizing market inefficiencies.

The *One Yr After Election* variable was also significantly negative, indicating that the year following an election was associated with an 0.86% decrease in urea prices on average. This result might reflect the winning party's efforts to lower fertilizer prices for farmers to maintain political favor with voters.

Next, the *Log GDP* was positive and statistically significant, as 1% increase in GDP was associated with a 1.91% increase in urea prices on average. Our initial expectation was that higher GDP would be associated with increased development that comes with better infrastructure, thus lowering transport costs and ultimately lowering fertilizer prices. However, we found the opposite effect in the Ghana model. The results suggested that economic growth increases overall demand for agricultural inputs and drives up fertilizer prices.

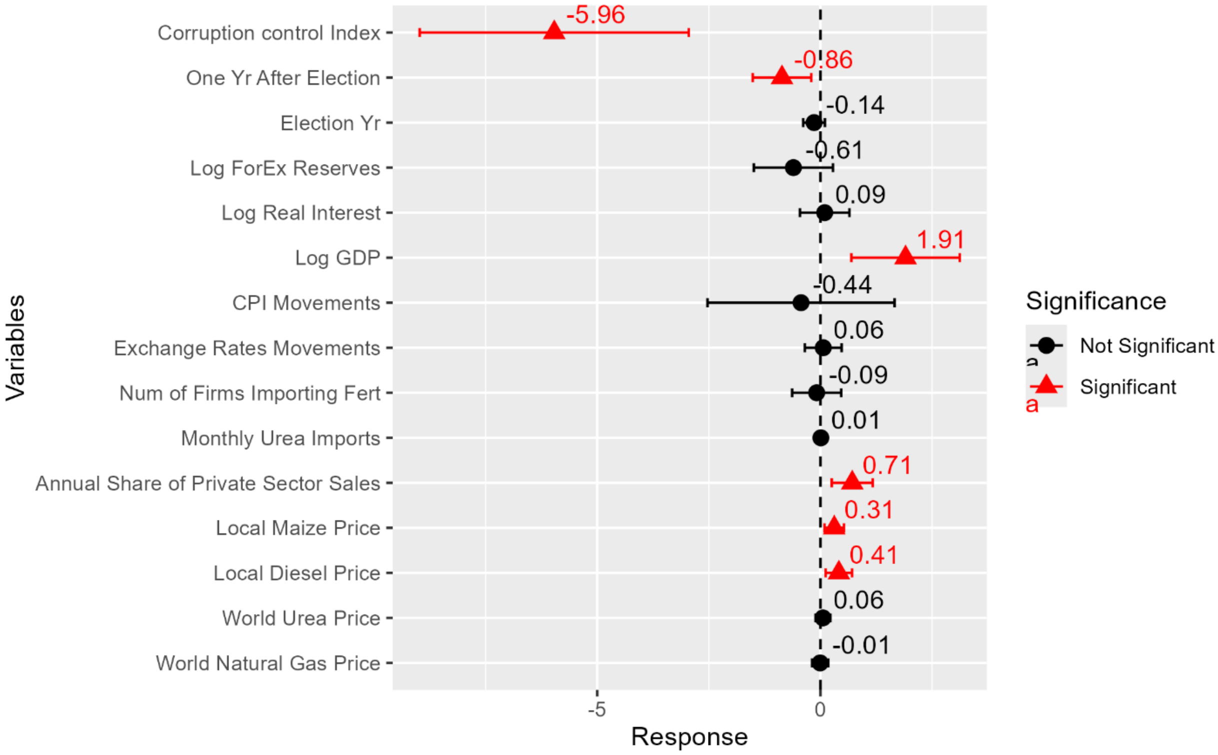
Annual Share of Private Sector Sales was positive and statistically significant, indicating that a 1% increase in the annual share of private sector sales is associated with a

0.71% increase in urea prices on average. This suggests that higher private sector sales may reflect robust demand for fertilizer that can support a larger private sector for fertilizer.

The one month lag of *Local Maize Price* was positive and statistically significant. This suggested that a 1% increase in maize prices was associated with a 0.31% increase in urea prices on average. This result could have occurred because higher maize prices may signal lead to increased demand for fertilizer, as farmers expect maize farming to be more profitable.

Local Diesel Price was positive and statistically significant in our model. It indicated that a 1% increase in diesel prices was associated with a 0.41% increase in urea prices on average. This aligned with our expectations, as diesel is a major cost component in the transportation of fertilizer.

Figure G.4. Factors affecting Urea prices in Ghana from 2010-2023 in Cedi/MT



Notes: Results are from a linear regression model of 138 monthly observations of nominal urea price levels in Ghana denominated in Cedi from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into Cedi to correspond to the impacts in local markets. Models include year fixed effects.

Results by Variable for Price Wedge Model in Cedi

In the price wedge model, the *Corruption Control Index* was statistically significant and negative. This suggested that an increase in the control of corruption by one standard deviation resulted in a 99% percent decrease in the price wedge on average.[6] This indicates

[6] Since the model in log linear in Control of Corruption index, the percent impact of a one standard deviation in crease in the variable is (exp(-113.78*0.07)-1)*100, where -113.78 is our estimated coefficient and .07 is the standard deviation of the Control of Corruption Index in Ghana.

that reducing corruption could lead to lower fertilizer prices by minimizing market inefficiencies and aligning local prices more closely with world prices.

The *Election Yr* variable was significantly negative, indicating that presidential election years were associated with a 7.85% decrease in the price wedge. This might reflect efforts by the incumbent government to lower fertilizer prices for farmers to curry favor during election years. Similarly, the *One Yr After Election* variable was also negative, and statistically significant, indicating that the year following an election was associated with a 20.01% decrease in the price wedge on average. This likely reflected post-election economic adjustments or policy changes after challengers win.

Log Forex Reserves was negative and statistically significant. It indicated that a 1% increase in foreign exchange reserves was associated with a 26.75% decrease in the price wedge on average. This implies that higher foreign exchange reserves may facilitate quicker payments during international trade transactions and allow local urea prices to align more closely with world prices.

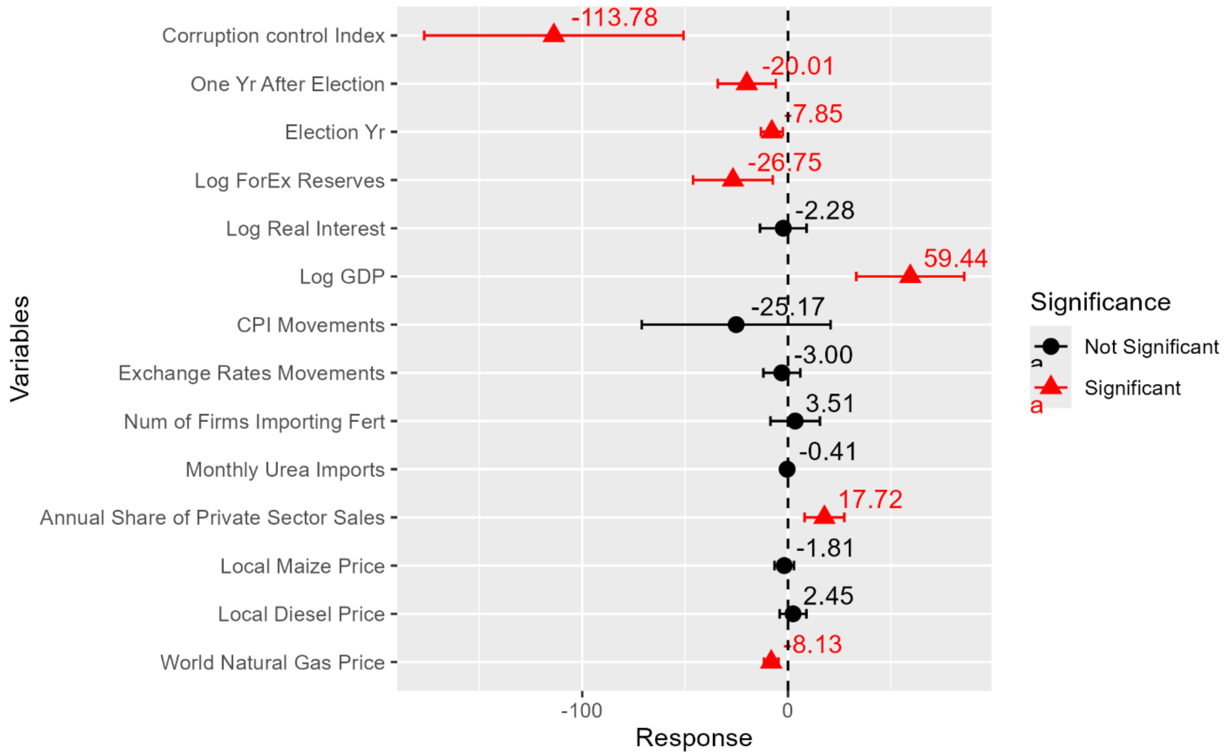
Next, the *Log GDP* was positive and statistically significant, as a 1% increase in GDP was associated with a 59.44% increase in the price wedge on average. As discussed above ourur initial expectation was that higher GDP would be associated with increased development that comes with better infrastructure, thus lowering transport costs and ultimately lowering fertilizer prices. However, we found the opposite effect in the Ghanian model. The results suggested that economic growth increases overall demand for agricultural inputs and drives up fertilizer prices..

Annual Share of Private Sector Sales was positive and statistically significant, indicating that a 1% increase in the annual share of private sector sales was associated with a 17.72% increase in the price wedge. This suggests that higher private sector sales may reflect robust demand for fertilizer that can support a larger private sector for fertilizer, therefore we observe a relationship between the variable and the wedge between local and world prices.

A higher *world natural gas price* was associated with a lower price wedge. Since natural gas is a key input into the production of urea, we would expect that an increase in world natural gas prices increased world urea prices and moved local urea prices in Ghana closer to the world price.

Figure G.5: Factors affecting Urea price wedge in Ghana 2010-2023 in Cedi/MT

Dependent variable: urea price wedge asinh(nominal urea price in Cedi – world price in Cedi)



Notes: Results are from a linear regression model of 139 monthly observations of nominal urea price wedges in Nigeria. The price wedge is calculated as the price of urea in Cedi in each country obtained from AfricaFertilizer.org minus the world price of urea obtained from the World Bank Pink Sheets converted to Cedi. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into Cedi to correspond to the impacts in local markets. Models include year fixed effects.

iii) *Analysis of the fertilizer market structure in Ghana*

NPK and urea are the main fertilizer blends used by Ghanaian farmers. They make up roughly 48% and 20% of the total fertilizer consumed in the country respectively (AfricaFertilizer.org). The other notable blends are ammonium sulfate (10%), triple superphosphate (TSP) (6%), and muriate of potash (MOP) (5%). Between 2017 and 2022 much of the fertilizer distributed into Ghana was brought in through the government's subsidy program (discussed in detail below). Table G.1 presents the structure of the fertilizer market in Ghana over the past ten years. Specifically, it denotes the number of companies that controlled 90% of the total fertilizer that moved through each particular point on the supply chain. The table indicates that the fertilizer sector in Ghana has been very concentrated along all stages of the chain except the retail sector which was much more competitive. As of 2023 there werey six companies that produced organic fertilizer. This increased from two in 2014. In addition, there was one company that manufactured lime in 2023. In 2018, the government announced plans to explore national inorganic fertilizer production, combining natural gas from Ghana and phosphate from Morocco. This has yet to come online.

There has been a slight increase in the number of firms importing fertilizer in Ghana in the past 10 years. In 2014, only three firms imported 90% of the fertilizer, and this increased to ten in 2019 just before the spike, and dropped to six importers through 2023. Yara is the largest importer followed by Invess, AMG, ETG Solevo and OCP. YARA, CHEMICO, OminiFert and MacroFertil. These companies were large enough and had enough capital to remain in the Ghanaian market throughout the fertilizer price spike of 2021/22. It should be noted that we defined importers as the companies who first receive the fertilizer from international sellers. Many other smaller companies put in orders with the primary importers to purchase and distribute fertilizer, but these companies are not considered importers in our analysis.

Ghana has two major ports, Tema and Takoradi, that have a high capacity to accommodate fertilizer imports. Tema is the largest, handling 70% of Ghana's seaborne trade, and is called upon by over 1,500 vessels (www.marineinsight.com). Most of the landlocked countries that border Ghana traditionally imported their fertilizers through the port of Tema. However, in recent years the government of Ghana has increased the import duties at the port to raise revenue. The result has been that the port is less competitive and many fertilizers intended for the Sahel now travel through Togo (ETG personal communication).

There have been between three and seven blending operations in different years over the past decade. However, blended fertilizers are produced for use on cocoa and most of the fertilizer that is used on cereal crops is already blended/finished when it arrives in Ghana. There have also been between three and six large wholesalers controlling 90% of the fertilizer wholesaling in Ghana over the past ten years.

Fertilizers arrive in Ghana in 50kg and 25kg bags since there are few suitable warehouses for storing bulk fertilizer products at the ports. The bags are transported by road to distribution depots, and warehouses of respective wholesalers in the country. Some fertilizer importers have their own trucks for transporting the products from the ports to the warehouse while others also use private commercial trucks to transport fertilizers as well. Transport availability for fertilizer distribution does not seem to pose any real problems to the distributors since most indicated that they have easy access to transport. The transport cost of fertilizers is greatly influenced by the distance from the port to a wholesaler. Wholesalers transfer the cost of transport in the price to the buyer. Transportation costs are affected by availability, road conditions, high prices of spare parts, and the high cost of energy (Paulina, 2017). Wholesalers are located in all the regions in the country with the major ones located at the larger regional capitals thus Kumasi and Tamale. Accra is the national spot where the importers' main operations are located. The distribution among wholesalers and retailers is concentrated in the Ashanti and Bono Regions (IFDC, 2018).

The fertilizer retail sector is highly competitive in Ghana with 100's of firms controlling 90% of the fertilizer that is sold to farmers. Retailers located across the districts in the country sell fertilizer to farmers in 50kg bags or in smaller quantities. Retailers usually start up with their own capital but those without enough capital take products from wholesalers on credit and pay them after the sale.

Cocoa farmers in Ghana consume approximately 20% of all imported fertilizers through licensed agro-dealers and the Ghana Cocoa Board (COCOBOD). Agribusinesses that grow fruits, rubber, and oil palm consume 10% of all imports through their out-grower schemes and nucleus farms. Distributors who reach small-scale farmers through the open market control a further 10% of imported fertilizers. The remaining 60% goes through the Ministry of Agriculture's subsidy program for food crop farmers and other producers.

Table G.1: The number of companies in Ghana that controlled 90% of the fertilizer that was available at different stages in the supply chain during key years.

Stage	In 2014 (ten years ago)	In 2019 (just before the fertilizer price spike)	In 2022 (during the fertilizer price spike)	In 2023 (last year)
Manufacturing	2 Organic compost manufacturing	5 Organic compost manufacturing	6 Organic compost manufacturing	6 Organic compost manufacturing and 1 Lime Manufacturing
Importing	3	10	10	6
Blending	3	5	6	7
Wholesaling	3	6	6	6
Retailing	100's	100's	100's	100's

Source: Importer Information from Afriqom; other information from International Fertilizer Development Corporation (IFDC); importers are companies who bring import fertilizer directly from international markets (first suppliers); wholesalers are hub agro-dealers

iv) Analysis of fertilizer policies in Ghana around the fertilizer price spike of 2021/22

Policy Response

When global economic shocks occur that affect domestic commodity supply chains and prices, countries typically respond with policies to try to mitigate the impact on their citizens. The policy responses often have protracted impacts well after the global shocks have lessened. Such policy responses might achieve their intended objectives but unintended consequences to other aspects of the economy are often also realized. They also might not necessarily achieve their intended objectives. The policy responses often have trade-offs, as countries often face options with differing consequences. It is, therefore, critical that a country's policy responses to economic shocks are guided by its contextual conditions and informed by up-to-date evidence as well as the global and regional dynamics. This section identifies key fertilizer policy interventions in Ghana before and during the recent fertilizer price spikes.

Fertilizer Policy Before Price Spike

Fertilizer is sold to farmers in Ghana through both the commercial open market and the government subsidy channels. The Fertilizer Subsidy Programme (FSP) was re-introduced in 2008 by the government to lower the cost of fertilizer for smallholders, with the stated goal of increasing fertilizer use on staple crops and increasing overall yields. In 2008, the government subsidized 12,000 MT of inorganic fertilizer at a cost of US $15m. Under this program, farmers bought subsidized fertilizer with region-specific and fertilizer-specific coupons distributed by the Ministry of Food and Agriculture (MOFA) through its District Directorates and extension officers (Banful, 2009).

The government consulted fertilizer importers during the design stage of the FSP, and relied exclusively on the existing private distribution system to deliver fertilizer to farmers. Farmers received vouchers covering approximately 50 percent of the negotiated price. Retailers accepted vouchers and passed them on to importers, who submitted invoices to the Ministry of Food and Agriculture (MoFA) for reimbursement within a week. The distribution network relied solely on privately owned fertilizer retailers, excluding those without direct importer relationships.

The quantity of fertilizer subsidized under the program surged from 12,000 MT in 2008 to 72,795 MT in 2009. Subsidized fertilizer imports increased again in 2011, but declined in 2012 and 2013, leading to a break in 2014 when no fertilizer subsidies were provided, despite budgetary statements indicating an intention to distribute 180,000 MT of subsidized fertilizer that year. The quantity distributed in 2015 amounted to 89,200.9 MT, which was less than half (50%) of the promised subsidized fertilizer quantity at the program's launch. Similarly, in 2016, the total quantity of subsidized fertilizer distributed was 134,227 MT, representing 74.57% of the annual target. The government's inability to reach its targets was likely to inefficiencies in fertilizer procurement and distribution, along with an overly optimistic assessment of how much fertilizer they could procure.

In 2016, Ghana utilized an electronic voucher system, known as the E-subsidy platform, for subsidy management. Although the free registration of farmers onto the MoFA e-platform was scheduled to begin in April 2016, this electronic system, heralded as a move by MoFA to enhance targeting, efficiency, and transparency in subsidy management, ultimately it did not become operational (Andoh, 2016).

In 2017 the FSP was repackaged as the Planting for Food and Jobs Programme (PFJ). In the program's first year, 11 fertilizer companies were selected to participate in the program with the opportunity to bid on government tenders for fertilizer (Paul & Samuel, 2018).[7] Approximately 80% (121,000 MT for MoFA and 80,000 MT for COCOBOD) of the fertilizer consumed by Ghanian farmers in 2017 was subsidized, indicating that the government subsidy program had a profound impact on fertilizer demand in Ghana.

The Planting for Food and Jobs (PFJ) program was originally designed to be implemented over four years, from 2017 to 2020, with a total estimated cost of GH¢3.3 billion ($718 million). The nationwide fertilizer subsidy component of the PFJ was estimated to cost GH¢1.8 billion ($401 million) over four years (2017-2020). The implementation of the Planting for Food and Jobs (PFJ) program was structured around five key pillars: (i) seed access and development; (ii) fertilizer access and fertilizer systems development; (iii) extension services; (iv) marketing and; (v) e-Agriculture. This comprehensive approach aimed to foster public-private partnerships, enhance productivity and farm incomes, and generate employment across various value chains.

Specifically, the PFJ tried to promote technology adoption, such as improved seeds for crops beyond just maize and fertilizers, by offering incentives and tailored training to farmers, while facilitating market access through the extensive use of information and communication technology. Farmers purchased subsidized fertilizers directly from agro-dealers without the need for vouchers initially. Fertilizer companies were mandated to issue waybills for all consignments dispatched to distributors, with distributors required to submit copies of these waybills to the Regional Department of Agriculture. This helped to increase transparency and accountability in the system. Retailers were then tasked with selling subsidized fertilizers to farmers along with passbooks. Payment to retailers by the government was contingent upon the quantities of fertilizers sold to farmers, which were documented on relevant fertilizer forms submitted to MoFA for verification.

A unique provision was introduced within the PFJ's fertilizer subsidy program to incentivize fertilizer uptake, particularly among smallholder farmers with limited incomes and resources for agricultural inputs. Eligible farmers received a 50% subsidy, enabling them to pay 25% of the fertilizer price upfront, with the remaining 25% due after harvest. Non-payment of this balance for two consecutive planting seasons rendered beneficiaries ineligible until their debt was settled. To prevent misuse, each eligible farmer was restricted to a maximum allocation of six bags of bio-fertilizer for soybeans and limited quantities of NPK, urea, or sulfate of ammonia for other crops, corresponding to a maximum fertilized crop area of two hectares per farmer.

While there were plans to expand the program to include more smallholder farmers, concerns were raised about the feasibility of such expansions. Under the PFJ, participating input distribution companies finance and deliver PFJ-branded inputs to agro-input retail

[7] These companies were AMG limited, Chemico Limited, Afcott Ghana limited, Yara Ghana Limited, Omni Energy Ghana Limited, Iddisal Company Limited, Louis Dreyfus Commodities Limited, ETC Ghana Limited, Centroid Supplies & Logistics Limited, RMG Ghana Limited and Ganorma Agro-Chemicals Limited

outlets, with verified waybills submitted to the Ministry of Agriculture for endorsement before payment by the Ministry of Finance. However, difficulties in fulfilling financial obligations to banks for importing raw materials have led to delays in fertilizer distribution, with some companies halting their participation due to financial constraints. In 2022 only one company was able to register with the government to import fertilizer. As a result, next to no fertilizer was distributed to farmers as part of the PFJ in that year.

Fertilizer policy during the price spike

The fertilizer spikes that began in 2021 led to about a 60% decrease in fertilizer importation compared to 2020 imports. At the time the fertilizer market in Ghana was dominated by the government which controlled 80% of its distribution through the PFJ (IFDC, 2021). The PFJ continued through 2022 but as mentioned above was not able to distribute meaningful quantities of fertilizer. In 2023 the country implemented the Planting for Food and Jobs Phase II (PFJ 2.0) This five-year program aims to address critical challenges faced under the PFJ I. According to the Ministry of Food and Agriculture (MoFA) website, the PFJ 2.0 is guided by four core principles: a private sector focus, a value chain approach, market-driven strategies, and inclusivity. These principles underpin the program's strategy to accelerate modernization and enhance competitiveness within the agricultural sector. The PFJ II introduces an innovative Input Credit System, replacing the traditional input subsidies with a credit-based mechanism. This system is meant to provide farmers with access to credit for purchasing inputs, thereby addressing the financial barriers to farming and promoting sustainable agricultural practices (MoFA, 2024). By linking input credits to structured market arrangements, the program hopes to ensure that farmers have a reliable market for their produce, thus enhancing their economic viability.

In an effort to ensure successful implementation, the PFJ 2.0 will prioritize the procurement and distribution of essential inputs such as seeds, fertilizers, and pesticides. This is meant to be accomplished through rigorous procurement processes by the MoFA. In addition to input provision, the finance minister in the 2024 budget explained that the program also emphasizes the promotion of commercial agriculture to scale up production and meet domestic food consumption requirements. The program targets key crops and poultry, including staples like maize, rice, soybean, and vegetables such as tomato and pepper. Through targeted interventions and support, PFJ 2.0 aims to increase production levels, establish strategic food reserves, and reduce reliance on food imports. To facilitate program implementation, PFJ 2.0 incorporates digital technologies for the management, monitoring, and coordination of farming activities (MoFA, 2024, p.7). A digitized platform will streamline processes, enhance transparency, and improve the efficiency of agricultural operations. Furthermore, PFJ 2.0 seeks to create job opportunities for youth by eliminating barriers to entry into agriculture. Through the provision of high-quality inputs, access to credit, and off-taker arrangements, the program empowers young farmers to engage in commercial farming and contribute to the nation's food security.

To date, there have been issues with the implementation and roll-out of PFJ II. For example, the program works with output aggregation companies rather than agro-dealers. The goal is for aggregators to offer fertilizer, seed, and extension to farmers on credit with repayment at harvest for the output that farmers sell them. The government has offered a repayment guarantee, but it is not clear that the government has money for the guarantee. Furthermore, the PFJ II has not been piloted but is being evaluated as it rolls out. There are concerns that agro-dealers are not included in the program and there have been reports of farmers side-selling the fertilizer that they acquired under the program.

Since the implementation of the PFJ II the market for importing fertilizer is regarded as being managed in the open market with little direct procurement from the government. Instead, the government issues an open tender for the suppliers to express their interest. However, firms who win the tender and supply fertilizer to the government often face delays in receiving payments. With the transition of PFJ I to PFJ II, it is believed that the guarantee provided by the government through financial institutions will enable suppliers to get their payment on time after supplying to the selected aggregators by the government. However, our key stakeholders expressed concerns that the government may not have the money to guarantee the loans given out through the PFJ II. In addition, the program is supposed to be run through maize and rice aggregators. It is also not clear if these operators have a broad enough network to distribute fertilizer on credit to enough farmers so that the PFJ II can effectively increase fertilizer use and staple crop production.

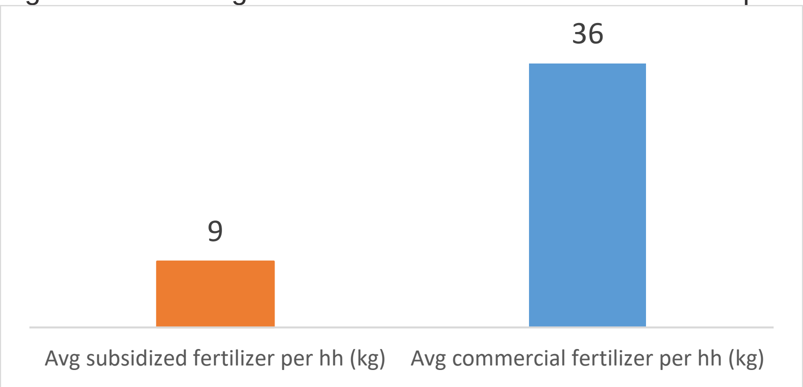
Typically, most fertilizer imports into Ghana occur between April-June. The cropping season mostly starts in March. Farmers gain access to subsidized fertilizer in the middle of the cropping season, and open-market fertilizers at the start of the season. The government's inability to pay suppliers on time in the subsidy market, and farmers' inability to afford fertilizer at commercial prices during the price spike have been major issues for the fertilizer sector in Ghana. Imported fertilizers are distributed through both subsidized channels and open market sales, with wholesalers and retailers playing essential roles in reaching farmers nationwide. The pricing structure, influenced by international market fluctuations and local economic conditions, poses challenges for distributors and retailers, often resulting in minimal profit margins.

v) Fertilizer Demand Impacts

Inorganic fertilizer use among farmers in Ghana is generally considered to be lower than it could or should be based on fertilizer profitability and economic constraints. One of the challenges with conducting analysis related to fertilizer use in Ghana is the lack of panel data that was collected for that purpose. We used the ISSER/Yale dataset from 2009/10 to look at the quantities of subsidized and commercial fertilizer used in that year. Unfortunately, the later rounds of data collected in 2013/14 and 2017/18 did not have reliable statistics on quantities of fertilizer used by farmers those rounds of data in the crowding-out analysis below.

Figure G.6 used data on 1,867 households from the 2010 ISSER/YALE Panel survey to estimate fertilizer use among Ghanaian households in that year. The results indicated that though commercial fertilizer use was much higher at 36 kilograms on average than subsidized fertilizer use at nine kilograms on average, total fertilizer use was low overall at 45 kilograms per household in 2009/10 on average. The low fertilizer use rate in the ISSER/Yale panel study was consistent with Ragasa and Chapoto (2017) who estimated an average fertilizer use rate of 44 kilograms per hectare of nitrogen use. These estimates were far below the recommended use rate of 225 kilograms per hectare. Subsequent analysis in this section will investigate inorganic fertilizer profitability and the constraints that Ghanian farmers face to using the input.

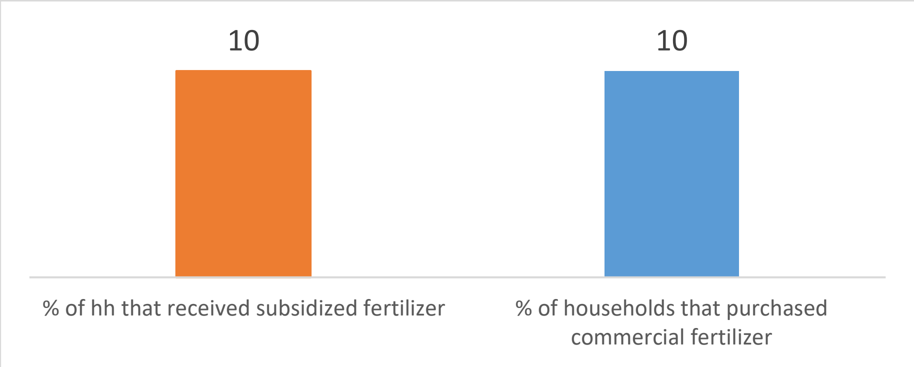
Figure G.6. Average subsidized fertilizer and commercial procured per household in 2009/10.



Source. ISSER/YALE survey (2010); the number of observations = 1,867

Consistent with relatively low average fertilizer use, fertilizer participation rates in Ghana were very low as well. Figure G.7 shows this participation rate. In the 2009/10 (2010 survey) 10% of farmers acquired subsidized fertilizer, and 10% of farmers purchased commercial fertilizer.

Figure G.7. Percentage of households who procured subsidized and commercial fertilizer by survey year.



Source. ISSER/YALE Panel survey (2010); the number of observations = 1,867.

Table G.2 presents the crowding-out rates of commercial fertilizer by subsidized fertilizer that we calculated from the 2009/10 ISSER/Yale panel survey. We found that the crowding-out rate of commercial fertilizer by subsidized was just under 7% on average. This meant that for every 100 kilograms of subsidized fertilizer acquired by farmers, only 93 kilograms of new fertilizer were applied to their fields. The remaining 7 kilograms were displaced commercial purchases.

Table G.2 also presents the estimated crowding-out rates of commercial fertilizer by the subsidized fertilizer in 2009/10, by breaking down the sample of respondents by landholding and assets. The table shows that the crowding out rates were highest for those with less than two hectares (38% on average), and those with between 2 and 5 hectares (11% on average). Larger-scale farmers with landholding greater than 5.0 hectares did not crowd out their commercial fertilizer purchases in any meaningful way. At the bottom of table G.2, we found that farmers between the 20-40 percentile of assets and those in the top 20 percentile of assets were more likely to crowd out their commercial fertilizer purchases when they acquired subsidized fertilizer. This result seems surprising, but it could be related to the intensity of fertilizer use. Table G. 4 shows that smaller farmers use commercial fertilizer more intensively on a per hectare basis. It could be that these intensive fertilizer users are more likely to have their commercial fertilizer purchases crowded out when they obtain subsidized fertilizer.

Table G.2: Crowding out by poverty status

Category	Average crowd-out	P-value
Overall	-0.067	(<0.10)
Area cultivated		
0/2 ha of Landholding	-0.380	(<0.01)
2/5 ha of Landholding	-0.111	(<0.05)
5/10 ha of Landholding	-0.248	(>0.10)
10 ha and above of Landholding	-0.379	(>0.10)
Asset Quintile		
Poorest 0 - 20%	-0.24	(>0.10)
20 - 40%tile	-4.797	(<0.10)
40 - 60%tile	-0.063	(>0.10)
60 - 80%tile	0.071	(<0.05)
Richest 80 - 100%tile	-0.153	(<0.05)

Source. ISSER/YALE survey (2010); the number of observations = 1,867

vi) *Fertilizer user demographics*

Table G.3 presents the characteristics of farming households who purchased commercial fertilizer in every agricultural survey year in the ISSER/YALE Panel survey (2010, 2014, 2018) those who bought in some years and not others, and those who never bought it. The table shows that 1% of smallholder farmers in the sample purchased commercial fertilizer in every survey year, while 22% bought fertilizer in some survey waves, but not in others. Additionally, 78% of households never bought commercial fertilizer during the four survey years.

Table G.3: Percentage of households that bought commercial fertilizer in every survey year, in some survey years, and none of the waves.

Group	% of the Sample in the group
% of the sample who purchased commercial fertilizer in every survey year	1
% of the sample who purchased commercial fertilizer in some of the survey years but not all.	22
% of the sample who never purchased commercial fertilizer in any survey year	78
Total	100

Source. ISSER/YALE Panel survey (2010, 2014, 2018); the number of observations = 1867 in each survey wave.

Given the fairly low fertilizer participation rate in Ghana, we used the 2009/10 ISSER/Yale dataset to disaggregate the landholding distribution of farmers into four categories: i) those with less than two hectares of cultivated land, ii) those with between two and five hectares, iii) those with five to ten hectares, and those with more than 10 hectares. The results are shown in Table G.4. Column 4 indicated that in 2010 farms with less than two hectares made up 48% of all farms in Ghana. These households cultivated 0.93 hectares on average and purchased an average of 56 kilograms of fertilizer. Conversely, households with between 2.0 and 5.0 hectares made up 39% of the sample. This group cultivated just over three hectares acres on average and purchased an average of 65 kilograms of fertilizer. The group of households with between 5.0 and 10 hectares made up 9% of the sample. These households farmed an average of 6.8 hectares and purchased an average of 80 kilograms. Households with more than 10 hectares made up just 3% of the sample. They owned just over 20 hectares on average and purchased 99 kilograms of fertilizer. It is not surprising that larger-scale farms purchased more fertilizer. However, when we averaged commercial fertilizer on a per-hectare basis in column 3, we found that the smallest farms used fertilizer more intensively than did larger farms. This was consistent with findings in other countries including Kenya, Nigeria and Tanzania.

Table G.4: Landholding and Location Demographics for Households Purchasing Commercial Fertilizer in Ghana

	(1) Mean area cultivated in group (hectare)	(2) Avg Commercial fertilizer purchased in group (kg)	(3) Amount Purchased per hectare in group (kg)	(4) Percent of sample in group
less than 2.0 hectares	0.93	56	86	48
between 2.0 and 5.0 hectares	3.07	65	23	39
between 5.0 and 10 hectares	6.8	80	12	9
greater than 10 hectares	20.48	99	6	3

Source. ISSER/YALE survey (2010); the number of observations = 1867

Table G.5 used linear regression to analyze the factors that were associated with purchasing commercial fertilizer in all three survey years (2010, 2014, and 2018) (column 1) and factors associated with not purchasing commercial fertilizer in any year (column 2). Since only 1% of the sample purchased fertilizer in all three waves according to table G.3, the results in column 1 should be treated with caution. The results from column 1 indicated that households who had older heads were slightly less likely to have purchased fertilizer in all three waves. Households where the head had a formal education were more likely to purchase commercial fertilizer in all three waves. In addition, households who had savings and higher assets were slightly more likely to have purchased commercial fertilizer in all three waves. None of the other household characteristics were statistically significant in explaining households who purchased commercial fertilizer in all three waves in column 1.

Column 2 indicated that older household heads were slightly more likely to have never bought commercial fertilizer. Conversely, female-headed households were 11 percentage points (pp) *less likely* to have never bought commercial fertilizer on average. This may seem surprising at first, but it could be because female households were more dependent on maize farming than male-headed households, and thus needed fertilizer to obtain higher yields and income. Larger households and those with more children were less likely to never have bought fertilizer, probably because they had more mouths to feed and needed to use fertilizer to obtain higher yields. Households with more adults over 60 were two pp more likely to have never bought fertilizer. Households that had savings, households that had larger social networks, and those that had higher assets were less likely to have never bought commercial fertilizer. These results speak to the important association between wealth, social connections, and fertilizer purchases.

Table G.5: Demographic characteristics of households who bought commercial fertilizer in all three survey years and who never bought commercial fertilizer

Characteristics	(1) Bought in all three waves	(2) Never bought fertilizer in any wave
Landholding size in hectares	NSS	NSS
Age of household head	Very small negative effect	Very small positive effect
Female headed household	NSS	11 percentage point negative effect
HH Head had any formal education	Very small positive effect	NSS
Number of family members	NSS	1 percentage point negative effect
Number of children under five	NSS	2 percentage point negative effect
Number of adults over sixty	NSS	2 percentage point positive effect
Household has savings	1 percentage point positive effect	3 percentage point negative effect
Household has borrowed money	NSS	NSS
Household has received income transfers	NSS	NSS
Number of social network connections	NSS	5 percentage point negative effect
Locality of residence	NSS	NSS
Asset index	Very small positive effect	2 percentage point negative effect

Source. ISSER/YALE Panel survey (2010, 2014, 2018); the number of observations = 1867 in each survey wave; NSS means that the factor was not found to be statistically significant in a regression model.

vii) Maize-to-fertilizer response rate impacts

The maize-to-fertilizer response rate tells us how many kilograms of maize a farmer obtains from a kilogram of fertilizer. This relationship is important for understanding how much an additional kilogram of fertilizer contributes to maize production, food security and the profitability of fertilizer for farmers. It is crucial to note that fertilizer is one input into the production of food and farmers must have sufficient amounts of complimentary inputs, such as seed, land, labor, soil fertility, water, and farm management ability for fertilizer use to be effective. Though Ghana has achieved significant economic growth over the past 25 years, as discussed in the previous section fertilizer use remains low as does agricultural productivity. Potential yields in the country have been estimated to be between 4-6 tons/ha (Ragasa et al. 2013). This leaves Ghana with a significant yield gap that many policymakers and experts have been working to close.

It is important to note that 4-6 tons per hectare should be viewed as an upper-bound estimate for the maize yields that Ghanaian farmers can achieve. Ragasa and Chapoto (2017) used cross-sectional data from 630 farmers in all five agro-ecological zones of Ghana collected during 2012 and 2013. They found that the average maize yield in Ghana was just over 1.2 tons/hectare. They also found that the maize-to-fertilizer response rate was 7.33.[8] This meant that every additional kilogram of fertilizer generated a return of 7.33 kilograms of maize on average. This rate was higher than the return found in Adzawla et al. (2021) who found a maize-to-fertilizer response rate of 5.50 on average based on a cross-sectional survey of 1,450 farm households in the Transitional and Guinea Savannah zones of Ghana conducted in 2019. These response rates were relatively high compared to returns we found for other countries in our analysis. For example, the average response rate was about 2.50 in Nigeria, and about 3.0 in Zambia. The relatively high response rates of maize to fertilizer found in Ghana should make fertilizer relatively more profitable for farmers there compared to other countries. We investigate fertilizer profitability in the next sub-section.

Despite fairly high response rates, both Ragasa and Chapoto and Adzawala et al. also found that the rate of fertilizer use was low among Ghanaian farmers. This was consistent with what we found in Figures G.6 and G.7. Thus, it is worth asking the question of what enabled farmers to access fertilizer. Also what allowed them to use it efficiently, to obtain the most maize per kilogram of fertilizer applied to the ground? Adzawala et al. found that institutional inputs that facilitate fertilizer use among farmers such as credit and access to extension were low among farmers. They also found that poverty status, lack of available labor, and perceptions of low soil fertility limited fertilizer use among farmers in their sample were associated with low use of inorganic fertilizer. Ragasa and Chapoto found that lack of access to modern seed varieties, mechanization, and hired labor were major constraints to fertilizer use. Furthermore, Adzawala et al. found that using integrated agronomic practices, such as organic manure, and intercropping maize with legumes was low among farmers in their sample. These practices are important for the efficient use of fertilizer among smallholder farmers and increased yields. The good news is that if these constraints can be overcome, then Ghanaian farmers can obtain relatively high maize-to-fertilizer response rates.

viii) Fertilizer profitability impacts

This subsection considers the profitability of fertilizer use in Ghana. The intention is to understand if the financial returns to Ghana's fertilizer subsidy program justified its cost between 2016 and 2023, and to understand if fertilizer was profitable for Ghanaian farmers when it was valued at the commercial price that they paid. The profitability of fertilizer is affected by three main factors: 1) the price of fertilizer, 2) the price of maize (or other staple crop), and 3) the maize-to-fertilizer response rate; As discussed in the previous section, the overall finding from previous studies is that Ghanaian farmers on average obtain a relatively high maize-to-fertilizer response rate compared to other countries in SSA. Yet there is still room for improvement so that observed yields on farmers' fields come closer to reaching their full yield potential.

As mentioned above, the price of fertilizer and the price of maize are the two other key components in fertilizer's profitability. One way to look at this is through the ratio between fertilizer prices and maize prices. This is known as the input/output price ratio, and this relationship between urea and the wholesale maize price in Ghana between 2010 and 2022 is shown in Figure G.8. A lower ratio means that fertilizer is more profitable, as the price of fertilizer is going down (i.e. the numerator in the ratio getting smaller) or the maize price is going up (i.e. the denominator is getting bigger). Figure G.8, indicates that the input/output price ratio before 2020 ranged from a high of 0.5 – 2.0 in all years. This generally suggests that fertilizer was profitable relative to maize during the pre-spike period. The input/output price ratio dropped at the end of 2020 before spiking in early 2021 reaching a peak of 3.0 in early 2022. It dropped briefly from there before spiking close to 3.0 in late 2022, indicating that a kilogram of urea was three times more expensive than a kilogram of maize.

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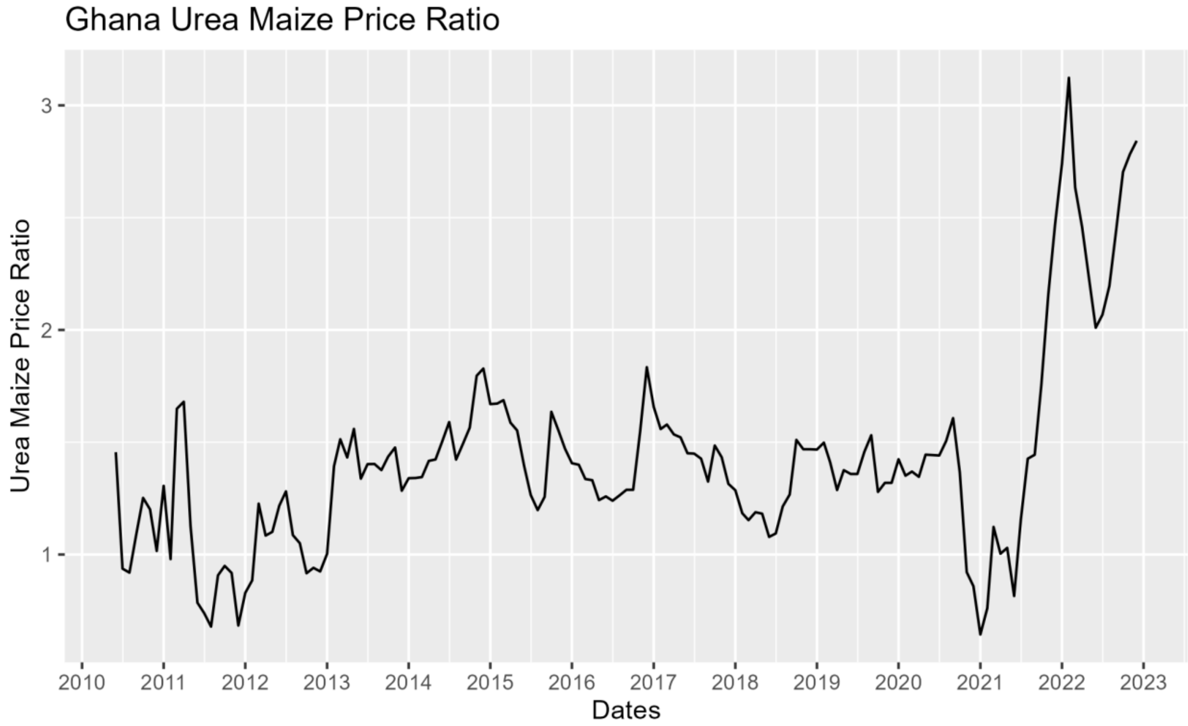
[8] Ragasa and Chapoto (2017) estimated maize-to-fertilizer response rates in nitrogen equivalents. Thus, their response rate was 22 kilograms of maize per kilogram of nitrogen. We converted this to total fertilizer equivalents by dividing 22 by 3 to get a response rate of 7.33 kilograms of maize per kilogram of fertilizer.

Figure G.8: Urea / Retail maize price ratio in Ghana 2010-2022



Source: Authors' calculations; Urea price data from AfricaFertilizer.org; Retail maize prices from FAOSTAT. We deducted 8% from the wholesale price to compute a farm-gate price.

Tables G.6.A, G.6.B and G.6.C present both the financial benefit-cost ratio (BCR) of Ghana's fertilizer subsidy program in different years and different regions of Ghana and the profitability of fertilizer for farmers when the input was valued at subsidized and commercial prices in different parts of the country. The return that farmers obtain from a kilogram of fertilizer valued at its commercial price is the marginal value-cost ratio (MVCR). The MVCR is calculated as follows:

MVCR = {incremental maize output (kilograms of maize/kilograms of fertilizer) * maize price/kilogram}
price of fertilizer per kilogram.

An MVCR that is greater than one indicates that using fertilizer generated a positive and profitable return for farmers. A ratio equal to one is break-even, meaning that the farmer made no profits using fertilizer, and a ratio less than one is a loss. However, whether or not fertilizer is likely to be profitable depends on outcomes that are uncertain when fertilizer decisions are made, as well as costs associated with the use of fertilizer that are unknown to the researcher. The types of risks that farmers face when using fertilizer at planting to increase staple crop yields at harvest include the chance of low yields due to adverse weather, and output prices at harvest being lower than expected. In the face of these uncertainties and unobserved costs, an MVCR of at least 2.0 (meaning a risk premium of one) has been recommended in the literature to be required in order for fertilizer to be profitable (Xu et al., 2009; Sauer and Tchale, 2009; Sheahan et al. 2013).

This also applies to the BCR for fertilizer subsidy programs. A BCR of a subsidy program equal to 1.0 means that the economy broke-even on it, essentially that the program was equal to giving farmers cash. A BCR greater than 1.0 indicates a gain for the economy from the subsidy program, while, a BCR <1.0 indicates a loss for the economy. Again, a break-even BCR of 1.0 assumes zero transaction costs for implementing the subsidy program. Thus 2.0 may be a better break-even point for subsidies as a rule of thumb.

G.6.A shows the BCR and MVCR estimates and their related calculations for Accra, representing southern Ghana, while G.6.B does the same in Kumasi, representing central

Ghana and G.6.C represents does the same in Tamale representing Northern Ghana. The difference in results between the regions was based on different farm-gate maize prices (from FAOSTAT) and retail fertilizer prices (from Africa Fertilizer Watch) among regions. The key rows of interest in Table G.6.A, G.6.B and G.6.C are row P, row U, and row V, all highlighted in grey. Row P shows the financial benefit-cost ratio (BCR) of Ghana's fertilizer subsidy programs for the years for which we had data on the costs of the program (2016-2021). All other rows that are directly associated with the costs and benefits of the subsidy are highlighted in green. The results in row P of Table G.6.A that used maize prices and fertilizer prices from Accra/Southern Ghana indicated that the financial BCR from the subsidy was greater than 2.0 in all years of the analysis other than 2017 when it was 1.68. The highest return was in 2021 went the BCR was 2.94. The BCR in Kumasi/central Ghana was more variable than in Southern Ghana, but it was also above 2.0 in all years except 2017 when the BCR was 1.75. The highest in central Ghana was 3.34 in 2021, and this positive return was due to relatively high harvest-season farmgate maize prices that averaged USD 361/MT, compared to an average maize price in the south of USD 318/MT. The BCR in Tamale/Northern Ghana was lower than in the other two regions. It was over 1.0 in all years, but was only above 2.0 in 2021. In that year maize price was at its highest at USD 234/MT, still considerably below the maize price in the other regions of Ghana. The lowest return for the subsidy program in northern Ghana was in 2017 when the BCR was just 1.07. Thus, the returns to the Ghanian economy from their subsidy program ranged between 7% in Tamale in 2017 and 234% in Kumasi in 2021.

The comparison of regional results for the MVCR of fertilizer between 2016 and 2023 were similar to those for the regional BCR results. This was the case when fertilizer was valued at the subsidized price that beneficiary farmers paid in row U and when fertilizer was valued at its commercial price in row V. Kumasi in central Ghana had the highest MVCRs over time, followed by Accra in the south, while Tamale in the north had the lowest MVCRs. The regional differences were due to the more favorable fertilizer to maize price ratio in central Ghana compared to other regions. The highest MVCR in row U when fertilizer was valued at its subsidized price was 7.89, that occurred in the central region in 2019. Conversely, the lowest return was 2.17 that occurred in northern Ghana in 2017. Likewise, the highest MVCR in row V when fertilizer was valued at its commercial fertilizer was 7.89, that occurred in the central region in 2019. The lowest return was 2.17 that occurred in northern Ghana in 2017.

These results suggest that the investment potential in fertilizer is highest in Central Ghana compared to other regions of the country. Furthermore, <u>the average return</u> to commercial fertilizer across Ghana between 2017 and 2023 ranged from 117% to 689%. This was a very high average return, and it indicates that fertilizer use has the potential to be profitable on average in Ghana. The challenge is that we found very low rates of fertilizer use among smallholders in the country. The disconnect between average profitability and low fertilizer use also points to a problem of liquidity and lack of access to financing for farmers. If farmers do not have cash at harvest then they lose out on the opportunity to use fertilizer and make money on an investment that would have likely generated a positive return. Promoting village savings groups and linking farmers to banking opportunities can help reduce this problem. In addition, farmers need better access to extension services, along with better availability of modern seed varieties, mechanization, and hired labor which can encourage farmers to participate in fertilizer markets and use the input more profitably.

Table 6.A: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Accra/ Southern Ghana (2016-2023)

Production Year		2016	2017	2018	2019	2020	2021	2022	2023
	Estimated program costs to Gov. and farmers								
	Cedi(GH₵)/US$	3.80	4.20	4.82	5.53	5.76	6.01	8.58	11.88
	Gov. Total prog cost (GH₵ Mil.)	302.46	476.4	408.2	547.3	746	797	-	-
	Govt. Fert prog cost (GH₵'000)	98,563	204,767	331,592	461,505	587,877	278,568	-	-
A	Gov. Total prog cost $	79,699,605	113,423,170	84,688,797	98,903,085	129,509,392	132,612,313	-	-
B	Govt. Fert prog cost $	25,971,805	48,751,726	68,795,021	83,398,992	102,058,435	46,350,749	-	-
C	GS Fert distributed (MT)	134,227	191,744	247,094	331,354	417,996	239,096	-	-
D	Diversion Rate	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-	-
E	Crowding out/in estimate	-0.067	-0.067	-0.067	-0.067	-0.067	-0.067	-	-
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	106,449	152,063	195,958	262,780	331,492	189,615	-	-
G	GS Fert redemption price ($/50kg)	22	21	11	13	13	14	-	-
H	GS Fert redemption cost ($/MT)	442	421	228	261	253	278	-	-
I = (C*H)	Farmer incremental. cost (Mil. $)	59,342,463	80,734,316	56,396,264	86,619,510	105,821,772	66,415,556	-	-
J = (B+I)	Government + Farmer Cost(Mil. $)	85,314,268	129,486,042	125,191,285	170,018,502	207,880,208	112,766,304	-	-
	Estimated incremental benefits								
K	Yield response (Maize Kg/ Nitrogen kg)	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
M = (C*L)	Incremental maize output from subsidy (MT)	585,468	836,344	1,077,768	1,445,292	1,823,205	1,042,883	-	-
N	Average Harvest Season producer Maize price ($/MT): (Dec-Jan)	396	260	313	255	274	318	494	379
O = (M*N)	Value of incremental maize ($)	231,845,317	217,449,488	337,341,519	368,549,356	499,558,034	331,636,780	-	-
P = (O/J)	Financial BCR of Subsidy program	2.72	1.68	2.69	2.17	2.40	2.94	-	-
Q	Subsidized pr. of fertilizer for farmers ($/MT)	442	421	228	261	253	278	-	-
	Commercial pr. of fertilizer for farmers (Cedi/50 kg bag)	112	103	90	98	110	113	483	480
R	Commercial pr. of fertilizer for farmers ($/MT)	590	490	429	407	398	392	1,607	1,119
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	1.12	1.62	0.73	1.03	0.92	0.87	-	-
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	1.49	1.89	1.37	1.59	1.45	1.23	3.25	2.95
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	4.93	3.40	7.54	5.37	5.95	6.30	-	-
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	3.69	2.92	4.02	3.45	3.79	4.46	1.69	1.86

Notes: Yield response in row K from Adzawala et al. et al. (2021); Maize prices in row N were wholesale prices from FAOSTAT. We deducted 8% from the retail price to compute a farm-gate price; urea prices in row R from AfricaFertilizer.org (2024); Subsidized fertilizer costs and quantities distributed from MOFA PFJ (2023)

Table 6.B: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Kumasi/Central Ghana (2016-2023)

Production Year		2016	2017	2018	2019	2020	2021	2022	2023
	Estimated program costs to Gov. and farmers								
	Cedi(GH₵)/US$	3.80	4.20	4.82	5.53	5.76	6.01	8.58	11.88
	Gov. Total prog cost (GH₵ Mil.)	302.46	476.4	408.2	547.3	746	797	-	-
	Govt. Fert prog cost (GH₵'000)	98,563	204,767	331,592	461,505	587,877	278,568	-	-
A	Gov. Total prog cost $	79,699,605	113,423,170	84,688,797	98,903,085	129,509,392	132,612,313	-	-
B	Govt. Fert prog cost $	25,971,805	48,751,726	68,795,021	83,398,992	102,058,435	46,350,749	-	-
C	GS Fert distributed (MT)	134,227	191,744	247,094	331,354	417,996	239,096	-	-
D	Diversion Rate	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-	-
E	Crowding out/in estimate	-0.067	-0.067	-0.067	-0.067	-0.067	-0.067	-	-
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	106,449	152,063	195,958	262,780	331,492	189,615	-	-
G	GS Fert redemption price ($/50kg)	22	21	11	13	13	14	-	-
H	GS Fert redemption cost ($/MT)	442	421	228	261	253	278	-	-
I = (C*H)	Farmer incremental. cost (Mil. $)	59,342,463	80,734,316	56,396,264	86,619,510	105,821,772	66,415,556	-	-
J = (B+I)	Government + Farmer Cost(Mil. $)	85,314,268	129,486,042	125,191,285	170,018,502	207,880,208	112,766,304	-	-
	Estimated incremental benefits								
K	Yield response (Maize Kg/ Nitrogen kg)	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
M = (C*L)	Incremental maize output from subsidy (MT)	585,468	836,344	1,077,768	1,445,292	1,823,205	1,042,883	-	-
N	Average Harvest Season producer Maize price ($/MT): (Dec-Jan)	341	271	233	375	266	361	617	634
O = (M*N)	Value of incremental maize ($)	199,644,579	226,649,274	251,120,045	541,984,348	484,972,398	376,480,747	-	-
P = (O/J)	Financial BCR of Subsidy program	2.34	1.75	2.01	3.19	2.33	3.34	-	-
Q	Subsidized pr. of fertilizer for farmers ($/MT)	442	421	228	261	253	278	-	-
	Commercial pr. of fertilizer for farmers (Cedi/50 kg bag)	105	100	90	93	107	120	-	433
R	Commercial pr. of fertilizer for farmers ($/MT)	553	476	429	386	387	417	376	1,009
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	1.30	1.55	0.98	0.70	0.95	0.77	-	-
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	1.62	1.76	1.84	1.03	1.45	1.15	0.61	1.59
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	4.24	3.54	5.61	7.89	5.78	7.15	-	-
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	3.39	3.13	2.99	5.34	3.78	4.77	9.03	3.45

Notes: Yield response in row K from Adzawala et al. et al. (2021); Maize prices in row N were wholesale prices from FAOSTAT. We deducted 8% from the retail price to compute a farm-gate price; urea prices in row R from AfricaFertilizer.org (2024); Subsidized fertilizer costs and quantities distributed from MOFA PFJ (2023).

Table 6.C: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Tamale/Northern Ghana (2016-2023)

Production Year		2016	2017	2018	2019	2020	2021	2022	2023
	Estimated program costs to Gov. and farmers								
	Cedi(GH₵)/US$	3.80	4.20	4.82	5.53	5.76	6.01	8.58	11.88
	Gov. Total prog cost (GH₵ Mil.)	302.46	476.4	408.2	547.3	746	797	-	-
	Govt. Fert prog cost (GH₵'000)	98,563	204,767	331,592	461,505	587,877	278,568	-	-
A	Gov. Total prog cost $	79,699,605	113,423,170	84,688,797	98,903,085	129,509,392	132,612,313	-	-
B	Govt. Fert prog cost $	25,971,805	48,751,726	68,795,021	83,398,992	102,058,435	46,350,749	-	-
C	GS Fert distributed (MT)	134,227	191,744	247,094	331,354	417,996	239,096	-	-
D	Diversion Rate	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-	-
E	Crowding out/in estimate	-0.067	-0.067	-0.067	-0.067	-0.067	-0.067	-	-
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	106,449	152,063	195,958	262,780	331,492	189,615	-	-
G	GS Fert redemption price ($/50kg)	22	21	11	13	13	14	-	-
H	GS Fert redemption cost ($/MT)	442	421	228	261	253	278	-	-
I = (C*H)	Farmer incremental. cost (Mil. $)	59,342,463	80,734,316	56,396,264	86,619,510	105,821,772	66,415,556	-	-
J = (B+I)	Government + Farmer Cost(Mil. $)	85,314,268	129,486,042	125,191,285	170,018,502	207,880,208	112,766,304	-	-
	Estimated incremental benefits								
K	Yield response (Maize Kg/ Nitrogen kg)	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
M = (C*L)	Incremental maize output from subsidy (MT)	585,468	836,344	1,077,768	1,445,292	1,823,205	1,042,883	-	-
N	Average Harvest Season producer Maize price ($/MT): (Dec-Jan)	235	166	166	166	186	234	363	388
O = (M*N)	Value of incremental maize ($)	137,584,974	138,833,135	178,909,560	239,918,404	339,116,038	244,034,612	-	-
P = (O/J)	Financial BCR of Subsidy program	1.61	1.07	1.43	1.41	1.63	2.16	-	-
Q	Subsidized pr. of fertilizer for farmers ($/MT)	442	421	228	261	253	278	-	-
	Commercial pr. of fertilizer for farmers (Cedi/50 kg bag)	100	88	80	120	120	120	415	480
R	Commercial pr. of fertilizer for farmers ($/MT)	527	420	381	498	434	417	1,381	1,119
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	1.88	2.54	1.37	1.57	1.36	1.19	-	-
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	2.24	2.53	2.29	3.00	2.33	1.78	3.80	2.88
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	2.92	2.17	4.00	3.49	4.04	4.63	-	-
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	2.45	2.17	2.40	1.83	2.36	3.09	1.45	1.91

Notes: Yield response in row K from Adzawala et al. et al. (2021); Maize prices in row N were wholesale prices from FAOSTAT. We deducted 8% from the retail price to compute a farm-gate price; urea prices in row R from AfricaFertilizer.org (2024); Subsidized fertilizer costs and quantities distributed from MOFA PFJ (2023).

6. Policy recommendations

Based on the results of this report we make the following recommendations for Ghana to better prepare for and address fertilizer price spikes to better ensure a response that benefits farmers and creates a more profitable and resilient supply chain.

i. It is important for Ghana to manage the political and social conditions in the country. Our model indicated that controlling corruption lowered the price of urea and the price wedge between local urea prices. We also found that fertilizer prices were lower in the year after the presidential election, suggesting politics are involved in fertilizer markets. It is essential to avoid politicization of fertilizer policy and reduce corruption for fertilizer and other markets to run efficiently.

ii. Ghana's subsidy program the planting for food and jobs (PFJ) is currently more comprehensive than many other programs in the region. It has a system of deferred payments allowing farmers to pay off 25% of the fertilizer's cost after harvest. It also emphasizes seed systems development and access to extension, marketing, and digital agriculture. Some of these provisions in the PFJ can help overcome the constraints to fertilizer access that many farmers in Ghana face including lack of access to credit, extension, improved seeds, and markets. The stated objectives are good, but there have been implementation issues including excluding agro-dealers, and side-selling of fertilizer by farmers. It is also not clear that running the program through maize aggregators will allow farmers to effectively access subsidized fertilizer. It is important to continue evaluating and improving the program to meet the needs of smallholder farmers.

iii. At the same time there is a need to continue to develop the private input market in Ghana and encourage competition. The government subsidy program takes up a significant share of the fertilizer market (roughly 60%) in the years before the price spike, and private retailers who sell directly to crop farmers have only 10% of the country's fertilizer. Thus, farmers' dependence on the government is very high. The government of Ghana needs to consider a strategy to scale down the fertilizer subsidy program in the medium term (five or so years) and let the private sector fill the void.

iv. Our analysis found that fertilizer use was profitable on average for farmers at commercial prices, so there is an opportunity for farmers to depend less on government support. However, commercial fertilizer participation rates are low in Ghana. Thus, there is a need to overcome the constraints to fertilizer use that many farmers in Ghana face. These include improving farmers' access to credit and extension services, in addition to lack of access to modern seed varieties, mechanization, and hired labor were major constraints to fertilizer use.

7. References

Adzawla, W., I.N. Kissidue, E. Martey, P.M. Etwire, W.K. Atakora, A. Gouzaye, and P.S. Bindraban. 2021. "Baseline Study on Fertilizer Use and Food/Nutrition Security in Sudan Savannah, Guinea Savannah, and Transitional Zones of Ghana." IFDC FERARI Research Report No. 5.

Andoh, C. 2016. MoFA launches fertiliser subsidy programme. Graphic online, 21 March 2016. Available at: http://www.graphic.com.gh/news/general-news/mofa-launchesfertiliser-subsidy-programme.html

Banful, A. B. 2009. “Operational Details of the 2008 Fertilizer Subsidy in Ghana—Preliminary Report.” International Food Policy Research Institute.

Banful, A. B. 2009. “Old Problems in the New Solutions? Politically Motivated Allocation of Program Benefits and the “New” Fertilizer Subsidies.” *World Development* 39(7):1166-1176.

IFDC. 2018. “Assessment of Fertilizer Distribution Systems and Opportunities for Developing Fertilizer Blends.” IFDC.

IFDC. (2021). Fertilizer Statistics Overview Ghana 2016-2020. *Ifdc Statistics, Fertilizer*, 48. Https://Africafertilizer.Org/Statistics/

MoFA. (2024). *Medium Term Expenditure Framework (MTEF) FOR 2024-2027*. *21*(4).

Paul, K. N., and Samuel, S. 2018. “A Baseline Assessment of Government of Ghana Fertilizer Subsidy Programme in the Sissal West and Lambussie Districts.” Community Development Alliance (CDA).

Paulina, A. 2017. “Exploring the Anticompetitive Practice in Fertiliser Transport in Ghana.” Consumer Unity & Trust Society.

Ragasa, C., and Chapoto, A. 2017. “Moving in the right direction? The role of price subsidies in fertilizer use and maize productivity in Ghana.” *Food Security*, 9(2): 329-353.

Ragasa, C., Dankyi, A., Acheampong, P., Wiredu, A. N., Chapoto, A., Asamoah, M., & Tripp, R. 2013. “Patterns of adoption of improved maize technologies in Ghana.” In GSSP working paper 34. IFPRI, Accra: Ghana.

Sauer, J., Tchale, H., 2009. “The economics of soil fertility management in Malawi. Applied Economics Perspectives and Policy.” 31 (3), 535–560.

Sheahan, M., Black, R., & Jayne, T. S. 2013. “Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research.” Food Policy, 41, 39-52.

Xu, Z., Guan, Z., Jayne, T. S., & Black, R. 2009. “Factors influencing the profitability of fertilizer use on maize in Zambia.” *Agricultural economics*, 40(4), 437-446.

ii. Kenya Country Report

1. Main Findings for Kenya

1. The input market in Kenya has generally been considered one of the most developed and dynamic in sub-Saharan Africa. Farmers have benefited from a vibrant and competitive agro-dealer network, causing their access and use of inputs to increase dramatically over the past 25 years (Ariga and Jayne 2011).

2. Similar to many other countries in the region, the fertilizer market structure in Kenya is pyramid-shaped. There has been no fertilizer manufacturing in Kenya since 2018. Only nine companies blended 90% of the fertilizer in 2023, and those same nine companies wholesaled 90% of the fertilizer as well. Between seven and ten primary fertilizer importers have operated in Kenya over the past ten years. These are the primary importers, but there were more than 135 secondary distributors, who worked with the large importers to procure fertilizers from them and move it throughout the country. Finally, there are thousands of agro-dealers selling fertilizer to farmers across the country in their retail outlets.

3. Our analysis of monthly Diammonium Phosphate (DAP) prices between 2010 and 2023 indicated that several key factors affected the price level and price wedge in Kenya (i.e. the difference between local urea prices and world urea prices). We used DAP prices for the country analysis in Kenya because it is the most commonly used fertilizer on maize in Kenya. We also show results of the model for urea in Kenya and used urea prices in Kenya for the cross-country model to maintain consistency across countries and avoid having the convert units of different fertilizers. However, DAP is the most appropriate fertilizer to consider in our Kenya single country analysis. These key factors identified included:

   Price Level Model
   a. *Corruption Control Index* was negatively related with Kenya DAP price. On average, a one standard deviation increase in the control of corruption, which meant that the country did more to reduce corruption, led to a 14.5% decrease in urea price. This makes sense since cleaning up corruption makes the supply chain for DAP more efficient and reduces costs to the farmer.
   b. *Election Yr and One Year After Election* had small but negative impacts on DAP prices, suggesting that politicians may have had influence on the fertilizer market. However, the effect sizes were quite small at.28% and .23% percent lower DAP prices on average, respectively.
   c. *Local Maize Price* was associated with an increase in DAP prices in Kena. A 10% increase in *Local Maize Price* was associated with a 2.1% increase in DAP price. This result is in line with expectations since we hypothesize that this relationship is driven by increased profitability of, and demand for, fertilizer when maize has a higher value.
   c. Cost components like *World DAP Price and World Natural Gas Price* were positively associated with DAP prices so that a 10% increase in each resulted in a 1.6% and 2.5% increase in DAP prices for each of the costs components respectively.

   Price Wedge Model
   a. *One Yr After Election* had small but negative impacts on the DAP wedge, suggesting that politicians may have had influence on the fertilizer market. The wedge was 10.36% smaller the year after an election.

d. *Local Maize Price* was positive and statistically significant, suggesting that a 1% increase in maize prices was associated with a 10.66% increase in the price wedge on average. Higher maize prices, indicating greater anticipated demand for fertilizer, push up local prices relative to world prices.

4. Kenya implemented several different input subsidy programs between the last price crisis in 2008 and the current price crisis of 2021/22.
   a. The National Accelerated Agricultural Inputs Access Program (NAAIAP) ran between 2008 and 2017. The program targeted limited-resource farmers who could obtain subsidized fertilizer at private-sector agro-dealers using vouchers.
   b. The National Fertilizer Price Stabilization Plan (NFPSP) ran in parallel to the NIAAP for much of its existence between 2008 and 2019. It was an untargeted subsidy program that sold subsidized fertilizer to farmers at government-run National Cereals and Produce Board (NCPB) depots. Under the NFPSP, any farmer could register with the government and acquire subsidized fertilizer at a discounted price. Since the program ran through the NCPB depots, it was mainly accessible to farmers near the depots.
   c. The National Value Chain Support Programme (NVSP) succeeded the NAAIAP and NFPSP in 2019. The program targets small-scale producers, uses an e-voucher, and inputs are redeemed through the private sector. This is generally seen as a progressive, “smart-subsidy” program.

5. In response to the rapid rise in fertilizer prices in 2021/22, the new government in Kenya responded by implementing the wider-scale untargeted National Fertilizer Subsidy Programme (NFSP) at the end of 2022 and early 2023. Like the earlier NFPSP, the NFSP made subsidized fertilizer available to farmers at NCPB and the Kenya National Trading Company (KNTC) depots.
   a. Private-sector agro-dealers were not allowed to retail subsidized fertilizer under the NFSP.
   b. A farmer had to register for the program and could acquire up to five tons of fertilizer at a reduced price, initially KES 3,500 and later KES 2,500 for 50kgs of fertilizer.
   c. The government allowed private-sector importers such as Yara and ETG to deliver the subsidized fertilizer to the NCPB and KNTC depots as part of the NFSP program in 2023. However, the government did not reimburse the importers until the NFSP fertilizer was purchased by farmers.
   d. At the same time, some county governments implemented separate fertilizer subsidy programs. There was little to no coordination between the national government and the counties regarding their respective subsidized fertilizer acquisition and distribution.

6. Analysis of the 2023 National Fertilizer Subsidy Programme (NFSP) using data collected by Ricker-Gilbert et al. (2024) indicated the following:
   a. Nearly 50% of agricultural households registered for the NFSP in 2023, and 32% of agricultural households received an SMS notification to go and purchase the subsidized fertilizer. However, only 25% of households acquired subsidized fertilizer in 2023. Of that group, 19% of them acquired NFSP fertilizer, while 8% acquired subsidized fertilizer from county governments.
   b. Larger-scale producers who were more educated, connected in the community, and had used fertilizer in the past were more likely to participate in the NFSP program during 2023.
   c. Most farmers acquired NFSP fertilizer during the first week of April 2023. This was one week later than most farmers acquired subsidized fertilizer from their county governments and two weeks later than most people purchased it from the private sector. However, 80% of farmers who received the NFSP fertilizer said that the NFSP fertilizer came in time for

planting, while 82% said the same for their county fertilizer, and 87% said that they bought commercial fertilizer in time for maize planting.

d. The crowding-out rate (displacement of sales) of commercial fertilizer by NFSP was estimated to have been 22% on average. This meant that every 100 kilograms of subsidized fertilizer acquired by farmers in 2023 only led to 88 kilograms of new fertilizer applied to their fields. The remaining 22 kilograms were displaced commercial purchases. Furthermore, farmers with less than two acres had a 21% crowding out rate while farmers with more than five acres had a 27% crowding out rate. A higher crowding out rate reduces the benefit-cost-ratio of fertilizer subsidy programs.
    (1) This crowding-out rate was estimated from surveys of farmers and thus the analysis considered fertilizer demand from their perspective. It did not consider the private retailers' lost commercial sales from the subsidy that Opiyo et al. (2023) found to be substantial.
e. We found that the Kenyan economy obtained a positive return to fertilizer subsidies in years before the price spike, but high fertilizer prices meant high program costs in 2022/23. This meant that the economy barely broke even from subsidizing fertilizer in 2022/23.

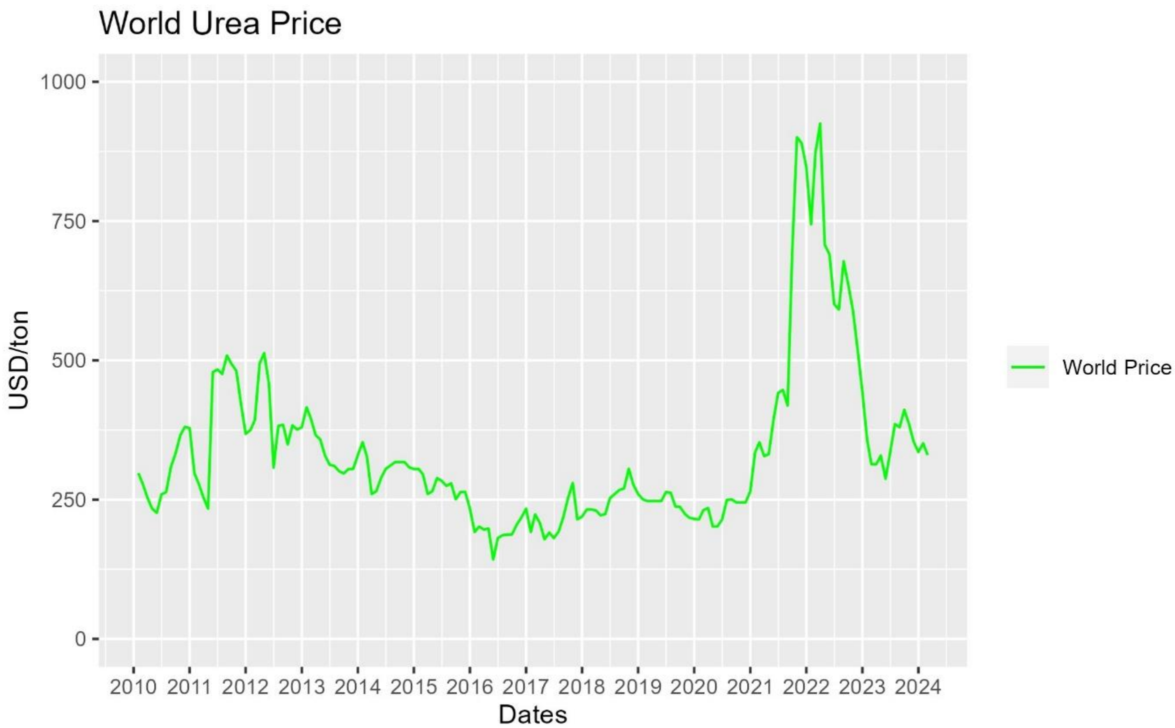
7. The average amount of maize that a farmer obtains from a kilogram of fertilizer (known as the maize-to-fertilizer response rate) was found to be high in on average for Kenyan farmers compared to other countries in the region. However, Kenya's varied agroecology led to wide variation in complementary inputs such as soil quality, rainfall, and labor availability along with access to inorganic fertilizer, seed, and other inputs (Sheahan et al. 2013). Generally, farmers that had higher response rates to fertilizer had higher levels of these necessary complementary inputs. Many farmers had limited knowledge of how to use complementary inputs and practices effectively. In addition, large variations in soil quality between localities led to experts making incorrect fertilizer recommendations that did not meet the conditions on individual farmer's fields (Tjernstrom et al. 2018). Farmers in Kenya have also had concerns about the adulteration of fertilizer. This uncertainty about quality has been found to undermine farmers' interest in fertilizer and made them reluctant to make complementary investments in seed, labor, and land to maximize the yield response to fertilizer.

2. Introduction

International fertilizer prices increased and then decreased substantially between 2020 and 2024. The initial global drivers of the increase were disruptions in the global supply chain caused by COVID-19. As a result, China and Russia, two of the largest fertilizer exporters, imposed restrictions on their exports. These restrictions also came at the same time that international coal and natural gas prices, key inputs in the production of fertilizer, were rising. Fertilizer prices increased further in early 2022, due to the fallout from the Ukraine crisis. Russia and Ukraine are major fertilizer exporters, and Russia's invasion of Ukraine greatly reduced the global fertilizer supply during the initial months of the war. At the same time that fertilizer prices increased, prices of staple foods increased as well. This increase in input and output prices had important implications for smallholder farmers, small-scale traders, and consumers in Kenya as it did in many other countries of sub-Saharan Africa (SSA). This is not surprising because Kenya imports virtually all its fertilizers from the international market. Figure K.1 shows the world price of urea, between 2010 and 2024 in nominal USD per metric ton (MT). The figure shows that prior to the price spike of 2021/22, the price of urea had declined from a high of about USD 500/MT in 2013 to a low of about USD 250/MT in 2020 before the spike began. The world price of urea then spiked beginning in early 2021 reaching a high of USD 925 in March of 2022. The price then dropped during the remainder of 2022 before reaching a monthly average of $375/MT in the second half of 2023.

This report analyses global and national-level urea prices and diammonium phosphate (DAP) prices. Urea is a type of fertilizer (46% nitrogen) that is traded and used globally, and DAP is a common fertilizer that is applied to maize in Kenya. Subsequent figures and analyses compare the price of urea and DAP in Kenya with the world price. The difference between the local price, and the world price is called the price wedge. Understanding the factors that affected the fertilizer price wedge before, during, and after the fertilizer price spike of 2021/22 in Kenya is important for developing policies, programs, and strategies to mitigate the effects of future shocks.

Figure K.1: World price of urea in nominal USD (2010 – 2023)



Source: World Bank Pink Sheets. Urea prices were reported for F.O.B. in the Black Sea before 2022 and in the Middle East since.

3. Objectives

This report has several main objectives. The first is to analyse and document what the change in the fertilizer price wedge during the global fertilizer price spike of 2021/22 meant for Kenya. We estimated which factors explained the local price of urea and DAP and the price wedge in the country over the past 13 years. Second, we assessed how the government, donors, and other multi-lateral organizations in Kenya responded to the price spike. Since subsidizing fertilizer was the major policy response of the Kenyan government to the price spike, we estimated the impact of fertilizer subsidies on commercial fertilizer demand, and how effective fertilizer policy was at increasing fertilizer use among smallholder farmers. Third, we estimated the profitability of fertilizer use for farmers in Kenya using data on smallholder farm household data in the country that was collected from a phone survey of Kenyan smallholder farm households collected in September and October of 2023 by Ricker-Gilbert et al. (2024). Fourth, we analyse the return on the government subsidy spend to see if subsidising fertilizer was a good use of agricultural budget. Finally, based on these analyses we made recommendations that the Government of Kenya, donors, and the private sector can take to increase the returns to fertilizer use among farmers. Ultimately this will help to make the fertilizer sector more resilient and better prepared for the next time fertilizer prices rise drastically.

4. Methodology

The study applied the following methodology: 1) a qualitative and quantitative econometric analysis of the factors that affected the fertilizer price wedge before during and after the fertilizer price spike in Kenya; 2) a review of the fertilizer market structure that was conducted by key informant interviews with important actors in the fertilizer sector, and review of relevant background documents 3) a scoping review of the literature and available databases on fertilizer subsidy policies in Kenya and fertilizer prices, both global and national, before, during and after the fertilizer price spikes of 2021/22. 4) an analysis of the farmer survey conducted by Ricker-Gilbert et al. (2024). Using these data we analysed fertilizer demand, including i) how Kenya's fertilizer subsidy program affected demand for commercial fertilizer for both the average household and along the distribution of assets and landholding, ii) how fertilizer purchasing behavior over time was associated with farm household characteristics, iii) how fertilizer profitability was affected by the price spike and the benefit-cost analysis of subsidizing fertilizer was impacted by rising fertilizer and maize prices during the price spike.

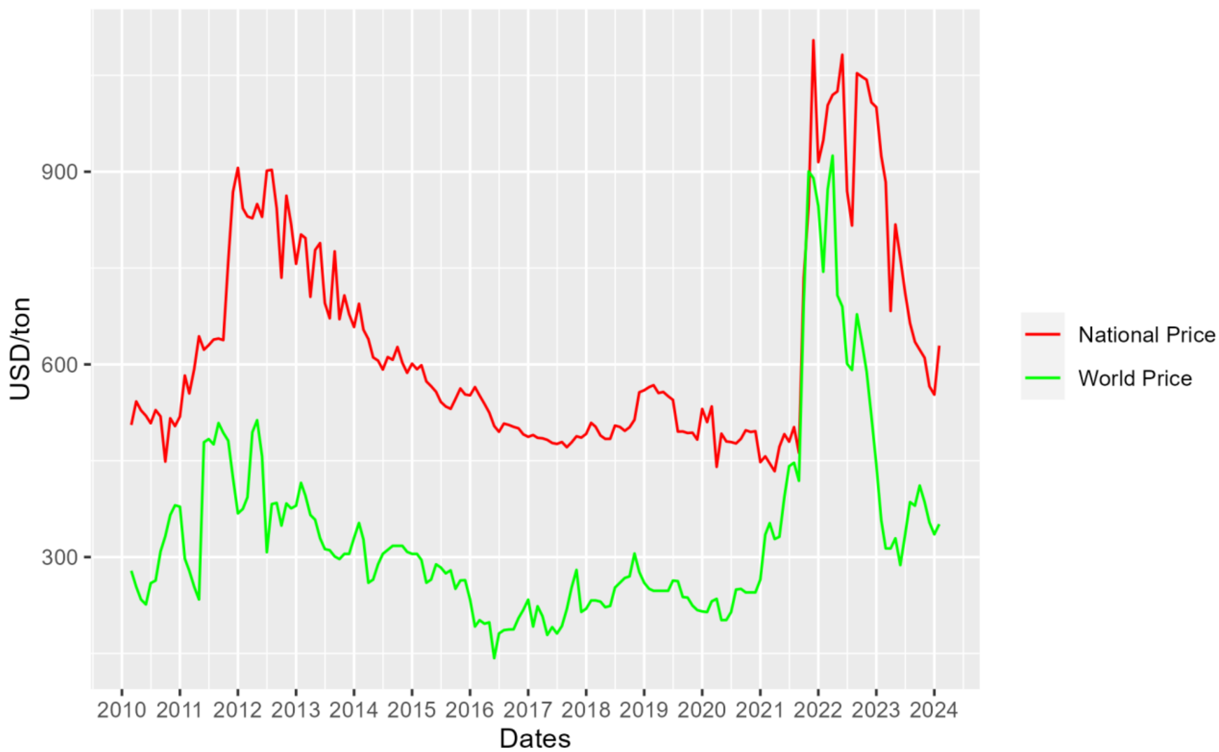
5. Results and Discussion

i) The fertilizer price wedge in Kenya

Figure K.2 shows the nominal price of urea in Kenya between 2010 and 2023 in USD in red and how it compares to the world price of urea in green. The figure indicated that the price of urea in Kenya was always above the world price before the price spike of 2021/22. This is not surprising, given Kenya's position as a fertilizer importer. However, urea prices in Kenya trended downward during that pre-spike period, meaning that the wedge got smaller. Urea price in Kenya went from a high close to USD 900/MT in 2012 to under USD 450/MT at the end of 2020. This suggests that fertilizer use was becoming more profitable for farmers during that period, in US dollar terms, before the price spike.

The world urea price rose at roughly the same time that the local price did in Kenya starting in 2021. There was a brief period at the end of 2020 and the start of 2021. The big difference between the urea price in Kenya and the world price came in early 2022, as the world price peaked at about USD 925/MT, the price in Kenya continued to rise. It reached a high of around USD 1,100/MT in 2021 and stayed as high as 1,050/MT into 2022. The world price of urea dropped to an average of USD 375 in the second half of 2023, but the local price in Kenya stayed higher for longer and only reached a low of around USD 560/MT at the end of 2023. There was a 49% decline in the price of urea in Kenya from its peak at the end of 2021 to the end of 2023, but in relative terms, the urea price in Kenya remained high compared to the world price. By the end of 2023, the world price was ~USD350/MT, and the price in Kenya was ~USD 560/MT. This meant that the price wedge in Kenya was ~ USD 210/MT, and that the price of urea in Kenya was 60% higher than the world price in US dollar terms.

Figure K.2: Retail prices of Urea in Kenya and the world price in USD/MT (2010-2023)

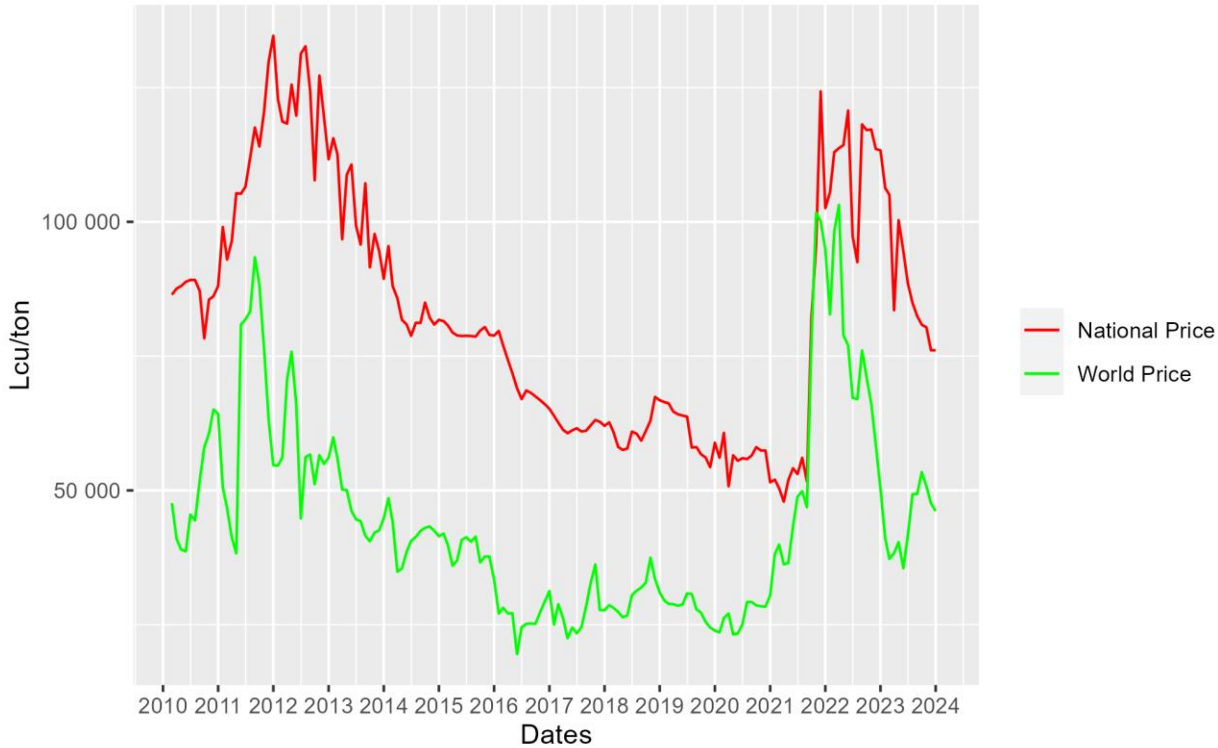


Notes: Price Wedge = Local urea price (US$/Ton) – World Price (US$/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Kenya began in 2010.

Figure 3 presents the same relationship between the price of urea in Kenya and the world price, but this time both price series were measured in nominal local Kenya Shillings. Just as when urea was USD, the world price and the Kenyan price of urea both rose sharply in 2021 when the commodity was valued in Shillings. The world price of urea valued in Shillings stayed high in 2021 and 2022, then dropped quickly, reaching a low of about Shillings 50,000/MT by the end of 2023. Conversely, the local price of urea in Kenya remained high, peaking at about Shillings 125,000/MT in late 2021 and throughout much of 2022. It dropped in 2023 to about Shillings 75,000/MT by the end of the year. This was equivalent to a 40% decline. By the end of 2023, the price wedge in Kenya was about Shillings 25,000/MT, meaning that the urea price in Shillings was about 50% higher than the world price at that time.

The next sub-section discusses the results of our quantitative results on factors that affect the price of urea the price of DAP and the price wedge in Kenya.

Figure K.3: Retail prices of Urea in Kenya and the world price in Shillings/MT (2010-2023)



Notes: Price Wedge = Local urea price (Shillings/Ton) – World Price (Shillings/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Kenya began in 2010.

ii) Quantitative analysis of factors affecting the fertilizer price wedge over time and across countries.

Results by Variable for the DAP Price Level Model in Shilling

Figure K.4 presents the box and whiskers plot for the factors that affected the price of DAP in Kenya between 2010 and 2023. This figure is based on a time series regression of monthly DAP prices collected by AfricaFertilizer.org. The DAP price was regressed against a set of factors that were hypothesized to affect them; the factors were the same ones used in the cross-country panel model.

The *Corruption Control Index* was statistically significant and negative, suggesting that an increase in the control of corruption by one standard deviation resulted in a 14.5% decrease in DAP prices on average.[9] This indicates that reducing corruption could lead to lower fertilizer prices by minimizing market inefficiencies.

The *Election Yr* variable was statistically significant and negative, indicating that election years were associated with a 0.28% decrease in DAP prices on average. This might reflect

[9] Control of Corruption is in Log-linear form, so impact of Control of Corruption on is (exp(-1.43*.11)-1)*100= 14.5%.

economic adjustments or policy changes by the incumbent to persuade his constituents. Similarly, the *One Yr After Election* variable was statistically significant and negative, indicating that the year following an election was associated with a 0.23% decrease in DAP prices on average. This might reflect post-election economic adjustments or policy changes or a winning candidate attempting to reward his constituents.

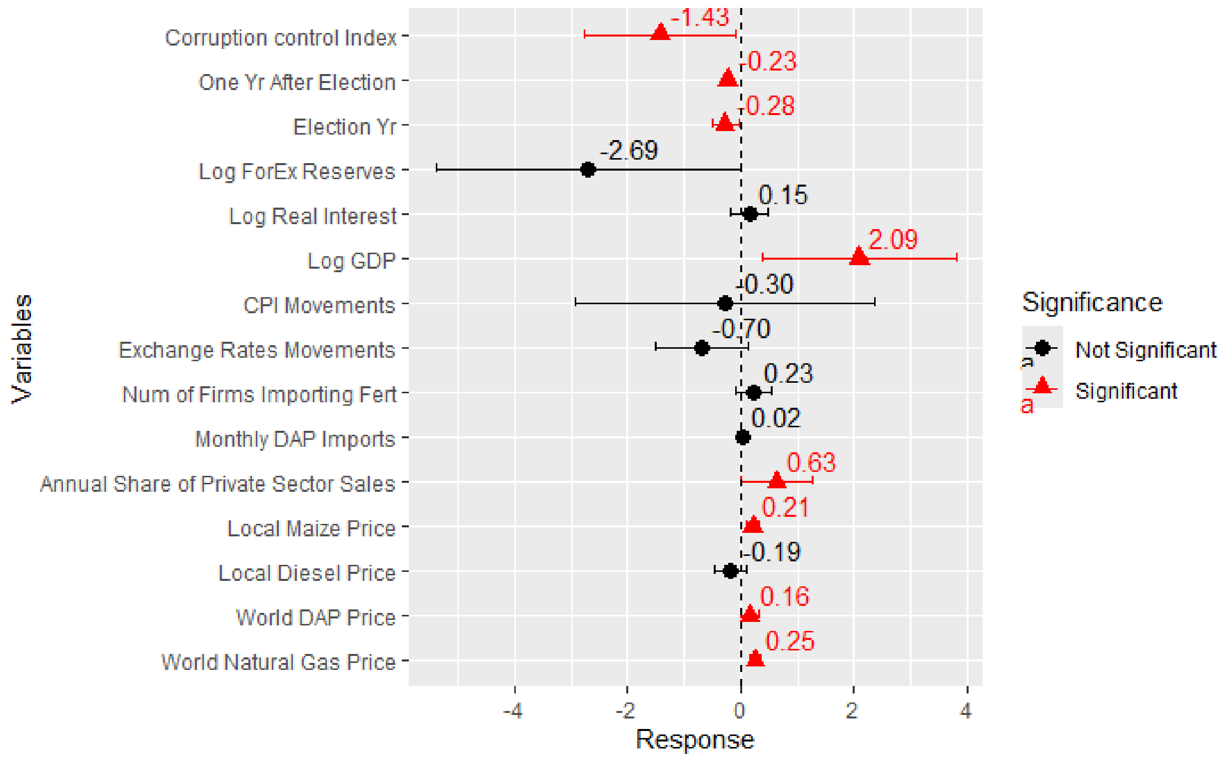
Next, the *Log GDP* is positively significant, meaning a 1% increase in GDP is associated with a 2.09% increase in DAP prices. Our initial expectation was that higher GDP would be associated with increased development that comes with better infrastructure, thus lowering transport costs and ultimately lowering fertilizer prices. However, we found the opposite effect in the Kenya DAP model. The results suggested that economic growth increases overall demand for agricultural inputs and drives up fertilizer prices.

We found a positive and significant relationship between *Annual Share of Private Sector Sales* (of total sales by private sector and government) and DAP price. A 10% increase in the *Annual Share of Private Sector Sales* was associated with an increase in the DAP price of 6.3% on average. We did not have a confident prediction on the sign. A high *Annual Share of Private Sector Sales* should be associated with healthy competition among suppliers, which should have a dampening effect on prices. However, a high *Annual Share of Private Sector Sales* can also be associated with a high demand for fertilizer from farmers, which more easily supports a robust private sector of fertilizer supply. The one-month lag of *Local Maize Price* was positive and statistically significant, suggesting that a 1% increase in maize prices was associated with a 0.21% increase in DAP prices. Higher maize prices can signal greater anticipated demand for fertilizer, leading to higher DAP prices.

World DAP Price was positive and statistically significant, indicating that a 1% increase in the world DAP price was associated with a 0.16% increase in DAP prices. This suggests that global market conditions for DAP influences DAP prices.

World Natural Gas Price was positive and statistically significant, indicating that a 1% increase in the world *Natural Gas Price* was associated with a 0.25% increase in DAP prices on average.

Figure K.4. Factors affecting DAP prices in Kenya from 2010-2023 in *Shillings*/MT



Notes: Results are from a linear regression model of 138 monthly observations of nominal DAP price levels in Kenya denominated in shilling from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on DAP price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on DAP prices, while variables that are greater than zero denoted that the factor had a positive effect on DAP prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World DAP Price and World Natural Gas Price, have been transformed into LCU to correspond to the impacts in local markets. Model includes year fixed effects.

Results by Variable for the DAP Price Wedge Model in Shillings

Figure K.5 presents the box and whiskers plot for the factors that affected the DAP price wedge in Kenya between 2010 and 2023. This figure is based on a time series regression of the monthly price wedge, defined as the difference between the DAP price in Kenya and the world price, both in shilling. The wedge was regressed against a set of factors hypothesized to affect it, similar to those used in the cross-country panel model.

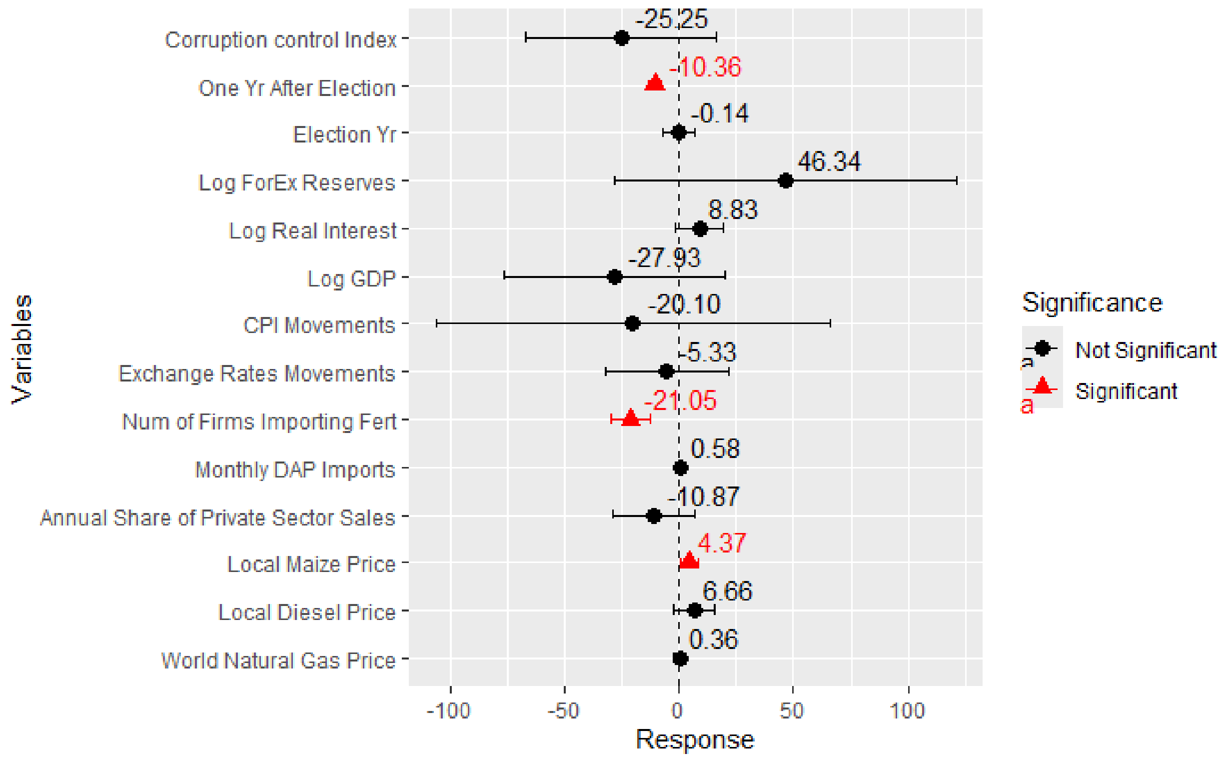
The *One Yr After Election* variable was statistically significant and negative, indicating that the year following an election was associated with a 10.36% decrease in DAP prices on average. This might reflect post-election economic adjustments or policy changes or a winning candidate attempting to reward his constituents.

We found *Num of Firms Importing Fert* to be negatively related to the DAP price wedge. A 1% increase in this variable was associated with a 21.05% decrease in the wedge. This is consistent with an industry where increased competition can help to reduce local prices and therefore the wedge.

The one-month lag of *Local Maize Price* was positive and statistically significant, suggesting that a 1% increase in maize prices is associated with a 4.37% increase in the price wedge on average. Higher maize prices, indicate greater anticipated demand for fertilizer, push up local prices relative to world prices.

Figure K.5: Factors affecting DAP price wedge in Kenya 2010-2023 in Shillings/MT

Dependent variable: DAP price wedge asinh(nominal DAP price in Shillings – world price in Shillings)



Notes: Results are from a linear regression model of 139 monthly observations of nominal DAP price wedge in Kenya. The price wedge is calculated as the price of DAP in shilling in each country obtained from AfricaFertilizer.org minus the world price of DAP obtained from the World Bank Pink Sheets converted to shilling. The triangles and circles are the mean estimates of each variable's effect on DAP price wedge. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on the DAP wedge, while variables that are greater than zero denoted that the factor had a positive effect on the DAP wedge. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World DAP Price and World Natural Gas Price, have been transformed into shilling to correspond to the impacts in local markets. Model includes year fixed effects.

Next, we discuss the Kenya price level model using Urea prices to facilitate consistent comparison with other countries.

Results by Variable for the Urea Price Level Model in shillings

Figure K.6 presents the box and whiskers plot for the factors that affected the price of urea in Kenya between 2010 and 2023. This figure is based on a time series regression of monthly Urea prices collected by AfricaFertilizer.org. The urea price was regressed against a set of factors that were hypothesized to affect them.

The model found that the *Corruption Control Index* was statistically significant and negative, suggesting that an increase in the control of corruption by one standard deviation resulted in a 13.6% decrease in Urea prices.[10] This indicated that reducing corruption could lead to lower fertilizer prices by minimizing market inefficiencies.

The *One Yr After Election* variable was statistically significant and negative, indicating that the year following an election was associated with a 0.18% decrease in Urea prices on average. This was the same finding in the DAP model and it might reflect post-election economic adjustments or a winning presidential candidate attempting to reward his constituents.

Next, the *Log GDP* is positively significant, meaning a 1% increase in GDP is associated with a 1.47% increase in urea prices. Our initial expectation was that higher GDP would be associated with increased development that comes with better infrastructure, thus lowering transport costs and ultimately lowering fertilizer prices. However, we found the opposite effect in the Kenya model. The results suggested that economic growth increases overall demand for agricultural inputs and drives up fertilizer prices.

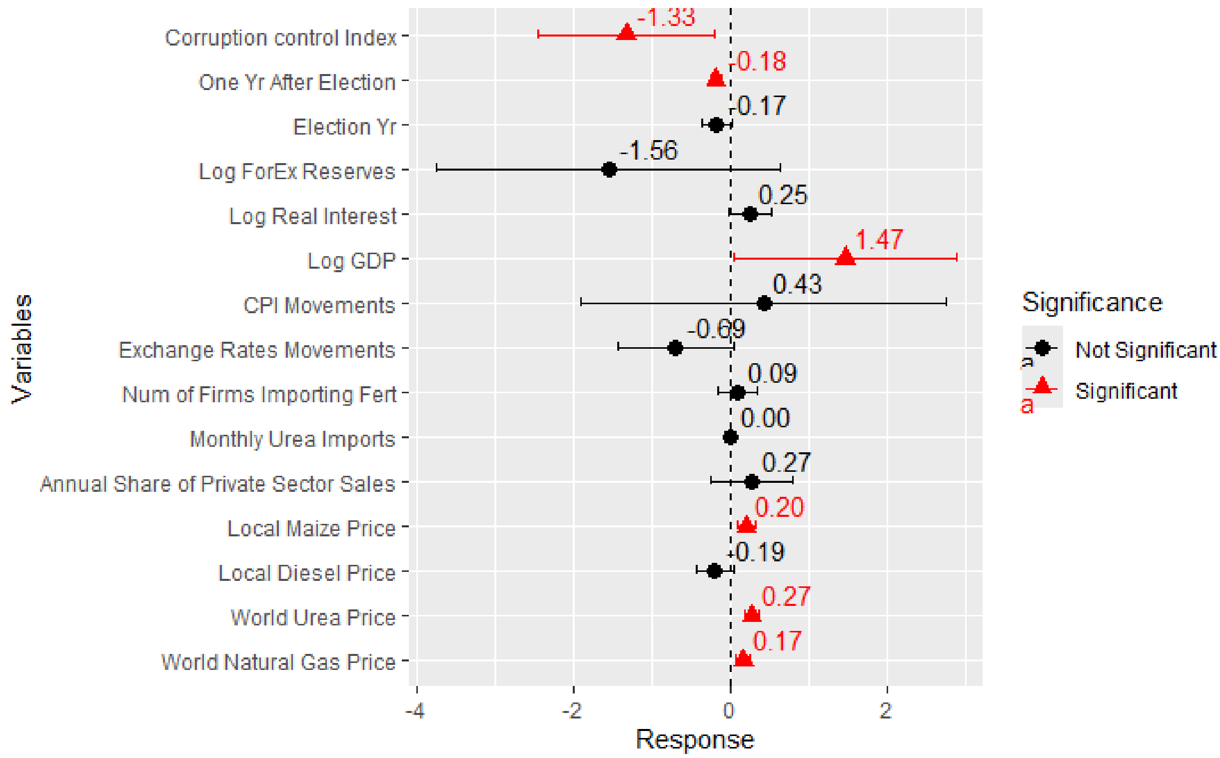
The previous month's *Local Maize Price* was positive and statistically significant, suggesting that a 1% increase in maize prices was associated with a 0.20% increase in urea prices on average. Higher maize prices can signal greater anticipated demand for fertilizer, leading to higher Urea prices.

World Urea Price was positive and statistically significant, indicating that a 1% increase in the world urea price was associated with a 0.27% increase in urea prices on average. This suggests that global market conditions for urea, a related fertilizer, also influence Urea prices.

World Natural Gas Price was positive and statistically significant, indicating that a 1% increase in the world urea price was associated with a 0.17% increase in urea prices on average. This suggests that this major production component of urea is significantly positively associated with the price of urea, as we expected.

[10] Control of Corruption is in Log-linear form, so impact of Control of Corruption on is (exp(-1.33*.11)-1)*100= 13.6%.

Figure K.6. Factors affecting Urea prices in Kenya from 2010-2023 in Shillings/MT



Notes: Results are from a linear regression model of 138 monthly observations of nominal Urea price levels in Kenya denominated in shilling from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into shilling to correspond to the impacts in local markets. Model includes year fixed effects.

Results by Variable for the Urea Price Wedge Model in Shillings

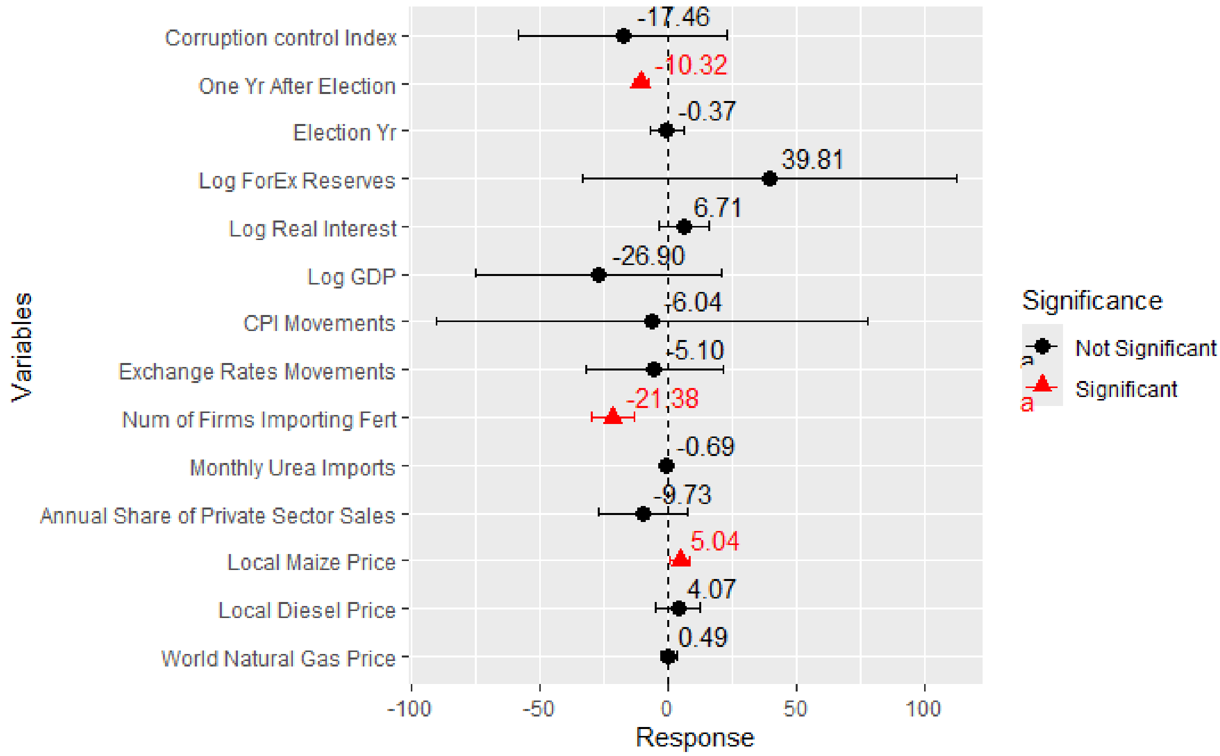
The *One Yr After Election* variable is significantly negative, indicating that the year following an election is associated with a 10.32% decrease in the urea wedge, which might reflect the winning party's efforts to lower fertilizer prices for farmers to maintain favor with voters.

We see a negative relationship between *Num of Firms Importing Fert* and the urea price wedge. A 1% increase in the variable was related to a 21.38 reduction in the wedge. We think that in this case, a larger number of firms is indicative of healthy competition which puts downward pressure on prices.

Local Maize Price is positively significant, suggesting that a 1% increase in maize prices is associated with a 5.04% increase in the wedge. Higher maize prices can signal greater anticipated demand for fertilizer, leading to a higher wedge.

Figure K.7: Factors affecting Urea price wedge in Kenya 2010-2023 in Shillings/MT

Dependent variable: Urea price wedge asinh(nominal Urea price in shillings – world price in shillings)



Notes: Results are from a linear regression model of 139 monthly observations of nominal Urea price wedge in Kenya. The price wedge is calculated as the price of urea in shilling in each country obtained from AfricaFertilizer.org minus the world price of urea obtained from the World Bank Pink Sheets converted to shilling. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into shilling to correspond to the impacts in local markets. Model includes year fixed effects.

iii) Analysis of fertilizer market structure in Kenya

Table K.1 presents the structure of the fertilizer market in Kenya, which is pyramid-shaped. There has been no fertilizer manufacturing in Kenya since 2018 when KEL Chemicals Ltd, a manufacturer of Single Super Phosphate (SSP), went out of business. Only nine companies blended 90% of the fertilizer in 2023, and those same nine companies wholesaled 90% of the fertilizer as well (IFDC, 2024). Between seven and ten primary fertilizer importers have operated in Kenya over the past ten years. These are the primary importers, but there were more than 135 secondary distributors, who worked with the large importers to procure fertilizers from them and move it throughout the country. There are thousands of agro-dealers selling fertilizer to farmers across the country in their retail outlets.

Conversations with key informant interviews revealed that with the increase in blending companies since 2019 has led to an increase in multi-nutrient fertilizers and more diversified blends for different crops and soils. Large companies like ETG and Yara have led this change. Domestic blending has helped enable some companies to thrive despite the challenges over the past five years like COVID-19 and the fertilizer price spike. Yara has nearly doubled its fertilizer sales volumes in Kenya since 2019. Their growth was enabled by strong agro-dealer networks and some supply to government subsidy programs. Conversely, some blending companies have been severely and negatively affected by recent shocks, even laying idle in recent years following the price spikes and the sharp increase in subsidized fertilizer volumes that started in 2022. Kenya's blending throughput is now well below capacity, which key informants estimated at about 1 million MT.

Our conversations with the agro-dealer association of Kenya indicated that the number of small-scale agro-dealers has increased in the last five years. However, many of these businesses are seasonal, rather than permanent. While operating seasonally makes sense in remote areas and requires lower fixed costs, the sustainability of many agro-dealers has been threatened by the recent subsidy program that does not leverage private retailers in the last-mile distribution to farmers, thereby crowding out their business in some areas. In addition, the margins on fertilizer for agro-dealers are low. Agro-dealers often regard fertilizer as a "loss leader" (AFAP 2024) that brings farmers into the shop where they then hopefully also buy other higher margin inputs like chemicals. To increase margins, some agro-dealers divide fertilizer into smaller quantities (1 to 5 kg bags).

Table K.1: The number of companies in Kenya that control 90% of the fertilizer that was available at different stages in the supply chain during key years.

Stage	In 2014 (ten years ago)	In 2019 (just before the fertilizer price spike)	In 2022 (during the fertilizer price spike)	In 2023 (last year)
Manufacturing	1 [a]	0	0	0
Importing	7	10	8	8
Blending	3	5	9	9
Wholesaling	3	5	9	9
Retailing	1,000's	1,000's	1,000's	1,000's

Source: Importer Information from Afriqom; other information from International Fertilizer Development Corporation (IFDC); [a] the only fertilizer manufacturing company KEL Chemicals Ltd. went out of business in 2018;

1. Analysis of fertilizer policies in Kenya around the fertilizer price spike

Policy Response

When global economic shocks occur that affect domestic commodity supply chains and prices, countries typically respond with policies to try to mitigate the impact on their citizens. Such policy responses might achieve their intended objectives but unintended consequences to other aspects of the economy are often also realized. They also might not necessarily achieve their intended objectives. The policy responses often have trade-offs, as countries often face options with differing consequences. It is, therefore, critical that a country's policy responses to economic shocks are guided by its contextual conditions and informed by up-to-date evidence as well as the global and regional dynamics.

Fertilizer Policy Before Price Spike

Prior to the fertilizer price spike of 2021/22, Kenya had implemented several different input subsidy programs since the last price crisis in 2008. The National Accelerated Agricultural Inputs Access Program (NAAIAP) ran between 2008 and 2017. The program targeted limited-resource farmers who could obtain subsidized fertilizer at private-sector agro-dealers using vouchers. Additionally, the National Fertilizer Price Stabilization Plan (NFPSP) ran in parallel to the NIAAP for much of its existence between 2008 and 2019. It was an untargeted subsidy program that sold subsidized fertilizer to farmers at government-run National Cereals and Produce Board (NCPB) depots. Under the NFPSP, any farmer could register with the government and acquire subsidized fertilizer at a discounted price. Since the program ran through the NCPB depots, it was mainly accessible to farmers in high potential areas near the NCPB depot locations.

The government of Kenya ended the NAAIAP in 2017 and the NFPSP in 2022. Their successor was the National Value Chain Support Programme (NVSP), which was initiated in 2019. The program targets small-scale producers, uses an e-voucher, and inputs are redeemed through the private sector. This is generally seen as a “smart-subsidy” program, as it is targeted, uses e-vouchers, and runs through the private sector. Thus, it can be said that before the fertilizer price spikes, Kenya’s fertilizer subsidy policy was moving in a progressive direction, and there were a number of new entrants throughout the supply chain but especially in retail.

Policy during the price spike

Despite the recognized efficiency of the NVSP, the program did not end officially, but it did not receive the expected government funding in 2023 for its operations. Instead, the government newly elected in 2022 focused most of its attention on a non-targeted national fertilizer subsidy programme (NFSP), which it initiated in late 2022 and was ongoing by the writing of this report. When instituting the NFSP, the new government argued that it was responding to the sharp increase in global fertilizer prices, which started in early 2022. It stated that the NFSP’s aim was to increase food production by making fertilizer affordable to farmers. Just like the untargeted NFPSP which was there before, the NFSP is managed through the NCPB and the Kenya National Trading Company (KNTC), both state agencies, with the distribution of the fertilizer to farmers through the NCPB depots and KNTC shops. The KNTC was responsible for the procurement of fertilizers through tendering the importation to private-sector importers. Once imported, the importers bagged and delivered the fertilizer to the NCPB and KNTC depots at a fee. The fertilizer was then sold to farmers from the depots. It is important to note that private-sector importers were not reimbursed by the government until the NFSP fertilizer was purchased by farmers.

To access the subsidized fertilizer through this program, farmers had to register their details, including name, national identification number, mobile phone number, area of cultivated land and crops to be grown. The information on cultivated land area was then used to allocate the quantity of fertilizer the farmer may purchase at a subsidized price at the NCPB depot.

When the NFSP was introduced, the domestic retail price of fertilizer ranged between US$ 928/mt and US$ 1,035/mt, while the subsidized price was US$ 564.5/mt (at an exchange rate of KES 124 to US$ 1.00). By the end of July 2023, the NFSP had imported 472,500 mt of fertilizer and sold 175,060 mt to 527,692 farmers Opiyo et al. (2023). In addition, the subsidized price of fertilizer was reduced to US$ 333/mt in 2024 (at an exchange rate of KES 150 to US$ 1). The government has not provided information regarding how long the NFSP will last, but it will likely continue for some time.

The NFSP used the same platform used by the NVSP to distribute e-vouchers to farmers. However, while the NVSP was targeted and included a package of inputs and hence offered some flexibility to farmers, the NFSP was not targeted and dealt only with fertilizer. In addition, the NVSP had private sector participation in the entire inputs supply chain, including the last-mile distribution, while the NFSP had private sector participation only at the level of fertilizer importation.

A rapid assessment of the effect of the NFSP by Opiyo et al. (2023) indicated inefficiencies in the distribution of subsidized fertilizer, such as farmers having to travel long distances to the distribution depots and incur more transport costs, late delivery of the fertilizer to the depots, and a mismatch between the subsidized fertilizer types offered and the types farmers prefer. Our conversations with agro-dealers indicated that the government announced quantities and types of fertilizers that were supposed to arrive at different depots, but the deliveries were often delayed and the types of fertilizer delivered were not what they originally had reported. In addition, farmers often waited to see if they could access government fertilizer before turning to the private sector to purchase fertilizer. Furthermore, private-sector agro-dealers often waited to see the quantity and type of fertilizer that the government planned to deliver in their areas before making their stocking decisions. All these led to delays, which became problematic as the planting window for maize is normally only two to three weeks.

Other input subsidy programs

In addition to the national government input subsidy programs discussed above, since the start of the devolved governance system in Kenya in 2013, some county governments (e.g. Kakamega, Bungom, Kakamega, Bungoma, Nyandarua Makueni and Taita Taveta, among others) have been providing input subsidies (mainly for fertilizer and maize seed) to farmers (Njagi et al, 2023). However, the county governments and the national government did not coordinate their respective subsidies, a scenario which might have generated overlapping beneficiaries and less efficient use of fertilizer.

Some donor-funded programs also provided subsidized inputs to farmers during the price spike of 2021/22. These included the Kenya Cereal Enhancement Programme Climate Resilient Agricultural Livelihoods Window (KCEP-CRAL). This program was funded by the European Union (EU) and the Government of Kenya, and it was managed by the International Fund for Agricultural Development (IFAD). USAID Feed the Future also had a “know your soil” campaign with agro-dealers and farmers that provided soil testing. This program intended to reduce soil acidity, by subsidizing lime for farmers. USAID and some local NGO’s such as One Acre Fund offered fertilizer to farmers on credit before, during, and after the price spikes. These programs have come under some strain in the last few years as fertilizer and maize prices have fluctuated within the season, limiting farmers' incentives to pay back a loan if relative prices change. While these other programs are collectively important, none of them operated on the scale of the NFSP in 2023 (Njagi et al, 2023).

v) Fertilizer Demand Impacts

An assessment of fertilizer demand in Kenya during the 2023 season conducted by Ricker-Gilbert et al. (2024) found that nearly 50% of households registered for the NFSP program in 2023, and 32% of households received an SMS of where to acquire their fertilizer. However, only 25% of households acquired subsidized fertilizer in 2023. Of that group, 19% of them acquired NFSP fertilizer, while 8% acquired subsidized fertilizer from their county government. Larger-scale producers who were more educated, connected in the community, and had used fertilizer in the past were more likely to participate in the NFSP program during 2023.

Most farmers acquired NFSP fertilizer during the first week of April 2023. This was one week later than most farmers acquired subsidized fertilizer from their county and two weeks later than most people purchased it from the private sector. However, 80% of farmers said that the NFSP fertilizer came in time for planting, while 82% said the same for their county’s subsidized fertilizer, and 87% said that they bought commercial fertilizer in time for maize planting.

The crowding-out rate of commercial fertilizer (displacement of commercial fertilizer sales through subsidized fertilizer purchases) by NFSP was 22% on average. This meant that for every 100 kilograms of subsidized fertilizer acquired by farmers in 2023 only 78 kilograms of new fertilizer were applied to their fields. The remaining 22 kilograms were displaced commercial purchases. It is important to note that his crowding-out rate was taken from surveys of farmers and thus the analysis considered fertilizer demand from their perspective. It did not consider the private retailers’ lost commercial sales from the subsidy that Opiyo et al. (2023) found to be substantial.

Table K.2 presents the estimated crowding-out rate of commercial fertilizer by the NFSP in 2023, breaking down the sample of respondents in Ricker-Gilbert et al. (2024) by assets and land cultivated. The table shows that the crowding-out rate increased as landholdings and assets increased. For example, panel 1 shows that the crowding out rate for those who cultivated less than two acres was 21%, but it was 27% for those who cultivated more than five acres. Additionally, the crowding out rate was 20% for the poorest asset quintile and increased to 27% for the highest asset quintile. These results make sense and are consistent with studies from other countries (Ricker-Gilbert et al. 2011; Jayne et al. 2013). Wealthier farmers with more land are more likely to buy commercial fertilizer, as seen in Table K.2. Thus, they crowd out more of their commercial fertilizer purchases when they access subsidized fertilizer than do smaller-scale, more limited-resource farmers.

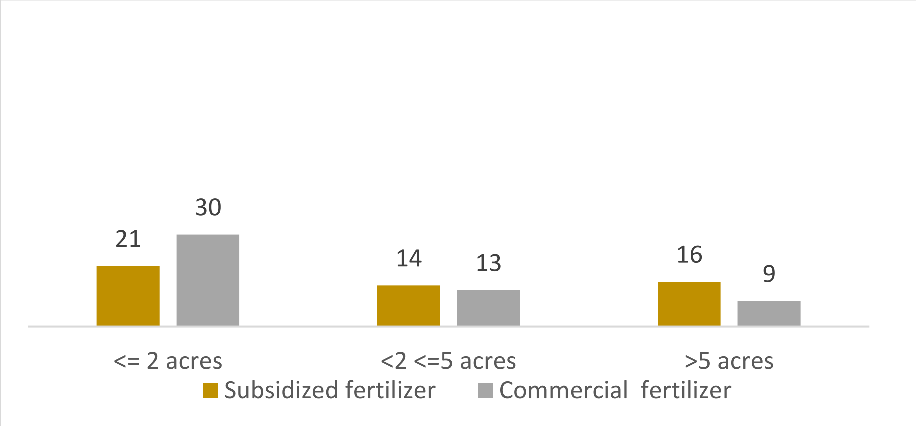
Table K.2: Crowding out by area cultivated and assets in 2023

Category	Average Crowding out	P-value	Number of observations
Overall	-0.22	(0.00)	1,510
Area cultivated			
Less than 2 Acres	-0.21	(0.00)	933
Between 2 and 5 Acres	-0.22	(0.00)	410
Greater than 5 Acres	-0.27	(0.00)	167
Asset Quintile			
POOREST 20%	-0.20	(0.00)	303
20 - 40%tile	-0.20	(0.00)	281
40 - 60%tile	-0.21	(0.00)	354
60 - 80%tile	-0.22	(0.00)	297
RICHEST 20%	-0.27	(0.00)	275

Source: Authors' calculations based on data collected in 2023 by Ricker-Gilbert et al. (2024); Number of observations is 1,510.

Figure K.8 shows both subsidized and commercial fertilizer acquisition by area cultivated in the 2023 long rains. The striking finding from the figure is that the farmers who cultivated less than two acres in 2023 used both subsidized and commercial fertilizer much more intensively than farmers with more land. For example, farmers with less than two acres acquired 51 kilograms of fertilizer per acre (21 kilograms from the subsidy and 30 from commercial sources). Farmers with between two and five acres acquired 27 kilograms of fertilizer (14 kilograms from the subsidy and 13 from commercial sources), while farmers with more than five acres only acquired 25 kilograms of fertilizer per acre (17 kilograms from the subsidy and nine from commercial sources). These results with those from other countries, including Ghana, Malawi, and Nigeria. They suggest that if the goal of the Kenyan government was to encourage farmers to intensify staple crop production then smaller-scale farmers should have been the ones they targeted with their fertilizer subsidy programs.

Figure K.8: Total fertilizer acquisition per acre, by group and source in 2023



Source: Authors' calculations based on data collected in 2023 by Ricker-Gilbert et al. (2024); Number of observations is 1,510.

vi) Fertilizer user demographics in 2022 and 2023 long rains

The next three tables present the characteristics of farming households who purchased commercial fertilizer in 2022 and 2023 and those who did not purchase it in either year. Table K.3 shows that 18% of smallholder farmers in the sample purchased commercial fertilizer in both 2022 and 2023, while 29% bought fertilizer in 2023 but not in 2022. Additionally, only 9% of households bought commercial fertilizer in 2022 but not in 2023. The higher % of households purchasing commercial fertilizer in 2023 compared to 2022, even in the presence of much more subsidized fertilizer competing in the market during 2023, was likely due to the decrease in the price of fertilizer during that year compared to the year before, and an increase in price of maize, which made fertilizer use more profitable. Finally, 34% of the sample did not find it profitable or accessible to purchase commercial fertilizer in either year 2022 or 2023.

Table K.3: Percentage of Households buying commercial fertilizer in 2022 and 2023

Group	% of the Sample in the group	Number of households in the group
Bought commercial fertilizer in 2022 & 2023	18	348
Bought commercial fertilizer in 2023 only	39	455
Bought commercial fertilizer in 2022 only	9	248
Did not buy commercial fertilizer in 2022 or 2023	34	459
Total	100	1,510

Source: Authors' calculations based on data collected in 2023 by Ricker-Gilbert et al. (2024); Number of observations is 1,510.

Given the fairly low participation rate and apparent uneven distribution of commercial fertilizer purchases in Kenya during the fertilizer price spike, we broke down the landholding distribution of farmers into three categories: i) those with less than two acres of cultivated land, ii) those with between two and five acres, iii) those with more than five acres. The results are shown in Table K.4. Column 4 indicates that in 2023 farms with less than two acres made up 62% of all farms in the maize-growing regions of Kenya.[11] These households cultivated 1.10 acres on average and purchased an average of 36 kilograms of fertilizer. Conversely, households with between 2.0 and 5.0 hectares made up 27% of the sample. This group cultivated 3.55 acres on average and purchased an average of 45 kilograms. The group of households with more than 5.0 acres only made up 11% of the sample. These households farmed an average of 10.30 acres and purchased an average of 92 kilograms. It is not surprising that larger-scale farms purchased more fertilizer. However, when we average commercial fertilizer on a per-acre basis, just as we did in Figure K.5, we found that the smallest farms used fertilizer more intensively than did larger farms. This was consistent with the previous tables and figures in this report. It was also consistent with findings in other countries including Ghana, Malawi, and Nigeria.

Table K.4: Landholding Demographics for Households Purchasing Commercial Fertilizer in Kenya in 2023

	(1) Mean area cultivated in group (acre)	(2) Avg Commercial fertilizer purchased in group (kg)	(3) Amount Purchased per acre in group (kg)	(4) Percent of sample in group
less than 2.0 acres	1.10	36	30	62
between 2.0 and 5.0 acres	3.55	45	13	27
greater than 5 acres	10.30	92	9	11
Total	2.62	43	23	100

Source: Authors' calculations based on data collected in 2023 by Ricker-Gilbert et al. (2024); Number of observations is 1,510.

Table K.5 used linear regression to analyse the factors that were associated with purchasing commercial fertilizer in both 2022 & 2023 (column 1) and factors associated with not purchasing commercial fertilizer in either year (column 2). The results from column 1 indicate that households who acquired subsidized fertilizer in 2022 were 20 percentage points (pp) more likely to buy commercial fertilizer in 2022. This provides some evidence that those who accessed Kenya's subsidized fertilizer program were more likely to also be the people who purchased commercial fertilizer. Furthermore, an additional acre of land made a household two pp more likely to buy commercial fertilizer in 2022 and 2023 on average. Conversely, female-headed households were 6 pp less likely to purchase fertilizer commercially in both years on average. This likely relates to resource constraints that female-headed households often face. Finally, having more livestock, measured in tropical livestock units made households slightly less likely to purchase commercial fertilizer in both years on average. This likely occurred because these people were more invested in livestock than in crop farming, and/ or because they were able to collect manure from their livestock, and an increase in assets led to an increase in the probability that a household bought fertilizer commercially in both years.

There were only two statistically significant factors that affected the probability of households buying commercial fertilizer in 2022 or 2023 as seen in column 2. These were a focus on tropical livestock that decreased the likelihood of buying commercial fertilizer (due to an income focus on livestock) and asset ownership which increased the likelihood of buying fertilizer at commercial prices. None of the other factors considered in Table K.4 were found to be statistically significant in determining commercial fertilizer purchases in 2022 and 2023.

[11] The northern region of Kenya does not grow much maize so households in that region were not part of the sampling frame.

Table K.5: Demographic characteristics of households who bought commercial fertilizer in 2022 and 2023 and those who did not buy fertilizer in either year

Characteristic	(1) Bought in 2022 & 2023	(2) Did not buy in either year
Acquired subsidized fertilizer in 2022	+ 20 percentage point effect on average	NSS
Land area (acres) operated by households in 2023	+ 2 per. point effect per acre on average	NSS
Household size	NSS	NSS
=1 if female-headed household	- 6 percentage point effect on average	NSS
Household head years of schooling	NSS	NSS
Age of household head	NSS	NSS
Years that the head has lived in the village	NSS	NSS
Household related to the village leader	NSS	NSS
Household member belongs to a community group	NSS	NSS
Household owns a smartphone	NSS	NSS
Travel time (minutes) to the nearest city/town in wet season	NSS	NSS
Distance (km) from home to nearest agro-dealer	NSS	NSS
Distance (km) from home to the nearest national government-subsidized sale point	NSS	NSS
Tropical Livestock Unit (TLU) owned	Very small (-) impact on average	Very small (+) impact on avg
Household asset index	+ 2 percentage point impact on average	- 2.4 percentage point impact on average

Source: Authors' calculations based on data collected in 2023 by Ricker-Gilbert et al. (2024); NSS means that the factor was not found to be statistically significant in a regression model; Number of observations is 1,510.

vii) Maize-to-fertilizer response rate impacts

The maize-to-fertilizer response rate tells us how many kilograms of maize a farmer obtains from a kilogram of fertilizer. This relationship is important for understanding how much an additional kilogram of fertilizer contributes to maize production, food security and the profitability of fertilizer for farmers. It is crucial to note that fertilizer is one input into the production of food and farmers must have sufficient amounts of complimentary inputs, such as seed, land, labor, soil fertility, water, and farm management ability for fertilizer use to be effective. The estimated maize-to-fertilizer response rate in Kenya is generally estimated to be higher than it is in neighboring countries, For example, a systematic review by Chapoto et al. (2023) found that the maize-to-fertilizer response rate in Kenya on smallholder farmers' fields was the highest in the five countries for which they could find data (Chapoto et al. 2023). Kenyan farmers were estimated to obtain an average response rate of 5.68 kilograms of maize per kilogram of fertilizer. By comparison, the estimated response rates in Nigeria and Malawi were close to 2.5.[12]

While the average maize-to-fertilizer response rate in Kenya from using fertilizer was high compared to other countries in the region, it has been noted that Kenya's varied agro-ecology leads to wide variation in complementary inputs such as soil quality, rainfall, labor availability along with access to fertilizer seed and other inputs. All of this led to wide variation in maize-to-fertilizer response rates. For example, Sheahan et al. (2013) found that the maize-to-fertilizer response rate in Kenya ranged from 3.67 to 13 kilograms of maize per kilogram of fertilizer and those farmers that had higher response rates had higher levels of these necessary complementary inputs. They also found that many farmers had limited knowledge of how to use complementary inputs and practices effectively. Tjernstrom et al. (2018) found that the great variation in soil quality between localities has led to experts making incorrect fertilizer recommendations that did not meet the conditions on individual farmer's fields. They also found that farmers in Kenya have concerns about the adulteration of fertilizer. This uncertainty about quality undermines farmers' interest in fertilizer and makes them reluctant to make complementary investments in seed, labor, and land to maximize the maize-to-fertilizer response rate on their farms. Overall, the maize-to-fertilizer response rate in Kenya suggests that though Kenyan farmers used the input relatively more efficiently than farmers in other countries in the region, there was room for improvement in promoting soil fertility management practices and providing assurances about the quality of the fertilizer that farmers purchase.

viii) Fertilizer Profitability Impacts

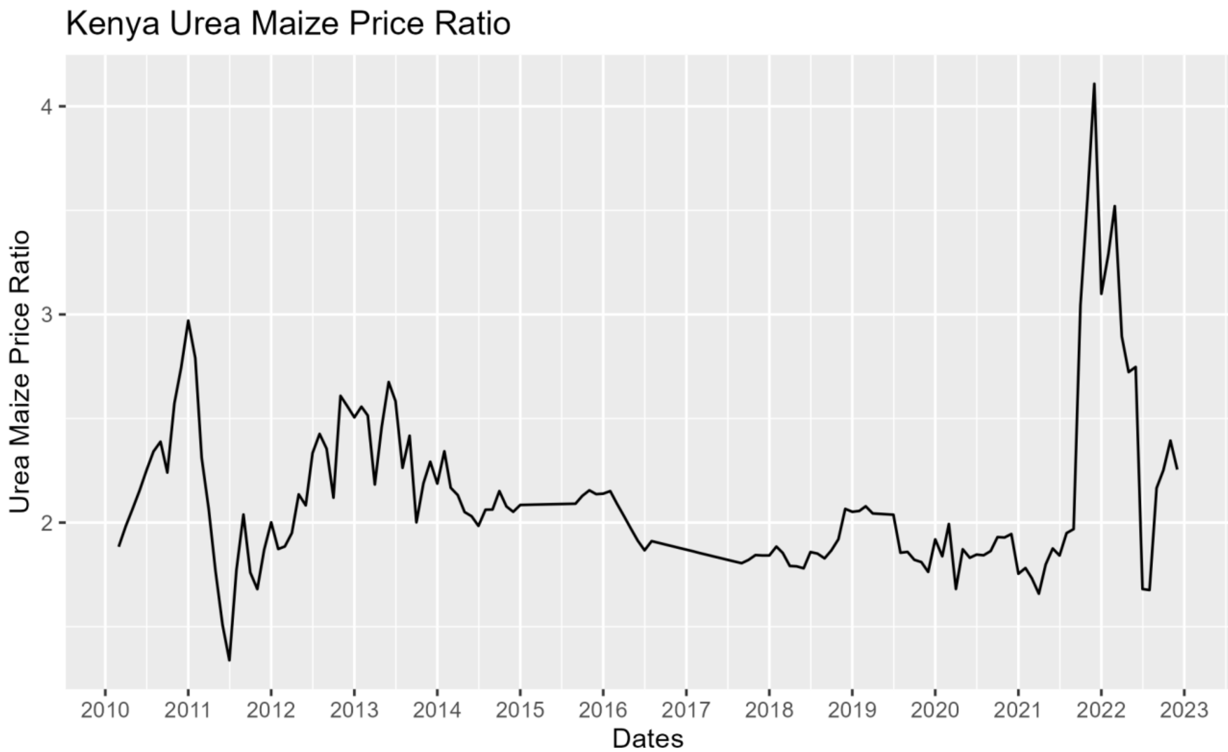
This subsection considers the profitability of fertilizer use in Kenya. The intention is to understand if the financial returns to Kenya's fertilizer subsidy program justified its cost. We also used data from selected years between 2010/11 and 2021/23 and to understand if fertilizer was profitable for Kenyan farmers when valued at the commercial price that they paid. The profitability of fertilizer is affected by three main factors: 1) the price of fertilizer, 2) the price of maize (or other staple crop), and 3) the maize-to-fertilizer response rate. the Maize-to-fertilizer response rate was discussed in the previous sub-section and the overall finding from previous studies is that Kenyan farmers use fertilizer efficiently on a per kilogram basis compared to other countries. Yet there is still room for improvement so that observed yields on farmers' fields come closer to reaching their full yield potential.

As mentioned above the price of fertilizer and the price of maize are key components in fertilizer's profitability. One way to look at this is through the ratio between fertilizer prices and maize prices. This is known as the input/output price ratio, and this relationship between urea and the wholesale maize price in Kenya between 2010 and 2022 is shown in Figure K.9. A lower ratio means that fertilizer is more profitable, as the price of fertilizer is going down (i.e. the numerator in the ratio getting smaller) or the maize price is going up (i.e. the denominator is getting bigger). Figure K.9, indicates that the input/output price ratio before 2020 ranged from a high of 3.0 – 1.0 in all years. This generally suggests that un-subsidized/commercial fertilizer was profitable relative to maize during the pre-spike period. The input/output price ratio spiked in early 2021 reaching a peak of 4.0 in late 2021 and early 2022. It dropped briefly from there and was at 2.5 by the end of 2022. This meant that at an input/output price of 2.5, a farmer would need to produce 2.5 kilograms of maize per kilogram of fertilizer to break even. Anything higher than that would be a profit and anything less than that would be a loss. Since our estimates from Chapoto

[12] ANAPRI reported response rates in terms of nitrogen. Their response rate for Kenya was 17.05 kilograms maize to a kilogram of nitrogen. In order to make a consistent comparison among studies we divided 17.05 by 3 to convert nitrogen to fertilizer equivalent.

et al. (2023) indicated that the average farmer obtained 5.68 kilograms of maize per kilogram of fertilizer in Kenya, fertilizer use was profitable in all years of our analysis on average. This was the case even when the input/output price ratio was over 4.0.

Figure K.9: Urea / Farmgate maize price ratio in Kenya 2010-2022



Source: urea prices from AfricaFertilizer.org; wholesale maize prices from FAOSTAT, we subtracted 8% from wholesale price to compute a farmgate price.

The set of three tables in K.6 present both the financial benefit-cost ratio of Kenya's fertilizer subsidy program in different years and the profitability of fertilizer for farmers when the input is valued at subsidized and commercial prices. Table K.6.A shows the return to fertilizer using maize farm gate maize prices in and around Nairobi in the central region of the country. Table K.6.B uses farm gate maize prices in the Rift Valley and Table K.6.C uses maize prices for Mombasa and the coastal region.

The return that farmers obtain from a kilogram of fertilizer valued at its commercial price is the marginal value-cost ratio (MVCR). The MVCR is calculated as follows:

$$MVCR = \frac{\{\text{incremental maize output (kilograms of maize/kilograms of fertilizer) * maize price/kilogram}\}}{\text{price of fertilizer per kilogram.}}$$

An MVCR that is greater than one indicates that using fertilizer generated a positive and profitable return for farmers. A ratio equal to one is break-even, meaning that the farmer made no profits using fertilizer and a ratio less than one is a loss. However, whether or not fertilizer is likely to be profitable depends on outcomes that are uncertain when fertilizer decisions are made, as well as costs associated with the use of fertilizer that are unknown to the researcher. The types of risks that farmers face when using fertilizer at planting to increase staple crop yields at harvest include the chance of low yields due to adverse weather, and output prices at harvest being lower than expected. In the face of these uncertainties and unobserved costs, an MVCR of at least 2.0 (meaning a risk premium of one) has been recommended in the literature to be required in order for fertilizer to be profitable (Xu et al., 2009; Sauer and Tchale, 2009; Sheahan et al. 2013).

This also applies to the BCR for fertilizer subsidy programs. A BCR of a subsidy program equal to 1.0 means that the economy broke-even on it, essentially that the program was equal to giving farmers cash. A BCR greater than 1.0 indicates a gain for the economy from the subsidy program, while, a BCR <1.0 indicates a loss for the economy. Again, a break-even BCR of 1.0 assumes zero transactions costs of implementing the subsidy program. Thus 2.0 may be a better break-even point for subsidies as a rule of thumb.

K.6.A shows the BCR and MVCR estimates and their related calculations for Nairobi representing central Kenya, while K.6.B does the same for Rift Valley, which is the grain basket of Kenya. G.6.C represents Mombasa in the coastal region of Kenya. The difference in results between the regions was based on different farm-gate maize prices (from FAOSTAT) and retail fertilizer prices (from AfricaFertilizer.org) among regions. The key rows of interest in Table G.6.A, G.6.B and G.6.C are row P, row U, and row V, all highlighted in grey. Row P shows the financial benefit-cost ratio (BCR) of Kenya's fertilizer subsidy programs for the years for which we had data on the costs of the program (2013/14, 2016/17, 2019/20 and 2022/23). All other rows that are directly associated with the costs and benefits of the subsidy are highlighted in green. The results in row P of Table K.6.A which used maize prices and fertilizer prices from Nairobi/Central Kenya indicated that the financial BCR from the subsidy was highly variable and depended on the price of maize and the cost of the subsidy program. For example, the BCR was 4.17 in 2016/17 but just 1.17 in 2019/20 and 1.29 in 2022/23. Table K.6.B which used prices from Rift Valley also found that the BCR was highly variable by year. It ranged from a high of 3.37 in 2016/17 to a low of 1.14 in 2022/23. Similarly, the BCR in Mombasa/Coastal Kenya ranged from a high of 3.67 in 2016 to a low of 1.10 in 2019/20 and 1.14 in 2022/23. Thus, the returns to the Kenyan economy from their subsidy program ranged between 10% in Mombasa in 2019/20 and 317% in Nairobi in 2016/17. Furthermore, the rates of return during the price spike year of 2022/23 when the government scaled up the NFSP was profitable at the 1.0 threshold, ranging from a 14-29% return for the economy. However, would not be considered profitable at the 2.0 threshold that factored in risk and transactions costs when using fertilizer.

The comparison of regional results for the MVCR of fertilizer over time and among regions were similar to those for the BCR results. This was the case when fertilizer was valued at the subsidized price that beneficiary farmers paid in row U and when fertilizer was valued at its commercial price in row V. Nairobi had the highest MVCRs over time, followed by Rift valley, while Mombasa in the coastal region had the lowest MVCRs. The regional differences were due to the more favorable fertilizer to maize price ratio in Nairobi compared to other regions. The highest MVCR in row U when fertilizer was valued at its subsidized price was 16.77, which occurred in the Nairobi in 2016/17. Conversely, the lowest return was 3.06 that occurred in Mombasa in 2022/23. Likewise, the highest MVCR in row V when fertilizer was valued at its commercial fertilizer was 3.27, which occurred in Nairobi in 2016/17. The lowest return was 1.50, which occurred in Rift Valley in the price spike year 2022/23. During that year commercial fertilizer prices were extremely high in Rift Valley, at USD 1,155/MT on average. The returns were also relatively low in 2022/23 in Nairobi at 2.23 and in Mombasa at 2.12.

These results suggest that the investment potential in fertilizer has been highest in Central Kenya around Nairobi compared to other regions of the country. Furthermore, the average return to commercial fertilizer across Kenya between 2013/14 and 2022/23 ranged from 50% to 249%. This was a fairly high average return to fertilizer. However, is important to note that even with positive BCR for subsidized fertilizer and the positive MVCR of fertilizer at subsidized and commercial fertilizer, there is still room for improvement in raising fertilizer use efficiency in Kenya so that the average farmer gets more maize from a kilogram of fertilizer. Kenya's relatively integrated fertilizer market and coastal position mean that the fertilizer/maize price ratio was favorable (as Figure K.6 showed) even during the price spikes. However, as we will discuss in our recommendations, farmers can do better and there is scope for the government and donors to help them invest in increased fertilizer use efficiency, rather than just making the input cheaper and potentially more accessible through subsidizing it.

Table K.6.A: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Kenya (Nairobi / Central Region)

Production Year		2012/13	2013/14	2016/17	2019/20	2021/22	2022/23
	Estimated program costs to Gov. and farmers						
	Shilling/US$ (Dec. 31 end of production year)	91	91	103	109	123	157
A	Gov. Total subsidy expenditure (Shilling)	2,246,061,128	2,700,993,644	2,804,000,000	2,773,060,000	-	12,000,000,000
B	Gov. Total subsidy expenditure ($)	24,796,436	29,818,874	27,152,125	25,403,628	-	76,677,316
C	GS Fert distributed (MT)	94,155	66,276	147,926	44,250	-	175,060
D	Diversion Rate based	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15
E	Crowding out estimate	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	62,424	43,941	98,075	29,338	-	116,065
G = (A/C)/20	Subsidized fertilizer redemption price ($/50kg)	7.90	13.50	5.51	17.22	-	28.25
H=A/C	Subsidized fertilizer redemption cost ($/MT)	158	270	110	344	-	565
I = (C*H)	Farmer incremental. cost ($)	14,877,861	17,891,325	16,291,275	15,242,177	-	98,821,370
J = (B+I)	Government + Farmer Cost ($)	39,674,297	47,710,199	43,443,401	40,645,804	-	175,498,686
	Estimated incremental benefits						
K[i]	Yield response (Maize Kg/ Nitrogen kg)	17.05	17.05	17.05	17.05	17.05	17.05
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	5.68	5.68	5.68	5.68	5.68	5.68
M = (F*L)	Incremental maize output from subsidy (MT)	354,779	249,730	557,393	166,736	-	659,635
N[ii]	Average Harvest Season Farmgate Maize price ($/MT): (Nov-Dec)	373	296	325	284	495	342
O = (M*N)	Value of incremental maize from subsdiy (Mil. $)	132,332,516	73,920,125	181,152,583	47,353,084	-	225,595,113
P = (O/J)	Financial BCR of Subsidy program	3.34	1.55	4.17	1.17	-	1.29
Q	Subsidized pr. of fertilizer for farmers ($/MT)	158	270	110	344	-	565
R[iii]	Commercial pr. of fertilizer for farmers (KES/50kg)	3100	2804	0	2750	7150	5,875
R[iii]	Commercial pr. of fertilizer for farmers ($/MT)	713	645	564.8	514	1243	870
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	0.42	0.91	0.34	1.21	-	1.65
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	1.91	2.18	1.74	1.81	2.51	2.54
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	13.42	6.23	16.77	4.69	-	3.44
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	2.97	2.61	3.27	3.14	2.26	2.23

Note:[i] yield response from Chapoto et al. (2023); [ii] Maize prices in row N were retail prices from FAO. We deducted 20% from the retail price to compute a farm-gate price; [iii] Commercial urea prices from Africafertilizer.org (2024); we do not have fertilizer subsidy cost data for 2021/22.

Table K.6.B: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Kenya (Rift Valley)

Production Year		2013/14	2016/17	2019/20	2021/22	2022/23
	Estimated program costs to Gov. and farmers					
	Shilling/US$ (Dec. 31 end of production year)	91	103	109	123	157
A	Gov. Total subsidy expenditure (Shilling)	2,700,993,644	2,804,000,000	2,773,060,000	-	12,000,000,000
B	Gov. Total subsidy expenditure ($)	29,818,874	27,152,125	25,403,628	-	76,677,316
C	GS Fert distributed (MT)	66,276	147,926	44,250	-	175,060
D	Diversion Rate based	-0.15	-0.15	-0.15	-0.15	-0.15
E	Crowding out estimate	-0.22	-0.22	-0.22	-0.22	-0.22
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	43,941	98,075	29,338	-	116,065
G = (A/C)/20	Subsidized fertilizer redemption price ($/50kg)	13.50	5.51	17.22	-	28.25
H=A/C	Subsidized fertilizer redemption cost ($/MT)	270	110	344	-	565
I = (C*H)	Farmer incremental. cost ($)	17,891,325	16,291,275	15,242,177	-	98,821,370
J = (B+I)	Government + Farmer Cost ($)	47,710,199	43,443,401	40,645,804	-	175,498,686
	Estimated incremental benefits					
K[i]	Yield response (Maize Kg/ Nitrogen kg)	17.05	17.05	17.05	17.05	17.05
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	5.68	5.68	5.68	5.68	5.68
M = (F*L)	Incremental maize output from subsidy (MT)	249,730	557,393	166,736	-	659,635
N[ii]	Average Harvest Season Farmgate Maize price ($/MT): (Nov-Dec)	279	263	296	453	304
O = (M*N)	Value of incremental maize from subsidy (Mil. $)	69,674,712	146,594,244	49,353,919	-	200,528,989
P = (O/J)	Financial BCR of Subsidy program	1.46	3.37	1.21	-	1.14
Q	Subsidized pr. of fertilizer for farmers ($/MT)	270	110	344	-	565
R.a[iii]	Commercial pr. of fertilizer for farmers (KES/50kg)	2,386	-	2,850	6,850	5,950
R.b[iii]	Commercial pr. of fertilizer for farmers ($/MT)	549	564.8	553	1330	1155
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	0.97	0.42	1.16	-	1.86
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	1.97	2.15	1.87	2.94	3.80
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	5.87	13.57	4.88	-	3.06
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	2.89	2.65	3.04	1.94	1.50

Note:[i] yield response from Chapoto et al. (2023); [ii] Maize prices in row N were retail prices from FAO. We deducted 20% from the retail price to compute a farm-gate price; [iii] Commercial urea prices from Africafertilizer.org (2024); we do not have fertilizer subsidy cost data for 2021/22.

Table K.6.C: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Kenya (Mombasa / Coastal)

Production Year		2013/14	2016/17	2019/20	2021/22	2022/23
	Estimated program costs to Gov. and farmers					
	Shilling/US$ (Dec. 31 end of production year)	91	103	109	123	157
A	Gov. Total subsidy expenditure (Shillings)	2,700,993,644	2,804,000,000	2,773,060,000	-	12,000,000,000
B	Gov. Total subsidy expenditure ($)	29,818,874	27,152,125	25,403,628	-	76,677,316
C	GS Fert distributed (MT)	66,276	147,926	44,250	-	175,060
D	Diversion Rate based	-0.15	-0.15	-0.15	-0.15	-0.15
E	Crowding out estimate	-0.22	-0.22	-0.22	-0.22	-0.22
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	43,941	98,075	29,338	-	116,065
G = (A/C)/20	Subsidized fertilizer redemption price ($/50kg)	13.50	5.51	17.22	-	28.25
H=A/C	Subsidized fertilizer redemption cost ($/MT)	270	110	344	-	565
I = (C*H)	Farmer incremental. cost ($)	17,891,325	16,291,275	15,242,177	-	98,821,370
J = (B+I)	Government + Farmer Cost ($)	47,710,199	43,443,401	40,645,804	-	175,498,686
	Estimated incremental benefits					
K[i]	Yield response (Maize Kg/ Nitrogen kg)	17.05	17.05	17.05	17.05	17.05
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	5.68	5.68	5.68	5.68	5.68
M = (F*L)	Incremental maize output from subsidy (MT)	249,730	557,393	166,736	-	659,635
N[ii]	Average Harvest Season Farmgate Maize price ($/MT): (Nov-Dec)	262	286	267	503	304
O = (M*N)	Value of incremental maize from subsidy (Mil. $)	65,429,300	159,414,273	44,518,569	-	200,528,989
P = (O/J)	Financial BCR of Subsidy program	1.37	3.67	1.10	-	1.14
Q	Subsidized pr. of fertilizer for farmers ($/MT)	270	110	344	-	565
R.a[iii]	Commercial pr. of fertilizer for farmers (KES/50kg)	2,304	-	2,600	6,700	5,500
R.b[iii]	Commercial pr. of fertilizer for farmers ($/MT)	530	564.8	486	1,165	815
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	1.03	0.39	1.29	-	1.86
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	2.02	1.97	1.82	2.32	2.68
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	5.52	14.76	4.41	-	3.06
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	2.81	2.88	3.12	2.45	2.12

Note:[i] yield response from Chapoto et al. (2023); [ii] Maize prices in row N were retail prices from FAO. We deducted 20% from the retail price to compute a farm-gate price; [iii] urea prices from Africa fertilizer watch (2024); we do not have fertilizer subsidy cost data for 2021/22.

6. Conclusion and policy recommendation

Kenya's fertilizer sector experienced tremendous development with the removal of government restrictions on fertilizer trade and prices in the 1990's and early 2000's. This incentivized private investments in the period following the structural adjustment programs. However, the government subsidy programs that have continued to be implemented in response to global fertilizer price crises during the past two decades have contributed to the crowding out of commercial fertilizers. This crowding out of private trade in fertilizer is a threat to the sustained development of the sector. While fertilizer subsidies in times of price crises are largely justified, the design and implementation of these programs influences their success and the extent to which potential negative consequences. We found that the Kenyan economy obtained a positive return to subsidized fertilizer in years before the price spike, but high fertilizer prices meant high program costs in 2022/23. This led to the National Fertilizer Subsidy Program (NFSP) barely breaking even when a BCR benchmark of 1.0 was used, and the economy lost money on subsidizing fertilizer at a BCR benchmark of 2.0. A targeted subsidy program that is inclusive of private sector players in the input supply chain, such as the NVSP, would be desirable and cost-effective for the sustained development of input supply chains.

Based on the results of this report we make the following recommendations for Kenya to better prepare for and address fertilizer price spikes and create a more profitable and resilient supply chain.

i. Policy that seeks to improve agricultural productivity should focus on helping farmers use fertilizer more efficiently. This includes emphasis on improving soil health, erosion control, adoption of improved maize varieties, along with training farmers on appropriate application of fertilizer and soil amendments, including fertilizer application techniques and timing.

ii. Move the retailing of NFSP fertilizer to farmers to the dense network of private-sector agro-dealers, who are located within easy reach of the millions of smallholder farmers.

iii. The government should not wait to reimburse private-sector fertilizer importers until after farmers have purchased NFSP fertilizer from NCPB depots. This delay in repayment adds to the private sector's risk and operating costs, driving up the price of fertilizer to all farmers and financial burden on the government.

iv. Move away from an untargeted input subsidy program to a targeted program that makes fertilizers available to smaller-scale, limited-resource farmers. These farmers crowd out less of their commercial fertilizer purchases when they use subsidized fertilizer, and they use fertilizer more intensively on a per-acre basis than do larger-scale farmers.

v. The national government and county governments should coordinate their input subsidy programs to enhance efficient use of inputs and utilization of public funds. This includes working together on the procurement, distribution, and retailing of subsidized fertilizer to improve the timeliness and cost-effectiveness of these programs.

vi. It is important to clean up corruption. Our model found that when corruption control improved in Kenya the price of DAP declined. This makes sense since cleaning up corruption makes the supply chain for DAP more efficient and reduces costs to the farmer.

vii. Politics should be taken out of fertilizer policy in Kenya. Our model found that DAP prices were slightly lower in presidential election years and in the year after a presidential election. This suggests that politicians may have influenced the fertilizer market.

7. References

Ariga, J., and Jayne T. 2011. “Fertilizer in Kenya: Factors Driving the Increase in Usage by Smallholder Farmers.” In Yes Africa Can: Success Stories from a Dynamic Continent, edited by Chuhan-Pole, P., and M. Angwafo, 269–288. Washington DC: World Bank.

Chapoto, A., L. Tiemann , A.M. Akyoo , J. Bonabana , N.F. Faye , M. Kalaba , I.K. Kanyama , L. Kirimi , G. Mandlhate , S. Mbai , E. Mwakiwa , C. Nyondo , I. Ogunbayo , N. Mebeelo , T.S. Jayne. 2023. “Farmer’s risks and economic use of fertilizer in Africa South of the Sahara.” ANAPRI Policy Report

Jayne, T.S., D. Mather, N. Mason, and J. Ricker-Gilbert. 2013. “How do Fertilizer Subsidy Programs Affect Total Fertilizer Use? A Synthesis of the Evidence on “Crowding in/out” in sub-Saharan Africa.” *Agricultural Economics* 44(6):687-703.

Opiyo, J., Z. Simba, T. Njagi, and J. Olwande. 2023. “A Rapid Assessment of the General Fertiliser Subsidy on Private Sector Fertiliser Markets.” Technical Report. Tegemeo Institute of Agricultural Policy and Development. Nairobi, Kenya.

Ricker-Gilbert, J., T.S. Jayne and E. Chirwa. 2011. “Subsidies and Crowding Out: A Double-Hurdle Model of Fertilizer Demand in Malawi.” *American Journal of Agricultural Economics*. 93(1): 26-42.

Sauer, J., Tchale, H., 2009. “The economics of soil fertility management in Malawi. Applied Economics Perspectives and Policy.” 31 (3), 535–560.

Sheahan, M., Black, R., & Jayne, T. S. 2013. “Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research.” Food Policy, 41, 39-52.

Tjernström, E., Carter, M.R. & Lybbert, T. 2018. “The dirt on dirt: Soil characteristics and variable fertilizer returns in Kenyan maize systems.” Working Paper.

Xu, Z., Guan, Z., Jayne, T. S., & Black, R. 2009. “Factors influencing the profitability of fertilizer use on maize in Zambia.” *Agricultural economics*, 40(4), 437-446.

iii. Malawi Country Report

1. Main Findings for Malawi

1. Malawi does not have an abundant and cheap source of fossil fuels, so does not manufacture any inorganic fertilizer. The other parts of the fertilizer supply chain in the country are highly concentrated with a few actors controlling 90% of the importing, blending, wholesaling, and retailing of fertilizer in the country. In 2014, only nine firms imported 90% of the fertilizer used in Malawi. However, this increased to 11 in 2019 and stayed at that number in 2022 and 2023. Three companies wholesaled 90% of the country's fertilizer in 2014. This increased to seven in 2019 but declined to five in 2022 and 2023. Furthermore, a relatively, small number of companies retail most of the fertilizer farmers buy in Malawi. In 2014, only six companies sold 90% of the fertilizer in Malawi, while in 2019 just before the spike 20 companies did so. This dropped to 15 companies retailing fertilizer in 2022 and 2023, during and after the price spike. Thus, it seems that the fertilizer market was becoming slightly less concentrated before the price spike of 2021/22, but the price spike caused some firms to exit the market, which increased concentration. These changes in market structure were also closely linked to the implementation of Malawi's input supply program, which has also changed since the price spikes.

2. Our analysis of monthly urea prices between 2010 and 2023 indicated that several key factors affected the price level and price wedge (i.e. the difference between local urea prices and world urea prices) in Malawi.

   Price Level Model

   a. *Corruption Control Index* was negatively related to the price of urea in Malawi. On average, a one standard deviation increase in the control of corruption index, which meant that the country did more to reduce corruption, led to a 28.9% decrease in urea price. This makes sense since cleaning up corruption makes the supply chain for urea more efficient and reduce costs to the farmer.
   b. Macro variables like *Real Interest rates* and *GDP* were significant factors as well. A 1% increase in interest rates was associated with a .5% increase in urea price on average, and a 1% increase in Log GDP was associated with a -1.02% decrease in urea price on average, reflecting a stronger local currency reducing local prices.
   c. The variable for the presidential *Election Yr,* and the year after the presidential election both had small and negative impacts on urea prices. This suggested that politicians may have influenced the fertilizer market in Malawi.
   d. The previous month's *Local Maize Price* was associated with an increase in urea prices in Malawi. Specifically, a 10% increase in last month's *Local Maize Price* was associated with a .26% increase in urea price on average. This result was in line with expectations since we hypothesized that this relationship was driven by increased profitability of, and demand for fertilizer among farmers when maize had a higher value.
   e. The *World Urea Price* was positively associated with urea prices in Malawi. This was to be expected and specifically, a 1% increase in world price of urea resulted in a .26% increase in the price of urea in Malawi.

   Price Wedge Model

   a. Malawi's *GDP* was found to be negative and statistically significant, meaning that a 1% increase in GDP was associated with a 1.15% decrease in the price wedge. This suggests that economic growth, which improves infrastructure and market efficiency, reduced the price differential between local and world urea prices.
   b. Exchange Rate Movements were negatively associated with the wedge. Specifically, a 1% decrease in the Malawian Kwacha against the USD was associated with a .84% increase in the wedge.

c. *The Share Private Sector annual sales* in total sales, was negative and statistically significant. It indicated that a 1% increase in the annual share of private sector sales was associated with a .13% increase in the price wedge. This implies that a larger share of private sector sales was associated with robust private demand for fertilizer that may have led to higher urea prices.

d. The previous month's Local *Maize Price* was positive and statistically significant. It indicated that a 1% increase in last month's maize prices was associated with a .35% increase in the price wedge. This result suggested greater anticipated demand for fertilizer, that pushed up local urea prices relative to world price.

e. *Diesel prices were* negative and statistically significant. This was the opposite of our expectation since diesel is a major cost factor in fertilizer transport. However, we found that it was positive in the cross-country price wedge model as well as other individual country price level models as expected. Therefore, we think that we happened to pick up some spurious correlation of diesel prices and the price wedge in Malawi.

f. World Natural Gas Price was positive and statistically significant. This indicated that a 1% increase in the world price of natural gas was associated with a .22% increase in the price wedge on average. This was as expected since natural gas is a major cost component of fertilizer, and we would expect that increased natural gas costs would get passed on in part to fertilizer consumers around the globe, including in Malawi.

3. Compared to coastal countries in the region, Malawi's landlocked position with high transportation costs means that its farmers must pay high prices for imported fertilizer that is delivered via truck mainly from Mozambique. At the same time, poor road infrastructure and lack of access to markets that pay remunerative prices means that Malawian farmers receive a relatively low price for the maize that they sell. The relatively high price of fertilizer and low price of maize has undermined fertilizer profitability over time in Malawi. However, the most important factor undermining the profitability of fertilizer has been that the amount of maize farmers obtain from a kilogram of fertilizer (known as the maize-to-fertilizer response rate) on smallholder farmers' fields is too low for most of them to use it profitably. We found that the average Malawian farmer only obtained 1.82 kilograms of maize per kilogram of fertilizer. This was significantly below an estimated return of around 5.68 kilograms in Kenya. The low response rate of maize to fertilizer in Malawi has implications for food security and the cost-effectiveness of fertilizer subsidy programs.

4. The price of fertilizer declined between 2009/10 and 2020 as fertilizer prices in Malawi (mainly urea) moved closer to the world price of fertilizer. This suggests that fertilizer markets in Malawi were becoming more efficient during the period before the price spikes of 2021/22.
   a. Fertilizer retail price data collected by IFDC, available at AfricaFertilizer.org, indicates that at its peak, the price wedge (the difference between the local price of urea in Malawi and the world price) was nearly USD 1,000/MT in 2013, but dropped to about USD 250/MT by the end of 2020.
   b. Household survey data collected by the World Bank and Malawi's National Statistical Office indicates that commercial fertilizer use increased by 15% between 2009/10 and 2018/19. Part of this increase was likely related to the scaling down of Malawi's fertilizer subsidy program during the past decade.

5. However, the fertilizer price spike of 2021/22 caused a significant increase in fertilizer prices in Malawi that continued through the end of 2023. The price of NPK and urea increased by more than 175% between 2019/20 and 2023/24 seasons in US dollar terms, and by more than 300% when fertilizer was valued in Malawian Kwacha.
   i. It is important to note that the price of fertilizer in Malawi stabilized in the 2022/23 and 2023/24 seasons in US dollar terms. However, the depreciation of the Kwacha relative to the dollar in the past two years meant that the cost of fertilizer to Malawian farmers continued to increase over that time.

6. Malawi has subsidized fertilizer for smallholder farmers in some form or another every year since independence. We note the following about Malawi's subsidy program over the past 20 years.[13]
   a. The country has mainly implemented targeted subsidy programs for farmers who were defined as productive poor since the early 2000's under the Farm Input Support Programme (FISP). The FISP was scaled up beginning in 2005/06 and expenditure on the program reached a high of $252 million in 2008/09 when it comprised 6.6% of GDP.
   b. Due to changes in government priorities, high costs, and pressure from donors the program was gradually scaled down between 2008/09 when 2 million beneficiaries were targeted, and 2019/20 when 900,000 beneficiaries were targeted and the program cost 1.3% of GDP.
   c. In 2020/21, a new government rebranded the subsidy program as the Affordable Input Program (AIP) and scaled it up to 3.8 million beneficiaries in that year. As fertilizer prices spiked in 2021/22 3.7 million beneficiaries were targeted, at 1.3% of GDP. In 2022/23 2.5 million beneficiaries were targeted at 1.6% of GDP as fertilizer prices in Malawi remained high.
   d. As subsidized fertilizer can account for up to 70% of all fertilizer used in Malawi, changes in the subsidy program can have huge impacts on the structure of the fertilizer sector. Following the 2021/2022 price spike, the government pivoted away from private sector distribution channels and fully controlled distribution to farmers in the 2022/23 season, resulting in a decline in smaller private sector retailers.

7. Our analysis of the financial benefits and costs of Malawi's subsidy program between the 2009/10 and 2022/23 seasons indicates that the government lost money subsidizing fertilizer under all scenarios in all years. Thus, the returns to the economy from subsidizing fertilizer never outweighed the costs. In addition, farmers lost money on average when they paid commercial prices for fertilizer in all years of our analysis. This was due in part to high fertilizer prices and relatively low maize prices, but more importantly to the low maize yield response that Malawian farmers get to fertilizer.

8. We found that the benefits of subsidizing fertilizer were reduced by an average crowding-out rate of 27%. This meant that 100 kilograms of subsidized fertilizer only added 73 new kilograms to farmers' fields, as the other 27 kilograms replaced fertilizer that would have otherwise been purchased at commercial rates with subsidized fertilizer. We also found that crowding-out was higher for wealthier farmers with more land than it was for poorer farmers since better-off farmers are more likely to purchase fertilizer at commercial prices. In addition, our analysis indicated that poor and wealthy farmers achieved the same maize yields from fertilizer. These findings indicated that poorer farmers should be targeted with subsidized fertilizer, as this will reduce crowding out of commercial fertilizer and will not reduce maize productivity.

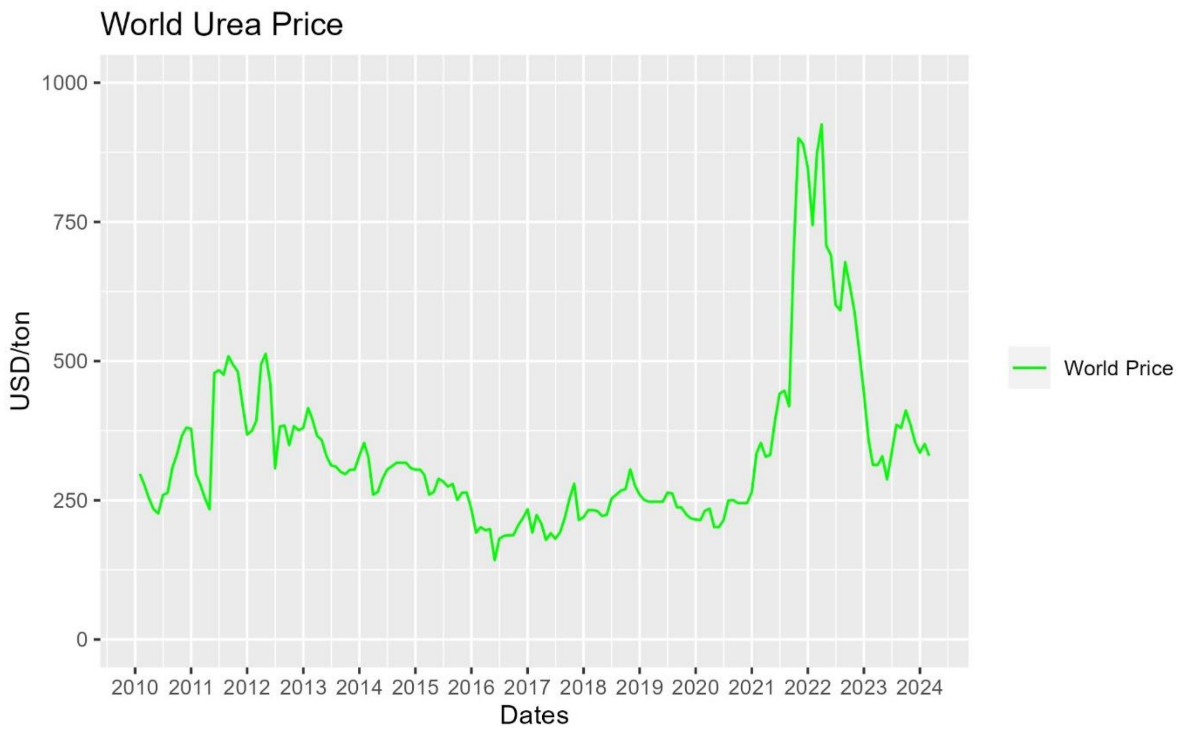
[13] Most of these costs estimates related to the subsidy program come from Benson et al. (2024).

2. Introduction

International fertilizer prices increased and then decreased substantially between 2020 and 2024. The initial global drivers of the increase were disruptions in the global supply chain caused by COVID-19. As a result, China and Russia, two of the largest fertilizer exporters, imposed restrictions on their exports. These restrictions also came at the same time that international coal and natural gas prices, key inputs in the production of fertilizer, were rising. Fertilizer prices increased further in early 2022, due to the fallout from the Ukraine crisis. Russia and Ukraine are major fertilizer exporters, and Russia's invasion of Ukraine greatly reduced the global fertilizer supply during the initial months of the war. At the same time that fertilizer prices increased, prices of staple foods increased as well. This increase in input and output prices had important implications for smallholder farmers, small-scale traders, and consumers in Malawi as it did in many other countries of sub-Saharan Africa (SSA). This is not surprising because Malawi imports virtually all its fertilizers from the international market. Figure M.1 shows the world price of urea, between 2010 and 2024 in nominal USD per metric ton (MT). The figure shows that prior to the price spike of 2021/22, the price of urea had declined from a high of about USD 500/MT in 2013 to a low of about USD 250/MT in 2020 before the spike began. The world price of urea then spiked beginning in early 2021 reaching a high of USD 925 in March of 2022. The price then dropped during the remainder of 2022 before reaching a monthly average of $375/MT in the second half of 2023.

This report analyses global and national-level urea prices because urea is a consistent type of fertilizer (comprised of 46% nitrogen) that is traded and used globally. Doing so allows us to make cross-country comparisons. Subsequent figures and analyses compare the price of urea in Malawi with the world price. The difference between the local price, and the world price is called the price wedge. Understanding the factors that affected the fertilizer price wedge before, during, and after the fertilizer price spike of 2021/22 in Malawi is important for developing policies, programs, and strategies to mitigate the effects of future shocks.

Figure M.1: World price of urea in nominal USD (2010 – 2023)



Source: World Bank Pink Sheets. Urea prices were reported for F.O.B. in the Black Sea before 2022 and in the Middle East since.

3. Objectives

This report has several main objectives. The first is to analyse and document what the change in the fertilizer price wedge during the global fertilizer price spike of 2021/22 meant for Malawi. We estimated which factors explained the local price of urea and the price wedge in the country over the past 13 years. Second, we assessed how the government, donors, and other multi-lateral organizations in Malawi responded to the price spike. Since subsidizing fertilizer was the major policy response of the Malawi government to the price spike, we estimated the impact of fertilizer subsidies on commercial fertilizer demand, and how effective fertilizer policy was at increasing fertilizer use among smallholder farmers. Third, we estimated the profitability of fertilizer use for farmers in Malawi using data on smallholder farm household data in the country that was collected from a phone survey of Malawian smallholder farm households collected in the World Bank's Living Standards Measurement Survey (LSMS) and analysed in Shah (2024). Fourth, we analysed the return on the government subsidy spend to see if subsidizing fertilizer was a good use of the country's agricultural budget. Finally, based on these analyses we made recommendations that the Government of Malawi, donors, and the private sector can take to increase the returns to fertilizer use among farmers. Ultimately this will help to make the fertilizer sector more resilient and better prepared for the next time fertilizer prices rise drastically.

4. Methodology

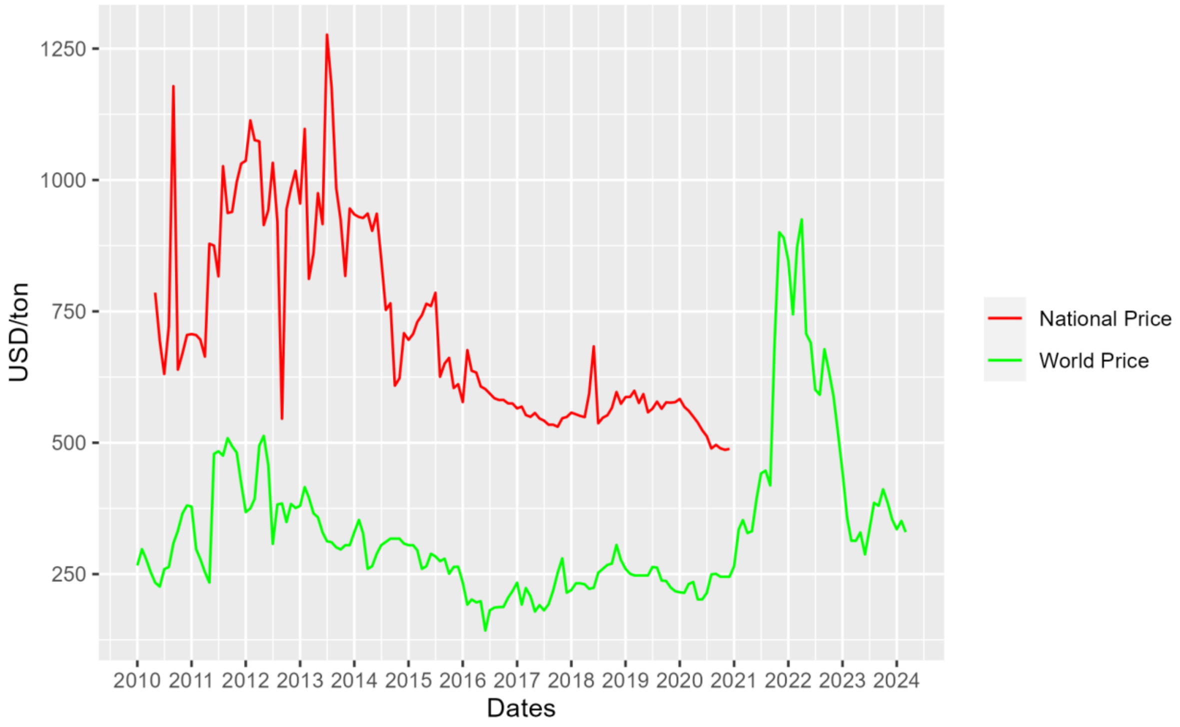
The study applied the following methodology: 1) a qualitative and quantitative econometric analysis of the factors that affected the fertilizer price wedge before during and after the fertilizer price spike in Malawi; 2) a review of the fertilizer market structure that was conducted through key informant interviews with important actors in the fertilizer sector, and review of relevant background documents 3) a scoping review of the literature and available databases on fertilizer subsidy policies in Malawi and fertilizer prices, both global and national, before, during and after the fertilizer price spikes of 2021/22. 4) an analysis of the farmer survey conducted by the World Bank's LSMS team. Using these data we analyzed fertilizer demand, including i) how Malawi's fertilizer subsidy program affected demand for commercial fertilizer for both the average household and along the distribution of assets and landholding, ii) how fertilizer purchasing behavior over time was associated with farm household characteristics, iii) how fertilizer profitability was affected by the price spike and how the benefit-cost analysis of subsidizing fertilizer was impacted by rising fertilizer and maize prices during the price spike.

5. Results and Discussion

i) The fertilizer price wedge in Malawi

Figure M.2a shows the nominal price of urea in Malawi between 2010 and 2020 in USD in red and how it compares to the world price of urea in green. AfricaFertilzer.org does not report fertilizer price data for Malawi beyond 2020 so the local urea price in Malawi ended at that time. The figure indicates that the price of urea in Malawi was always above the world price before the price spike of 2021/22. This is not surprising, given Malawi's position as a fertilizer importer. However, urea prices in Malawi trended downward during that pre-spike period, meaning that the wedge got smaller. The price of urea in Malawi went from a high of over USD 1,250/MT in 2012 to under USD 500/MT at the end of 2020. This suggests that fertilizer use was becoming more profitable for farmers during that period, in US dollar terms, before the price spike.

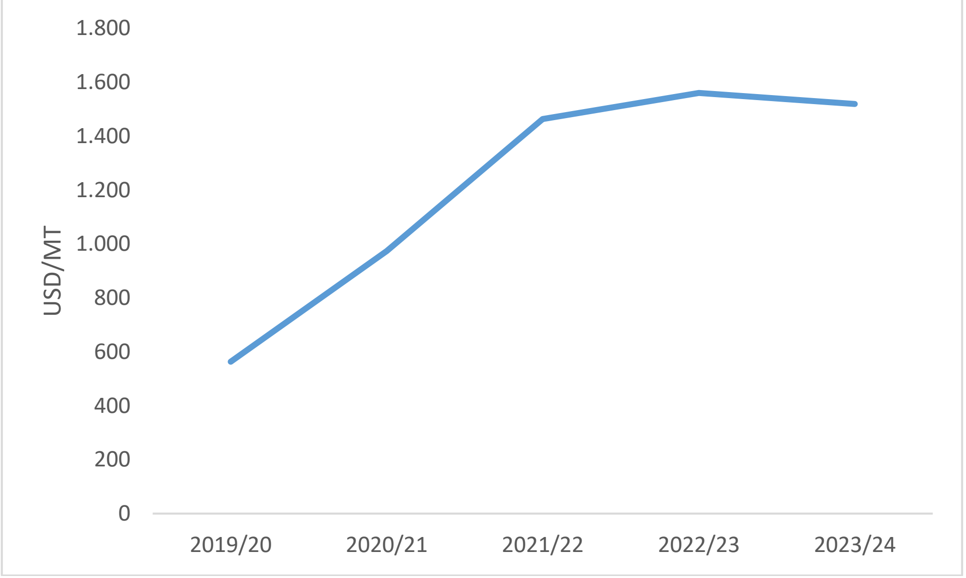
Figure M.2a: Retail prices of Urea in Malawi and the world price in USD/MT (2010-2020)



Notes: Price Wedge = Local urea price (US$/Ton) – World Price (US$/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Malawi began in 2010.

Figure M.2b shows retail prices of NPK and urea between 2020-2024 from the fertilizer association of Malawi denominated in USD. These data supplement the missing data from AfricaFertilizer.org. The figure shows that although the world price of urea in Figure M.2a increased in 2021/22 and then declined, the price in Malawi continued to climb reaching a high near USD 1,600/MT during the 2022/23 season and staying there into the 2023/24 season. This provides evidence that the price of fertilizer in Malawi was extremely decoupled from the world price after the price spike and remained very high for farmers in US dollar terms.

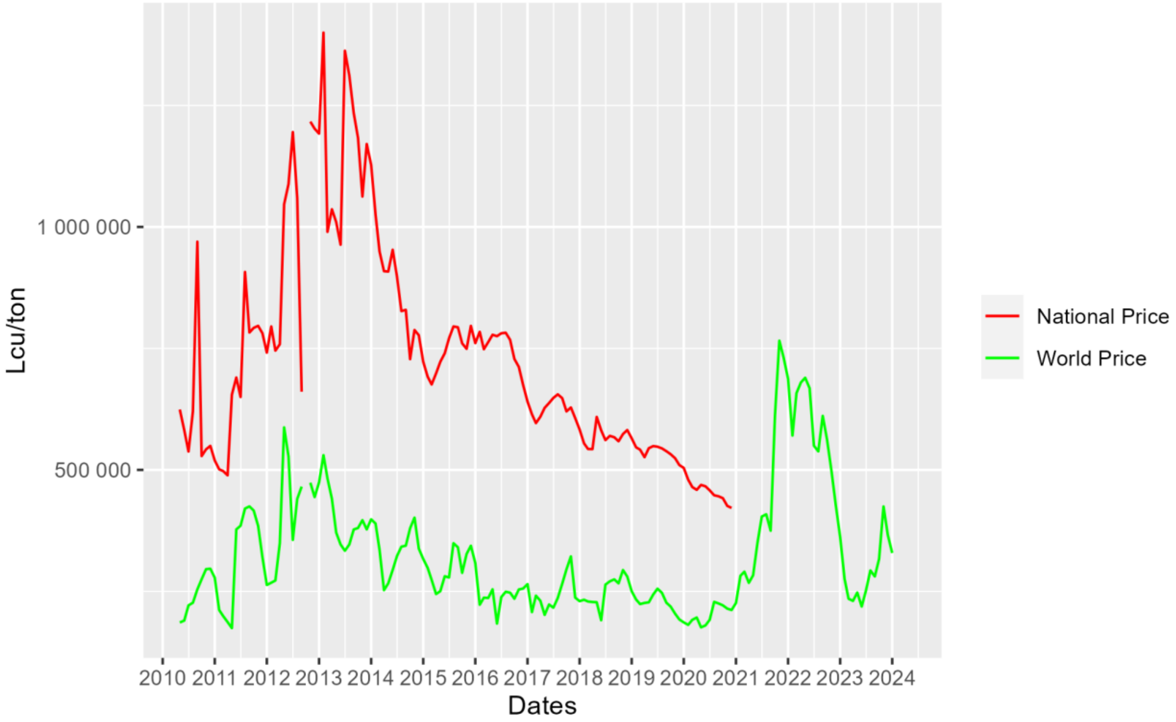
Figure M.2b: Retail prices in Malawi for NPK and Urea from 2020- 2024 (USD/MT)



Source: Agrodealer Association of Malawi.

Figure M.3a presents the same relationship between the price of urea in Malawi and the world price between 2010 and 2020, but this time both price series were measured in nominal local Malawi Kwacha. As with prices in USD, the price of urea in Kwacha declined significantly before the price spike. This again suggested that the fertilizer market may have been becoming more efficient.

Figure M.3a: Retail prices of Urea in Malawi and the world price in Kwacha/MT (2010-2020)

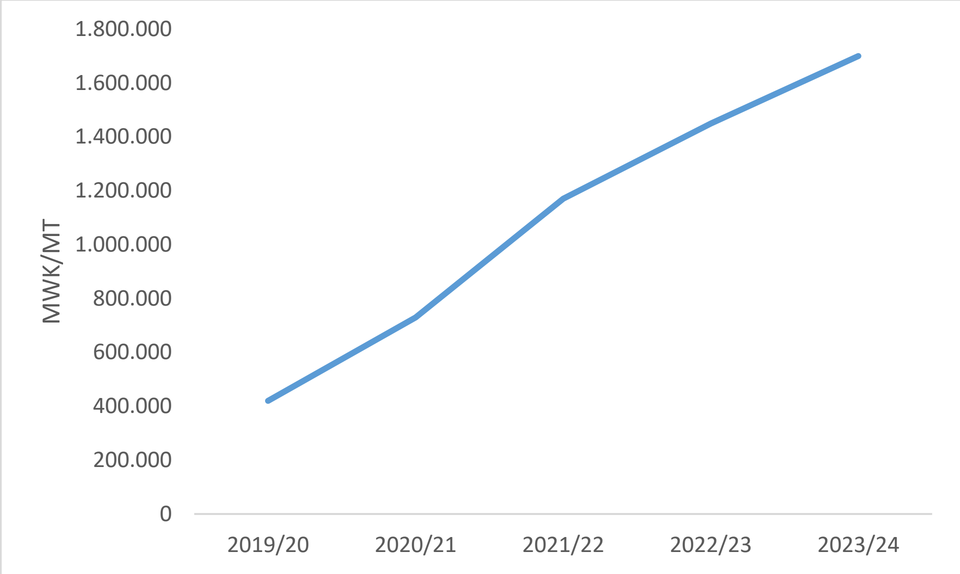


Notes: Price Wedge = Local urea price (Kwacha/Ton) – World Price (Kwacha/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Malawi began in 2010.

Figure M.3b shows retail prices of NPK and urea between 2020-2024 from the fertilizer association of Malawi denominated in Kwacha. As in the dollar-denominated price in Figure M.2b the Kwacha price of urea increased in 2021/22. However, while Figure M.2b shows that the price of fertilizer levelled off in dollar terms in 2022/23 and 2023/24, Figure M.3b shows that the Kwacha urea price continued to rise. It reached Kwacha 1.8 million per ton during the 2023/24 season as the value of the Kwacha was devalued against the dollar and decreased substantially.

The next sub-section discusses the results of our quantitative results on factors that affect the price of urea and the price wedge in Malawi.

Figure M.3b. Retail prices in Malawi for NPK and Urea from 2020- 2024 (Kwacha /MT)



Source: Agrodealer Association of Malawi.

ii) *Quantitative analysis of factors affecting the fertilizer price wedge over time and across countries.*

Figure M.4 presents the box and whiskers plot for the factors that affected the price of urea in Malawi between 2010 and 2023. This figure is based on a time series regression of monthly urea prices collected by AfricaFertilizer.org. The urea price was regressed against a set of factors that were hypothesized to affect them; the factors were the same ones used in the cross-country panel model.

The World Bank's *Corruption Control Index* was negative and statistically significant, suggesting that an increase in control of corruption (meaning more control of corruption) by one standard deviation resulted in a 28.9% decrease in urea prices on average.[14] This indicates that reducing corruption could lead to lower fertilizer prices by minimizing market inefficiencies.

The variable *Election Yr* representing the year of a presidential election was negative and statistically significant. It indicated that election years were associated with a 0.14% decrease in urea price on average. This might reflect efforts by the incumbent government to influence fertilizer prices during election periods.

The *Log of Real Interest* was positive and statistically significant. This suggested that a 1% increase in real interest rates was associated with a 0.50% increase in urea prices on average. Higher real interest rates may increase the cost of financing to purchase fertilizers, leading to higher prices.

The Log of Malawi's GDP was negative and statistically significant. It indicated that a 1% increase in GDP was associated with a 1.02% decrease in urea prices on average. This suggests that economic growth, which is likely correlated with improved infrastructure and market efficiency, reduced fertilizer prices.

CPI Movements were negative and statistically significant. The result indicated that a 1 percentage point increase in CPI was associated with a 1.12% decrease in urea prices on average. This is the opposite of our expectations and likely is the result of a spurious relationship between this variable and urea price levels.

[14] Control of Corruption is in log linear form so the impact on y is (exp(-1.6*.15)-1)*100, where .15 is the standard deviation of control of corruption in Malawi.

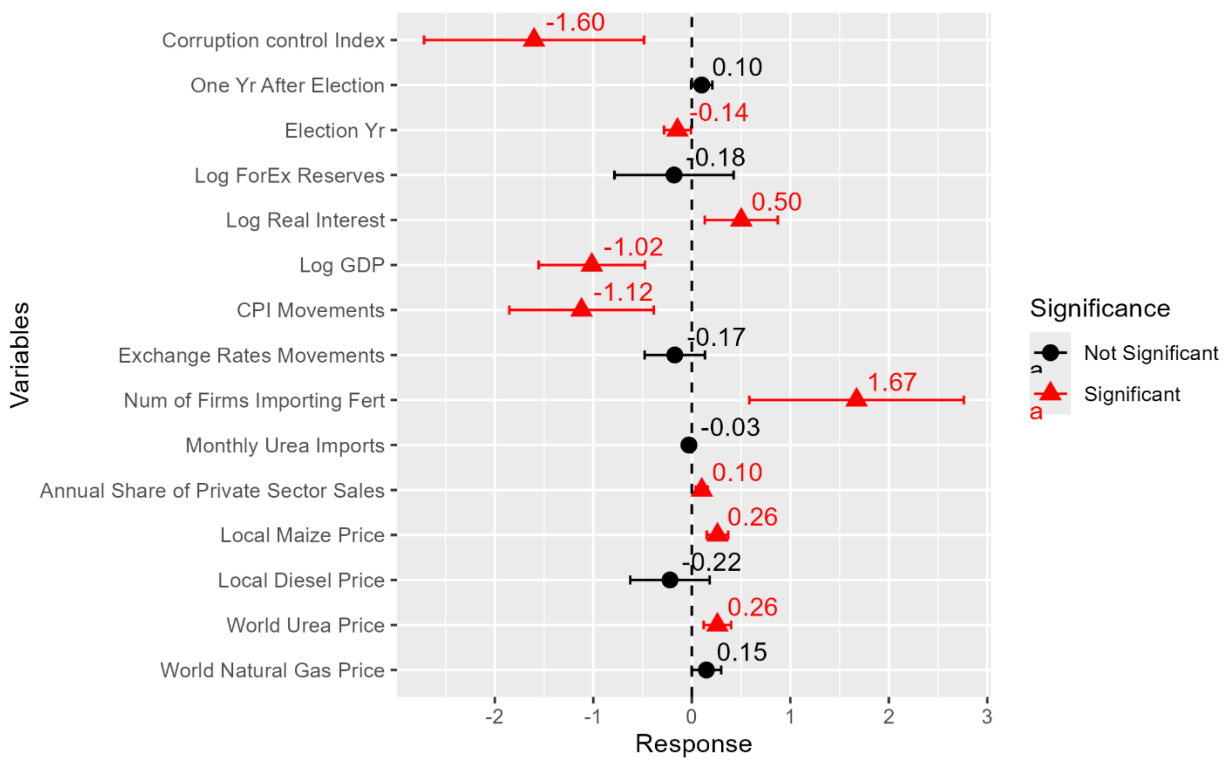
The *Num of Firms Importing Fert* was positive and statistically significant. It suggested that a 1% increase in the number of firms importing fertilizer was associated with a 1.67% increase in urea prices on average. This could indicate that stronger private sector demand supports more private sector firms and leads to higher prices.

The Annual Share of Private Sector Sales in total sales was positive and statistically significant. It indicated that a 1% increase in the annual share of private sector sales was associated with a 0.10% increase in urea prices on average. This implies that high demand for fertilizer can support a larger private sector and robust demand is associated with higher fertilizer prices.

The previous month's *Local Maize Price* was positive and statistically significant. It suggested that a 1% increase in maize prices was associated with a 0.26% increase in urea prices on average. Higher maize prices can signal greater anticipated demand for fertilizer, leading to higher urea prices.

The *World Urea Price* was positive and statistically significant. It indicated that a 1% increase in the world urea price was associated with a 0.26% increase in urea prices on average. This suggests that global market conditions for urea influence local prices.

Figure M.4. Factors affecting Urea prices in Malawi from 2010-2020 in Kwacha/MT



Notes: Results are from a linear regression model of 138 monthly observations of nominal urea price levels in Malawi denominated in Kwacha from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into Kwacha to correspond to the impacts in local markets. The model includes year fixed effects.

Results by Variable for Price Wedge Model in Kwacha

Figure M.5 presents the box and whiskers plot for the factors that affected the price wedge in Kenya between 2010 and 2023. This figure is based on a time series regression of the monthly price wedge, defined as the difference between the urea price in Malawi and the world price, both in Kwacha. The wedge was regressed against a set of factors hypothesized to affect it, similar to those used in the cross-country panel model.

The *One year after the presidential Election* variable was positive and statistically significant. It indicated that the year following an election was associated with a 0.17 Kwacha increase in the price wedge. This is opposite of our hypothesis and may just indicate a spurious correlation between this variable and higher urea prices.

Log of Malawi's GDP was negative and statistically significant. This meant that a 1% increase in GDP was associated with a 1.15% decrease in the price wedge on average. This suggests that economic growth, which improves infrastructure and market efficiency, reduces the price differential between local and world fertilizer prices.

Movements in Malawi's CPI was negative and statistically significant. It indicated that a 1 percentage point increase in CPI was associated with a 1.26% decrease in the price wedge on average. This is opposite of our hypothesis and may just indicate a spurious correlation between this variable and higher urea prices.

The variable, *Exchange Rates Movements* was negative and statistically significant. It indicated that when Malawi's Kwacha depreciated by 1% against the dollar the price wedge increased by 0.84% on average. A weakening local currency increases the cost of imported fertilizers, thereby raising local prices relative to world prices.

The variable *Log Share Private Sector Sales in total annual sales* was positive and statistically significant. It suggested that a 1% increase in the annual share of private sector sales was associated with a 0.13% increase in the price wedge. This implies that higher private sector sales may reflect robust demand that is related to a higher price differential.

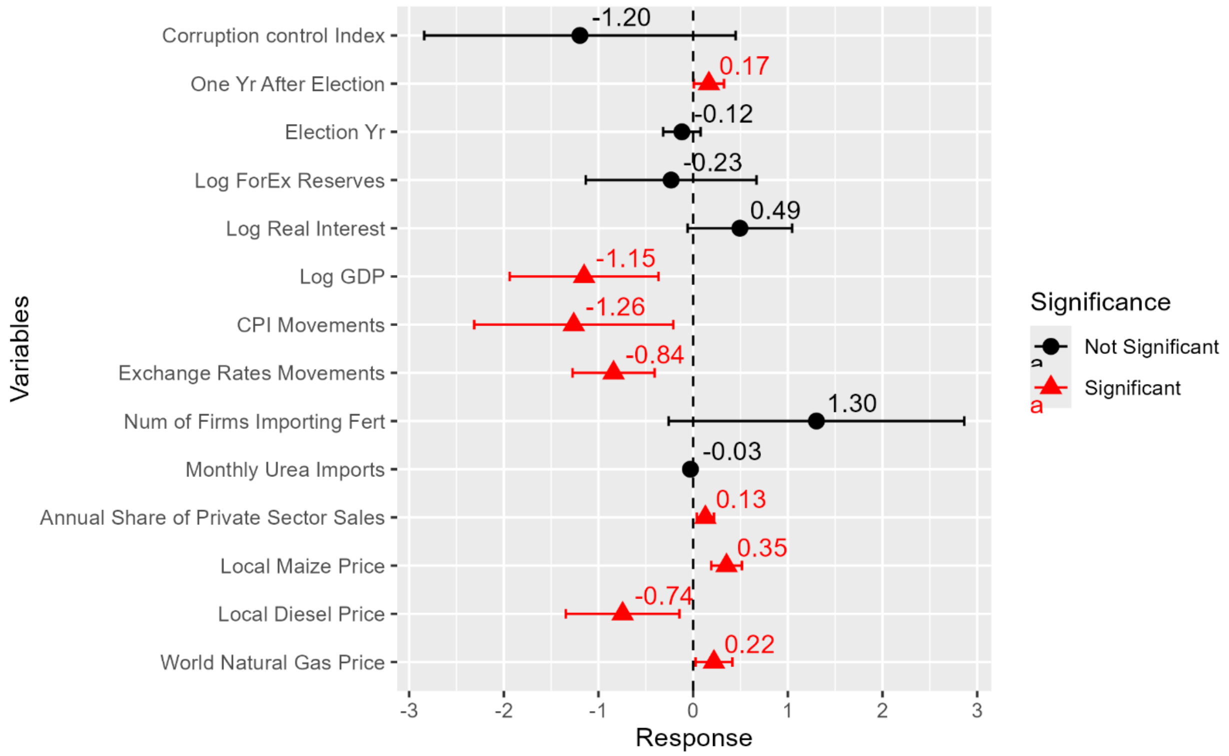
The previous month's *Lagged Maize Price* was positive and statistically significant. It suggested that a 1% increase in maize prices was associated with a 0.35% increase in the price wedge. Higher maize prices, indicated greater anticipated demand for fertilizer, pushed up local prices relative to world prices.

Local Diesel prices in Malawi were negative and statistically significant in the wedge model. This was the opposite of our expectation since diesel is a major cost factor in fertilizer transport. However, we found that it was positive in the cross-country price wedge model as well as other individual country price level models as expected. Therefore, we may have picked up some spurious correlation between diesel prices and the price wedge in Malawi.

World Natural Gas Price was positive and statistically significant. It indicated that a 1% increase in the world's natural gas price was associated with a .22% increase in the price wedge on average. This was as expected since natural gas is a major cost component of fertilizer. We expected that increased natural gas costs would get passed on in part to fertilizer consumers around the globe, including in Malawi.

Figure M.5: Factors affecting Urea price wedge in Malawi 2010-2020 in Kwacha/MT

Dependent variable: urea price wedge asinh(nominal urea price in Kwacha – world price in Kwacha)



Notes: Results are from a linear regression model of 139 monthly observations of nominal urea price wedges in Malawi. The price wedge is calculated as the price of urea in Kwacha in each country obtained from AfricaFertilizer.org minus the world price of urea obtained from the World Bank Pink Sheets converted to Kwacha. The triangles and circles are the mean estimates of each variable's effect on urea price wedge. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea price wedge, while variables that are greater than zero denoted that the factor had a positive effect on urea price wedge. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into Kwacha to correspond to the impacts in local markets. The model includes year fixed effects.

iii) *Analysis of the fertilizer market structure in Malawi*

Malawi's fertilizer market structure has been closely linked to the government's subsidy programs which can account for up to 70% of total fertilizer use in the country (Chapoto et al. 2023). Variations in how the government implemented its input subsidy program have strongly impacted the fertilizer market and its structure. These variations include the level of direct government engagement in fertilizer procurement and distribution, along with the targeted quantities of subsidized fertilizer it distributes. Table K.1 presents the structure of the fertilizer market in Malawi over the past ten years. It indicates that the fertilizer sector has been very concentrated along all stages of the supply chain. Malawi has never had an abundant or cheap source of domestic fossil fuels, so it has not manufactured any fertilizer (though two companies in Malawi have been involved with blending). There was a slight increase in the number of firms importing fertilizer in Malawi in the past 10 years. In 2014, only nine firms imported 90% of the fertilizer used in Malawi. This increased to 11 in 2019 and stayed at that level in 2022 and 2023 during and after the fertilizer price spike.

The main port to import fertilizer into Malawi is Beira in Mozambique. This port has traditionally had congestion issues but recently has made infrastructure upgrades that have made it run more smoothly. Nakara port in Mozambique handles a small amount of Malawian fertilizer while the port of Durban, South Africa has handled an even smaller amount of fertilizer meant for Malawi. It can take between three and four weeks from order placement to delivery in Malawi - one week to clear the port and between one and two weeks t from the port to the destination in Malawi.

In 2014, three fertilizer wholesalers controlled 90% of the fertilizer in Malawi. That number increased to seven in 2019, then it dropped to five during and after the spike in 2022 and 2023. A relatively, small number of companies retailed most of the fertilizer that farmers bought in Malawi over the past ten years. In 2014, only six companies sold 90% of the fertilizer in Malawi, while in 2019, 20 companies did so. This dropped to 15 companies retailing fertilizer in 2022 and 2023, during the price spike, and again linked to changes in the subsidy program. While the same two firms – Malawi Fertilizer Company (MFC) and Optichem – accounted for 90% of the domestic fertilizer blending from 2014 to 2024, recent investments after 2022 have more than doubled the bending capacities of both firms. MFC recently supplied specific blends to other companies such as Agora, Farmer's World and the parastatal Smallholder Farmers Fertilizer Revolving Fund of Malawi (SFFRFM). However, as of 2023, MFC did not reach its production capacity, in part due to high prices.

Malawi's weak infrastructure led to significant transport and marketing margins throughout the country. An analysis of cost buildups along Malawi's fertilizer supply chain estimated a 50% price increase from cost and freight at the port to wholesale in major cities in Malawi and an additional 15% price increase to retail outlets (Chapoto et al. 2023). This ultimately implied an 80% price increase from port to retail. These costs excluded last-mile delivery to farms, which in Malawi can be quite high due to a damaged rural road network and limited rural penetration of agro-dealers who are mostly operating near larger trade centers on main roads. Further, agro-dealers emphasized that the distribution and transport costs have increased markedly with rising fuel prices and currency devaluation in the past three years, and these costs have been directly passed on to farmers through higher prices.

According to our conversations with agro-dealers in Malawi, the private sector was significantly affected by the fertilizer price spikes. Many companies have adjusted their import quantities and types as a result of lower demand from farmers caused by higher prices. Since the price spike there have been reports of more fertilizer outages and shortages where dealers ran out of stocks. This also meant that many companies stocked the type of fertilizer that was available, not necessarily the type of fertilizer that farmers wanted to buy.

Before the price spikes, and under a different subsidy program that prioritized private sector distribution, smaller 'satellite' input retailers would set up in rural areas, providing better fertilizer access to farmers. But since 2022 these seasonal fertilizer retailers have effectively stopped, with larger retailers instead concentrating sales in primary trade centers. With declines in fertilizer sales, rural agro-dealers pivoted to selling a more diverse portfolio of products including hardware and groceries.

The Malawian market has been quite volatile in terms of buyers and sellers. In 2023, nine companies who sold fertilizer exited the market, compared to only 2 in 2020. 2023 exits included large regional players such as Nitron, OCP and Omnia. However, 11 new sellers of fertilizer entered the market in 2023, compared with only two in 2019. Several existing companies also continued to struggle as of 2023. Ag Resources Limited effectively shut down during the spike while Blantyre Limited and Afriventures have barely been operating. Meanwhile, some companies increased their operations after the spike. This included Paramount Holdings Limited, and Export Trading Group, both of whom increased the scale of their fertilizer distribution in part because they had been able to secure the distribution of a portion of subsidized fertilizer. Other large fertilizer companies including Farmer's World and Agora have maintained a steady presence during the sector changes. Thus, it seems that the fertilizer price spike may have ushered some firms out of the market in Malawi while providing new opportunities for other firms. However, it remains to be seen how this change in market structure affects farmers' access to and use of fertilizer in Malawi.

Table M1: The number of companies in Malawi that control 90% of the fertilizer that was available at different stages in the supply chain during key years.

Stage	In 2014 (ten years ago)	In 2019 (just before the fertilizer price spike)	In 2022 (during the fertilizer price spike)	In 2023 (last year)
Manufacturing	0	0	0	0
Importing	9	11	11	11
Blending	2	2	2	2
Wholesaling	3	7	5	5
Retailing [1]	6	20	15	15

Source: Importer Information from Afriqom; other information from International Fertilizer Development Corporation (IFDC). [1]It is important to note that at number of firms refers to the number of companies, not the number of shops selling fertilizer. For example, larger companies have hundreds of retail shops across the country selling fertilizer under their brand. All of these shops count as one company in Table M.1. It is also important to note that there are hundreds of independent agro-dealers located across Malawi that sell fertilizer to smallholder farmers. These agro-dealers each count as separate companies, but the volume of fertilizer they sell is relatively small so they make up the other 10 percent of the market that is not counted in Table M.1.

iv) Analysis of fertilizer policies in Malawi around the fertilizer price spike

Policy Response

When global economic shocks occur that affect domestic commodity supply chains and prices, countries typically respond with policies to try to mitigate the impact on their citizens. . The policy responses often have protracted impacts well after the global shocks have lessened. Such policy responses might achieve their intended objectives but unintended consequences to other aspects of the economy are often also realized. They also might not necessarily achieve their intended objectives. The policy responses often have trade-offs, as countries often face options with differing consequences. It is, therefore, critical that a country's policy responses to economic shocks are guided by its contextual conditions and informed by up-to-date evidence as well as the global and regional dynamics. This section identifies key fertilizer policy interventions in Malawi before and during the recent fertilizer price spikes.

Fertilizer Policy Before the Price Spike

The government of Malawi has a long history of engagement in fertilizer markets. The primary policy tool has been to subsidize inorganic fertilizers and maize seed for farmers. The justification for subsidizing inputs in Malawi has been because the country's landlocked position with poor infrastructure, declining soil fertility, and sporadic rainfall made fertilizer use risky and unprofitable for the millions of smallholder farmers who grow maize for food security in the country (Benson et al. 2024). Thus, the rationale has been that farmers have not found it profitable to use enough fertilizer to grow sufficient quantities of maize to meet their caloric needs without a subsidy that lowered its price. Furthermore, it has often been argued that subsidizing fertilizer so Malawians can grow maize has been cheaper and more cost-effective than importing maize (Chirwa and Dorward 2013). However, challenges to that claim have been increasing. The challenge for input subsidy programs in a country like Malawi is that they become the largest social safety net program and consume large shares of the country's agricultural budget (for example in 2008/09 funding input subsidies accounted for 17% of Malawi's budget). This substantial expenditure puts a tremendous amount of pressure on subsidy programs to reach multiple objectives such as increasing agricultural productivity, enhancing food security, and reducing poverty.

Malawi implemented universal subsidy programs that existed up to the early 1990s (ADMARC's implicit taxation and the Starter Pack). Targeted subsidies started in the late 1990's and continue to date, including the Targeted Farm Input Program (TIP), the Farm Input

Subsidy Program (FISP), and the Affordable Input Program (AIP). In 2005/06 the government resumed the implementation of the input subsidy program abandoned in 1995 due to the enormous pressure it exerted on the government budget. The FISP was scaled up beginning in 2005/06 and expenditure on the program reached a high of $252 million in 2008/09 when it comprised 6.6% of GDP. Due to changes in government priorities, high costs, and pressure from donors, the program was gradually scaled down between 2008/09 when 2 million beneficiaries were targeted, and 2019/20 when 900,000 beneficiaries were targeted and the program cost 1.3% of GDP.

Fertilizer policy during the price spike

The new government in Malawi announced a rebranded subsidy program called the Affordable Inputs Program (AIP) during the 2020/21 growing season. The program was universal and intended to target all smallholder households in the country. During that season about 3.8 million beneficiaries were each offered 100 kg of subsidized fertilizer plus improved seed. The cost of AIP was over 1.5 percent of Malawi's GDP, making it one of the largest public investment programs for the government. The fiscal sustainability of AIP was questioned, as fertilizer prices spiked in 2021/22. Regardless, 3.7 million beneficiaries were targeted for the AIP, at 1.3% of GDP in that year. In 2022/23 2.5 million beneficiaries were targeted at 1.6% of GDP as fertilizer prices in Malawi remained high. The ongoing AIP, dubbed AIP 2.0, was launched in October 2023 to support farmers during the 2023/24 season. It was expected that 1.49 million farming households would each access 50-kilogram bags of NPK 23-10-5 and Urea fertilizer and 5 kilograms of seed at a subsidized rate of MWK15,000 ($13) per 50kg bag during that season.[15] Malawi's national budget for the 2023/24 fiscal year allocated MWK117 billion to the AIP, of which MWK110 billion was earmarked for fertilizer subsidies[16]. This budget allocation and number of beneficiaries suggested that the government may have been trying to move back towards a smaller subsidy program.

The government's strategies for procuring and distributing fertilizer have changed as a result of the price spike. In the 2021/22 season and prior, subsidized fertilizer was distributed largely through private agro-dealers of varying sizes. However, the unexpected rise in fertilizer prices along with a currency devaluation increased the government's bill for the subsidies. A public dispute followed where the government blamed the private sector for the rising prices and theft, but the private sector openly complained of delayed payments. In the 2022/23 season, AIP was distributed fully through the government-run SFFRFM. This too had challenges in the form of corruption and late fertilizer deliveries. For the 2023/24 season, the government again was a large player in distribution through SFFRFM, but they also engaged a few large-scale agro-dealers in the subsidy program.

Other fertilizer program responses

The overarching development goal for the Government of Malawi has been to promote economic growth by improving the productivity and profitability of agriculture, especially among smallholder farmers. While the fertilizer subsidy program has been the focal government support program, public-private partnerships and encouraging private investment, especially in the fertilizer sector are an important complementary strategy.[17] In addition to changes in the subsidy program, the government has made deliberate efforts to reduce its reliance on imported chemical fertilizers since the price spikes. The government has promoted a large increase in domestic blending capacities through investments in Malawi's two largest blenders – Agrichem and Malawi Fertilizer Company – both have expanded existing facility capacity and built a new blending plant in Liwonde. There is also a new organic fertilizer production plant in Blantyre.

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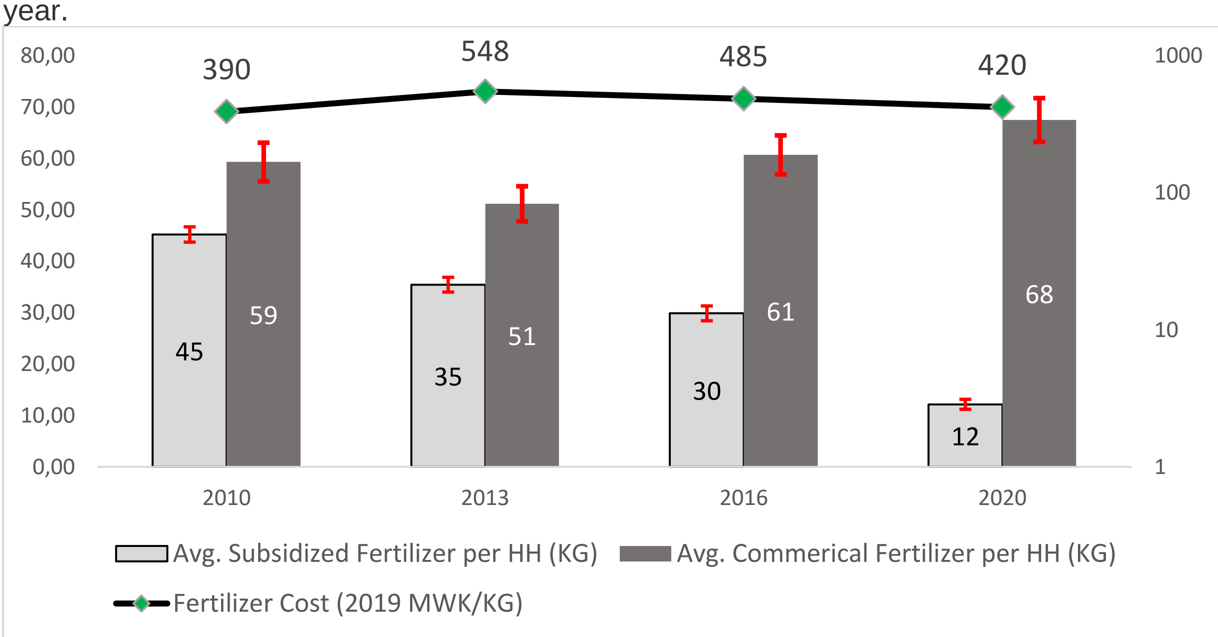
[15] https://malawi24.com/2023/10/17/1-5-million-farmers-to-benefit-from-2023-aip/
[16] https://massp.ifpri.info/2023/03/22/how-to-weather-the-lean-season-with-a-lean-aip/
[17] IFDC, 2013. Malawi fertilizer assessment.

On the farmer side, there has been an increase in the use of 'mbeya' fertilizers because of the high prices of inorganic fertilizers. Mbeya fertilizer is a mixture of inorganic fertilizer, manure, and organic materials. It is intended to increase crop production with lower application rates of inorganic fertilizers. Mbeya methods have been promoted by government extension agents and NGOs.

v) Fertilizer Demand Impacts

The following section uses analysis from the World Bank LSMS panel dataset, collected to cover the 2009/10, 2012/13, 2015/16 and 2018/19 growing seasons. This panel tracked Malawian smallholder households over the previous decade. Though this data does not cover the fertilizer price spike of 2021/22, it is the most comprehensive dataset on Malawian smallholder farmers. As such, we drew on the analysis conducted by Shah (2024) to make some predictions about the impacts of the fertilizer price spike on fertilizer demand and profitability in Malawi. Figure M.6 shows the average fertilizer prices that farmers paid in the different years of the survey, compared to the average amount of subsidized and commercial fertilizer that they acquired. The bar graph at the top shows that the real average price of fertilizer (NPK and urea) rose from MWK 390/kg in 2009/10 to MWK 548/kg in 2012/13, before dropping to 485/kg in 2015/6 and then MWK 420/kg in 2018/19. At the same time, average commercial fertilizer purchases declined from 59 kilograms per household in 2009/10 to 51 kilograms in 2012/13 but grew to 61 kilograms in 2015/16 and 68 kilograms in 2018/19. Thus, between 2009/10 and 2018/19 commercial fertilizer use increased by 15%. While commercial fertilizer use generally trended upward over the decade, the average amount of subsidized fertilizer that farmers acquired was scaled down. This finding was consistent with the discussion of subsidy policy in the previous section, as the government limited subsidized fertilizer allocations in the latter half of the past decade. From these figures, it seems that commercial fertilizer rose at the same time subsidized fertilizer declined in Malawi between 2009/10 and 2018/19.

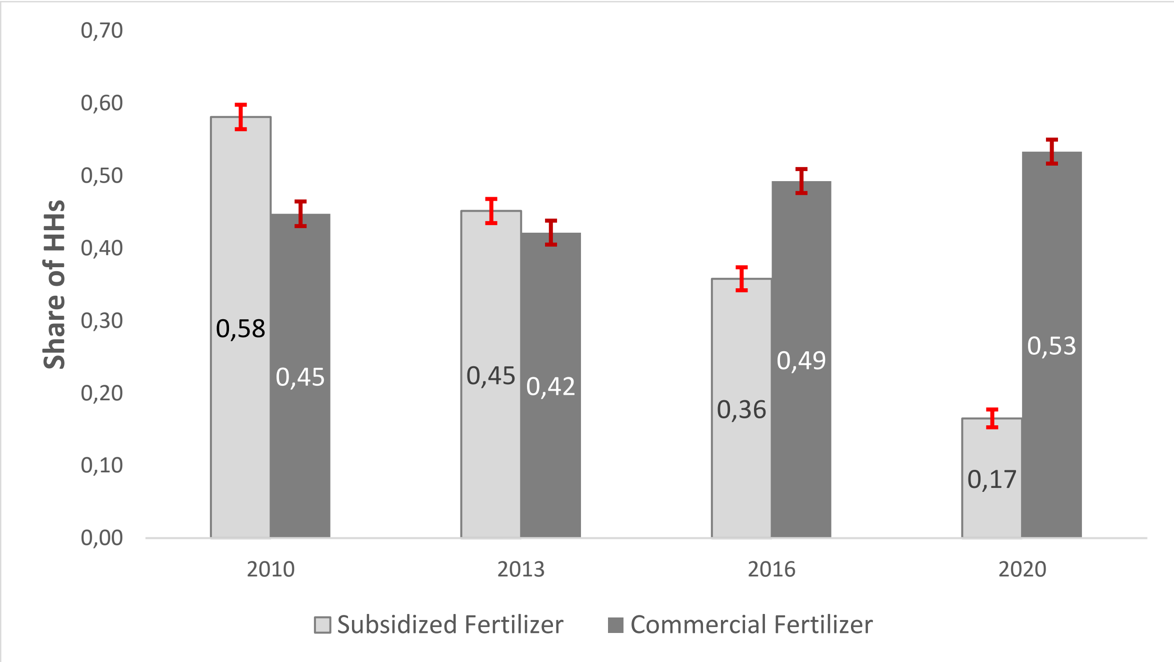
Figure M.6: Average subsidized fertilizer and commercial procured per household by survey year.



Source: constructed from the World Bank LSMS data; the years of the survey were 2009/10, 2012/13, 2015/16, and 2018/19; red bars on the figures are the standard errors.

Figure M.7 relates to Figure M.6 by showing the percentage of households who purchased subsidized and commercial fertilizer between 2009/10 and 2018/19 in Malawi. The results were consistent as the percentage of households acquiring subsidized fertilizer went down over the decade as the government scaled down the subsidy program, reaching a low of 17% participation in 2018/19. At the same time, the percentage of people purchasing commercial fertilizer declined from 45% in 2009/10 to 42% in 2012/13, but then rose to 49% in 2015/16 and rose further to 53% in 2018/19. This was an 18% increase in participation rate in commercial fertilizer markets between 2009/10 and 2018/19 which was consistent with a 15% increase in total fertilizer over that time, as seen in Figure M.6. Together these figures suggested that commercial fertilizer participation rates and average use may have increased over the decade due to lower fertilizer prices and less subsidized fertilizer distributed by the government. The following quantitative analysis will test this descriptive finding more rigorously.

Figure 7: Share of households who procured subsidized and commercial fertilizer by survey year.



Source: constructed from the World Bank LSMS data; the years of the survey were 2009/10, 2012/13, 2015/16, and 2018/19; red bars on the figures are the standard errors.

Table M.2 presents the crowding out (displacement) rates of commercial fertilizer by subsidized fertilizer that we calculated from the LSMS data for Malawian farmers between 2009/10 and 2018/19. We found that the crowding-out rate of commercial fertilizer by Malawi's subsidy program was 27% on average. This meant that every 100 kilograms of subsidized fertilizer acquired by farmers in 2023 only led to 73 kilograms of new fertilizer applied to their fields. The remaining 27 kilograms were displaced commercial purchases.

Table M.2 also shows the crowding out rates estimated by year, area cultivated, and assets. panel 1 shows that the crowding out rate was 29% in 2009/10, and declined to 27% in 2012/13 and then to 26% in both 2015/16 and 2018/19. This finding was consistent with the descriptive Figures M.5 and M.6, because the crowding out rate declined over the decade as the amount of subsidized fertilizer allocated to households declined over time as well. Panel 2 shows that the crowding out rate for the 20% of the sample with the smallest area cultivated was 19%. This more than doubled for the 20% of the sample with the most land. Their crowding out rate averaged 44%. This was consistent with the finding in Panel III that showed that the crowding-out rate for the poorest 20% of the sample in terms of assets was 21% on average, but that rate rose to 36% for the wealthiest 20% of the sample. These results make sense and are consistent with studies from other countries (Ricker-Gilbert et al. 2011; Jayne et al. 2013). Wealthier farmers with more land are more likely to buy commercial fertilizer. Thus, they displace more of their commercial fertilizer purchases when they access subsidized fertilizer than do smaller-scale, more limited-resource farmers.

Table M.2: Crowding out by year, area cultivated, and assets

Category	Average Crowding out	P-value	Category Average
Overall	-0.27	(0.00)	-
Year			
2009/10	-0.29	(0.00)	-
2012/13	-0.27	(0.00)	-
2015/16	-0.26	(0.00)	-
2018/19	-0.26	(0.00)	-
Area cultivated			*Hectares*
SMALLEST 20%	-0.19	(0.00)	0.18
20 - 40%tile	-0.21	(0.00)	0.37
40 - 60%tile	-0.22	(0.00)	0.57
60 - 80%tile	-0.27	(0.00)	0.86
LARGEST 20%	-0.44	(0.00)	1.70
Asset Quintile			*US $*
POOREST 20%	-0.21	(0.00)	0.75
20 - 40%tile	-0.23	(0.00)	9.27
40 - 60%tile	-0.24	(0.00)	36.24
60 - 80%tile	-0.28	(0.00)	79.30
RICHEST 20%	-0.36	(0.00)	668.98

Source: constructed from the World Bank LSMS data; the years of the survey were 2009/10, 2012/13, 2015/16, and 2018/19.

vi) *Fertilizer user demographics*

The next three tables present the characteristics of farming households who purchased commercial fertilizer in every survey year from the LSMS data (2009/10, 2012/13, 2015/16, and 2018/19), those who bought in some years and not others, and those who never bought it. Table M.3 shows that 15% of smallholder farmers in the sample purchased commercial fertilizer in every survey year, while 63% bought fertilizer in some survey waves, but not in others. Additionally, 22% of households never bought commercial fertilizer during the four survey years.

Table M.3: Percentage of households that bought commercial fertilizer in every survey year, in some survey years, and in none of the waves.

Group	% of the Sample in the group
% of the sample who purchased commercial fertilizer in every survey year	15
% of the sample who purchased commercial fertilizer in some of the survey years but not all.	63
% of the sample who never purchased commercial fertilizer in any survey year	22
Total	100

Source: constructed from the World Bank LSMS data; the years of the survey were 2009/10, 2012/13, 2015/16, and 2018/19.

To better understand the characteristics of farmers who were using fertilizer over time in Malawi, we broke down the landholding distribution of farmers into three categories: i) those with less than one hectare of land, ii) those with between one and two hectares, iii) those with more than two hectares. We also disaggregated these categories by whether or not the household was classified as living in the northern, central or southern regions of the country. The results are shown in Table M.4. Column 4 indicated that farms with less than one hectare made up 84% of all farms nationally, and they made up the vast majority of all farms in each region. Column 2 indicated that across all regions of Malawi, farms that had more than two hectares used more fertilizer in total than did smaller farms. However, column 3 showed that on a per-hectare basis, the smallest farms that were less than one hectare used fertilizer more intensively than larger farms did. It is interesting to note that in all regions and nationally the group that had more than two hectares used less fertilizer per hectare than the group that had less than one hectare but they used more fertilizer than the group that had between one and two hectares. It could be because the smallest landholding group farmed their plots very intensively to make fertilizer use high on a per hectare basis compared to other groups, but the group that had between one and two hectares. Overall Table M.4 suggested that small-scale farms in Malawi use less fertilizer overall, but farm more intensively than larger farms in Malawi.

Table M.4: Landholding and Location Demographics for Households Purchasing Commercial Fertilizers in Malawi

Landholding size	**(1) Mean Land Holding in group (Ha)**	**(2) Average Commercial fertilizer purchased in group (kg)**	**(3) Amount Purchased per hectare in group (kg) *(conditional*)***	**(4) Percent of total sample in group**
North				
Less than 1.0 hectares	0.3	70	162	6.3%
Between 1.0 and 2.0 hectares	1.4	158	110	1.5%
Greater than 2 hectares	2.6	330	126	0.2%
Central				
Less than 1.0 hectares	0.3	52	107	36.1%
Between 1.0 and 2.0 hectares	1.4	115	83	7.1%
Greater than 2 hectares	2.7	255	89	1.6%
South				
Less than 1.0 hectares	0.3	25	68	41.3%
Between 1.0 and 2.0 hectares	1.3	56	43	5.2%
Greater than 2 hectares	2.8	176	66	0.7%
National – Total				
Less than 1.0 hectares	0.3	40	92	84%
Between 1.0 and 2.0 hectares	1.4	98	71	14%
Greater than 2 hectares	2.8	240	86	3%

Source: constructed from the World Bank LSMS data; the years of the survey were 2009/10, 2012/13, 2015/16, and 2018/19.

Table M.5 used linear regression to analyse the factors that were associated with purchasing commercial fertilizer in all four survey years (2009/10, 2012/13, 2015/16, 2018/19) in column 1, and factors associated with not purchasing commercial fertilizer in any year in column 2. The results from column 1 indicate that households who acquired subsidized fertilizer were 10 percentage points (pp) less likely to buy commercial fertilizer in every year on average. Conversely, an additional acre of land was associated with households being 9 pp more likely to purchase commercial fertilizer on average. Conversely, a female-headed household was 7 pp less likely to purchase fertilizer commercially in all years on average. This likely relates to resource constraints that female-headed households often face. Finally, an increase in assets led to an increase in the probability that a household bought fertilizer commercially in all years.

Column 2 indicated that households who acquired subsidized fertilizer were 5 pp less likely to never have bought fertilizer in any survey year. This is consistent with the finding that people who acquired subsidized fertilizer were more likely to have been the ones who bought it commercially in Malawi. In addition, a higher maize price in the previous season had a very small positive effect on the probability of never buying commercial fertilizer. Female-headed households were 12 pp more likely to have never bought commercial fertilizer, again likely due to resource constraints. Additionally, households in which the head of the household attended school, were 10 pp less likely to never have purchased fertilizer, possibly because these households had a better understanding of how to use the input. Conversely, households with older heads were more likely to have never purchased fertilizer, possibly because older heads were less interested in adopting the technology. Households further from government ADMARC fertilizer depots were more likely to have never purchased fertilizer, possibly because they lacked easy access to the input. Finally, households with more assets were less likely to never have purchased commercial fertilizer, likely because they had the financial resources to buy and use the input.

Table M. 5: Demographic characteristics of households who bought commercial fertilizer in every survey year and those who did not buy in any survey year

Characteristic	(1) Bought in every survey year	(2) Did not buy in any year
Acquired subsidized fertilizer in 2022	-10 percentage point effect on average	-5 percentage point effect on average
Fertilizer price		
Previous lean season maize price	NSS	Very small (+) effect on average
Land area (acres) operated by households in 2023	+ 9 percentage point effect per acre on average	NSS
Household size	NSS	NSS
=1 if female-headed household	- 7 percentage point effect on average	+ 12 percentage point effect on average
Age of household head	NSS	Very small (+) effect on average
If the household head attended school	NSS	-10 percentage point effect on average
Death of HH member in last 12 months	NSS	NSS
Borrowed on credit in last 12 months	NSS	NSS
The number of comm. fertilizer sellers in community	NSS	NSS
Annual precipitation (in mm)	NSS	NSS
Distance to the nearest ADMARC depot	NSS	Very small (+) effect on average
Distance (km) from home to nearest agro-dealer	NSS	NSS
Distance (km) from home to the nearest national government-subsidized sale point	NSS	NSS
Household assets	Very small (+) effect on average	Very small (-) effect on average

Source: constructed from the World Bank LSMS data; years of the survey were 2009/10, 2012/13, 2015/16, 2018/19; NSS means that the factor was not found to be statistically significant in a regression model

vii) Maize-to-fertilizer response rate impacts

The maize-to-fertilizer response rate tells us how many kilograms of maize a farmer obtains from a kilogram of fertilizer. This relationship is important for understanding how much an additional kilogram of fertilizer contributes to maize production, food security and the profitability of fertilizer for farmers. It is crucial to note that fertilizer is one input into the production of food and farmers must have sufficient amounts of complimentary inputs, such as seed, land, labor, soil fertility, water, and farm management ability for fertilizer use to be effective. Estimates of maize-to-fertilizer response rates in Malawi conducted during the mid-1990's that were obtained from productive farmers on good soil with management from researchers indicated that these farmers could obtain an average of 8 kilograms of additional maize per kilogram of additional fertilizer they applied (Benson et al. 2021). Thus if a farmer used the recommended rate of 100 kilograms of fertilizer per acre (~250 kilograms per hectare), he or she could obtain an additional 800 kilograms of maize per acre (~2,000 kilograms per hectare) compared to a farmer who did not use inorganic fertilizer.

However, this estimate can be an upper-bound estimate for maize-to-fertilizer response rates. A review of the literature on response rates in Malawi from surveys that used farmers' field-level data from the early 2000s found that response rates on farmer's fields were only about 2.5 kilograms of maize per kilogram of fertilizer (Lunduka, Ricker-Gilbert and Fisher 2013). This means that 100 kilograms of fertilizer only added 250 kilograms of additional maize per acre (~625 per hectare). The 650 kilogram /acre (~1,375) per hectare yield gap between a potentially optimal response to fertilizer in Benson et al. and the more realistic response rate in Lunduka et al. has major implications for food security and fertilizer's lack of profitability in Malawi. Other studies have found even lower response rates than Lunduka et al. For example, Shah (2024) used nationally representative farm household panel data from Malawi collected between 2009/10 and 2018/19. He found that the response rate for maize to fertilizer in Malawi was just 1.84. Shah's low estimated response rate from maize to fertilizer on nationally representative data was supported by Burke, Snapp and Jayne (2021) who used a four-year panel data set on farmers' plots with detailed information on soil carbon, sandiness, and labor allocation to estimate maize response rates to fertilizer. The authors found that the maize yield response to fertilizer was very low, only 0.87 under ideal circumstances and statistically nil under many conditions.[18] These low estimated maize to fertilizer response rates raise serious questions about whether or not farmers in Malawi should be applying fertilizer to maize, without complementary investments in soil fertility, water, and farm management.

It is also worth investigating the characteristics of farmers who have the highest maize-to-fertilizer response rates in Malawi. Shah (2024) investigated this issue with the panel dataset from Malawi by estimating the maize-to-fertilizer response rates for households with different levels of assets and landholding. One might think that wealthier households with more land could get a higher maize response to fertilizer because they have more access to complementary inputs like labor, seeds, and herbicides, and cultivate land of better soil quality. Alternatively, poorer households may be more dependent on maize cultivation and have fewer off-farm opportunities, causing them to value fertilizer very highly and use the input more efficiently than wealthier households who may not engage in maize cultivation for their main source of income and food security. Shah found that households with more assets and larger landholding did not use fertilizer more effectively than did limited resource farmers and they obtained similar maize yields response to fertilizer. This finding compliments our analysis of fertilizer demand and crowding out in Table M.2. Those results clearly showed that relatively wealthier farmers who cultivated more land and higher assets in Malawi crowded out more of their commercial fertilizer than did poorer farmers with less land and fewer assets on average.

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[18] Burke, Snapp and Jayne reported maize-to-fertilizer response rate response rates in terms of nitrogen. Their response rate was 2.6 kilograms maize to a kilogram of nitrogen. In order to make a consistent comparison among studies we divided 2.6 by 3 to convert nitrogen to fertilizer equivalent.

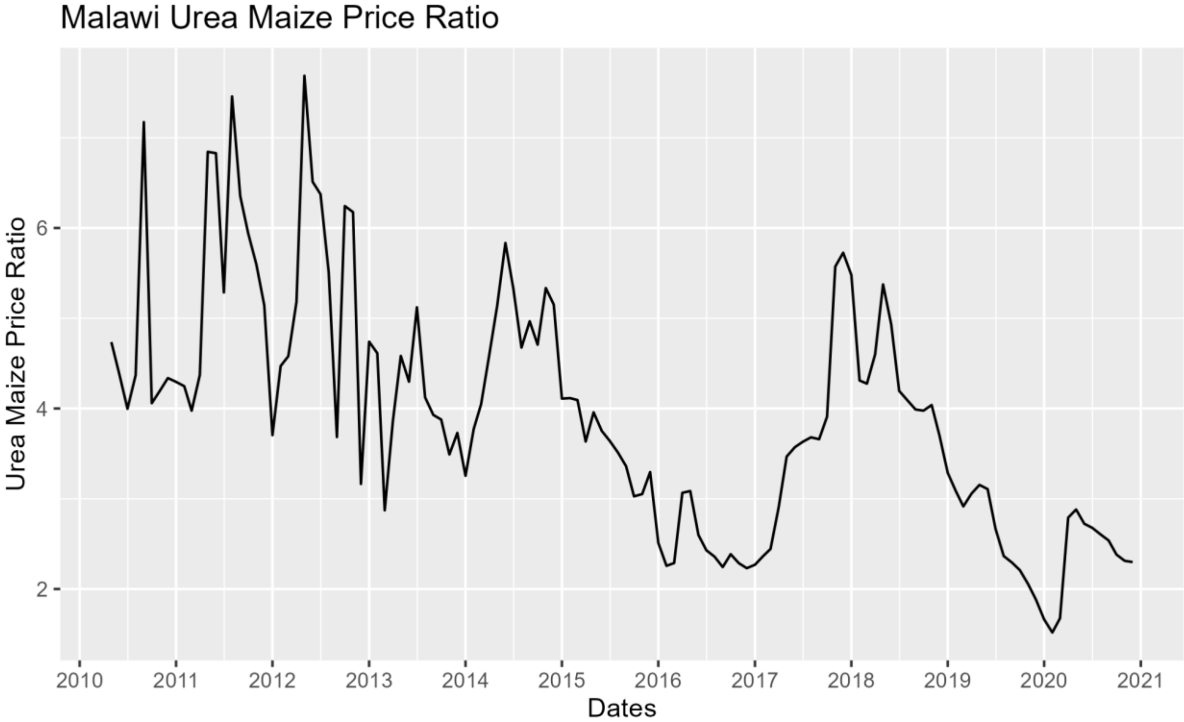
Thus, the finding that limited-resource farmers crowded out less of their commercial fertilizer purchases than wealthier farmers and obtained similar yield responses to fertilizer, indicates that fertilizer subsides should be targeted to poorer farmers rather than better-off farmers.

viii) Fertilizer profitability impacts

This subsection considers the profitability of fertilizer use in Malawi. The intention is to understand if the financial returns to Malawi's fertilizer subsidy program justified its cost with data from selected years between 2010/11 and 2022/23 and to understand if fertilizer was profitable for Malawian farmers when valued at the commercial price that they paid. The profitability of fertilizer is affected by three main factors: 1) the price of fertilizer, 2) the price of maize (or other staple crop), and 3) the maize-to-fertilizer response rate. the Maize-to-fertilizer response rate was discussed in the previous sub-section and the overall finding from previous studies is that Malawian farmers do not use fertilizer efficiently on a per kilogram basis compared to other countries. Thus, there is a great deal of room for improvement so that observed yields on farmers' fields come closer to reaching their full yield potential.

As mentioned above the price of fertilizer and the price of maize are key components in fertilizer's profitability. One way to look at this is through the ratio between fertilizer prices and maize prices. This is known as the input/output price ratio, and this relationship between urea and the farmgate price of maize in Malawi between 2010 and 2020 is shown in Figure M.8. A lower ratio means that fertilizer is more profitable, as the price of fertilizer is going down (i.e. the numerator in the ratio getting smaller) or the maize price is going up (i.e. the denominator is getting bigger). Figure M.8 indicates that the input/output price ratio before 2020 was highly variable and ranged from a high of 8.0 to a low of less than 2.0 in all years. This suggests that fertilizer use was not profitable relative to maize during the pre-spike period, but it was moving in a favorable direction for farmers as the ratio declined. At an input/output ratio of 8.0, a farmer would need to produce 8.0 kilograms of maize per kilogram of fertilizer to break even. Anything higher than that would be a profit and anything less than that would be a loss. Since our estimates from Shah (2024) indicated that the average farmer obtained 1.82 kilograms of maize per kilogram of fertilizer in Malawi, fertilizer use was not going to be profitable in all years of our analysis on average. This was the case even when the input/output price ratio was as low as 2.0.

Figure M.8: Urea / Farmgate maize price ratio in Malawi 2010-2020



Source: urea prices from AfricaFertilizer.org; wholesale maize prices from FAOSTAT, we subtracted 8% from wholesale price to compute a farmgate price.

The set of three tables in M.6 present both the financial benefit-cost ratio of Malawi's fertilizer subsidy program in different years and the profitability of fertilizer for farmers when the input is valued at subsidized and commercial prices. Table M.6.A shows the return to fertilizer using farmgate maize prices (from FAOSTAT) and commercial urea prices (from AfricaFertilizer.org) in Mizuzu in the northern region of the country. Table M.6.B does the same using prices from Lilongwe, in the central region, and Table M.6..C also does the same using prices from Liwonde, in the southern region of Malawi..

The return that farmers obtain from a kilogram of fertilizer valued at its commercial price is the marginal value-cost ratio (MVCR). The MVCR is calculated as follows:

MVCR = {incremental maize output (kilograms of maize/kilograms of fertilizer) * maize price/kilogram}
price of fertilizer per kilogram.

An MVCR that is greater than one indicates that using fertilizer generated a positive and profitable return for farmers. A ratio equal to one is break-even, meaning that the farmer made no profits using fertilizer and a ratio less than one is a loss. However, whether or not fertilizer is likely to be profitable depends on outcomes that are uncertain when fertilizer decisions are made, as well as costs associated with the use of fertilizer that are unknown to the researcher. The types of risks that farmers face when using fertilizer at planting to increase staple crop yields at harvest include the chance of low yields due to adverse weather, and output prices at harvest being lower than expected. In the face of these uncertainties and unobserved costs, an MVCR of at least 2.0 (meaning a risk premium of one) has been recommended in the literature to be required in order for fertilizer to be profitable (Xu et al., 2009; Sauer and Tchale, 2009; Sheahan et al. 2013).

This also applies to the BCR for fertilizer subsidy programs. A BCR of a subsidy program equal to 1.0 means that the economy broke-even on it, essentially that the program was equal to giving farmers cash. A BCR greater than 1.0 indicates a gain for the economy from the subsidy program, while, a BCR <1.0 indicates a loss for the economy. Again, a break-even BCR of 1.0 assumes zero transactions costs of implementing the subsidy program. Thus 2.0 may be a better break-even point for subsidies as a rule of thumb. The key rows of interest in Table M.6.A - C are row P, row U, and row V, all highlighted in grey. Row P shows the financial benefit-cost ratio (BCR) of Malawi's fertilizer subsidy programs for the years for which we had data on costs of the program between 2010/11 and 2022/23. All other rows associated with the costs and benefits of the subsidy are highlighted in green.

The key rows of interest in Table M.6.A, M.6.B and M.6.C are row P, row U, and row V, all highlighted in grey. Row P shows the financial benefit-cost ratio (BCR) of Malawi's fertilizer subsidy programs for the years for which we had data on the costs of the program (2012/13, 2015/16, 2018/19, 2021/22, and 2022/23). All other rows that are directly associated with the costs and benefits of the subsidy are highlighted in green. The results in row P of Table M.6.A which used maize prices and fertilizer prices from Mzuz/Northern Malawi indicated that the financial BCR from the subsidy was consistently below 1.0 in every year we analyzed. The highest BCR was 0.42 in 2022/23 when maize prices were relatively high at USD 421/MT, which improved the ratio. The lowest BCR was just 0.13 in 2015/16. The results were similar for the BCR calculations in Lilongwe/Central Malawi and in Liwonde/Southern Malawi. The highest BCR was 0.95 in Liwonde during 2022/23 when maize prices were high, and the lowest BCR was 0.17 in Lilongwe during 2015/16 when maize prices were low. Thus, across years and locations the Malawian economy only returned between 0.13 and 0.95 kwacha for every kwacha they spent subsidizing fertilizer.

The comparison of regional results for the MVCR of fertilizer over time and among regions was similar to those for the BCR results. When fertilizer was valued at its subsidized price in row U, the returns varied by year, but were similar across regions. The highest MVCR in row U was 12.96 in northern Malawi during 2012/13 when the fertilizer/maize price ratio was relatively low, making fertilizer profitable for farmers. The lowest MVCR in row U was 1.59 in Northern Malawi. These results indicated that for the few farmers who were fortunate enough to acquire subsidized fertilizer at a reduced price, the return on the input was profitable on average.

The highest MVCR in row V when fertilizer was valued at its commercial fertilizer was 0.74, which occurred in Central Malawi in 2015/16. The lowest return was 0.37, which occurred in Northern Malawi in the price spike year of 2021/22. Overall fertilizer never came close to breaking even (i.e. = 1.0) <u>on average</u> when it was priced at its commercial value in any of the years or regions of our analysis. Overall, farmers only gained between 0.37 and 0.74 kwacha for every kwacha they spent on fertilizer.

Overall, the results from the BCR of Malawi's fertilizer subsidy and the MVCR of commercial fertilizer use clearly indicate that 1) subsidizing fertilizer did not generate a positive return for the economy and 2) fertilizer was not profitable for the average Malawian farmer to use when it was valued at its commercial price. The few farmers who were fortunate enough to access subsidized fertilizer benefited from doing so, but the program generated an overall loss to the economy when the costs to the government of implementing the program were considered. The regional analysis of fertilizer profitability in Malawi indicated that there was not a region of the country where farmers used fertilizer relatively more profitability than anywhere else. These results mean that fertilizer use among smallholders in Malawi is not profitable and the country needs to seriously question what they are getting from its fertilizer subsidy program and why they are still funding it. The maize-to-fertilizer response rate is too low and the price of fertilizer is too high relative to the price of maize for the program to come close to break-even. The conclusion section discusses some ways to address the challenge of inefficient fertilizer subsidies and lack of fertilizer profitability in Malawi.

Table M.6.A: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Malawi (Mzuzu/Northern Region)

Production Year		2012/13	2015/16	2018/19	2021/22	2022/23
	Estimated program costs to Gov. and farmers					
A	Gov. Total prog cost (Mil. $)	149.5	94.6	51.4	170	210
B = (0.85*A)	Govt. Fert prog cost (Mil. $)	127.1	80.4	43.7	144.5	178.5
C	GS Fert distributed (MT)	153,897	70,000	99,485	370,000	250,000
D	Diversion Rate based on 09/10 IHS	-0.35	-0.35	-0.35	-0.35	-0.35
E	Crowding out estimate	-0.27	-0.26	-0.26	-0.26	-0.26
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	73,024	33,670	47,852	177,970	120,250
G	Subsidized fert redemption price (MWK/50kg)	500	3,500	6,700	7,500	7,500
H	Subsidized fert redemption cost ($/MT)	40	140	183	188	161
I = (C*H)	Farmer incremental. cost (Mil. $)	6.2	9.8	18.2	69.6	40.3
J = (B+I)	Government + Farmer Cost(Mil. $)	133.3	90.2	61.9	214.1	218.8
	Estimated incremental benefits					
K[i]	Yield response (Maize Kg/ Nitrogen kg)	5.51	5.51	5.51	5.51	5.51
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	1.82	1.82	1.82	1.82	1.82
M = (F*L)	Incremental maize output (MT)	132,780	61,222	87,010	323,603	218,651
N	Average Harvest Season Farmgate Maize price ($/MT): (April – June of marketing year)	285	197	160	181	421
O = (M*N)	Value of incremental maize (Mil. $)	37.8	12.1	13.9	58.6	92.1
P = (O/J)	Financial BCR of Subsidy program	0.28	0.13	0.22	0.27	0.42
Q	Subsidized pr. of fertilizer for farmers ($/MT)	40	140	183	188	161
R.a[iii]	Commercial pr. of fertilizer for farmers (MWK/50kg)	18,175	23,000	21,000	0	0
R.b[iii]	Commercial pr. of fertilizer for farmers ($/MT)	909	637	575	880	1,880
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	0.14	0.71	1.14	1.04	0.38
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	3.19	3.23	3.60	4.86	4.47
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	12.96	2.56	1.59	1.75	4.75
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	0.57	0.56	0.51	0.37	0.41

Note: [i] Yield response estimates from Chapoto et al. (2023); [ii]Maize prices were retail prices from FAO. We deducted 20% from the retail price to compute a farm-gate price; Commercial urea prices from Africafertilizer.org (2024).

Table M.6.B: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Malawi (Lilongwe/Central Region)

Production Year		2012/13	2015/16	2018/19	2021/22	2022/23
	Estimated program costs to Gov. and farmers					
A	Gov. Total prog cost (Mil. $)	149.5	94.6	51.4	170	210
B = (0.85*A)	Govt. Fert prog cost (Mil. $)	127.1	80.4	43.7	144.5	178.5
C	GS Fert distributed (MT)	153,897	70,000	99,485	370,000	250,000
D	Diversion Rate based on 09/10 IHS	-0.35	-0.35	-0.35	-0.35	-0.35
E	Crowding out estimate	-0.27	-0.26	-0.26	-0.26	-0.26
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	73,024	33,670	47,852	177,970	120,250
G	Subsidized fertilizer redemption price (MWK/50kg)	500	3,500	6,700	7,500	7,500
H	Subsidized fertilizer redemption cost ($/MT)	40	140	183	188	161
I = (C*H)	Farmer incremental. cost (Mil. $)	6.2	9.8	18.2	69.6	40.3
J = (B+I)	Government + Farmer Cost(Mil. $)	133.3	90.2	61.9	214.1	218.8
	Estimated incremental benefits					
K[i]	Yield response (Maize Kg/ Nitrogen kg)	5.51	5.51	5.51	5.51	5.51
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	1.82	1.82	1.82	1.82	1.82
M = (F*L)	Incremental maize output (MT)	132,780	61,222	87,010	323,603	218,651
N	Average Harvest Season Farmgate Maize price ($/MT): (April – June of marketing year)	275	248	176	205	368
O = (M*N)	Value of incremental maize (Mil. $)	36.5	15.2	15.3	66.3	80.5
P = (O/J)	Financial BCR of Subsidy program	0.27	0.17	0.25	0.31	0.37
Q	Subsidized pr. of fertilizer for farmers ($/MT)	40	140	183	188	161
R.a[iii]	Commercial pr. of fertilizer for farmers (MWK/50kg)	18703	22000	22000	0	0
R.b[iii]	Commercial pr. of fertilizer for farmers ($/MT)	935	609	603	880	1880
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	0.15	0.56	1.04	0.92	0.44
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	3.40	2.46	3.42	4.29	5.11
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	12.50	3.22	1.75	1.98	4.16
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	0.53	0.74	0.53	0.42	0.36

Note: [i] Yield response estimates from Chapoto et al. (2023); [ii]Maize prices were retail prices from FAO. We deducted 20% from the retail price to compute a farm-gate price; Commercial urea prices from Africafertilizer.org (2024).

Table M.6.C: Financial Benefit-Cost Ratios of Fertilizer Subsidy program and marginal value cost ratio for farmers in Malawi (Liwonde/Southern Region)

Production Year		2012/13	2015/16	2018/19	2021/22	2022/23
	Estimated program costs to Gov. and farmers					
A	Gov. Total prog cost (Mil. $)	149.5	94.6	51.4	170	210
B = (0.85*A)	Govt. Fert prog cost (Mil. $)	127.1	80.4	43.7	144.5	178.5
C	GS Fert distributed (MT)	153,897	70,000	99,485	370,000	250,000
D	Diversion Rate based on 09/10 IHS	0.35	0.35	0.35	0.35	0.35
E	Crowding out estimate	-0.27	-0.26	-0.26	-0.26	-0.26
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	151,665	69,930	99,386	369,630	249,750
G	Subsidized fert redemption price (MWK/50kg)	500	3,500	6,700	7,500	7,500
H	Subsidized fert redemption cost ($/MT)	40	140	183	188	161
I = (C*H)	Farmer incremental. cost (Mil. $)	6.2	9.8	18.2	69.6	40.3
J = (B+I)	Government + Farmer Cost(Mil. $)	133.3	90.2	61.9	214.1	218.8
	Estimated incremental benefits					
K[i]	Yield response (Maize Kg/ Nitrogen kg)	5.51	5.51	5.51	5.51	5.51
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	1.82	1.82	1.82	1.82	1.82
M = (F*L)	Incremental maize output (MT)	275,773	127,154	180,713	672,098	454,120
N	Average Harvest Season Farmgate Maize price ($/MT): (April – June of marketing year)	227	227	216	213	456
O = (M*N)	Value of incremental maize (Mil. $)	62.6	28.9	39.0	143.2	207.1
P = (O/J)	Financial BCR of Subsidy program	0.47	0.32	0.63	0.67	0.95
Q	Subsidized pr. of fertilizer for farmers ($/MT)	40	140	183	188	161
R.a[iii]	Commercial pr. of fertilizer for farmers (MWK/50kg)	17,848	-	21,500	-	-
R.b[iii]	Commercial pr. of fertilizer for farmers ($/MT)	892	610	589	880	1,880
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	0.18	0.62	0.85	0.88	0.35
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	3.93	2.69	2.73	4.13	4.12
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	10.32	2.95	2.15	2.06	5.15
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	0.46	0.68	0.67	0.44	0.44

Note: [i] Yield response estimates from Chapoto et al. (2023); [ii]Maize prices were retail prices from FAO. We deducted 20% from the retail price to compute a farm-gate price; Commercial urea prices from Africafertilizer.org (2024).

6. Results and Discussion

Based on the results of this report we make the following recommendations for Malawi to better prepare for and address fertilizer price spikes to better ensure a response that benefits farmers and creates a more profitable and resilient supply chain.

i. The focus of smallholder agricultural policy in Malawi should be to help farmers increase their fertilizer use efficiency so that they obtain more maize from a kilogram of fertilizer. This involves shifting investment towards improving soil fertility, climate change adaptation, encouraging the adoption of improved maize varieties, and perhaps most importantly extension.

ii. Given the low yield and variable maize productivity among smallholders, it is essential to promote livelihood diversification, especially helping many farmers move away from maize into other crops such as legumes that generate higher returns.

iii. The country needs to seriously consider why they are subsidizing fertilizer for farmers and if that money could be better spent elsewhere. Malawi has spent many years and millions of dollars subsidizing fertilizer for farmers. However, our analysis suggests that the government lost money doing so. Furthermore, many farmers still do not grow enough maize to meet their food security needs and depend on food aid in bad years.

iv. If the government intends to continue subsidizing fertilizer it makes sense to scale down the program and target it towards limited resource farmers. We found that they crowded out less of their commercial fertilizer and used fertilizer just as efficiently as wealthier farmers. It makes sense to return to a subsidy program similar to the one in 2019/20 when about 900,000 productive poor farmers were targeted. The program targeting between 2.5-3.8 million farmers in 2021/22 and 2022/23 was expensive and inefficient. The move in 2023/24 to shrink the program to around 1.5 million beneficiaries was a step in the right direction.

v. The government also needs predictable policies on fertilizer subsidies and these policies need to be communicated to the private input supply sector and farmers. In the years when the subsidy was scaled between 2009/10 and 2018/19 down in Malawi commercial fertilizer use increased. This suggests that if the subsidy is scaled down again, farmers will continue to use fertilizer that they purchase at commercial prices.

vi. Further, if subsidies continue, the government should re-engage the private sector in procurement and distribution, and minimize its direct distribution channel through the Smallholder Farmer Fertilizer Revolving Fund of Malawi (SFFRFM). Engaging the private sector will improve farmer access to inputs and ensure more timely delivery of fertilizer.

vii. Malawi should focus on creating an enabling environment for new entrants into the fertilizer supply chain. Increasing competition in the fertilizer supply chain could reduce the price of fertilizer even further.

viii. Malawi should focus on cleaning up corruption to improve fertilizer prices. Our analysis found that higher control of corruption was associated with lower fertilizer prices.

ix. Politics should be taken out of fertilizer policy in Malawi. Our model found that urea prices were slightly lower in presidential election years. This suggests that politicians may have influenced the fertilizer market.

7. References

Benson, T. 2021. Disentangling Food Security from Subsistence Agriculture in Malawi. Washington, D.C.: International Food Policy Research Institute.

Benson, T., De Weerdt, J. Duchoslav, J. & Masanhala, W. 2024. Fertilizer Subsidies in Malawi. From Past to Present. International Food Policy Research Institute. Strategy Support Program Working Paper 44. Lilongwe, Malawi.

Burke, W., Snapp, S., & Jayne, T. 2020. An in-depth examination of maize fertilizer response in Central Malawi reveals low profits and too many weeds. Agricultural Economics, 51(6), 923-940.

Chirwa, E., & Dorward, A. 2013. Agricultural Input Subsidies: The Recent Malawi Experience. Oxford, UK: Oxford University Press.

Jayne, T.S., D. Mather, N. Mason, and J. Ricker-Gilbert. 2013. “How do Fertilizer Subsidy Programs Affect Total Fertilizer Use? A Synthesis of the Evidence on “Crowding in/out” in sub-Saharan Africa.” *Agricultural Economics* 44(6):687-703.

Lunduka, R., Ricker-Gilbert, J., & Fischer, M. 2013. “What are the farm-level impacts of Malawi’s farm input subsidy program? A critical review.” *Agricultural Economics*, 41, 563–579.

Ricker-Gilbert, J., T.S. Jayne and E. Chirwa. 2011. “Subsidies and Crowding Out: A Double-Hurdle Model of Fertilizer Demand in Malawi.” *American Journal of Agricultural Economics*. 93(1): 26-42.

Sauer, J., Tchale, H., 2009. “The economics of soil fertility management in Malawi. Applied Economics Perspectives and Policy.” 31 (3), 535–560.

Shah, M. 2024. “Three Essays on Development Economics.” Dissertation Prepared for the Faculty in Agricultural Economics. Purdue University. West Lafayette IN. USA.

Sheahan, M., Black, R., & Jayne, T. S. 2013. “Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research.” Food Policy, 41, 39-52.

Xu, Z., Guan, Z., Jayne, T. S., & Black, R. 2009. “Factors influencing the profitability of fertilizer use on maize in Zambia.” *Agricultural economics*, 40(4), 437-446.

iv. Nigeria Country Report

1. Main Findings for Nigeria

1. Nigeria is one of sub-Saharan Africa's (SSA) only significant fertilizer producers and exporters. Nigeria consumed more than 1.8 million tons of fertilizer in 2021 and produced over 2.7 million tons. In 2022 production was 3.4 million tons, and in 2023 it was 3.6 million (AfricaFertilizer.Org). While fertilizer production has grown rapidly in Nigeria, consumption has remained relatively stagnant at around 1.0 million MT per year, and between 70-75% of the fertilizer produced in 2022 and 2023 was exported (AfricaFertilizer.org). The vast majority went to Brazil, (greater than 80% of total exports went there in 2021, and 43% in 2022), and to the E.U. A small but growing percentage went to other nearby coastal countries (Benin, Cameroon, Cote D'Ivoire, Ghana, Senegal). In 2022 a small amount went to landlocked countries in the region, with 1,000 MT going to Mali, and 20,400 going to Niger. None of it goes to any countries in Eastern and Southern Africa (AfricaFertilizer.org). The pattern of fertilizer exports out of Nigeria illustrates the economics of international trade and the infrastructure and institutional challenges with intra-African trade in bulky commodities like fertilizer.

2. The fertilizer market in Nigeria is pyramid-shaped with few firms at the top of the supply chain. Three firms manufactured 90% of the fertilizer produced in the country in 2023. 14 firms imported 90% of the fertilizer into Nigeria in 2014, but only one firm did the importing in 2023. This firm, NAIC NPK, is a subsidiary of the Nigerian Sovereign Investment Authority which was mandated by the government in 2018 to bulk purchase fertilizer raw materials (DAP & MOP) to supply to national blenders. Granting NAIC NPK the only importing license was accompanied by a ban in 2018 on the import of pre-blended NPK fertilizers. This was part of a strategy to increase national blending. The number of blenders in the country increased from 10 in 2014 to 28 in 2022 to about 30 in 2023. The significant increase in blending investment has also led to the development of various marketing strategies, including introducing new product types (i.e., specialized blends) into the market (IFDC 2024).

3. Our analysis of monthly NPK prices between 2010 and 2023 indicates that several key factors affected the local NPK price in Nigeria:
   The previous month's *Local Maize Price* was positive and statistically significant. The result implied that a 1% increase in last month's maize price was associated with a .29 increase in urea prices on average. This suggests that higher maize prices, which can signal greater demand for fertilizer, are associated with higher urea prices.

4. Nigeria was engaged in directly subsidizing fertilizer for farmers for many years, before starting to scale them down in 2016.
   a. Between 12% and 21% of farmers participated in Nigeria's fertilizer subsidy program between 2010 and 2018 according to our analysis of the World Bank's LSMS panel dataset. Though significant, Nigeria's fertilizer subsidy program was smaller in terms of participation rates compared to other countries in the region.
   b. We do not have access to the financial cost data for Nigeria's subsidy program.
   c. In several years Nigeria's program utilized components of smart subsidies, including the use of e-vouchers and allowing private-sector agro-dealers to retail subsidized fertilizer to farmers. However, there were still concerns about corruption, poor targeting of appropriate beneficiaries, and late delivery of fertilizer.
   d. Nigeria scaled down direct subsidies to farmers beginning in 2016 when the country's fertilizer policy shifted its focus towards promoting domestic fertilizer production and blending. This occurred with the support of the Nigerian government, the African Development Bank (AfDB), and agreements with the government of Morocco through the Presidential Fertilizer Initiative (PFI) to import phosphate for blending with the

country's abundant supply of nitrogen. Several public-private partnerships were developed as a result of these investments, including Indorama's Indorama Eleme Fertilizer production plant. This support helped Nigeria move from a net importer of fertilizer to a major producer and exporter of fertilizer in ten years.

e. The stated goal of the PFI was to support the fertilizer industry and in doing so help make fertilizer more affordable and accessible to smallholder farmers. However, it is not clear that this has been achieved. For example, the PFI aimed to support the fertilizer industry so that the cost of NPK to farmers would be Naira 5,500 per 50 kg bag. However, farmers were paying double the PFI price by the end of 2021, and triple the price in 2022. This prompted inquiries into the effectiveness of the PFI.

f. The issue of high fertilizer prices was exacerbated by the Nigerian government's withdrawal of fuel subsidies in 2023, further impacting the situation. Furthermore, when the global price of fertilizer spiked in 2021/22, the global economic conditions meant that most of the domestically produced fertilizer in Nigeria was exported by the private sector, mainly to Brazil as mentioned previously. Nigeria has a quota requirement that a certain amount of domestic fertilizer must be held back for domestic consumption. However, in aggregate Nigerian farmers have purchased less fertilizer than the quota in recent years. This is presumably due to the price of fertilizer being high. Thus, even with increased production, and an export quota, Nigerian farmers experienced fertilizer price increases and decreased fertilizer availability during the price spike just like farmers in other countries did.

5. Our analysis of nationally representative smallholder data collected by the World Bank Living Standards Measurement Survey (LSMS) in 2010, 2012, 2015, 2018, and 2023 indicated that between 2010 and 2018, average commercial fertilizer use increased by 66% among Nigerian smallholders. The upward trend in fertilizer use tracked the decline in the nominal price of fertilizer over that period. The rise in commercial fertilizer use by farmers during this period also coincided with the scaling down of direct subsidies to farmers. However, in 2022/23 fertilizer prices spiked in Nigeria and fertilizer use declined among smallholder households in our dataset. The average price paid by farmers for inorganic fertilizer increased by 161% between 2017/18 and 2022/23 in nominal terms. Thus, the percentage of farmers who bought commercial fertilizer declined from 39% to 13% over that period. This raises questions about how much the government's policy of supporting fertilizer production in Nigeria benefited smallholder farmers there as intended.

6. We found that 40% of smallholder households in Nigeria never bought commercial fertilizer in any of the survey years of 2010, 2012, 2015, 2018, and 2023. Furthermore, in any given year only between 22-35% of households bought commercial fertilizer across the country. As such, even though average commercial fertilizer use increased in Nigeria during the previous decade, the majority of farmers still did not purchase any commercial fertilizer over that period. The previous finding that fertilizer use increased along with this finding that many households did not use it, points to the strong likelihood that fertilizer access is highly unequal in Nigeria. It also suggests that even though Nigeria is a large fertilizer producer, and fertilizer prices declined over time, many other barriers existed that prevented smallholders from buying commercial fertilizer.

7. Our calculations of fertilizer profitability suggested that for those smallholders who bought commercial fertilizer, the returns to using it were positive on average before and during the fertilizer price spike of 2021/22. The highest return to fertilizer use came in 2021 as fertilizer prices began to rise. This was because fertilizer prices rose but not as much as maize prices did, so the input was still profitable on average.

8. The reason why fertilizer has been relatively profitable in Nigeria has been due to the relatively low price of fertilizer in the country, and not because farmers used it efficiently. The maize-to-fertilizer response rate in Nigeria has been estimated to be very low at 2.56 kilograms of maize generated per kilogram of fertilizer applied by farmers on average (Liverpool-Tasie et al. 2017). This is compared to estimates of maize-to-fertilizer response rates in Nigeria conducted on agricultural experiment stations that found maize could obtain a response rate of 8.66 kilograms of maize per kilogram of fertilizer on average (Chapoto et al. 2023).
    a. This low response rate on smallholder farmers' fields is the result of numerous factors. For example, Nigeria, like many other countries in SSA, suffers from nutrient depletion and acidification in its soils. This is caused by the continuous cultivation of nutrient-hungry cereals like maize. Also, Nigeria is a large country with vastly different agro-ecologies between the north and the south. Thus, most standard blends of NPK and urea available to farmers in many areas have not been formulated appropriately for the soil conditions there and thus have not allowed farmers to maximize their potential yields.
    b. This may be changing as the number of blenders creating more site-specific blends has increased dramatically in recent years. However, to our knowledge, no study has looked at whether these new blends have increased maize to fertilizer response rates and yields.

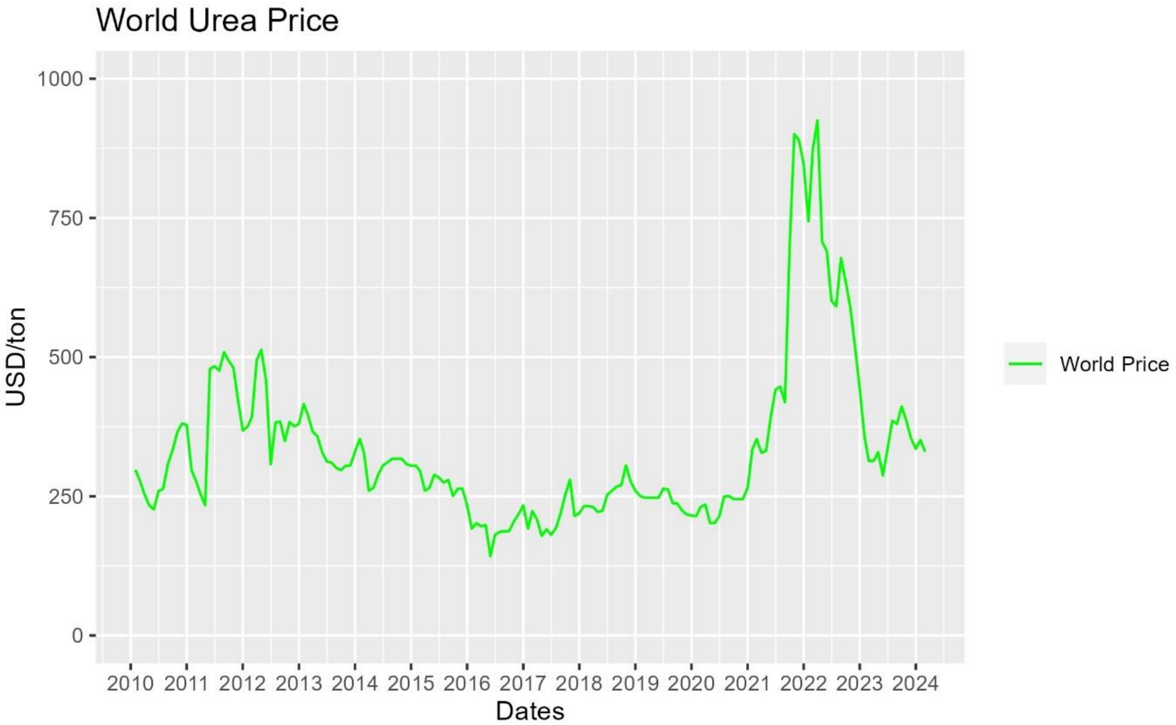
9. Our analysis of Nigeria's subsidy programs that were in place between 2010 and 2018 found that the benefits to subsidizing fertilizer were reduced by an average crowding-out rate of 44%. This meant that 100 kilograms of subsidized fertilizer only added 56 new kilograms to farmers' fields, as the other 44 kilograms were displaced commercial fertilizer purchases. We also found that crowding out was higher for wealthier farmers with more land than it was for poorer farmers since better-off farmers are more likely to purchase fertilizer at commercial prices. This makes sense as these farmers are more likely to have the cash and credit to purchase fertilizer commercially, so they use some of the subsidized fertilizer that they acquire in place of some of their planned commercial purchases.

2. Introduction

International fertilizer prices increased and then decreased substantially between 2020 and 2024. The initial global drivers of the increase were disruptions in the global supply chain caused by COVID-19. As a result, China and Russia, two of the largest fertilizer exporters, imposed restrictions on their exports. These restrictions also came at the same time that international coal and natural gas prices, key inputs in the production of fertilizer, were rising. Fertilizer prices increased further in early 2022, due to the fallout from the Ukraine crisis. Russia and Ukraine are major fertilizer exporters, and Russia's invasion of Ukraine greatly reduced the global fertilizer supply during the initial months of the war. At the same time that fertilizer prices increased, prices of staple foods increased as well. This increase in input and output prices had important implications for smallholder farmers, small-scale traders, and consumers in Nigeria as it did in many other countries of sub-Saharan Africa (SSA). Nigeria is in a unique position as a major fertilizer producer and the only substantial exporter of fertilizer in the region. However, the country was not immune to the effects of the global fertilizer price spike. Figure N.1 shows the world price of urea, between 2010 and 2024 in nominal USD per metric ton (MT). The figure shows that prior to the price spike of 2021/22, the price of urea had declined from a high of about USD 500/MT in 2013 to a low of about USD 250/MT in 2020 before the spike began. The world price of urea then spiked beginning in early 2021 reaching a high of USD 925 in March of 2022. The price then dropped during the remainder of 2022 before reaching a monthly average of $375/MT in the second half of 2023.

This report analyses global and national-level urea and NPK prices. Urea is a consistent type of fertilizer (46% nitrogen) that is traded and used globally, and NPK 10-10-10 is commonly applied to maize in Nigeria. Analysis of both of these types of fertilizer allowed us to make cross-country comparisons. Subsequent figures and analyses compare the price of urea in Nigeria with the world price. The difference between the local price, and the world price of fertilizer is called the price wedge. Understanding the factors that affected the fertilizer price wedge before, during, and after the fertilizer price spike of 2021/22 in Nigeria is important for developing policies, programs, and strategies to mitigate the effects of future shocks.

Figure N.1: World price of urea in nominal USD (2010 – 2023)



Source: World Bank Pink Sheets. Urea prices were reported for F.O.B. in the Black Sea before 2022 and in the Middle East since.

3. Objectives

This report has several main objectives. The first is to analyse and document what the change in the fertilizer price wedge during the global fertilizer price spike of 2021/22 meant for Nigeria. We estimated which factors explained the local price of urea and the price wedge in the country over the past 13 years. Second, we assessed how the government, donors, and other multi-lateral organizations in Nigeria responded to the price spike. Since supporting and subsidizing domestic fertilizer production was a major policy of the Nigerian government before and during the price spike, we discussed this policy in detail. We also estimated the impact of direct fertilizer subsidies to farmers that occurred in the previous decade on commercial fertilizer demand, and how effective fertilizer policy was at increasing fertilizer use among smallholder farmers in Nigeria. Third, we estimated the profitability of fertilizer use for farmers in Nigeria using data on smallholder farm household data in the country by analysing data from the World Bank's Living Standards Measurement Survey (LSMS). Finally, based on these analyses we made recommendations that the Government of Nigeria, donors, and the private sector can take to increase the returns to fertilizer use among farmers. Ultimately this will help to make the fertilizer sector more resilient and better prepared for the next time fertilizer prices rise drastically.

4. Methodology

The study applied the following methodology: 1) a qualitative and quantitative econometric analysis of the factors that affected the fertilizer price wedge before during and after the fertilizer price spike in Nigeria; 2) a review of the fertilizer market structure that was conducted by key informant interviews with important actors in the fertilizer sector, and review of relevant background documents 3) a scoping review of the literature and available databases on fertilizer subsidy policies in Nigeria and fertilizer prices, both global and national, before, during and after the fertilizer price spikes of 2021/22. 4) an analysis of the farmer survey collected by the World Bank LSMS team. Using these data we analysed fertilizer demand, including i) how Nigeria's fertilizer subsidy program affected demand for commercial fertilizer for both the average household and along the distribution of assets and landholding, ii) how fertilizer purchasing behavior over time was associated with farm household characteristics, iii) how fertilizer profitability was affected by the price spike.

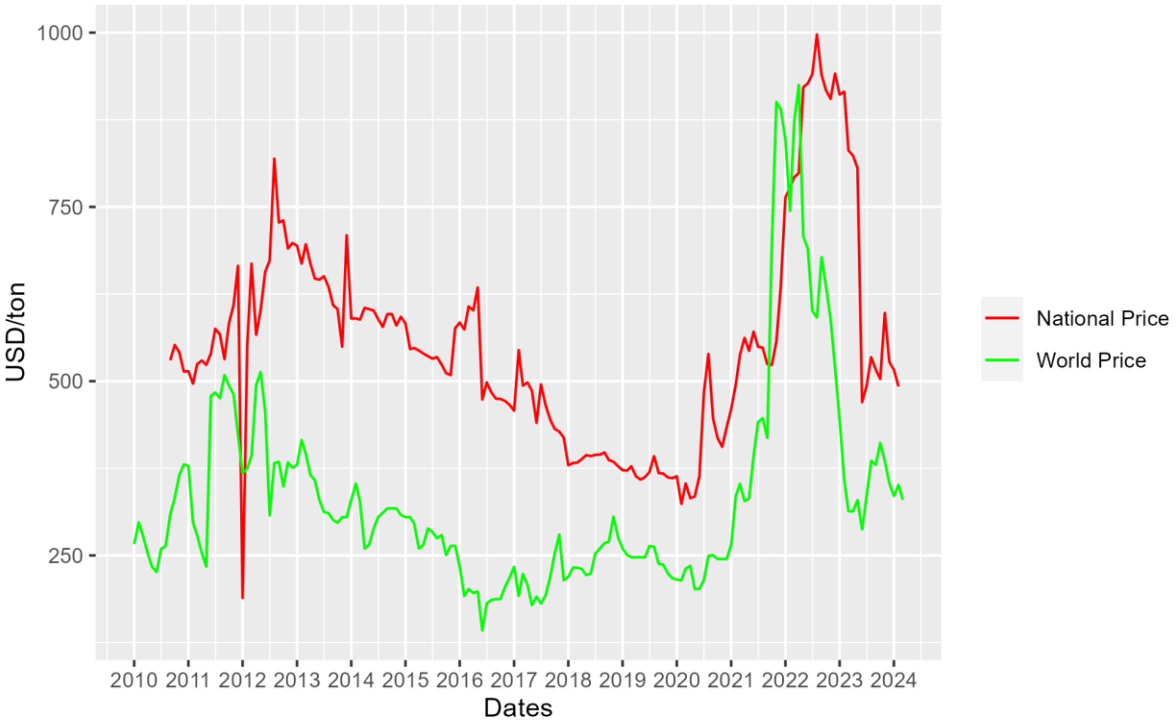
5. Results and Discussion

i) The fertilizer price wedge in Nigeria

Figure N.2 shows the nominal price of urea in Nigeria between October 2010 and December 2023 in USD in red and how it compares to the world price of urea in green. The figure indicated that the price of urea in Nigeria was mainly above the world price before the price spike of 2021/22. The only exception was a brief period in 2012 when the world price was above the price in Nigeria. Most of the time between 2012 and 2020, the price of urea declined relative to the world price from a high close to USD 800/MT to a low of about USD 375/MT in 2020. This suggests that fertilizer use was becoming more profitable for farmers during that period, in US dollar terms, before the price spike.

The local price of urea in Nigeria started to rise in 2020 before the world price started to rise in 2021. There was a brief period at the end of 2021 and the start of 2022 when the price of urea in Nigeria was below the world price. However, the world price of urea peaked in 2022 at about USD 925/MT but the local price in Nigeria kept rising to about USD 1,000/MT in mid-2022. It stayed high into 2022 and then declined in 2023 to about USD 500/MT at the end of the year. The decline in urea price in Nigeria from its peak in 2022 to the end of 2023 was 50%, but in relative terms, the price of urea in Nigeria remained high compared to the world price. By the end of 2023, the world price was ~$350/MT, and the price in Nigeria was ~USD 500/MT. This meant that the price wedge in Nigeria was ~ $150/MT and that the price of urea in Nigeria was 43% higher than the world price in US dollar terms.

Figure N.2: Retail prices of Urea in Nigeria and the world price in USD/MT (2010-2023)

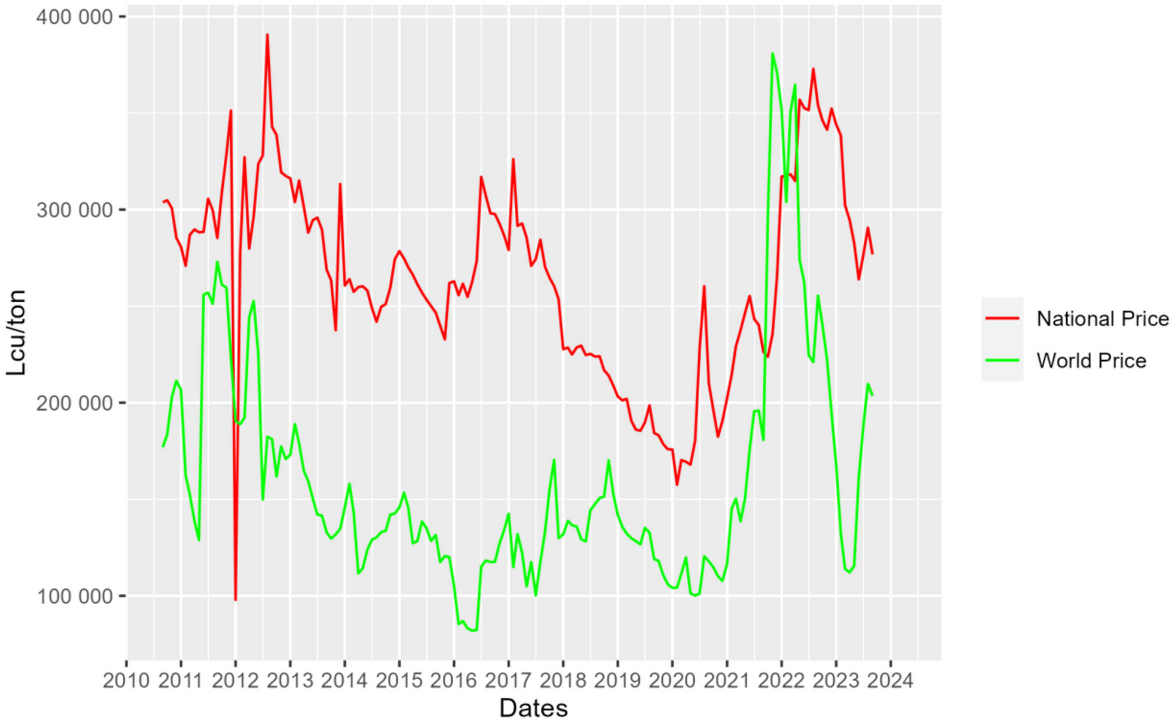


Notes: Price Wedge = Local urea price (US$/Ton) – World Price (US$/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Nigeria began in 2010.

Figure N.3 presents the same relationship between the price of urea in Nigeria and the world price, but this time both price series were measured in nominal local Nigerian Naira. Just as when urea was USD, the price of fertilizer declined in the years before the spike, but then rose sharply in 2020 before the world price did in 2021. The world price of urea valued in Naira stayed high in 2021 and 2022, then dropped quickly, reaching a low of about Naira 100,000/MT in 2023 and rising back up to Naira 200,000 by the end of 2023. Conversely, the local price of urea in Naira remained high, peaking at about Naira 360,000/MT in 2022. It dropped in 2023 to about Naira 280,000/MT by the end of the year. This was equivalent to a 22% decline. By the end of 2023, the price wedge in Naira was about Naira 80,000/MT, meaning that the urea price in Naira was about 40% higher than the world price at that time.

The next sub-section discusses the results of our quantitative results on factors that affect the price of urea and the price wedge in Nigeria.

Figure N.3: Retail prices of Urea in Nigeria and the world price in Naira/MT (2010-2023)



Notes: Price Wedge = Local urea price (Naira/Ton) – World Price (Naira/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Nigeria began in 2010.

ii) Quantitative analysis of factors affecting the fertilizer price level and wedge over time.

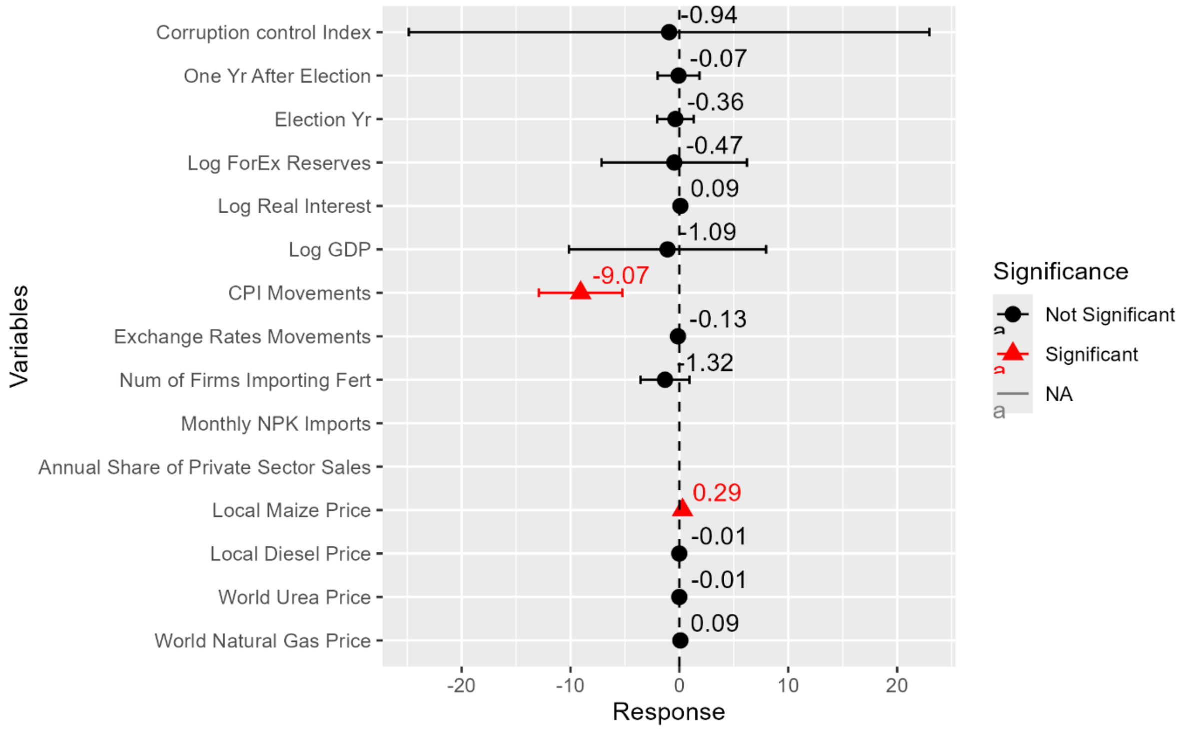
Results by Variable for Price Level Model in Naira

Since the main fertilizers used in Nigeria are NPK blends, we ran the Nigeria country model with average NPK price as the dependent variable. Figure N.4 presents the results based on the analysis of factors that drove the NPK price level

The Difference in CPI is significantly negative, suggesting that a 1 percentage point increase in CPI returns is associated with a 9.07% decrease in NPK price, which is contrary to what we would expect. We attribute this to the low number of observations in our country models and the fact that the *Difference in CPI* likely does not have enough variation to generate a reliable estimate of the variable. This makes it very hard to tease out an estimate of effect size for this variable.

The one-month lag of *Local Maize Price* was positive and statistically significant, suggesting that a 1% increase in maize prices was associated with a 0.29% increase in NPK prices. Higher maize prices can signal greater anticipated demand for fertilizer, leading to higher NPK prices.

Figure N4. Factors affecting NPK prices in Nigeria from 2010-2023 in *Naira*/MT



Notes: Results are from a linear regression model of 138 monthly observations of nominal NPK price levels in Nigeria denominated in Naira from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on NPK price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on NPK prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into Naira to correspond to the impacts in local markets.

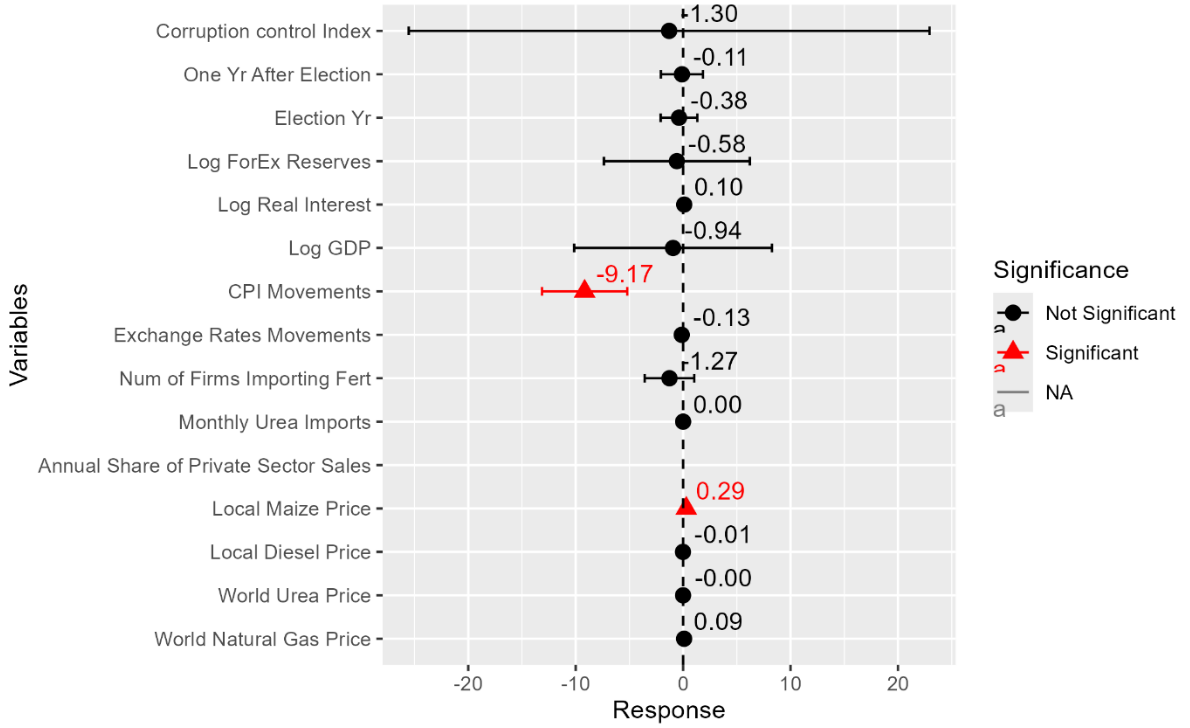
Results by Variable for Urea Price Level Model in Naira

Urea is one of the main types of fertilizer produced and consumed in Nigeria. Thus, we ran the Nigeria country model with the average monthly Urea price as the dependent variable. Figure N.5 presents the results based on the analysis of factors that drove the Urea price level, and Figure N.6 presents the results based on factors that drove the Urea price wedge.

Results from the model indicated that *CPI Movements* was statistically significant and negative. This suggested that a 1 percentage point increase in *CPI Movements* was associated with a 9.17% decrease in Urea price on average. This is contrary to what we would expect. We attribute this to the low number of observations in our country models and the fact that *CPI Movements* is a very noisy variable. This makes it very hard to tease out an estimate of the effect size for this variable.

The previous month's *Local Maize Price* was positive and statistically significant. The result implied that a 1% increase in last month's maize price was associated with a .29 increase in urea prices on average. This suggests that higher maize prices, which can signal greater demand for fertilizer, are associated with higher urea prices.

Figure N5. Factors affecting Urea prices in Nigeria from 2010-2023 in Naira/MT



Notes: Results are from a linear regression model of 138 monthly observations of nominal urea price levels in Nigeria denominated in Naira from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into Naira to correspond to the impacts in local markets. The model includes year fixed effects.

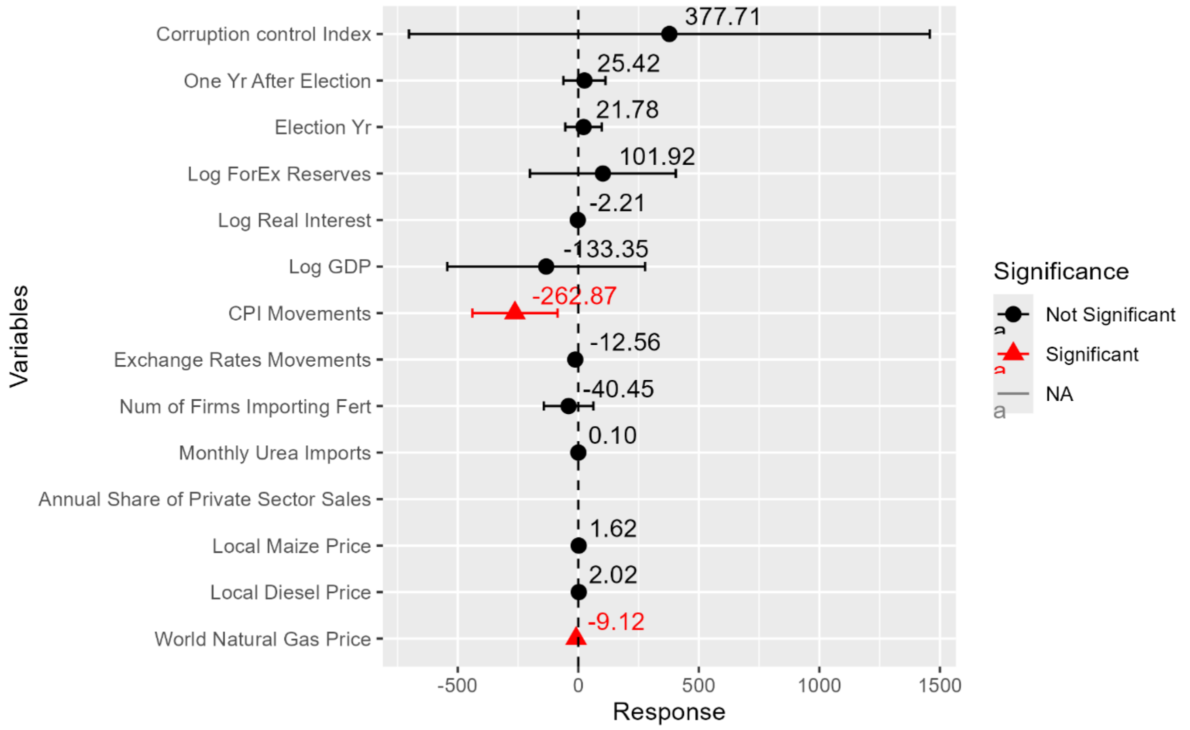
Results by Variable for Urea Price Wedge Model in LCU

Results from the urea price wedge model in table N.6 in Nigeria indicated that *The CPI Movements* was statistically significant and negative. It indicated that a 1 percentage point increase in Nigeria's *CPI* was associated with a 262.87% decrease in Urea price, which is contrary to what we would expect. We attribute this to the low number of observations in our country models and the fact that the *CPI Movements* is a very noisy variable. This makes it very hard to tease out an estimate of the effect size for this variable.

The World *Natural Gas Price* is negatively associated with the wedge; a 1% decrease in natural gas price was associated with a 9.12% decrease in the wedge – again, this was contrary to our expectation since gas is needed to produce urea. It could be that world natural gas prices are already captured in world urea prices, which led to the unexpected result.

Figure N.6: Factors affecting Urea price wedge in Nigeria 2010-2023 in LCU/MT

Dependent variable: Urea price wedge asinh(nominal Urea price in LCU – world price in LCU)



Notes: Results are from a linear regression model of 139 monthly observations of nominal Urea price wedges in Nigeria. The price wedge is calculated as the price of Urea in Naira in each country obtained from AfricaFertilizer.org minus the world price of urea obtained from the World Bank Pink Sheets converted to Naira. The triangles and circles are the mean estimates of each variable's effect on Urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on Urea prices, while variables that are greater than zero denoted that the factor had a positive effect on Urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into Naira to correspond to the impacts in local markets. Model includes year fixed effects.

iii) *Analysis of fertilizer market structure in Nigeria*

Table N.1 presents the structure of the fertilizer market in Nigeria. It indicates that the supply chain is pyramid-shaped. At the top of the market, Nigeria is one of the few countries in SSA with an abundant fossil fuel source and thus is the largest fertilizer producer in the region. That being said, there are very few fertilizer manufacturers in the country, with one in 2014 and three in 2023. These firms are Dangote Fertilizer Limited, Indorama Eleme Fertilizers and Chemicals Limited, and Notore Chemical Industries PLC. In addition, six firms imported 90% of the fertilizer into Nigeria in 2014, but only one firm imported in 2022 and 2023. This firm, NAIC NPK, is a subsidiary of the Nigerian Sovereign Investment Authority which was mandated by the government in 2018 to bulk purchase fertilizer raw materials (DAP & MOP) to supply to national blenders. Granting NAIC NPK the only importing license was accompanied by a ban in 2018 on the import of pre-blended NPK fertilizers. This was part of a strategy to increase national blending. The increase was seen in the fact that the number of blenders in the country increased from 10 in 2014 to 28 in 2022 to about 30 in 2023. The significant increase in blending investment has also led to the development of various marketing strategies which include the introduction of new product types (i.e. specialized blends) into the market (IFDC 2024).

The lower ends of the fertilizer supply chain are much less concentrated in Nigeria. There are hundreds of firms that wholesale and retail 90% of the fertilizer in the country through thousands of retail outlets.

Table N.1: The number of companies in Nigeria that control 90% of the fertilizer that was available at different stages in the supply chain during key years.

Country	In 2014 (ten years ago)	In 2019 (just before the fertilizer price spike)	In 2022 (during the fertilizer price spike)	In 2023 (last year)
Manufacturing	1	2	3	3
Importing	6	3	1	1
Blending	10	15	28	30
Wholesaling	100's	100's	100's	100's
Retailing	100's	100's	100's	100's

Source: Importer Information from Afriqom; other information from International Fertilizer Development Corporation (IFDC).

iv) Analysis of fertilizer policies in Nigeria around the fertilizer price spike

Policy Response

When global economic shocks occur that affect domestic commodity supply chains and prices, countries typically respond with policies to try to mitigate the impact on their citizens. Such policy responses might achieve their intended objectives but unintended consequences to other aspects of the economy are often also realized. They also might not necessarily achieve their intended objectives. The policy responses often have trade-offs, as countries often face options with differing consequences. It is, therefore, critical that a country's policy responses to economic shocks are guided by its contextual conditions and informed by up-to-date evidence as well as the global and regional dynamics. This section identifies key fertilizer policy interventions in Nigeria before and during the recent fertilizer price spikes.

Fertilizer Policy Before Price Spike

Since the early 2000s, Nigeria's fertilizer policies and approaches to subsidies have evolved in response to the changing needs of the agricultural sector. The Federal Market Stabilization Programme (FMSP), which had been introduced to improve the livelihoods of poor farmers was discontinued in August 2000 only to be reintroduced in 2001 alongside the National Fertilizer Policy. The program aimed to reduce the volatility of fertilizer prices, in an attempt to increase their use among small-scale farmers. However, the policy encountered setbacks due to implementation issues. These problems included wealthy farmers accessing disproportionate amounts of the subsidy, large displacement of commercial sales and high costs relative to the program's benefits. The program ran for 10 years and was discontinued in 2011.

Subsequent policies like the National Special Program for Food Security (NSPFS) and the Developing Agri-Input Markets in Nigeria (DAIMINA) program targeted farmers to enhance food security and facilitate access to affordable fertilizers. The NSPFS grappled with challenges such as input delivery delays and inadequate supplies of fertilizer being delivered. However, the innovative voucher scheme under DAIMINA garnered farmer satisfaction owing to its streamlined supply chain and convenience. The National Fertilizer Policy ran from 2004 to 2006 in Kano, Oyo and Bauchi States. Its goal was to enhance fertilizer quality and access which led to an increase in fertilizer use per cultivated hectare. However, the policy later failed due to the lack of enforcement of regulatory measures and inadequate quality assurance of the fertilizer.

The Fertilizer Voucher Program of 2009 piloted through the International Fertilizer Development Center (IFDC) was introduced in an effort to efficiently target rural smallholder farmers through a smart subsidy voucher system. It was a relatively small program that targeted 140,000 smallholder farmers in Kano State and 76,000 in Taraba State. The program provided cost-effective fertilizers to participants. However, issues arose from bureaucratic procurement processes, resulting in delays and disparities in the quantity received among farmers. As such the program was ended after the 2011/12 season.

Subsequent years saw the introduction of the Growth Enhancement Support Scheme (GESS) in the Agricultural Transformation Agenda (ATA) which ran between 2012 and 2015. This program took a step forward in the efficient delivery of fertilizer and seed through the utilization of e-vouchers to target farmers. The program covered 23.88 million farmers who could redeem subsidized fertilizer vouchers through private-sector agro-dealers at a 50% subsidy. The agro-dealers were then reimbursed by the government. The GEES increased access to fertilizer and seed inputs by farmers and facilitated the restructuring of the federal fertilizer procurement system (FMARD 2016). Ultimately over 2 million MT of fertilizer was distributed to Nigerian farmers through the program at a cost of Naira 224 billion. Despite its scale and scope, the GEES faced challenges related to delayed input supply, inadequate record-keeping, and fraud among agro-dealers. This highlighted the complexities of implementation and administration.

In 2016, the Presidential Fertilizer Initiative (PFI) noted the challenges faced by prior input subsidy programs and pushed for their removal. As such, direct subsidies for inputs were scaled down beginning in 2016. The PFI was created as an executive order between the King of Morocco and President Buhari of Nigeria to allow discounted phosphorous to be imported from OCP in Morocco. This allowed Nigeria to take advantage of this country's abundant supply of nitrogen and promote domestic blending. The initiative focused on supporting local fertilizer production to reduce costs and reduce the sale of low-quality and adulterated fertilizer. The program allowed for the collaboration of private and public stakeholders in the production and distribution of fertilizer and this to the increase in local fertilizer production and the establishment of several fertilizer plants across the country. The PFI significantly bolstered local fertilizer production in Nigeria, resulting in over 3.4 million metric tons of fertilizer being produced domestically in 2022, along with the establishment of 52 blending plants across 19 states. One example of a successful public-private-partnership was the Indorama Eleme Fertilizer production plant co-funded by the African Development Bank (AfDB). The completion of the plant in 2016 helped to turn Nigeria into a net fertilizer exporter.

The most recent fertilizer policy in Nigeria, the National Agricultural Technology and Innovation Policy (NATIP), started in 2019 aimed to build on the successes of the PFI program by regulating and improving access to high-quality fertilizers by enhancing input supply and service delivery to agro-dealers and farmers. The policy aimed to enhance productivity through the rapid deployment of knowledge and technology, promote private-sector investment in local fertilizer production, and increase the domestic sourcing of blending materials under the Ministry of Mines oversight. The policy is ongoing.

Policy during the price spike

It is clear from the previous section that the Nigerian government has been willing to change and adapt its fertilizer policy to take advantage of its position as a fertilizer producer. However, these policies and programs have faced various challenges that have reduced their effectiveness and impact. This included market distortions, supply-chain inefficiencies, limited access to credit, and inadequate infrastructure (IFDC &AFAP, 2018). These challenges came to a head during the fertilizer price spike of 2021/22. The increased global price of fertilizer caused many of the local fertilizer companies that had been supported under the PFI to export 70-75% of their production, leaving limited and costly fertilizer access for rural farmers, exacerbating the challenge. For example, the Presidential Fertilizer Initiative (PFI), aimed to support the fertilizer industry so that the cost of NPK to farmers would be Naira 5,500 per 50 kg bag. However, farmers were paying double the PFI price by the end of 2021 and triple the price in 2022. This prompted inquiries into potential shifts in government policies to address these price spikes (Balana and Fasoranti, 2022). The issue of high fertilizer prices was exacerbated by the Nigerian government's withdrawal of industry subsidies for fuel in 2023. This created further economic hardship for people and may have contributed to further increase fertilizer prices by raising transport costs.

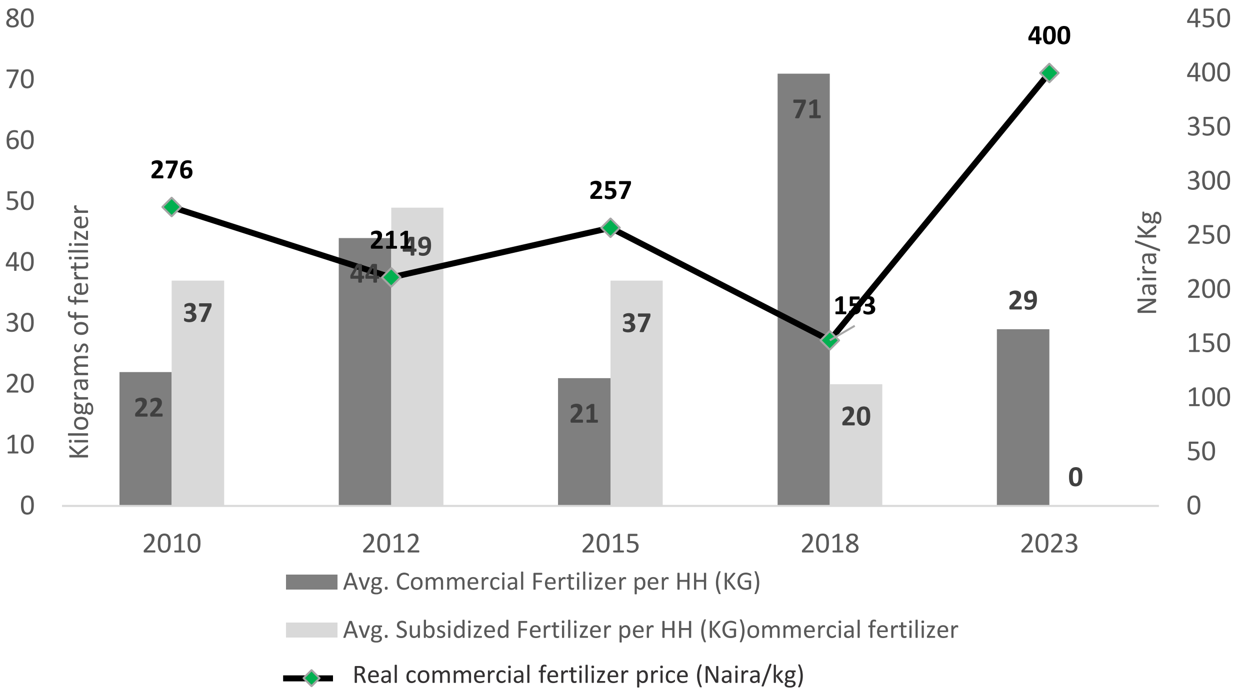
Other input subsidy programs

Another significant project related to agricultural inputs was the Agro-Pocket scheme. It launched in 2023 with a $134 million loan funded by the AfDB to the Federal Government. This program covers the distribution of fertilizer, seeds, and agrochemicals.

v) Fertilizer Demand Impacts

The following section uses analysis from the World Bank LSMS panel dataset, collected to cover the 2010, 2012, 2015, and 2018 growing seasons. We also added in the phone survey data from the panel data that was collected of the same households in 2023. This panel is the most comprehensive dataset on Nigerian smallholder farmers. We analysed these data to make some predictions about the impacts of the fertilizer price spike on fertilizer demand and profitability in Nigeria. Figure N.7 shows the average retail commercial fertilizer prices that farmers paid in the different years of the survey, compared to the average amount of subsidized and commercial fertilizer that they acquired. The line graph at the top shows that the real average price of fertilizer (NPK and urea) declined slightly from Naira 208/kg in 2010 to Naira 195/kg in 2012, before rising to Naira 231/kg in 2015, a 19% increase. The commercial price of fertilizer then declined to Naira 153/kg in 2018, a 34% decrease. However, in 2023 the price of fertilizer spiked to Naira 400/kg. Over this time, average commercial fertilizer purchases rose from 22 kilograms per household in 2010 to 44 kilograms in 2012 but declined to 21 kilograms in 2015 and then shot up to 71 kilograms in 2018. In 2023 it declined to 29 kilograms per household on average. Thus, between 2010 and 2018 commercial fertilizer use increased by 66% on average, but then declined by 45% in 2023. The trends in fertilizer demand across the five survey waves tracked the relative price of fertilizer. The rise in commercial fertilizer over this period also tracked the decline in subsidized fertilizer acquisition. While commercial fertilizer use generally trended upward over the decade before the spike, the average amount of subsidized fertilizer that farmers acquired went down. This finding is consistent with the discussion of subsidy policy in the previous section, as the government limited subsidized fertilizer allocations after 2016. It seems from this figure that commercial fertilizer rose at the same time subsidized fertilizer declined in Nigeria in the past decade. However, it is not clear that the increased investment in fertilizer production or the export quota to hold some fertilizer back for domestic consumption in Nigeria benefited smallholder farmers there in terms of lower fertilizer prices and increased fertilizer access during the recent price spike.

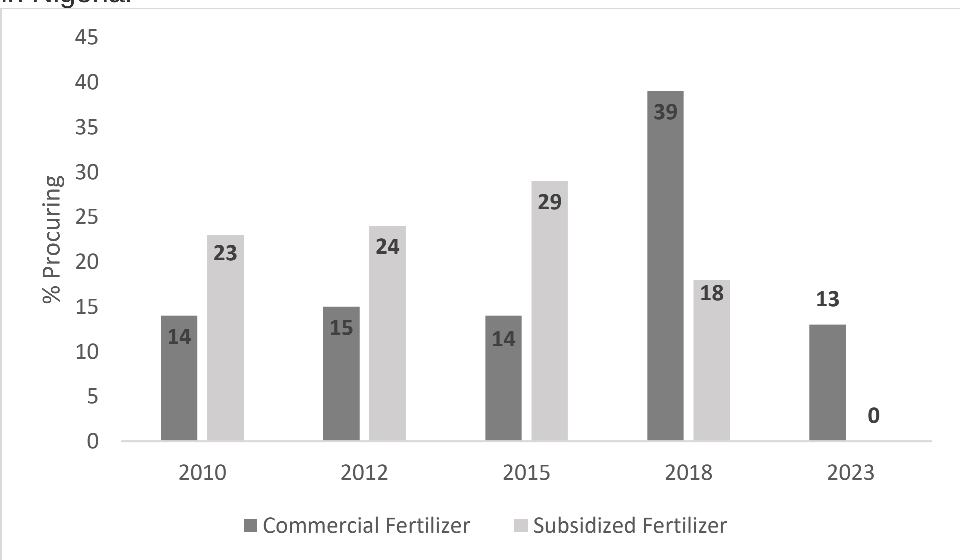
Figure N.7: Average subsidized fertilizer and commercial procured per household in 5 survey waves in Nigeria.



Source: constructed from the World Bank LSMS data; years of the survey were 2010, 2012, 2015, 2018, and 2023; this analysis uses data from 143 households who were surveyed in all five waves.

Figure N.8 also uses the LSMS data from the same years to track fertilizer use participation rates by source. It shows that the commercial fertilizer participation rate stayed between 14-15% in 2010, 2012, and 2015. It then shot up to 39% in 2018, as the subsidy was scaled down. However, due to the price spike, only 13 percent of farmers purchased fertilizer at commercial prices in 2023.

Figure N.8: Percent of households who procured subsidized and commercial fertilizer in 5 survey waves in Nigeria.



Source: constructed from the World Bank LSMS data; years of the survey were 2010, 2012, 2015, 2018, and 2023; this analysis uses data from 143 households who were surveyed in all five waves

Table N.2 presents the crowding out rates of commercial fertilizer by subsidized fertilizer (the percentage of total sales of fertilizer accounted for by displaced commercial fertilizer sales – i.e. fertilizer that would have been bought at commercial prices that was instead purchased at subsidized prices) that we calculated from the LSMS data for Nigerian farmers between 2010 and 2018. This is a quantitative, counterfactual analysis that used regression analysis to control for other factors besides subsidized fertilizer that may have also affected demand for commercial fertilizer, such as fertilizer prices, maize and rice prices, household assets, landholding credit access, distance to market, and demographic factors. Results of our analysis estimated that the crowding-out rate of commercial fertilizer by Nigeria's subsidy program between 2010 and 2018 was 40% on average. This meant that every 100 kilograms of subsidized fertilizer acquired by farmers in 2023 only led to 60 kilograms of new fertilizer applied to their fields. The remaining 40 kilograms were displaced commercial purchases.

Table N.2 also shows the crowding-out rates estimated by year, landholding quintile, and asset quintile. Panel 1 shows that the crowding out rate was 36% in 2010, 46% in 2012, and then declined to 32% in 2015. It is interesting to note that 2015 was the year that Nigeria's subsidy program was implemented using an e-voucher program which may have improved the targeting of the subsidy to farmers who would not have bought much commercial fertilizer otherwise. The crowding-out rate increased to 48% in 2018. Panel 2 shows that the average crowding out rate for the 20% of the sample with the smallest landholding was 30%. The average crowding-out rate increased as landholding increased, reaching 51% for the 20% of the sample with the most land. This was consistent with the finding in Panel III that showed that the crowding-out rate for the poorest 20% of the sample in terms of assets was 33% on average, but that rate rose to 46% and 43% for the wealthiest 40% and wealthiest 20% of the sample respectively. These results make sense and are consistent with studies from other countries (Ricker-Gilbert et al. 2011; Jayne et al. 2013). Wealthier farmers with more land are more likely to buy commercial fertilizer. Thus, they crowd out more of their commercial fertilizer purchases when they access subsidized fertilizer than do smaller-scale, more limited-resource farmers.

Table N.2: Crowding out by year, area cultivated, and assets

Category	Average Crowding out	P-value	Category Average
Overall	-0.40	(0.00)	-
Year			
2010	-0.36	(0.00)	-
2012	-0.46	(0.00)	-
2015	-0.32	(0.00)	-
2018	-0.48	(0.00)	-
Landholding			*Hectares*
SMALLEST 20%	-0.30	(0.00)	0.1
20 - 40%tile	-0.34	(0.00)	0.4
40 - 60%tile	-0.43	(0.00)	0.8
60 - 80%tile	-0.45	(0.00)	1.5
LARGEST 20%	-0.51	(0.00)	4.1
Asset Quintile			*'000 Naira*
POOREST 20%	-0.33	(0.00)	13
20 - 40%tile	-0.40	(0.00)	38
40 - 60%tile	-0.38	(0.00)	76
60 - 80%tile	-0.46	(0.00)	140
RICHEST 20%	-0.43	(0.00)	484

Source: constructed from the World Bank LSMS data; years of the survey were 2010, 2012, 2015, 2018; this analysis uses data from 740 households who were surveyed in the first four waves.

vi) ***Fertilizer user demographics***

The next two tables present the characteristics of farming households in Nigeria who purchased commercial fertilizer in every survey year from the LSMS data (2010, 2012, 2015, and 2018), those who bought in some years and not others, and those who never bought it. Table N.3 shows that only 2% of smallholder farmers in the sample purchased commercial fertilizer in all four years of the LSMS survey, while 58% bought fertilizer in some survey years, but not in others. Additionally, 40% of households never bought commercial fertilizer during the four survey years. This finding suggests that even though average commercial fertilizer use increased in Nigeria during the previous decade (as we saw in Figure N.6) the majority of farmers still did not purchase any commercial fertilizer over that period. This was consistent with the finding in Figure N.7, showing the % of farmers purchasing commercial fertilizer over time. It also indicates that even though Nigeria is the largest fertilizer producer in the region, and prices declined over time, many other barriers existed that prevented smallholders from buying commercial fertilizer.

Table N.3: Percentage of households that bought commercial fertilizer in every survey year, in some survey years, and in none of the waves in Nigeria.

Group	% of the Sample in the group
% of the sample who purchased commercial fertilizer in every survey year	2
% of the sample who purchased commercial fertilizer in some of the survey years but not all.	58
% of the sample who never purchased commercial fertilizer in any survey year	40
Total	100

Source: constructed from the World Bank LSMS data; years of the survey were 2010, 2012, 2015, 2018; this analysis uses data from 740 households who were surveyed in the first four waves.

Given the low participation rate and apparent uneven distribution of commercial fertilizer purchases in Nigeria, we broke down the landholding distribution of farmers into three categories: i) those with less than two hectares of land, ii) those with between two and five hectares, iii) those with more than five hectares. We also disaggregated these categories by households classified as living in the north, center, or south of the country. The results are shown in Table N.4. Column 4 indicated that farms with less than two hectares made up 77% of all farms nationally, 91% of all farms in the south where land holdings are very small, 72% in the central region, and 71% in the north. Column 2 indicates that in the north and central regions, farms with less than two hectares used significantly less fertilizer than those with between 2.0 and 5.0 hectares and those with more than five hectares. The south was a bit different with very low fertilizer use overall. In that region farms with less than 2.0 hectares used more fertilizer than farms with more than 5.0 hectares, at 14 and 1.2 kilograms per household on average respectively. However, in column 3 when we divided commercial fertilizer purchases by landholding it is clear that smaller farms in all regions used the input more intensively than did larger farms. For example, when we consider the national data, farms with less than 2.0 hectares acquired 68 kilograms of fertilizer per hectare, while farms between 2.0 and 5.0 hectares acquired 20 kilograms per hectare, and farms over 5.0 hectares acquired 11 kilograms per hectare. Thus, the results from Table N.4 indicated that fertilizer purchasing was uneven in Nigeria. This was consistent with the previous tables and figures. It showed that small-scale farms in Nigeria used less fertilizer overall but farmed more intensively than larger-scale farms by using higher amounts of fertilizer on a per-hectare basis. This finding was consistent with our analysis of fertilizer use in other countries including Kenya, Malawi, and Tanzania.

Table N.4: Landholding and Location Demographics for Households Purchasing Commercial Fertilizers in Nigeria

Landholding size	**(1) Mean Land Holding in group (Ha)**	**(2) Average Commercial fertilizer purchased in group (kg)**	**(3) Amount Purchased per hectare in group (kg)**	**(4) Percent of sample in group**
North				
Less than 2.0 hectares	0.8	74	93	71.4
Between 2.0 and 5 hectares	3.1	77	25	21.7
Greater than 5 hectares	7.0	121	17	6.9
Central				
Less than 2.0 hectares	0.8	28	35	71.7
Between 2.0 and 5 hectares	3.0	63	21	24.1
Greater than 5 hectares	6.4	47	7	4.2
South				
Less than 2.0 hectares	0.4	14	35	91
Between 2.0 and 5 hectares	3.0	13	4	6.8
Greater than 5 hectares	7.9	1.2	0.2	2.2
National – Total				
Less than 2.0 hectares	0.6	41	68	76.6
Between 2.0 and 5 hectares	3.0	59	20	17.9
Greater than 5 hectares	7.1	79	11	5.5

Source: constructed from the World Bank LSMS data; years of the survey were 2010, 2012, 2015, 2018; this analysis uses data from 740 households who were surveyed in the first four waves.

Table N.5 used linear regression to analyse the factors that were associated with purchasing commercial fertilizer in two or more survey years. This is consistent with the crowding out of commercial fertilizer by subsidized fertilizer in Table N.2. Households in areas where the fertilizer price is higher were more likely to buy fertilizer in two or more years. This may be because fertilizer prices were higher in areas where there was more demand. Households, where the head attended primary school, were 10.1 percentage points more likely to have purchased fertilizer in two or more years on average. These latter two results raise the issue of knowledge and education affecting fertilizer demand. Worse soil quality made households less likely to buy commercial fertilizer, while households with higher assets were more likely to buy it.

Table N.5: Demographic characteristics of households who bought commercial fertilizer in two or more survey years in Nigeria

Characteristic	**(1) Bought in two or more survey years**
Acquired subsidized fertilizer in 2022	NSS
Fertilizer price	Very small (+) positive effect
Farmgate maize price	NSS
Farmgate rice price	NSS
Landholding in hectares	NSS
Household size	+1.5 percentage point effect on average
=1 if female-headed household	NSS
Age of household head	-0.5 percentage point effect on average
If the household head primary educ	+ 10.1 percentage point effect on average
Access to formal credit	NSS
Access to informal credit	NSS
Member of savings group	NSS
Net maize buyer	- 32.5 percentage point effect on average
Net maize seller	NSS

Distance (km) from home to market	NSS
Accessed extension	NSS
Soil quality (1=good, 2= fair, 3=bad)	-30.4 percentage point effect on average
Household assets '000 Naira	Very small (+) positive effect
Received social safety net	NSS

Source: constructed from the World Bank LSMS data; years of the survey were 2010, 2012, 2015, 2018; this analysis uses data from 740 households who were surveyed in the first four waves; NSS means that the factor was not found to be statistically significant in a regression model; standard errors clustered at the

vii) Maize-to-fertilizer response rate impacts

The maize-to-fertilizer response rate tells us the number of kilograms of maize that a farmer obtains from a kilogram of fertilizer. It is an important measure for understanding how much an additional kilogram of fertilizer contributes to maize yields, food security and the profitability of fertilizer for farmers. It is crucial to note that fertilizer is one input into the production of food and farmers must have sufficient amounts of complimentary inputs, such as seed, land, labor, soil fertility, water, and farm management ability for fertilizer use to be effective. Estimates of Maize-to-fertilizer response rates in Nigeria conducted on agricultural experiment stations found that maize could obtain a response rate of 8.66 kilograms of maize per kilogram of fertilizer, and 7.66 kilograms of maize per kilogram of fertilizer on researcher-managed plots (Chapoto et al. 2023). The latter response rate estimate of 7.66 would imply that a 100 kilogram per acre application rate would generate 766 extra kilograms of maize per acre (~2,000 kilograms more per hectare). Thus, if response rates on researcher-managed plots were generalizable to Nigerian farmers' fields, inorganic fertilizer application could greatly enhance maize yields and food security.

Unfortunately, estimated maize-to-fertilizer response rates on researcher-managed plots should be considered an upper-bound estimate of what Nigerian farmers obtain on their own plots using their own management skills and complementary inputs. For example, Liverpool-Tasie et al. (2017) used the 2010 and 2012 Nigeria LSMS data to estimate maize-to-fertilizer response rates on maize plots for Nigerian smallholders. They estimated that the average response rate on farmer's fields was only about 2.56 kilograms of maize per kilogram of fertilizer. This meant that 100 kilograms of fertilizer only added 256 kilograms of additional maize per acre (~635 per hectare). The 510 kilogram /acre (~1,365) per hectare yield gap between a potentially optimal response to fertilizer cited in Chapoto et al. and the more realistic response rate in Liverpool-Tasie et al. has major implications for food security and fertilizer's lack of profitability in Nigeria. Other studies have found even lower response rates than Liverpool-Tasie et al. on farmers' fields in Nigeria with estimates close to zero (Onuk et al. 2010; Gani and Omonona 2009; Kehinde et al. 2012). These low estimated maize to fertilizer response rates raise serious questions about whether or not farmers in Nigeria should be applying fertilizer to maize, without complementary investments in soil fertility, water, and farm management.

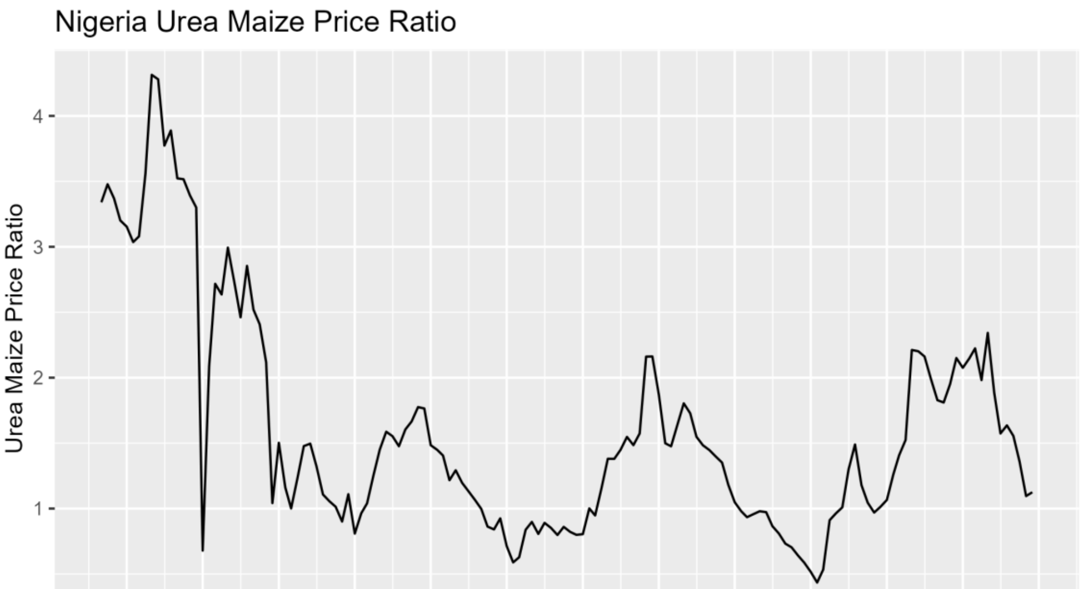
It is also worth asking the question of what limits maize yield response rates to fertilizer in Nigeria and elsewhere in the region. Nigeria, like many other countries in SSA, suffers from nutrient depletion and acidification in its soils (Jones and Wild, 1975; Liverpool-Tasie et al. 2017). This is caused by the continuous cultivation of nutrient-hungry cereals like maize. Given Nigeria's large and growing population, this challenge is likely to continue to worsen, unless major changes in farming systems occur. Thus, agricultural policy in Nigeria should focus on improving soil fertility and reducing acidity through the use of better soil management practices, liming to increase soil pH, erosion control, and better water management. In addition, Nigeria is a large country with vastly different ago-ecologies between the north and the south. This means that the blends of fertilizer and optimal application rates of fertilizer are likely to vary across widely. The explosion of new blending operations in recent years in Nigeria is potentially a positive development that can help meet the needs of farmers by creating new fertilizer blends that are better suited for soil conditions in specific areas of the country.

viii) Fertilizer profitability impacts

This subsection considers the profitability of fertilizer use in Nigeria. The intention is to understand if fertilizer was profitable for Nigerian farmers when valued at the commercial price that they paid. The profitability of fertilizer is affected by three main factors: 1) the price of fertilizer, 2) the price of maize (or other staple crop), and 3) the maize-to-fertilizer response rate. the Maize-to-fertilizer response rate was discussed in the previous sub-section and the overall finding from previous studies is that Nigerian farmers do not use fertilizer efficiently on a per-kilogram basis. Thus, the yield response to fertilizer in the country is low. This causes maize yields in Nigeria to not reach their full potential, thus reducing fertilizer profitability, as we will discuss below.

As mentioned above the price of fertilizer and the price of maize are key components in fertilizer's profitability. One way to look at this is through the ratio between fertilizer prices and maize prices. This is known as the input/output price ratio, and this relationship between urea and the farmgate maize price in Nigeria between 2010 and 2022 is shown in Figure N.9. A lower ratio means that fertilizer is more profitable, as the price of fertilizer is going down (i.e. the numerator in the ratio getting smaller) or the maize price is going up (i.e. the denominator is getting bigger). Figure N.9 indicates that the input/output price ratio before 2020 ranged from a high of 4.5 to a low of 0.5 across those years. This generally suggests that fertilizer was profitable relative to maize during the pre-spike period. The input/output price increased in early 2021 reaching a peak of 2.0 in 2022, before dropping to about 1.0 at the end of the year. This meant that at an input/output price of 2.0, a farmer would need to produce 2.0 kilograms of maize per kilogram of fertilizer to break even. Anything higher than that would be a profit and anything less than that would be a loss. Since our estimates from Chapoto et al. (2023) indicated that the average farmer obtained 2.56 kilograms of maize per kilogram of fertilizer in Nigeria, fertilizer use was profitable on average most of the time between 2010 and 2022, except in the earlier years of 2011 and 2012 when the input/output price ratio was at or above 3.0. Figure N.9 suggested that the input/output price ratio became more favorable for farmers on average over time. Furthermore, the price increase in 2021/22 did not undermine the input/output price ratio too much because maize prices rose at the same time fertilizer prices did in Nigeria. This meant that fertilizer profitability was not reduced much on average.

Figure N.9: Urea / farmgate maize price ratio in Nigeria 2010-2022



Source: Commercial fertilizer price for urea from AfricaFertilizer.org; wholesale maize price from FAOSTAT. We subtracted 8% from the wholesale price of maize to convert it to the retail price.

The set of three tables N.6 presents our calculations of the profitability of fertilizer for farmers when the input is valued at its commercial price. This is called the marginal value-cost ratio (MVCR) of an additional kilogram of fertilizer at that price. The MVCR is calculated as follows:

$$\text{MVCR} = \frac{\{\text{incremental maize output (kilograms of maize/kilograms of fertilizer) * maize price/kilogram}\}}{\text{price of fertilizer per kilogram.}}$$

An MVCR that is greater than one indicates that using fertilizer generated a positive and profitable return for farmers. A ratio equal to one is break-even, meaning that the farmer made no profits using fertilizer and a ratio less than one is a loss. However, whether or not fertilizer is likely to be profitable depends on outcomes that are uncertain when fertilizer decisions are made, as well as costs associated with the use of fertilizer that are unknown to the researcher. The types of risks that farmers face when using fertilizer at planting to increase staple crop yields at harvest include the chance of low yields due to adverse weather, and output prices at harvest being lower than expected. In the face of these uncertainties and unobserved costs, an MVCR of at least 2.0 (meaning a risk premium of one) has been recommended in the literature to be required in order for fertilizer to be profitable (Xu et al., 2009; Sauer and Tchale, 2009; Sheahan et al. 2013).

Table N.6.A shows the return to fertilizer using farm gate maize prices in and around Lagos in the south of the country. Table N.6.B used farm gate maize prices in Kano in the north of the country, and Table N.6.C used maize prices in Maiduguri in the north-eastern part of Nigeria. For virtually all years of our analysis across all three regions, the MVCR of commercial fertilizer use was between 1.0 and 2.0. The only exception was in Lagos/southwest in 2018/19 when the MVCR was 2.22. These findings generally meant that fertilizer was profitable when we ignored risk and transaction costs but it was not profitable when we included those extra measures of uncertainty. Our results were consistent with Liverpool-Tasie et al. (2017), who found that the MVCR was greater than 1.0 for more than half the farmers in their sample.

In Table N.6.A, the lowest MVCR in Lagos/southwest Nigeria was during the price spike in 2022/23 as seen in row G. At that time fertilizer prices were high relative to maize. Still, this MVCR of 1.54 indicated that the average farmer who used fertilizer would have obtained a 54% return on their investment. The highest return to fertilizer use came in 2018/19 when the MVCR was 2.22. The findings were similar in Table N.6.B and Table N.6.C when prices for Kano and Maiduguri were used. 2021/22, and 2022/23 were years with relatively low MVCRs in both regions. 2015/16 and 2018/19 were the years that had the highest MVCRs on average.

There are three important points to note from these findings. First, fertilizer profitability was relatively consistent across regions in Nigeria over time. This was due to the fact that fertilizer prices and maize prices did not vary much spatially in a given year, suggesting reasonable levels of price and market integration in Nigeria. Second, the results in tables N.6.A, N.6.B, and N.6.C were reflective of fertilizer profitability on average. The fact that in any given year between 2010 and 2018, only about between 20-33% of households bought any commercial fertilizer points to major access constraints and inequality in fertilizer purchasing and use. Thus, the government should focus on increasing fertilizer access by creating an enabling environment for the private sector to make fertilizer available to farmers. The disconnect between average profitability and low fertilizer use also points to a problem of liquidity and lack of access to financing for farmers. If farmers do not have cash at harvest then they lose out on the opportunity to use fertilizer and make money on an investment that would have likely generated a positive return. Promoting village savings groups and linking farmers to banking opportunities can help reduce this problem.

Second, it is important to note the reason why fertilizer has been relatively profitable according to the MVCR calculations is due to the relatively low price of fertilizer relative to the price of maize and not because farmers use fertilizer efficiently. As discussed in the previous section, the yield response rate to fertilizer is very low at 2.5 kilograms of maize per kilogram of fertilizer. There is significant room for improvement in this aspect. The government should invest in working with farmers to implement complementary practices such as soil fertility management, erosion control, climate change adaption, and use of appropriate fertilizer blends, and proper timing of fertilizer application. The conclusions section offers additional recommendations to address these challenges in Nigeria.

Table N.6.A: Marginal value cost ratio of using fertilizer at commercial prices for farmers in Nigeria (Lagos/Southwest)

Production Year		2010/11	2012/13	2015/16	2018/19	2021/22	2022/23
	Estimated incremental benefits						
A	Yield response (Maize Kg/ Nitrogen kg)	7.67	7.67	7.67	7.67	7.67	7.67
B = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	2.53	2.53	2.53	2.53	2.53	2.53
C	Average Harvest Season Farmgate Maize price ($/MT): (May-July)	328	482	437	322	564	491
D	Commercial pr. of fertilizer for farmers (NGN/50kg)	3627	5197	5800	6,600	16833	18700
E	Commercial pr. of fertilizer for farmers ($/MT)	471	658	583	367	811	806
F= E/C	Harvest Season Input/Output Price Ratio (fertilizer pr. /maize pr.)	1.44	1.36	1.33	1.14	1.44	1.64
G = (C*B)/E	Harvest Season Marginal Value Cost Ratio of Fertilizer per kg	1.76	1.85	1.90	2.22	1.76	1.54

Source: authors' calculations. Commercial fertilizer price for urea from AfricaFertilizer.org; wholesale maize price from FAOSTAT; Yield response estimate from Chapoto et al. (2023).

Table N.6.B: Marginal value cost ratio of using fertilizer at commercial prices for farmers in Nigeria (Kano/North)

Production Year		2010/11	2012/13	2015/16	2018/19	2021/22	2022/23
	Estimated incremental benefits						
A	Yield response (Maize Kg/ Nitrogen kg)	7.67	7.67	7.67	7.67	7.67	7.67
B = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	2.53	2.53	2.53	2.53	2.53	2.53
C	Average Harvest Season Farmgate Maize price ($/MT): (May-July)	345	345	415	261	491	495
D	Commercial pr. of fertilizer for farmers (NGN/50kg)	3787	5280	5700	6,567	17967	18900
E	Commercial pr. of fertilizer for farmers ($/MT)	492	668	573	365	866	815
F= E/C	Harvest Season Input/Output Price Ratio (fertilizer pr. /maize pr.)	1.43	1.94	1.38	1.40	1.76	1.65
G = (C*B)/E	Harvest Season Marginal Value Cost Ratio of Fertilizer per kg	1.78	1.31	1.83	1.81	1.44	1.54

Source: authors' calculations. Commercial fertilizer price for urea from AfricaFertilizer.org; wholesale maize price from FAOSTAT; Yield response estimate from Chapoto et al. (2023).

Table N.6.C: Marginal value cost ratio of using fertilizer at commercial prices for farmers in Nigeria (Maiduguri/North East)

Production Year		2010/11	2012/13	2015/16	2018/19	2021/22	2022/23
	Estimated incremental benefits						
A	Yield response (Maize Kg/ Nitrogen kg)	7.67	7.67	7.67	7.67	7.67	7.67
B = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	2.53	2.53	2.53	2.53	2.53	2.53
C	Average Harvest Season Farmgate Maize price ($/MT): (May-July)	372	493	440	268	460	502
D	Commercial pr. of fertilizer for farmers (NGN/50kg)	3787	5280	5700	6,567	17967	18900
E	Commercial pr. of fertilizer for farmers ($/MT)	492	668	573	365	866	815
F= E/C	Harvest Season Input/Output Price Ratio (fertilizer pr. /maize pr.)	1.32	1.36	1.30	1.36	1.88	1.62
G = (C*B)/E	Harvest Season Marginal Value Cost Ratio of Fertilizer per kg	1.91	1.87	1.94	1.86	1.34	1.56

Source: authors' calculations. Commercial fertilizer price for urea from AfricaFertilizer.org; wholesale maize price from FAOSTAT; Yield response estimate from Chapoto et al. (2023).

6. Policy recommendations

Based on the results of this report we make the following recommendations for Nigeria to better prepare for and address fertilizer price spikes to better ensure a response that benefits farmers and creates a more profitable and resilient supply chain.

i. The Maize-to-fertilizer response rate is very low in Nigeria and there is significant room for improvement in this aspect. The government should invest in working with farmers to implement complementary practices such as soil fertility management, erosion control, climate change adaption, and use of appropriate fertilizer blends, and proper timing of fertilizer application. The fact that we found fertilizer use to be profitable on average even with low fertilizer response rates, due to favorable fertilizer and maize prices, suggests that there is significant potential for Nigeria to increase fertilizer profitability, yields, incomes, and food security if the government commits to making these investments.
   a. The fact that new site-specific fertilizer blends are entering the markets is a positive development. Future research should evaluate the extent to which these new blends increase fertilizer use and maize-to-fertilizer response rates among smallholder farmers.

ii. Nigeria's emphasis on supporting domestic fertilizer production has made it the largest fertilizer producer and exporter in the region. However, this has not translated into lower prices and more fertilizer access for smallholder farmers in Nigeria or in neighboring countries. The government needs to recognize that the benefits from subsidies for the fertilizer industry do not necessarily trickle down to farmers. Thus, they should consider how they balance financial support for fertilizer production with farmers' ability to access fertilizer, for example:
   a. Review the existing export quota that determines the amount of domestically produced fertilizer that stays in the country and cannot be exported abroad. In recent years farmers have not purchased up to the quota limit, likely because the price of fertilizer has been high. Thus, there may need to be a price ceiling along with an export quota to ensure domestically produced fertilizer is available at a profitable price for Nigerian farmers.
   b. Use revenue generated from fertilizer production to implement a small-scale targeted fertilizer subsidy program that reaches limited-resource farmers who do not purchase much fertilizer commercially. This program should use e-vouchers, be time-limited, and run through private agro-dealers.

iii. To improve farmers' access to fertilizer, it is important that the government focus on creating an enabling environment for new entrants into the fertilizer supply chain. The emphasis should be on developing the last mile of the fertilizer supply chain from wholesalers to hub agro-dealers and retail outlets located in rural areas. Doing so is essential as only 20-30% of Nigerian farmers buy any commercial fertilizer in a given year.

iv. The fact that in any given year between 2010 and 2018 only about between 22-35% of households bought any commercial fertilizer in Nigeria points to major access constraints and inequality in fertilizer purchasing and use. The disconnect between average profitability and low fertilizer use also points to a problem of liquidity and lack of access to financing for farmers. If farmers do not have cash at harvest, then they lose out on the opportunity to use fertilizer and make money on an investment that would have likely generated a positive return. promoting village savings groups and linking farmers to banking opportunities can help reduce this problem.

v. The government should consider alternative programs to subsidies, such as 'commodity buy-back' and structured off-taker arrangements with a constant market. This may reduce the possibility of corrupt practices in fertilizer subsidy and encourage farmers to use more fertilizer due to guaranteed return on investment.

vi. The government must take deliberate action to have a harmonized and updated national farmer registry in Nigeria. This must be void of political, ethnic, or religious considerations. The registry must have a structured and effective monitoring system to track genuine farmers and those who enter and exit the sector.

7. References

Chapoto, A., L. Tiemann , A.M. Akyoo , J. Bonabana , N.F. Faye , M. Kalaba , I.K. Kanyama , L. Kirimi , G. Mandlhate , S. Mbai , E. Mwakiwa , C. Nyondo , I. Ogunbayo , N. Mebeelo , T.S. Jayne. 2023. "Farmer's risks and economic use of fertilizer in Africa South of the Sahara." ANAPRI Policy Report.

Gani,B.S., Omonona,B.T. 2009. Resource use efficiency among small-scale irrigated maize producers in Northern Taraba State of Nigeria. *J.Hum.Ecol*. 28(2), 113119.

Jayne, T.S., D. Mather, N. Mason, and J. Ricker-Gilbert. 2013. "How do Fertilizer Subsidy Programs Affect Total Fertilizer Use? A Synthesis of the Evidence on "Crowding in/out" in sub-Saharan Africa." *Agricultural Economics* 44(6):687-703.

Kehinde, F.T., Olukosi, J.O., Ala, A.L., Maikasuwa, M.A., Odunsi, A.A., 2012. Determination of the level of resource-use efficiency in Quality Protein Maize (QPM) production in Kaduna State, Nigeria. I*nt. J. Appl. Agric. Apiculture Res.* 8 (1),24–30.

Liverpool-Tasie, L., Omonona, B., Sanou, A., & Ogunleye, W. 2015. Is increasing inorganic fertiliser use for maize production in SSA a profitable proposition? Evidence from Nigeria. *Food policy*, 67, 41-51.

Onuk, E.G., Ogara, I.M., Yahaya, H., Nannim, N., 2010. Economic analysis of maize production in Mangu local government area of Plateau State, Nigeria. PAT J. 6 (1), 1–11.

Ricker-Gilbert, J., T.S. Jayne and E. Chirwa. 2011. "Subsidies and Crowding Out: A Double-Hurdle Model of Fertilizer Demand in Malawi." *American Journal of Agricultural Economics*. 93(1): 26-42.

Sauer, J., Tchale, H., 2009. "The economics of soil fertility management in Malawi." *Applied Economics Perspectives and Policy*. 31 (3), 535–560.

Sheahan, M., Black, R., & Jayne, T. S. 2013. "Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research." *Food Policy*, 41, 39-52.

Xu, Z., Guan, Z., Jayne, T. S., & Black, R. 2009. "Factors influencing the profitability of fertilizer use on maize in Zambia." *Agricultural Economics*, 40(4), 437-446.

v. Tanzania Country Report

1. Main Findings for Tanzania

1. The fertilizer supply chain in Tanzania is very concentrated. At the top of the market, three companies produced fertilizer in 2022 and 2023. This was up from one company in 2014 and two companies in 2019. Even though Tanzania produces some fertilizer, domestic production is only enough to meet roughly 10% of the country's fertilizer demand, the rest of which is met through imports. The blending industry is also very concentrated with three companies controlling 90% of that activity in 2022 and 2013. This was up from one blender from 2014 to 2019. The importing business is fairly concentrated but has seen an increase from four firms that controlled 90% of the fertilizer imports in 2014 to six in 2022 and seven in 2023. The trend is similar in the wholesaling and retailing sectors as seven firms were responsible for 90% of these activities in 2014, 12 were in 2019, 32 were in 2022 and 34 were in 2023 (IFDC 2024). Thus, it can be said that the fertilizer sector in Tanzania is concentrated but has become less so over the past decade.
   a. The increased competition in Tanzania's fertilizer sector has led to the development of new formulations that have been blended to suit basic plant nutrient requirements and soil fertility status. The general view from key informants with a cross-country perspective is that the fertilizer sub-sector in Tanzania is both farmer and market-oriented.
   b. Dar es Salaam is a major port where fertilizer enters both for the Tanzanian market and to serve other countries in the region, like Zambia, Malawi, Uganda, Rwanda, and Burundi. There is evidence that the port's growth has been associated with the fertilizer market's development in Tanzania (Baum et al 2021).

2. The urea price wedge is the difference between the urea price in Tanzania and the world price according to the World Bank Pink Sheet. We found that the price wedge in Tanzania increased between 2010 and 2012, but then generally trended downward between 2012 and 2020. At its peak, the wedge was over $600/MT in 2012, but dropped close to zero in 2017 and 2018, before rising to between $200-$300/MT in 2019 and 2020. The general downward trend in the price wedge during the previous decade also suggests that the fertilizer market in Tanzania may have been gaining efficiency as the local price moved closer to the world price during that time.

3. Our analysis of monthly urea prices between 2010 and 2020 indicated that several key factors affected the urea price level and wedge (i.e. the difference between local urea prices and world urea prices) in Tanzania:

Urea Price Level Results

a. Results of the model indicated that an increase a 1% increase in Tanzania's Forex Reserves was associated with a 0.83% decrease in urea prices on average. This implies that higher foreign exchange reserves may facilitate efficient trade transactions and help to reduce the cost of imported fertilizers.

b. A 1% increase in Tanzania's GDP was associated with a 0.58% increase in urea prices on average. This suggests that economic growth, which may increase overall demand for agricultural inputs, can put upward pressure on fertilizer prices.

c. A 1% increase in the world urea price was associated with a 0.32% increase in urea prices on average. This suggests that global market conditions for urea influence local prices.

Urea Price Wedge Results

a. The *One Yr After Election* variable was statistically significant and negative in the wedge model. It indicated that the year following a presidential election was associated with a

0.23% decrease in the price wedge on average. This might reflect post-election economic adjustments or the desire of the winning candidate to reward their constituents.

b. The *Election Yr* variable was also statistically significant and negative. It indicated that election years were associated with a 0.21% decrease in the price wedge on average. This might reflect efforts by the incumbent government to influence fertilizer prices during election periods.

c. Tanzania's *ForEx Reserves* were found to be statistically significant and negative. It suggested that a 1% increase in foreign exchange reserves was associated with a 1.20% decrease in the price wedge on average. This implies that higher foreign exchange reserves may facilitate efficient international trade transactions and help to lower the price wedge.

d. The previous month's *Local Maize Price* was positive and statistically significant. It indicated that a 1% increase in maize prices was associated with a 0.27% increase in the urea price wedge on average. Higher maize prices, indicating greater anticipated demand for fertilizer, push up local prices relative to world prices.

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4. Tanzania has intervened in the fertilizer market in different ways since independence. The following are the major initiatives in the sector over the past 20 years:
   a. Tanzania began with a small untargeted subsidy program in 2003/04 that was internally funded without donor support. That program ran until 2007.
   b. The international food price crisis of 2007/08 caused the government of Tanzania and development partners like the World Bank to consider the need to scale up a larger, targeted subsidy program at the end of the decade.
   c. The resulting program was known as the National Agricultural Input Voucher Scheme (NAIVS). It was funded by the Tanzanian government and the World Bank. NAIVS began in 2007/08 targeting 500,000 beneficiaries in 53 districts. In 2009/2010 this was expanded to 57 districts targeting 1.5 million beneficiaries. This rose to a high of more than 2.0 million beneficiaries in 2010/11 before scaling back to 1.8 million in 2011/12, 1.0 million in 2012/13 and 500 thousand in 2013/14.
   d. The NAIVS had numerous elements of a smart subsidy program. These included i) using the private sector to import subsidized fertilizer and the existing agro-dealer network to retail it to farmers, ii) using vouchers in an attempt to target limited-resource farmers who did not buy much commercial fertilizer, and iii) having an exit path for beneficiaries to graduate from receiving the subsidy after three years. A village selection committee determined beneficiaries and these farmers would select a participating agro-dealer where they could redeem two fertilizer vouchers, each for one 50-kilogram bag of fertilizer at a 50% subsidy and one 10-kilogram bag of maize seed at a 100% subsidy.
   e. The Tanzanian government ended the NAIVS in 2016/17 and moved to a bulk procurement system (BPS) for fertilizer. The objective of the BPS was to reduce the cost of fertilizer at the farm level. This was done by reducing the negotiated price of fertilizer products bought in the global market and imported into the country. The BPS was motivated by the apparent success of the model used for the procurement of petroleum products in Tanzania. However, the overall assessment of the bulk procurement that ran between 2021/22 was that it was not successful in lowering fertilizer prices for farmers nor did it increase their access to the input.
   f. In response to the sharp increase in fertilizer prices in 2021/22, the government of Tanzania first reintroduced direct fertilizer subsidies for farmers for the first time since 2016/17. The program aimed to reduce the price of fertilizer by about 37% to improve access to affordable fertilizer for farmers. Second, the government encouraged domestic production of fertilizer by promoting the use of local materials in its production. The government's third action was to abolish the BPS. In doing so they allowed more than one company to import fertilizers and opened the competition to a wide group of private sector firms. The rationale was to increase access to affordable fertilizers for farmers. Opening up the market has been associated with the increased

number of fertilizer market actors, although the new subsidy program has experienced a number of challenges. We discuss those in detail in the report.

5. According to FAOSTAT fertilizer use per acre stood at less than one kilogram in the year 2000 but rose to more than 16 kilograms per acre in 2019 in Tanzania. While the growth was impressive in percentage terms, fertilizer use in Tanzania is still below other countries in the region like Kenya, Malawi, and Zambia. It is far below the target set by the Abuja declaration of 50 kilograms per hectare. The findings from our analysis of nationally representative smallholder data collected by the World Bank Living Standards Measurement Survey (LSMS) in 2010, 2012, 2015, and 2020, were consistent with FAOSTAT. We found that between 2010 and 2018, average commercial fertilizer use increased from nine kilograms per household in 2010 to 27 kilograms per household in 2015, a 200% increase from a very low base. The average commercial fertilizer use then dropped down to 23 kilograms per household in 2020.

6. The increase in commercial fertilizer use by farmers in the past decade also coincided with the scaling down of direct subsidies to farmers over that period. Our analysis of commercial fertilizer demand in Tanzania using the LSMS data found that the NAIVS program did not have a significant crowding-out effect on commercial fertilizer use in Tanzania. This stands in contrast to subsidy programs in other countries in the region, including Kenya, Malawi, Nigeria, and Zambia. The fact that NAIVS incorporated many elements of a smart subsidy program and distributed a relatively small volume of subsidized fertilizer may have contributed to its efficiency and low crowding out rate.

7. We found that between 2010 and 2020 at most only 22% of households purchased commercial fertilizer across the country. As such, even though average commercial fertilizer use increased in Tanzania during the previous decade, the majority of farmers still did not purchase any commercial fertilizer over that period. The previous finding that fertilizer use increased along with this finding that many households did not use it, points to the strong likelihood that fertilizer access is highly unequal in Tanzania. It also suggests that even though fertilizer prices declined between 2010 and 2020, many other barriers existed that prevented smallholders from buying commercial fertilizer.

8. Our calculations of fertilizer profitability suggested that returns to using commercial fertilizer were positive <u>on average</u> before and during the fertilizer price spike of 2021/22. The lowest return was in 2015/16 when fertilizer prices were relatively high in the pre-spike period. The lowest return was in 2022/23 when fertilizer prices were $1,062/MT on average at the height of the fertilizer price-spike period and maize was valued at its average harvest season price of $344/MT. The highest return to fertilizer use came the next year in 2023/24 the price of fertilizer declined to an average of $630/MT and maize prices climbed to an average of $429/MT. In the pre-spike decade of 2010-2021, we found that the fertilizer was profitable on average in all years that we analyzed.
    a. The reason why fertilizer has been relatively profitable in Tanzania is due to the relatively low price of fertilizer in Tanzania relative to the price of maize, and not because farmers use it efficiently. The maize-to-fertilizer response rate in Tanzania has been estimated to be low, as the average farmer was found to obtain 3.32 kilograms of maize per kilogram of fertilizer (Chapoto et al. 2023). This was higher than some other countries in the region like Malawi and Zambia, but lower than in Kenya, and there is significant room for improvement. Chapoto et al. (2023) highlighted some of the constraints that limit fertilizer the efficiency of fertilizer used in the country. First, the price of fertilizer has been high in recent years and the Tanzanian Shilling has depreciated against the US dollar over the past decade which has eroded farmers purchasing power for fertilizer. Second, counterfeit fertilizer has

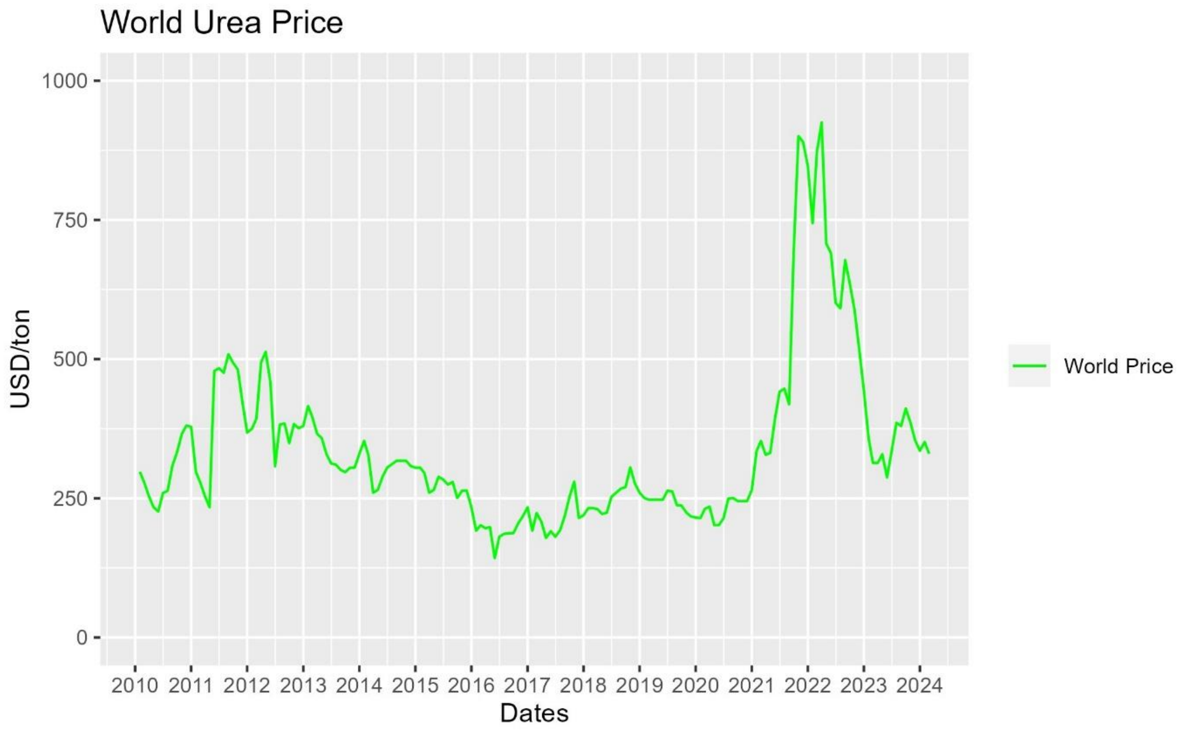
been an issue. Third, government agencies that regulate the fertilizer sector often are slow to grant private-sector actors the permits and authority they need to import and distribute fertilizer in the country due to poor coordination. Fourth, at the farm level, there is limited awareness of the benefits of inorganic fertilizer among smallholder farmers. Historically, Tanzania's vast land area and low population density along with relatively favorable agro-climatic conditions meant that fertilizer was not a common input in smallholders' production systems. Finally, given the country's size and diverse agroecology, there has been a lack of site-specific fertilizer blends and recommendations that match the soil-nutrient requirements on farmers' fields.

2. Introduction

International fertilizer prices increased and then decreased substantially between 2020 and 2024. The initial global drivers of the increase were disruptions in the global supply chain caused by COVID-19. As a result, China and Russia, two of the largest fertilizer exporters, imposed restrictions on their exports. These restrictions also came at the same time that international coal and natural gas prices, key inputs in the production of fertilizer, were rising. Fertilizer prices increased further in early 2022, due to the fallout from the Ukraine crisis. Russia and Ukraine are major fertilizer exporters, and Russia's invasion of Ukraine greatly reduced the global fertilizer supply during the initial months of the war. At the same time that fertilizer prices increased, prices of staple foods increased as well. This increase in input and output prices had important implications for smallholder farmers, small-scale traders, and consumers in Tanzania as it did in many other countries of sub-Saharan Africa (SSA). This is not surprising because Tanzania imports roughly 90% of all its fertilizers from the international market. Figure T.1 shows the world price of urea, between 2010 and 2024 in nominal USD per metric ton (MT). The figure shows that prior to the price spike of 2021/22, the price of urea had declined from a high of about USD 500/MT in 2013 to a low of about USD 250/MT in 2020 before the spike began. The world price of urea then spiked beginning in early 2021 reaching a high of USD 925 in March of 2022. The price then dropped during the remainder of 2022 before reaching a monthly average of $375/MT in the second half of 2023.

This report analyzes global and national-level urea prices because urea is a consistent blend of fertilizer (46% nitrogen) that is traded and used globally. Doing so allows us to make cross-country comparisons. Subsequent figures and analyses compare the price of urea in Tanzania with the world price. The difference between the local price, and the world price is called the price wedge. Understanding the factors that affected the fertilizer price wedge before, during, and after the fertilizer price spike of 2021/22 in Tanzania is important for developing policies, programs, and strategies to mitigate the effects of future shocks.

Figure T.1: World price of urea in nominal USD (2010 – 2023)



Source: World Bank Pink Sheets. Urea prices were reported for F.O.B. in the Black Sea before 2022 and in the Middle East since.

3. Objectives

This report has several main objectives. The first is to analyse and document what the change in the fertilizer price wedge during the global fertilizer price spike of 2021/22 meant for Tanzania. We estimated which factors explained urea's local price and the country's price wedge over the past 13 years. Second, we assessed how the government, donors, and other multi-lateral organizations in Tanzania responded to the price spike. Since supporting the bulk importation of fertilizer was a major policy of the Tanzania government before the price spike and implementing a new subsidy for fertilizer was a major policy during the price spike, we discussed these policies in detail. We also estimated the impact of direct fertilizer subsidies to farmers on commercial fertilizer demand, and how effective fertilizer policy was at increasing fertilizer use among smallholder farmers in Tanzania. Third, we estimated the profitability of fertilizer use for farmers in Tanzania using data on smallholder farm household data in the country that was collected by the World Bank's Living Standards Measurement Survey (LSMS). Finally, based on these analyses we made recommendations that the Government of Tanzania, donors, and the private sector can take to increase the returns to fertilizer use among farmers. Ultimately this will help to make the fertilizer sector more resilient and better prepared for the next time fertilizer prices rise drastically.

4. Methodology

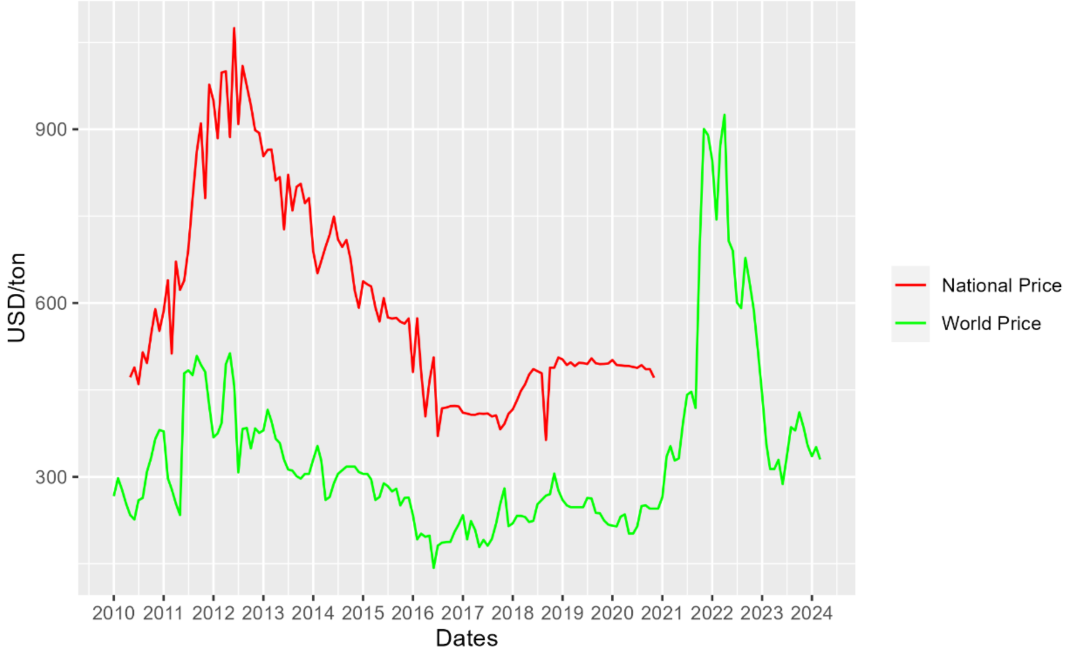
The study applied the following methodology: 1) a qualitative and quantitative econometric analysis of the factors that affected the fertilizer price wedge before during and after the fertilizer price spike in Tanzania; 2) a review of the fertilizer market structure that was conducted by key informant interviews with important actors in the fertilizer sector, and review of relevant background documents 3) a scoping review of the literature and available databases on fertilizer subsidy policies in Tanzania and fertilizer prices, both global and national, before, during and after the fertilizer price spikes of 2021/22. 4) an analysis of the farmer survey conducted by the World Bank's LSMS team. Using these data we analysed fertilizer demand, including i) how Tanzania's fertilizer subsidy program affected demand for commercial fertilizer for both the average household and along the distribution of assets and landholding, ii) how fertilizer purchasing behavior over time was associated with farm household characteristics, iii) how fertilizer profitability was affected by the price spike.

5. Results and Discussion

i) The fertilizer price wedge in Tanzania

Figure T.2 shows the nominal price of urea in Tanzania between June 2010 and November 2020 in USD in red and how it compares to the world price of urea in green. AfricaFertilzer.org does not report fertilizer price data for Tanzania beyond 2020 which is why the local price in Tanzania in the figure ended at that time. The figure indicated that the price of urea in Tanzania was always above the world price before the price spike of 2021/22. This is not surprising, given Tanzania's position as a fertilizer importer. However, urea prices in Tanzania trended downward during that pre-spike period, moving closer to the world price. This meant that the wedge got smaller. Urea's price in Tanzania went from a high of over USD 1,050/MT in 2012 to about USD 450/MT at the end of 2020. This suggests that fertilizer use was becoming more profitable for farmers during that period, in US dollar terms, before the price spike.

Figure T.2: Retail prices of Urea in Tanzania and the world price in USD/MT (2010-2020)

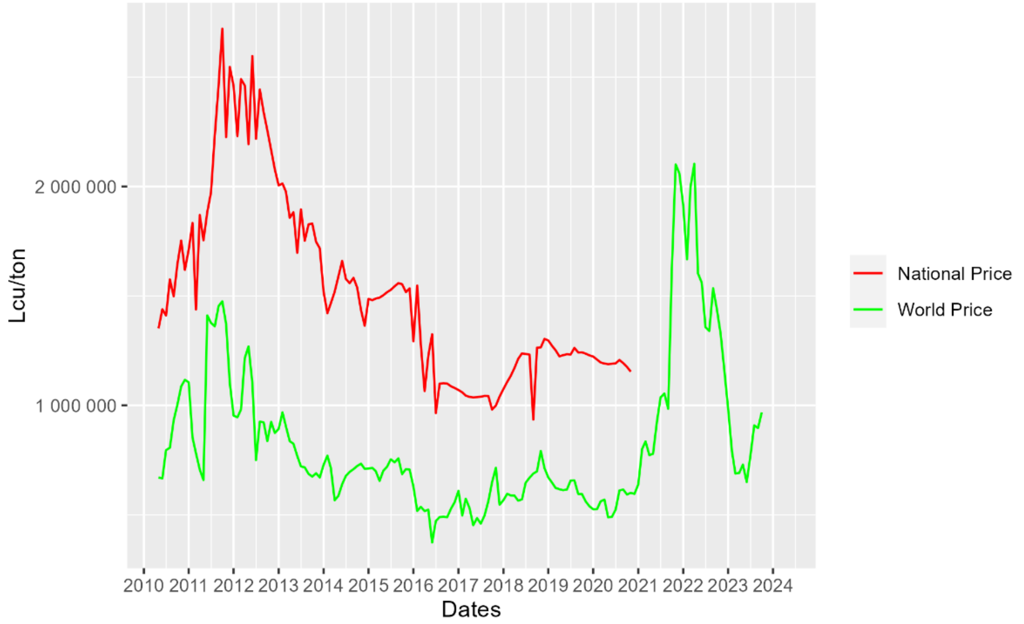


Notes: Price Wedge = Local urea price (US$/Ton) – World Price (US$/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Tanzania began in 2010.

Figure T.3 presents the same relationship between the price of urea in Tanzania and the world price between 2010 and 2020, but this time both price series were measured in nominal local Tanzanian Shilling. Just as when urea was USD, the price of urea in Tanzania declined significantly before the price spike in Shilling terms, and moved closer to the world price. This again suggested that the fertilizer market may have been becoming more efficient.

The next sub-section discusses the results of our quantitative results on factors that affect the price of urea and the price wedge in Tanzania.

Figure T.3: Retail prices of Urea in Tanzania, and the world price in Shillings/MT (2010-2020)



Notes: Price Wedge = Local urea price (Shilling/Ton) – World Price (Shilling/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Tanzania began in 2010.

ii) Quantitative analysis of factors affecting the fertilizer price wedge over time in Tanzania.

Results by Variable for Price Level Model in Shillings

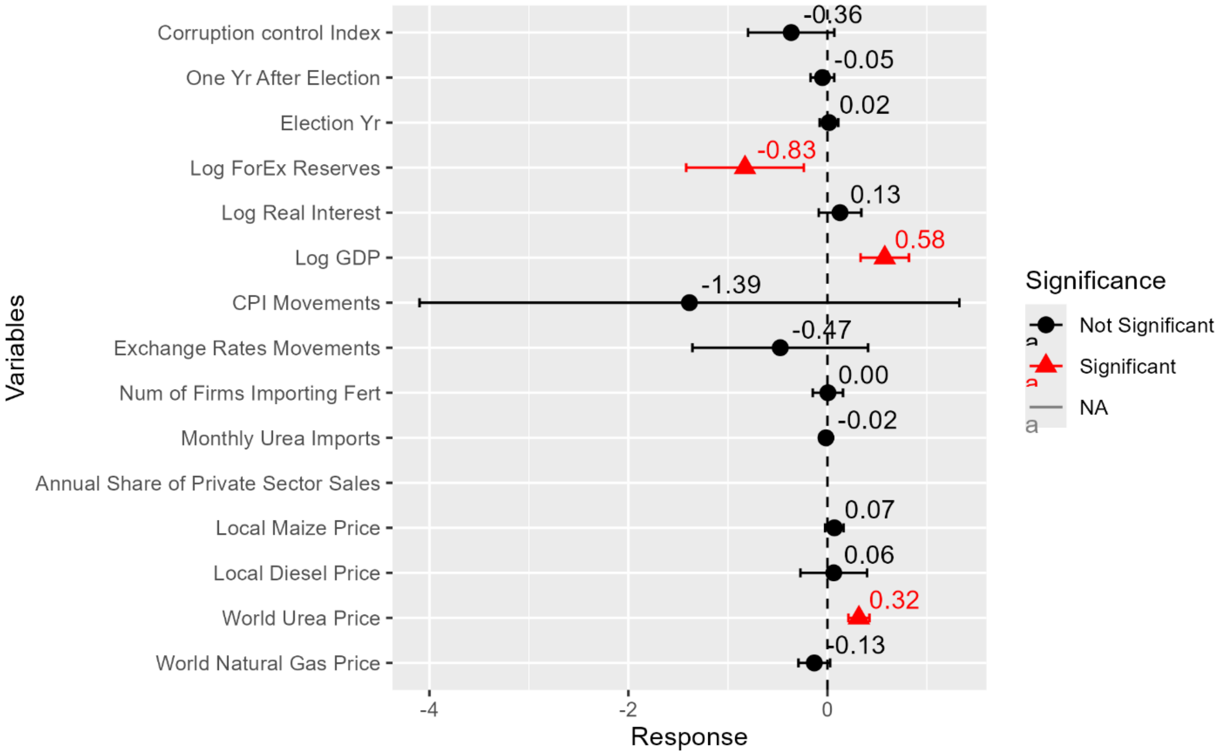
Figure T.4 presents the box and whiskers plot for the factors that affected the price of urea in Tanzania between 2010 and 2020. This figure is based on a time series regression of monthly urea prices collected by AfricaFertilizer.org. The urea price was regressed against a set of factors that were hypothesized to affect them.

Model results indicated that the *Log Forex Reserves* were negative and statistically significant. It meant that a 1% increase in foreign exchange reserves was associated with a 0.83% decrease in urea prices on average. This implies that higher foreign exchange reserves may facilitate efficient trade transactions and help to reduce the cost of imported fertilizers.

The *Log of Tanzania's GDP* was positive and statistically significant. This meant that a 1% increase in GDP was associated with a 0.58% increase in urea prices on average. This suggests that economic growth, which may increase overall demand for agricultural inputs, can put upward pressure on fertilizer prices.

The Log of World Urea was positive and statistically significant. It indicated that a 1% increase in the world urea price was associated with a 0.32% increase in urea prices on average. This suggests that global market conditions for urea influence local prices.

Figure T.4. Factors affecting Urea prices in Tanzania from 2010-2020 in Shillings/MT



Notes: Results are from a linear regression model of 138 monthly observations of nominal urea price levels in Tanzania denominated in shillings from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into shillings to correspond to the impacts in local markets. Model includes year fixed effects.

Results by Variable for Price Wedge Model in shillings

Figure G.5 presents the box and whiskers plot for the factors that affected the urea price wedge in Tanzania between 2010 and 2020. This figure is based on a time series regression of the monthly price wedge, defined as the difference between the urea price in Tanzania and the world price, both in shillings. The wedge was regressed against a set of factors hypothesized to affect it, similar to those used in the cross-country panel model.

The *One Yr After Election* variable was statistically significant and negative. It indicated that the year following an election was associated with a 0.23% decrease in the price wedge on average. This might reflect post-election economic adjustments or policy changes that affect fertilizer prices to reward constituents after a president wins an election.

The variable for *Election Yr* was also negative and statistically significant. It indicated that election years were associated with a 0.21% decrease in the price wedge. This might reflect efforts by the incumbent government to influence fertilizer prices during election periods.

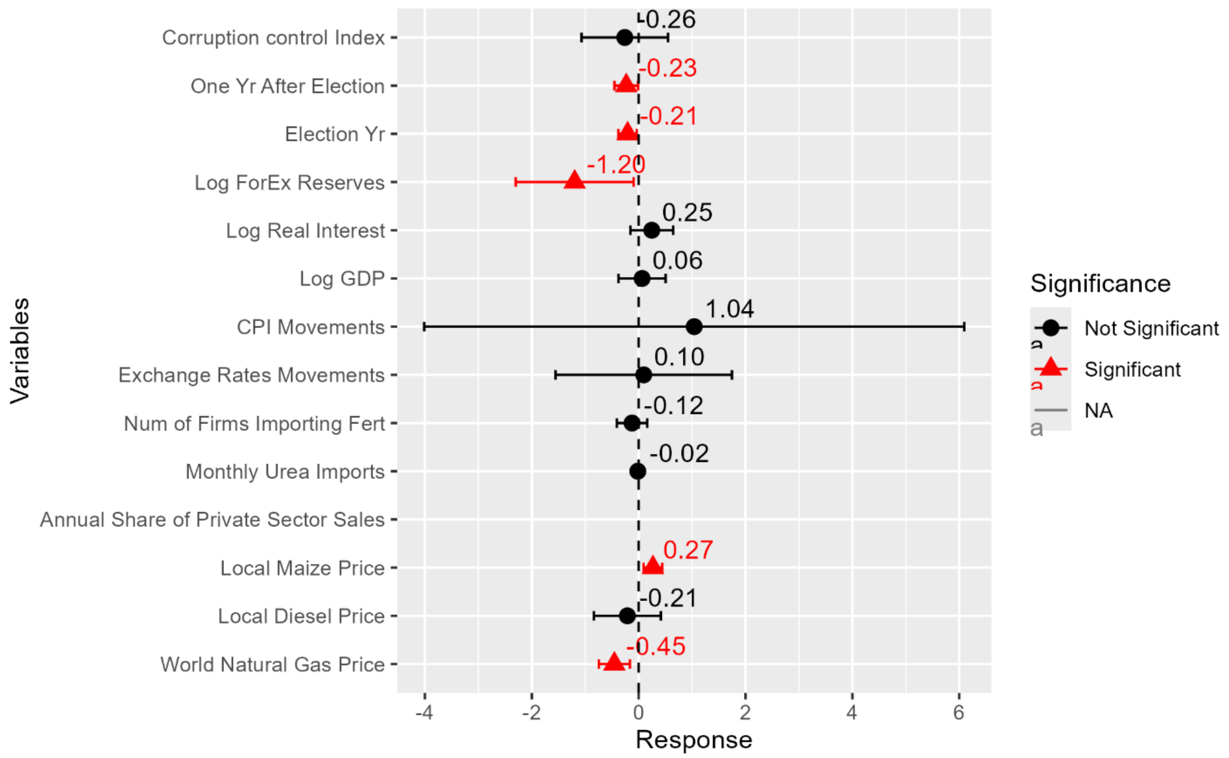
Log of Tanzania's ForEx Reserves was statistically significant and negative. It indicated that a 1% increase in foreign exchange reserves was associated with a 1.20% decrease in the price wedge on average. This implies that higher foreign exchange reserves may facilitate efficient international trade transactions and help to lower the wedge.

The previous month's *Local Maize Price* was positive and statistically significant, suggesting that a 1% increase in maize prices was associated with a 0.27% increase in the price wedge on average. Higher maize prices, indicating greater anticipated demand for fertilizer, likely push up local urea prices relative to world prices.

World Natural Gas Price was negative and statistically significant in the wedge model. It indicated that a 1% increase in the natural gas index was associated with a 0.45% decrease in the price wedge on average. This result is at odds with our expectations, and likely indicates that the variable is spuriously correlated with a lower wedge in some years.

Figure T.5: Factors affecting Urea price wedge in Tanzania 2010-2023 in Shillings /MT

Dependent variable: urea price wedge asinh(nominal urea price in shillings – world price in shillings)



Notes: Results are from a linear regression model of 139 monthly observations of nominal urea price wedges in Tanzania. The price wedge is calculated as the price of urea in shillings in each country obtained from AfricaFertilizer.org minus the world price of urea obtained from the World Bank Pink Sheets converted to shillings. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into shillings to correspond to the impacts in local markets. Models include year fixed effects.

iii) *Analysis of fertilizer market structure in Tanzania*

Table T.1 presents the structure of the fertilizer market in Tanzania. It indicates that the supply chain is very concentrated. At the top of the market, three companies produced inorganic fertilizers in 2022 and 2023. This was up from one company in 2014 and 2 companies in 2019. Minjingu is the major fertilizer producer in Tanzania. They mine phosphate and use it in blending and granulation. Though there is domestic production of fertilizer, the vast majority of it is imported. For example, in 2022/23 demand for fertilizer was estimated to be about 700,000 MT, with domestic production at just under 44,000 MT, imports made up 420,000 MT and carryover stock was about 118,000 MT (African Development Bank, 2023).

The blending industry is also very concentrated in Tanzania with three companies controlling 90% of that activity in 2022 and 2013. This was up from one blender from 2014 to

2019. In addition, to Minjingu, Yara and Export Trading Group (ETG) are major blenders in the country. The importing business is fairly concentrated but has seen an increase from four firms that controlled 90% of the fertilizer imports in 2014 to six firms in 2022 and seven in 2023. The increased number of importers in recent years occurred because of the government ended the Bulk Procurement System and allowed more companies to import fertilizer. The trend is similar in the fertilizer wholesaling and retailing sectors as seven companies were responsible for 90% of these activities in 2014, 12 were in 2019, 32 were in 2022 and 34 were in 2023. Thus, it can be said that the fertilizer sector in Tanzania is concentrated but has become less so over the past decade.

Table T.1: The number of companies in Tanzania that control 90% of the fertilizer that was available at different stages in the supply chain during key years.

Country	In 2014 (ten years ago)	In 2019 (just before the fertilizer price spike)	In 2022 (during the fertilizer price spike)	In 2023 (last year)
Manufacturing	1	2	3	3
Importing	4	4	6	7
Blending	1	1	3	3
Wholesaling	7	12	32	34
Retailing[1]	7	12	32	34

Source: Importer Information from Afriqom; other information from International Fertilizer Development Corporation (IFDC); [1]It is important to note that at number of firms refers to the number of companies, not the number of shops selling fertilizer. For example, larger companies have hundreds of retail shops across the country selling fertilizer under their brand. All of these shops count as one company in Table T.1. It is also important to note that there are hundreds of independent agro-dealers located across Tanzania that sell fertilizer to smallholder farmers. These agro-dealers each count as separate companies, but the volume of fertilizer they sell is relatively small so they make up the other 10 percent of the market that is not counted in Table T.1.

Dar es Salaam is a major port where fertilizer enters both for the Tanzanian market and to serve other countries in the region, like Zambia, Malawi, Uganda, Rwanda, and Burundi. There is evidence that the port's growth has been associated with the development of the fertilizer market in Tanzania. Baum et al. (2021) noted that more than half of all urea shipments come in on cargo ships carrying 10,000 tons or more. This has enabled Tanzania to generate economies of scale that lowered the per unit cost of fertilizer and allowed Tanzanian companies to expand their operations into other countries. Baum et al., also highlighted that the discharge rate at the port increased from 1,000-1,500 MT/day in 2004 to 3,000 – 5,000 MT/day in 2021, further reducing transportation costs associated with importing fertilizer.

The increased competition in Tanzania's fertilizer sector has led to the development of new formulations that have been blended to suit basic plant nutrient requirements and soil fertility status. The general view from key informants with a cross-country perspective is that the fertilizer sub-sector is both farmer and market-oriented. The government has put rules and regulations in place for quality assurance and timely delivery to farmers. They have also intervened in the fertilizer market over time with both subsidies for bulk procurement of fertilizer and direct subsidies to farmers for purchasing fertilizer. This has caused fertilizer use in the country to rise from less than 100,000 MT in the 1990s to over 300,000 MT in 2015/16. These policy issues will be discussed in detail in the following sections. The issue is that even with a relatively efficient sector, in addition to government support fertilizer use in Tanzania is very low among smallholder farmers. This challenge will be discussed in subsequent sections of the report.

iv) Analysis of fertilizer policies in Tanzania around the fertilizer price spike

Policy Response

It is conventional that when global economic shocks occur that affect domestic commodity supply chains and prices, countries respond with policies to try to mitigate their impacts on their citizens. Such policy responses might achieve their intended objectives but unintended consequences to other aspects of the economy are often also realized. They also might not necessarily achieve their intended objectives. The policy responses often have trade-offs, as countries often face options with differing consequences. It is, therefore, critical that a country's policy responses to economic shocks are guided by its contextual conditions and informed by up-to-date evidence as well as global and regional dynamics. This section identifies key fertilizer policy interventions in Tanzania before and during the recent fertilizer price spikes.

Fertilizer Policy Before Price Spike

Tanzania does not have a standalone fertilizer policy, but it is embedded in the national agricultural policy framework. Fertilizer is regulated through the Fertilizer Act of 2009 and its re-authorizations in 2017 and 2021. Some other policies that have embedded fertilizer policies include the National Agriculture Policy (2013), the National Fisheries Policy (2015), the National Livestock Policy (2006), the National Cooperative Policy (2002), the National Land Policy (1997), and Food and Nutrition Policy (1992),

Fertilizer subsidies in Tanzania existed since the country's independence but were scaled down in the 1990s during structural adjustment. Fertilizer subsidies were re-introduced in 2003/04 following a drought year in 2002/03. Tanzania began with a small untargeted subsidy program in 2003/04 that was internally funded without donor support. That program ran until 2007. The international food price crisis of 2007/08 caused the government of Tanzania and development partners like the World Bank to consider the need to scale up a larger, targeted subsidy program at the end of the decade.

The resulting program was known as the National Agricultural Input Voucher Scheme (NAIVS). It was funded by the Tanzanian government and the World Bank. NAIVS began in 2007/08 targeting 500,000 beneficiaries in 53 districts. In 2009/2010 this was expanded to 57 districts targeting 1.5 million beneficiaries. This rose to a high of more than 2.0 million beneficiaries in 2010/11 before scaling back to 1.8 million in 2011/12, 1.0 million in 2012/13 and 500 thousand in 2013/14.

The NAIVS had numerous elements of a smart subsidy program. These included i) using the private sector to import subsidized fertilizer and the existing agro-dealer network to retail it to farmers, ii) using vouchers in an attempt to target limited resource farmers who did not buy much commercial fertilizer, and iii) having an exit path for beneficiaries to graduate from receiving the subsidy after three years. Beneficiaries were determined by a village selection committee and these farmers would select a participating agro-dealer where they could redeem two fertilizer vouchers, each good for one 50-kilogram bag of fertilizer at a 50% subsidy and one 10-kilogram bag of maize seed at a 100% subsidy.

Evaluations of the NAIVS found it to be a relatively successful program compared to input subsidy programs in other countries of SSA. For example, Wanzala et al. (2013) evaluated input subsidy programs in Ghana, Kenya, Malawi, Nigeria, Rwanda, and Zambia that were implemented in the 2000s and early 2010s. They found that the NAIVS was the most private sector-friendly of any input subsidy program between 2010 and 2014. Mather and Ndyetabula (2017) noted that part of the reason for the private sector approach to NAIVS was that the government felt they were not capable of importing and distributing subsidized fertilizer in bulk. Thus, their best option was to rely on the private sector.

Despite its success, the NAIVS program was discontinued in 2016/17. This was due to budgetary constraints, and the belief that the conditions in the country had changed enough to merit a re-orienting of the program (Baum et al. 2021; Mather and Ndyetabula 2017). This led to a focus on streamlining, tax reduction, and efficient procurement of fertilizer rather than reduced prices through subsidies directly.[19]

The Tanzanian government ended the NAIVS in 2017 and moved to a bulk procurement system (BPS) for fertilizer. The objective of the BPS was to reduce the cost of fertilizer at the farm level. This was done by reducing the negotiated price (FOB) of fertilizer products bought in the global market and imported into the country. The BPS was inspired by the apparent success of the model used for the procurement of petroleum products in Tanzania (the “Petroleum Model”) established in 2011 (Bumb, et al, 2021).

The BPS focused on imports of DAP and urea, and the Tanzania Fertilizer Regulatory Authority (TFRA) was responsible for implementing it. Potential private sector importers were prequalified, and one was selected through the TFRA’s tender committee to import the pooled demand on behalf of all fertilizer importers and fertilizer companies or dealers for a given fertilizer product. Other importers acted as distributors who could place their orders with the selected firm and then sell imported fertilizer through their networks. No public funds were used for procurement under the BPS as financing came from the private sector. Thus, the BPS could be considered government coordination rather than a subsidy for fertilizers. Savings were supposed to come in the form of economies of scale through procuring and importing in bulk. In principle, these savings were supposed to be passed back to farmers.

The BPS was in place for four seasons between June 2017 and July 2021. The overall assessment of the program was that it was not successful at reducing fertilizer prices. This was due to the volatility in imported fertilizer prices and the fact that the program focused on fertilizer supply rather than directly supporting fertilizer consumers (i.e. farmers) (Chapoto et al. 2021). As a result, the BPS was repealed on July 1, 2021, and for the next year, the government was not involved in the fertilizer market.

Policy during the 2021/22 fertilizer price spike

In response to the sharp increase in fertilizer prices in 2021/22, the government of Tanzania took several steps to address high fertilizer prices in the country during 2022. First, they reintroduced direct fertilizer subsidies for farmers for the first time since 2016/17. It was called Tanzania Agricultural Inputs Support Project (TAISP). With funding from the AFDB it intended to spend USD 50 million (60% of total project cost) on fertilizer availability and affordability. It aimed to reduce the price of fertilizer by about 37%, and to improve access to affordable fertilizer for farmers. Second, the government encouraged domestic fertilizer production by encouraging manufacturers to use local materials in the production process. This was seen as a way to reduce reliance on imported fertilizer but received mixed reactions from stakeholders. Some supported the move, but others argued that Tanzania does not have sufficient fertilizer production and distribution because it still imports most of the raw materials used in its production.

The government’s third action was to end the BPS and issue government tenders for fertilizer, but to allow a wide group of private sector firms to compete for it. Opening up the market has been associated with the increased number of fertilizer market actors. This was consistent with our findings in the previous section which showed a significant increase in the number of fertilizer importers, wholesalers, and retailers that entered the Tanzanian market in the past few years. The TAISP did not subsidize imported fertilizer that was brought in by the private sector. Rather it allowed them to compete for the lowest price of the tender. Thus, the importers paid the commercial price, then the sold to wholesalers and agro-dealer/retailers at commercial prices. The retailers were supposed to sell fertilizer at a 50% subsidized rate and the government then paid the importers for the difference The importers were supposed to then pay the wholesalers and agro-dealers for their share of the subsidized fertilizer.

The results of the TAISP to date have been mixed and no formal evaluation has been conducted of the program. On the positive side, there has been some evidence that the price

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[19] See Mather and Ndyetabula (2017) for a detailed discussion of NAIVS implementation.

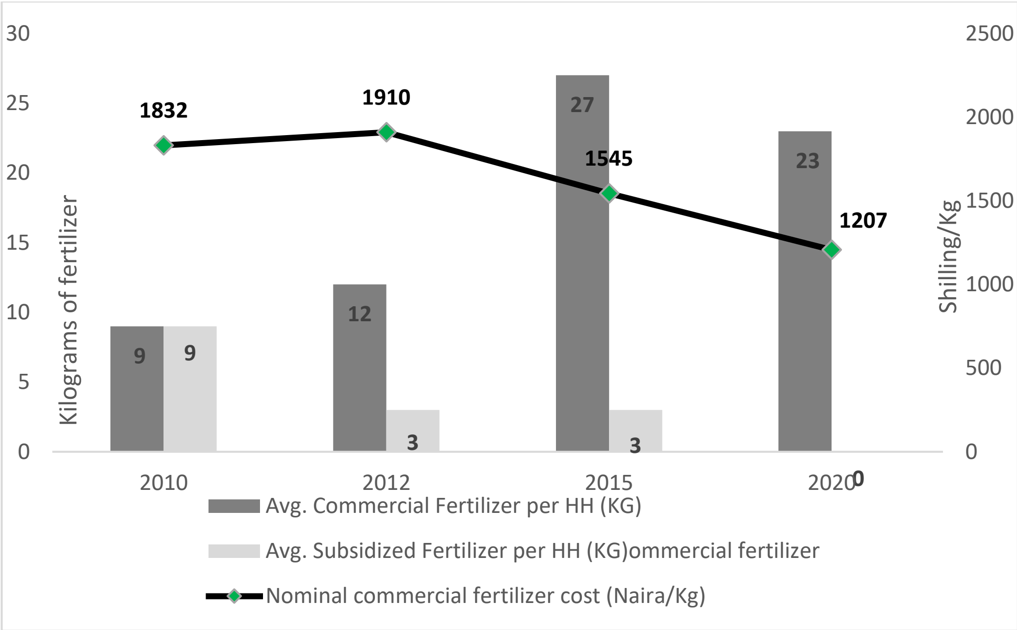
of fertilizer has declined during 2023 and 2024. In addition, the government began to set up a digital registry of farmers. The intention was to help make the distribution of future entitlements like subsidized fertilizer reach the correct people more effectively. The digitization was also meant to help the private sector coordinate with and pay agro-dealers promptly for subsidized fertilizer that they sell to farmers.

Some of the problems with the TAISP have been that the government controlled the entire supply of fertilizer supply chain, and there were no private sector imports outside the program. Furthermore, only about 45% of the farming households (3.7 million) were registered for the 2023 season and the rest were excluded from the program. Many agro-dealers who were not able to register for the program so were also excluded from the program. The government also did not pay back many agro-dealers and owed roughly $100 million for the program by the end of 2023 (Wallace and Associates 2023). Regardless, of the challenges the TAISP has continued into 2024. It is possible that more farmers and agro-dealers may be able to register for the program in 2024, which would increase the program’s coverage, although the issues with lack of repayment continue.

v) Fertilizer Demand Impacts

Fertilizer use in Tanzania is low but has risen rapidly over the past 20 years. According to FAOSTAT, fertilizer use per acre stood at less than one kilogram per acre in the year 2000 but rose to more than 16 kilograms per acre in 2019. While the growth was impressive in percentage terms, fertilizer use in Tanzania is still below other countries in the region and is far below recommended application rates. The following section helps clarify the constraints to continued low fertilizer use in Tanzania. To inform this issue, we analyzed the World Bank LSMS panel dataset, collected on the same smallholder households in Tanzania during the 2010/11, 2012/13, 2014/15, and 2020/21 growing seasons. This panel does not cover the fertilizer price spike of 2021/22 but is the most comprehensive dataset on Tanzanian smallholder farmers that is available. As such, we analyzed these data to make some predictions about the impacts of the fertilizer price spike on fertilizer demand and profitability in Tanzania. Figure T.6 shows the average retail commercial fertilizer prices that farmers paid in the different years of the survey, compared to the average amount of subsidized and commercial fertilizer that they acquired. The line graph at the top shows that the real average price of fertilizer (NPK and urea) increased slightly from Shillings 1,832/kg in 2010 to Shillings 1,910/kg in 2012, before dropping to Shillings 1,545/kg in 2015, nearly a 20% decrease. The commercial price of fertilizer then declined to Shillings 1,207/kg in 2020, a further 22% decrease. At the same time, the average commercial fertilizer purchase amount rose consistently across the first three survey years, from nine kilograms per household in 2010 to 12 kilograms in 2012, to 27 kilograms in 2014, and before dropping to 23 kilograms in 2020. Thus, between 2010 and 2015 commercial fertilizer use increased by 200% on average (though it was from a low base). The average commercial fertilizer use then dropped down to 23 kilograms per household in 2020. The trend in commercial fertilizer demand across the four survey years tracked the relative decline in the price of fertilizer, and it also tracked the decline in subsidized fertilizer that the government allocated to farmers. This finding was consistent with the discussion of subsidy policy in the previous section, as the government scaled down the NAIVS program in 2011/12 and ended it in 2016/17. From these figures, it seemed that demand for commercial fertilizer rose at the same time subsidized fertilizer allocation declined in Tanzania between 2010 and 2020.

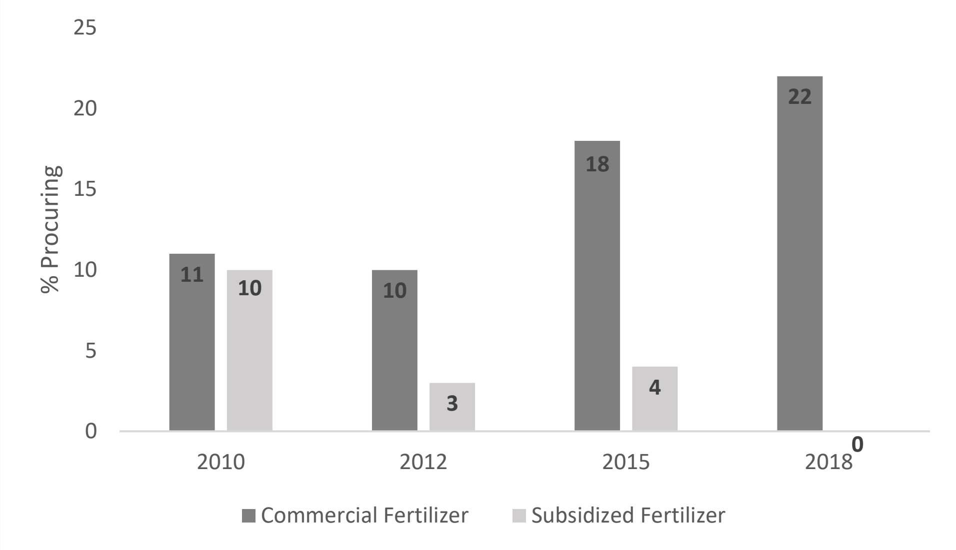
Figure T.6: Average subsidized fertilizer and commercial procured per household by survey year in Tanzania



Source: Authors' calculations from LSMS data; the years of the survey were 2010, 2012, 2015, and 2020

Figure T.7 relates to Figure T.6 by showing the percentage of households that procured subsidized and commercial fertilizers between 2010 and 2020 in Tanzania. The results in Figure T.7 were consistent with those in Figure T.6 as the percentage of households acquiring subsidized fertilizer went down between 2012 and 2020 while the percentage of commercial fertilizer went up. However, the highest participation rate for purchasing commercial fertilizer was in 2020, when 22% of households bought some commercial fertilizer. This corresponded with the lowest level of subsidy participation in the survey and the lowest price of fertilizer as seen in Figure T.6. Though there was evidence that commercial fertilizer participation went up and so did average fertilizer use, the fact that in the best year for fertilizer use 78% of the sample did not purchase commercial fertilizer. In addition, the average purchase rate was 23 kilograms, suggesting that fertilizer use in Tanzania was low and unequal. Many households still purchased little to no fertilizer while relatively few households purchased a great deal. The results also indicated that moving from direct subsidies in 2010, 2012, and 2015 to the bulk procurement system (BPS) in 2020 did not lead to substantial increases in commercial fertilizer participation rates and the volume of commercial fertilizer purchased declined between 2015 and 2020. This result implied that the government of Tanzania's efforts to coordinate most fertilizer imports under the BPS did not have much impact at the household level.

Figure T.7: Percent of households who procured subsidized and commercial fertilizer by survey year in Tanzania.



Source: Authors' calculations from LSMS data; the years of the survey were 2010, 2012, 2015, and 2020

Table T.2 presents the crowding out rates of commercial fertilizer by subsidized fertilizer that we calculated from the LSMS data for Tanzanian farmers between 2010 and 2020. This is a quantitative, counterfactual analysis that used regression analysis to control for other factors besides subsidized fertilizer that may have also affected demand for commercial fertilizer, such as fertilizer prices, maize and rice prices, household assets, landholding credit access, distance to market, and demographic factors. The crowding-out rate was estimated from the farmers' perspective as they represented the demand side of the market. It did not directly estimate how agro-dealers sales were affected by the subsidy program. However, since the NAIVS subsidy program was run through the private sector, agro-dealers' total sales likely increased as a result of the program, even if some of their commercial fertilizer sales were crowded out by the subsidy.

Results of our analysis estimated that the crowding-out rate of commercial fertilizer by Tanzania's NAIVS subsidy program was small and negative but was not statistically different from zero on average. This is true when we look at the crowding out rate by year and break the sample down into asset and landholding quintiles. This is an important finding and is very different from crowding out estimates of other countries in SSA, including Nigeria, Kenya, Malawi, and Zambia. On average, we found that in these other countries, all of which had large fertilizer subsidy programs, 20-40% of their commercial fertilizer was crowded out by the subsidy (Jayne et al. 2013; Ricker-Gilbert et al. 2011). That level of crowding out is a major loss of program efficiency that affects how much new fertilizer a subsidy program adds to farmers' fields, and we did not find this to be a statistically significant issue in Tanzania under the NAIVS program. The reasons for this were the positive aspects of the program discussed earlier, such as the fact that i) the government scaled down NAIVS after 2010/11 and ended it in 2016/17, ii) they allowed the private sector to sell subsidized fertilizer to farmers, iii) there were relatively clear targeting criteria for beneficiaries, and the beneficiaries knew that they would only officially be eligible for the program for three years and no longer (at least in principle). Our finding of negligible crowding out of commercial fertilizer by the NAIVS subsidy program was consistent with the finding in Wanzala et al. (2013) that the NAIVS was the most private sector-friendly program in the region in the previous decade.

Table T.2: Crowding out by year, area cultivated, and assets

Category	Average Crowding out	P-value	Category Average
Overall	-0.08	(0.11)	-
Year			
2010/11	-0.05	(0.18)	-
2012/13	-0.08	(0.24)	-
2014/15	-0.09	(0.13)	-
2020/21	-0.09	(0.16)	-
Landholding			*Hectares*
SMALLEST 20%	-0.06	(0.22)	0.3
20 - 40%tile	-0.06	(0.25)	0.7
40 - 60%tile	-0.11	(0.14)	1.2
60 - 80%tile	-0.07	(0.23)	2.3
LARGEST 20%	-0.10	(0.14)	5.8
Asset Quintile			*'000 Shillings*
POOREST 20%	-0.04	(0.11)	59
20 - 40%tile	-0.05	(0.17)	361
40 - 60%tile	-0.05	(0.22)	1,378
60 - 80%tile	-0.10	(0.16)	4,664
RICHEST 20%	-0.15	(0.17)	30,474

Source: Authors' calculations from LSMS data; the years of the survey were 2010, 2012, 2015, and 2020. This analysis used data from 437 households surveyed in all four waves; Note, none of these estimates are statistically different from zero.

vi) *Fertilizer user demographics*

The next three tables present the characteristics of farming households in Tanzania who purchased commercial fertilizer in every survey year from the LSMS data (2010, 2012, 2015, and 2020), those who bought it in some years and not others, and those who never bought it. Table T.3 showed that only 1% of smallholder farmers in the sample purchased commercial fertilizer in every survey year, while 40% bought fertilizer in some survey waves, but not in others. Additionally, 59% of households never bought commercial fertilizer during the four survey years. This finding suggested that even though average commercial fertilizer use increased in Tanzania during the previous decade (as we saw in Figure T.7) the majority of farmers still did not purchase any commercial fertilizer over that period. This was consistent with the finding in Figure N.7, showing the low percentage of farmers purchasing commercial fertilizer over time. This suggested that even with a modest increase in fertilizer use, there were still many constraints that prevented Tanzanian farmers from purchasing fertilizer.

Table T.3: Percentage of households that bought commercial fertilizer in every survey year, in some survey years, and in none of the waves in Nigeria.

Group	% of the Sample in the group
% of the sample who purchased commercial fertilizer in every survey year	1
% of the sample who purchased commercial fertilizer in some of the survey years but not all.	40
% of the sample who never purchased commercial fertilizer in any survey year	59
Total	100

Source: Authors' calculations from LSMS data; the years of the survey were 2010, 2012, 2015, and 2020. This analysis used data from 437 households surveyed in all four waves.

Given the low participation rate and apparent uneven distribution of commercial fertilizer purchases in Tanzania we broke down the landholding distribution of farmers into three categories: i) those with less than two hectares of land, ii) those with between two and five hectares, iii) those with more than five hectares. We also disaggregated these categories by whether or not the household was classified as living in a rural or an urban area. The results are shown in Table T.4. Column 4 indicates that farms with less than two hectares made up 68% of all farms nationally, 65% in rural areas, and 79% of farms in urban areas. Table T.3 shows that these farms acquired the least amount of fertilizer on a per-household basis. For example, nationally farms less than 2.0 hectares acquired 14 kilograms of fertilizer, while households between 2.0 and 5.0 hectares acquired 16 kilograms on average, and farms over 5.0 hectares acquired 34 kilograms on average. However, in column 3 when we divided commercial fertilizer purchases by landholding it was clear that smaller farms in both urban areas, rural areas, and in aggregate used the input more intensively than did larger farms. For example, farms less than 2.0 hectares acquired 18 kilograms per hectare, while farms between 2.0 and 5.0 hectares acquired five kilograms per hectare, and farms over 5.0 hectares also acquired five kilograms per hectare. Thus, the results from Table T.4 indicated that fertilizer purchasing was uneven in Tanzania. This was consistent with the previous tables and figures. It indicated that small-scale farmers in Tanzania used less fertilizer overall, but farmed more intensively than larger farms and acquired more fertilizer on a per hectare basis.

Table T.4: Landholding and Location Demographics for Households Purchasing Commercial Fertilizer in Tanzania

Landholding size	**(1) Mean Land Holding in group (Ha)**	**(2) Average Commercial fertilizer purchased in group (kg)**	**(3) Amount Purchased per hectare in group (kg)**	**(4) Percent of sample in group**
National – Urban				
Less than 2.0 hectares	0.7	28	40	79
Between 2.0 and 5 hectares	3.0	23	8	16
Greater than 5 hectares	8.1	53	6.5	5
National – Rural				
Less than 2.0 hectares	0.9	11	12	65
Between 2.0 and 5 hectares	3.0	17	6	23
Greater than 5 hectares	7.0	30	4	12
National – Total				
Less than 2.0 hectares	0.8	14	18	68
Between 2.0 and 5 hectares	3.0	16	5	18
Greater than 5 hectares	7.1	34	5	14

Source: Authors' calculations from LSMS data; the years of the survey were 2010, 2012, 2015, and 2020. This analysis used data from 437 households surveyed in all four waves.

Table T.5 built on the previous analysis of fertilizer acquisition using linear regression to analyse the factors that were associated with households who purchased fertilizer in one or more years. Households who had more landholding were more likely to purchase commercial fertilizer. This was consistent with results in Table T.4 that indicated larger farms bought more commercial fertilizer than smaller ones. Older household heads were less likely to buy commercial fertilizer and households who had received a social safety net transfer (other than subsidized fertilizer) were less likely to purchase commercial fertilizer.

Table T.5: Demographic characteristics of households who bought commercial fertilizer in one or more survey waves in Tanzania

Characteristic	(1) Bought in one or more survey years
Acquired subsidized fertilizer in 2022	NSS
Fertilizer price	NSS
Farmgate maize price	NSS
Farmgate rice price	NSS
Landholding in hectares	Small (+) effect on average
Household size	NSS
=1 if female-headed household	NSS
Age of household head	Small (-) effect on average
If the household head attended school	NSS
Access to formal credit	NSS
Access to informal credit	NSS
Member of savings group	NSS
Net maize buyer	NSS
Net maize seller	NSS
Distance (km) from home to market	NSS
Accessed extension	NSS
Soil quality (1=good, 2= fair, 3=4)	NSS
Household assets in Shillings	NSS
Received social safety net	Small (-) effect on average

Source: Authors' calculations from LSMS data; the years of the survey were 2010, 2012, 2015, and 2020. This analysis used data from 437 households surveyed in all four waves; NSS means that the factor was not found to be statistically significant in a regression model.

vii) Maize-to-fertilizer response rate impacts

The maize-to-fertilizer response rate is a measure of the number of kilograms of maize or other crops obtained from a kilogram of fertilizer. It is an important estimate for understanding how much an additional kilogram of fertilizer contributes to crop yields, food security and the profitability of fertilizer for farmers. It is crucial to note that fertilizer is one input into the production of food and farmers must have sufficient amounts of complimentary inputs, such as seed, land, labor, soil fertility, water, and farm management ability for fertilizer use to be effective. Estimates of the maize-to-fertilizer response rate in Tanzania conducted on agricultural experiment stations and farmers' fields that were managed by researchers found that farmers could obtain a response rate of about 11.11 kilograms of maize per kilogram of fertilizer (Chapoto et al. 2023). This response rate estimate of 11.11 would imply that a 100 kilogram per acre application rate would generate 1,111 extra kilograms of maize per acre (~2,745 kilograms more per hectare). Thus, if response rates on researcher-managed plots were generalizable to fields that were managed by Tanzanian farmers under the conditions in which they operate, inorganic fertilizer application could greatly enhance maize yields and food security in the country.

Unfortunately, estimated maize-to-fertilizer response rates on researcher-managed plots should be considered an upper-bound estimate of what Tanzania farmers could obtain on their own plots using their own management skills and complementary inputs. For example, Chapoto et al. (2017) synthesized the literature on response rates to fertilizer on maize plots that were managed by Tanzanian smallholders. They estimated that the average response rate on farmer's fields was only about 3.33 kilograms of maize per kilogram of fertilizer. This meant that 100 kilograms of fertilizer only added 333 kilograms of additional maize per acre (~823 per hectare). The 778 kilogram /acre (~1,922) per hectare yield gap between a potentially optimal maize-to-fertilizer response rate on researcher-managed and farmer-managed plots has major implications for food security and fertilizer profitability in Tanzania.

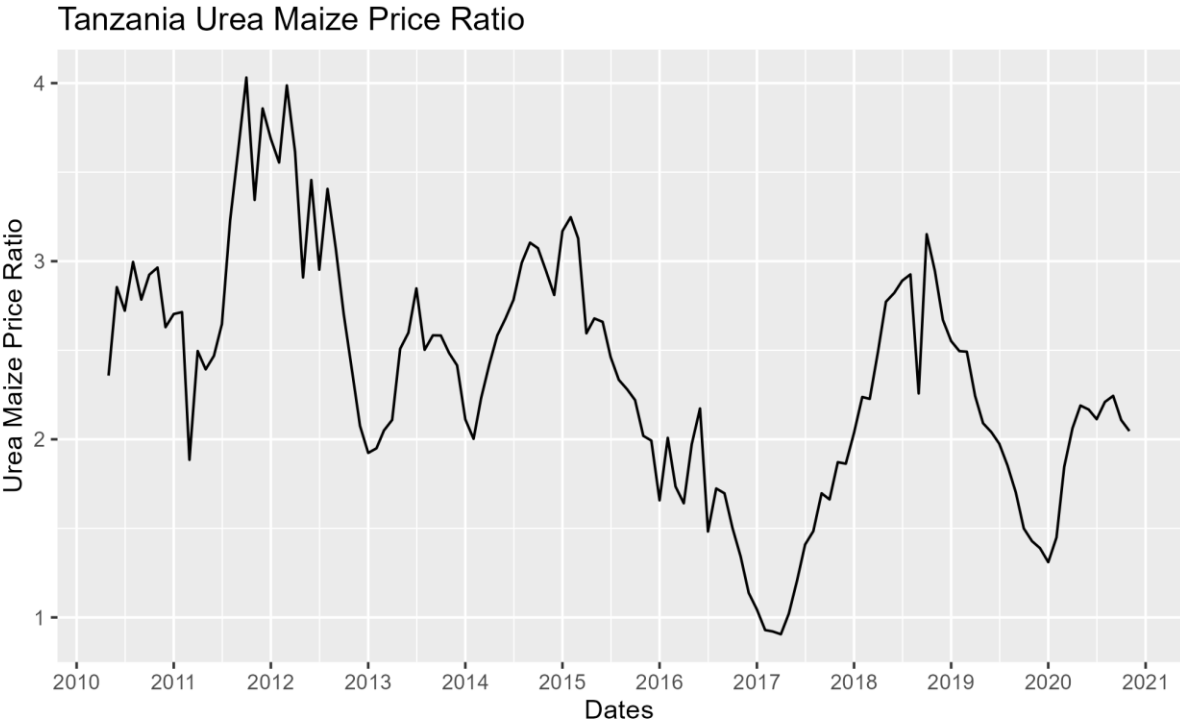
These low estimated maize-to-fertilizer response rates on farmers' actual fields raise serious questions about what drives this gap, and why farmers' have not been using the complimentary inputs that are necessary for fertilizer response rates and yields in Tanzania to reach their potential. Chapoto et al. highlighted some of the constraints that limit the efficiency of fertilizer used in the country. First, the price of fertilizer is high and the Tanzanian Shilling has depreciated against the US dollar over the past decade which has eroded farmers purchasing power for fertilizer. Second counterfeit fertilizer has been an issue; a 2016 report found that 40% of fertilizer in the country was counterfeit. Third, government agencies that regulate the fertilizer sector often are slow to grant private-sector actors the permits and authority they need to import and distribute fertilizer in the country due to poor coordination. This increases transaction costs and makes fertilizer more expensive for farmers. Fourth at the farm level, there is limited awareness of the benefits of inorganic fertilizer among smallholder farmers. Historically, Tanzania's vast land area and low population density along with relatively favorable agro-climatic conditions meant that fertilizer was not a common input in smallholders' production systems. Finally, given the country's size and diverse agroecology, there has been a lack of site-specific fertilizer blends and recommendations that match the soil-nutrient requirements on farmers' fields. While many of these challenges are difficult to address, the expansion of new fertilizer importers, wholesalers, and retailers in recent years in Tanzania is potentially a positive development. As mentioned earlier in the report, this increased competition in the input sector can help meet the needs of farmers by creating new fertilizer blends that are better suited for soil conditions in specific areas of the country.

viii) Fertilizer profitability impacts

This subsection considers the profitability of fertilizer use in Tanzania. The intention is to understand if the financial returns to Tanzania's fertilizer subsidy program justified its cost with data from selected years between 2010/11 and 2022/23 and to understand if fertilizer was profitable for Tanzanian farmers when valued at the commercial price that they paid. The profitability of fertilizer is affected by three main factors: 1) the price of fertilizer, 2) the price of maize (or other staple crop), and 3) the maize-to-fertilizer response rate. the Maize-to-fertilizer response rate was discussed in the previous sub-section and the overall finding from previous studies is that Tanzanian farmers do not use fertilizer efficiently on a per kilogram basis compared to other countries. Thus, there is a great deal of room for improvement so that observed yields on farmers' fields come closer to reaching their full yield potential. This has reduced fertilizer profitability, as we will discuss below.

As mentioned above the price of fertilizer and the price of maize are key components in fertilizer's profitability. One way to look at this is through the ratio between fertilizer prices and maize prices. This is known as the input/output price ratio, and this relationship between urea and the farmgate price of maize in Tanzania between 2010 and 2020 is shown in Figure T.8. A lower ratio means that fertilizer is more profitable, as the price of fertilizer is going down (i.e. the numerator in the ratio getting smaller) or the maize price is going up (i.e. the denominator is getting bigger). Figure T.8 indicates that the input/output price ratio before 2020 was highly variable and ranged from a high of 4.0 to a low of less than 1.0 across all years. This generally suggested that fertilizer use was profitable in some years relative to maize during the pre-spike period and not in others. However, the ratio was decreasing over time, so it was moving in a favorable direction for farmers. At an input/output price of 4.0, a farmer would need to produce 4.0 kilograms of maize per kilogram of fertilizer to break even. Anything higher than that would be a profit and anything less than that would be a loss. Since our estimates from Chapoto et al. (2023) indicated that the average farmer obtained 3.32 kilograms of maize per kilogram of fertilizer in Tanzania on average. Thus this was the break-even input/output price ratio for the average farmer in Tanzania to use fertilizer.

Figure T.8: Urea / Farmgate maize price ratio in Tanzania, 2010-2020



Source: Commercial fertilizer price for urea from AfricaFertilizer.org; wholesale maize price from FAOSTAT. We subtracted 8% from the wholesale price of maize to convert it to the retail price.

Table T.6 the profitability of fertilizer for farmers when the input is valued at subsidized and commercial prices. The return that farmers obtain from a kilogram of fertilizer valued at its commercial price is the marginal value-cost ratio (MVCR). The MVCR is calculated as follows:

$$MVCR = \frac{\{\text{incremental maize output (kilograms of maize/kilograms of fertilizer) * maize price/kilogram}\}}{\text{price of fertilizer per kilogram.}}$$

An MVCR that is greater than one indicates that using fertilizer generated a positive and profitable return for farmers. A ratio equal to one is break-even, meaning that the farmer made no profits using fertilizer and a ratio less than one is a loss. However, whether or not fertilizer is likely to be profitable depends on outcomes that are uncertain when fertilizer decisions are made, as well as costs associated with the use of fertilizer that are unknown to the researcher. The types of risks that farmers face when using fertilizer at planting to increase staple crop yields at harvest include the chance of low yields due to adverse weather, and output prices at harvest being lower than expected. In the face of these uncertainties and unobserved costs, an MVCR of at least 2.0 (meaning a risk premium of one) has been recommended in the literature to be required in order for fertilizer to be profitable (Xu et al., 2009; Sauer and Tchale, 2009; Sheahan et al. 2013).

Table T.6 presents the MVCR when maize is valued at its harvest-season farmgate price in row F for selected years between 2010/11 and 2023/24. If we use a threshold MVCR of 1.0, we see that the returns to using commercial fertilizer were positive on average across all years when maize is valued at harvest season price, but it was never greater than 2.0 which was the profitability threshold when considering risks and transaction costs. Our profitability results for fertilizer were consistent with Chapoto et al. (2023), who found that the MVCR was greater than 1.0 for the studies that they reviewed in Tanzania. In Table T.6 the lowest return was in 2022/23, as seen in row F, when fertilizer prices were USD 1,064/MT on average at the height of the fertilizer price-spike period and maize was valued at its average harvest season price of USD 395/MT. Still, this MVCR of 1.07 indicated that the average farmer who used fertilizer would have obtained a 7% return on their investment. The highest return to fertilizer use came the next year in 2023/24, as the price of fertilizer declined to an average of $630/MT and maize stayed at an average of USD 395/MT. In the pre-spike decade of 2010-2021, we found that the MVCR for fertilizer was between 1.0-2.0 in all years in all maize price scenarios. The MVCR ranged from 1.14 in the lean season of 2014/15 to 1.69 in the harvest season of 2020/21.

There are two important points to note from these findings. First, these findings are reflective of fertilizer profitability on average. The fact that in any given year between 2010 and 2020 at most 20% of households bought any commercial fertilizer (Figure T.7) points to major access constraints and inequality in fertilizer purchasing and use. Thus, the government should focus on increasing fertilizer access by creating an enabling environment for the private sector to make fertilizer available to farmers. The disconnect between average profitability and low fertilizer use also points to a problem of liquidity and lack of access to financing for farmers. If farmers do not have cash at harvest then they lose out on the opportunity to use fertilizer and make money on an investment that would have likely generated a positive return. Promoting village savings groups and linking farmers to banking opportunities can help reduce this problem.

Second, it is important to note that the reason why fertilizer has been relatively profitable according to the MVCR calculations is due to the relatively low price of fertilizer and not because farmers use it efficiently. As discussed in the previous section, the yield response rate to fertilizer is 3.32 kilograms of maize per kilogram of fertilizer. Though the response rate is higher in Tanzania than it is in some other countries in SSA, there is still significant room for improvement in this aspect. The government should invest in working with farmers to implement complementary practices such as soil fertility management, erosion control, climate change adaption, and use of appropriate fertilizer blends, and proper timing of fertilizer application.

Table T.6: Marginal value cost ratio of using fertilizer at commercial prices for farmers in Tanzania (Using national level maize and fertilizer prices)

Production Year		2010/11	2012/13	2014/15	2018/19	2020/21	2022/23	2023/24
	Estimated incremental benefits							
A[i]	Yield response (Maize Kg/ N kg)	9.97	9.97	9.97	9.97	9.97	9.97	9.97
B = (0.33*K)	Yield response (Maize Kg/ IF kg)	3.32	3.32	3.32	3.32	3.32	3.32	3.32
C[ii]	Average Harvest Season Farmgate Maize price($/MT) (May-July- of marketing year)	262	294	223	244	172	395	395[iv]
D[iii]	Commercial pr. Of fertilizer for farmers ($/kg)	610	960	670	450	490	1,064	630
D= E/(C/1000)	Harvest Input/Output Price ratio (fertilizer pr./maize pr.)	2.14	2.92	2.31	2.42	1.97	3.09	1.47
F= (C/1000)*B/E	Harvest Season Marginal Value Cost Ratio (MVCR) of Fertilizer per kg	1.55	1.14	1.44	1.37	1.69	1.07	2.26

Source: authors' calculations. [i]Yield response estimate from Chapoto et al. (2023); [ii] wholesale maize price from FAOSTAT; We deducted 8% from the wholesale price to compute a farm-gate price; [iii]Commercial fertilizer price for urea from AfricaFertilizer.org (2024); wholesale maize price from FAOSTAT; [iv] 2024 maize prices not available on FAOSTAT so we used 2023 price.

6. Policy recommendation

Based on the results of this report we make the following recommendations for Tanzania to better prepare for and address fertilizer price spikes to better ensure a response that benefits farmers and creates a more profitable and resilient supply chain.

a. There is significant room to improve the maize-to-fertilizer response rate in Tanzania. The government should invest in working with farmers to implement complementary practices such as soil fertility management, erosion control, climate change adaption, and the use of appropriate fertilizer blends, lime, and proper timing of fertilizer application. The fact that we found fertilizer use to be profitable on average even with low fertilizer response rates, due to favorable fertilizer and maize prices, suggests that there is significant potential for Tanzania to increase fertilizer profitability, yields, incomes, and food security if the government commits to making these investments.

ii. Tanzania's current subsidy program should be modeled after NAIVS to target limited resource farmers and to minimize crowding out of commercial fertilizer by the subsidy. In addition, the bulk procurement system (BPS) that intended to leverage economies of scale to make imported fertilizer cheaper was not successful. Ending the BPS was a good decision, and it should not be reinstated. Tanzania implemented a relatively successful subsidy program NAIVS in the previous decade. This program was well-designed and private-sector-friendly. The current fertilizer policy following the price spike has re-introduced an untargeted fertilizer subsidy program that subsidized 50% of the price of fertilizer to all farmers. There have been implementation challenges with the program.

iii. To improve the farmers' access to fertilizer, it is important that the government focus on creating an enabling environment for new entrants into the fertilizer supply chain. The supply chain in Tanzania is become slightly less concentrated and more competitive in recent years The emphasis should be on developing the last mile of the fertilizer supply chain from wholesalers to hub agro-dealers and retail outlets located in rural areas.

iv. There is evidence that government poor coordination among government agencies that regulate the fertilizer sector in Tanzania has burdened the private sector. Improving coordination and lowering bureaucracy can make fertilizer more affordable and increase its use among smallholder farmers.

v. The fact that in any given year between 2010 and 2020 less than 23% of households bought any commercial fertilizer in Tanzania points to major access constraints and inequality in fertilizer purchasing and use. The disconnect between average profitability and low fertilizer use also points to a problem of liquidity and lack of access to financing for farmers. If farmers do not have cash at harvest, then they lose out on the opportunity to use fertilizer and make money on an investment that would have likely generated a positive return. Our model found that people who had access to credit were more likely to purchase fertilizer. Thus, promoting village savings groups and linking farmers to banking opportunities can help reduce this problem.

vi. Fertilizer use has historically been low in Tanzania. This points to the need to invest in making farmers aware of the benefits of fertilizer and how to use it properly. The expansion of new entrants that are blending and selling fertilizer may be able to help create awareness of new blends of fertilizer that better meet the agronomic conditions on farmers' fields.

vii. Politics should be taken out of fertilizer policy in Tanzania. Our model found that Urea price wedge was slightly lower one year after presidential election years. This suggests that politicians may have influenced the fertilizer market.

7. References

African Development Bank 2023. *The African Development Bank provides a USD 2 million partial credit guarantee and a USD 528,600 grant to facilitate access to fertilizer for smallholder farmers.* Available at https://www.afdb.org/en/news-and-events/press-releases/tanzania-african-development-bank-provides-usd-2-million-partial-credit-guarantee-and-usd-528600-grant-facilitate-access-fertilizer-smallholder-farmers-61608#:~:text=Tanzania%20is%20heavily%20dependent%20on,over%20from%20the%20previous%20season .

Bumb, B. L., Ariga, J., Anand, M., Cameron, A. & Nkonya, N.M. 2021. Assessment of the Fertilizer Market and Bulk Procurement System in the United Republic of Tanzania. Policy Report. Monitoring and Analysing Food and Agriculture Policies (MAFAP). Rome, FAO. https://doi.org/10.4060/cb4180en.

Chapoto, A., L. Tiemann , A.M. Akyoo , J. Bonabana , N.F. Faye , M. Kalaba , I.K. Kanyama , L. Kirimi , G. Mandlhate , S. Mbai , E. Mwakiwa , C. Nyondo , I. Ogunbayo , N. Mebeelo , T.S. Jayne. 2023. “Farmer’s risks and economic use of fertilizer in Africa South of the Sahara.” ANAPRI Policy Report
.

Jayne, T.S., D. Mather, N. Mason, and J. Ricker-Gilbert. 2013. “How do Fertilizer Subsidy Programs Affect Total Fertilizer Use? A Synthesis of the Evidence on “Crowding in/out” in sub-Saharan Africa.” *Agricultural Economics* 44(6):687-703.

Mather, D., and Ndyetabula, D. 2016. “Assessing the drivers of Tanzania’s Fertilizer Subsidy Programs from 2003-2016: An application of the Kaleidoscope model of policy change.” Feed the Future Innovation Lab for Food Security Policy Research Paper 34. Michigan State University. East Lansing. MI

Ricker-Gilbert, J., T.S. Jayne and E. Chirwa. 2011. “Subsidies and Crowding Out: A Double-Hurdle Model of Fertilizer Demand in Malawi.” *American Journal of Agricultural Economics*. 93(1): 26-42.

Sauer, J., Tchale, H., 2009. “The economics of soil fertility management in Malawi. Applied Economics Perspectives and Policy.” 31 (3), 535–560.

Sheahan, M., Black, R., & Jayne, T. S. 2013. “Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research.” Food Policy, 41, 39-52.

Xu, Z., Guan, Z., Jayne, T. S., & Black, R. 2009. “Factors influencing the profitability of fertilizer use on maize in Zambia.” *Agricultural economics*, 40(4), 437-446.

Wallace and Associates 2023. Tanzania Fertilizer Policy Review.

vi. Zambia Country Report

1. Main Findings for Zambia

1. Zambia has not produced much, if any inorganic fertilizer over the past decade. However, in response to the recent price spikes in fertilizer prices during 2021/22, and the depreciation of the Kwacha, the country has moved to develop local production of inorganic fertilizer. The government re-capitalized the parastatal Nitrogen Chemicals of Zambia (NCZ) to scale up urea production. Furthermore, the most significant investment occurred in 2023 when United Capital Fertilizer (UCF) of Zambia announced its plan to invest $1 billion in fertilizer production by 2024, with $600 million already invested. While UCF had a production capacity of 200,000 metric tons of both urea and compound D fertilizers, the company's targets were to expand production capacity to 600,000 metric tons in 2024, producing 300,000 metric tons each of urea and compound D. The goal is to supply 80% of the country's urea demand and 60% of its D compound demand, all of which is currently imported. The raw materials: coal, and phosphate are expected to be sourced from Zambia's southern province, while the rest of it will be imported. The goal of this expansion is to reduce Zambia's dependence on imported fertilizer and in doing so, hopefully lower the price for smallholder farmers. The impact and cost-effectiveness of this plan are yet to be determined.

2. The other parts of the fertilizer supply chain in Zambia are highly concentrated with a few actors controlling 90% of the importing, blending, and wholesaling, of fertilizer in the country. That being said, the number of companies engaged in these activities increased slightly between 2014 and 2024. For example, seven companies imported 90% of Zambia's fertilizer in 2014 and 13 did so in 2023. Eight companies wholesaled 90% of the fertilizer in 2014, and 12 did in 2023. The retail sector is much more competitive with hundreds of agro-dealers selling fertilizer to farmers.

3. At the retail level the number of agro-dealers in the market is highly dependent on the size and scope of government subsidy contracts in a given year. The number of small-scale local agro-dealers has gone down over time due to fewer contracts from the government. According to our interviews with the Agro-dealer Association of Zambia, the numbers have stabilized and more small-scale retailers are starting to enter the market. This is due to farmers becoming more aware of fertilizer over time and willing to pay for it. In addition, Zambia is a country with low population density and the rural population is growing. Thus, the number of farms and land under cultivation is expanding. This has also led to increased aggregate demand for fertilizer in the country.

4. However, the margins on fertilizer for agro-dealers are low, estimated at only 2% on average. Agro-dealers see unpredictable government involvement as the major threat to the sector, citing inconsistent and unclear policies that make it hard for the private sector to effectively plan and strategize.

5. Our analysis of monthly urea prices between 2014 and 2022 in Zambia indicated that some factors affected the price of urea and the price wedge in USD (i.e. the difference between local urea prices and world urea prices):

Price Level

a. The *Log of Zambia's GDP* was found to be negative and statistically significant in the model. This meant that a 1% increase in GDP was associated with a 1.27% decrease in urea prices on average. This suggests that economic growth, which improves infrastructure and market efficiency, reduces fertilizer prices.

b. *A* 1 percentage point increase in CPI was associated with a 4.06% increase in urea prices on average. This reflects the impact of inflationary pressures pushing fertilizer prices higher.
c. A 1% increase in the previous month's maize price was associated with a 0.19% increase in urea prices on average. Higher maize prices can signal greater anticipated demand for fertilizer, leading to higher urea prices.

Price Wedge

a. A 1 percentage point increase in CPI was associated with a 9.05% increase in the price wedge on average. This reflects the impact of inflationary pressures on fertilizer prices, widening the gap between local and world prices.
b. *A* 1% increase in last month's maize price was associated with a 0.36% increase in the price wedge on average. Higher maize prices, indicating greater anticipated demand for fertilizer, push up local prices relative to world prices.

6. Compared to coastal countries in the region, Zambia's landlocked position with high transportation costs means that its farmers must pay high prices for imported fertilizer that must be delivered via road from Mozambique and Tanzania. At the same time, poor infrastructure means that Zambian farmers receive a relatively low price for the maize that they sell as the traders have to account for the high transportation costs to and from farm gates. The relatively high price of fertilizer and low price of maize has undermined fertilizer profitability in Zambia.

7. Another important factor undermining the profitability of fertilizer is the finding that the maize-to-fertilizer response rate on smallholder farmers' fields is too low for most of them to use it profitably. We found that the average Zambian farmer only obtained about 3.0 kilograms of maize per kilogram of fertilizer (Chapoto et al. 2023). This is significantly below an estimated return of around 5.68 kilograms in Kenya. The low maize-to-fertilizer response rate in Zambia has implications for food security and the cost-effectiveness of fertilizer subsidy programs.

8. That being said, the nominal price of fertilizer declined between 2014 and 2020 as fertilizer prices in Zambia (mainly urea) moved closer to the world price of fertilizer in both Kwacha and USD terms. This suggests that fertilizer markets in Zambia were becoming more efficient during the period before the price spikes of 2021/22.
   a. This is clear in the fertilizer retail price data collected by IFDC, available at AfricaFertilizer.org. It indicates that at its peak, the wedge between the local price of urea in Zambia and the world price was about $450 in 2013, but dropped to about $200 in nominal terms by the end of 2020.

9. The price of urea rose significantly in Zambia in both Kwacha and US dollar terms during the price spike of 2021/2022. The peak price of urea was US $900/MT, equivalent to ZMW 17,500/MT in 2022. The price dropped from there, but the depreciation in the Kwacha against the dollar had a big effect on the relative decline in urea price when it was valued in local currency. Specifically, the nominal price of urea in Zambia declined by 42% from the peak in 2022 to the end of 2023 when it was valued in nominal USD. Conversely, the decline in urea price over that period when it was denominated in nominal Kwacha was only 14%. This indicated that the local conditions for buying fertilizer were not favorable for Zambian farmers who paid for fertilizer in Kwacha over the last two years, even though global and local prices have declined in USD terms.

10. Zambia has subsidized fertilizer for smallholder farmers in some form or another in every year this century. We note the following about Zambia's subsidy program over the past 25 years.

i. In the 2002/2003 season, the Government established the Fertilizer Support Programme (FSP) which ran through 2008/2009.
ii. In 2009/2010, the Fertilizer Support Programme was renamed Farmer Input Support Programme (FISP) which runs to date.
iii. In terms of delivery modality, the FSP was implemented purely as a direct input supply (DIS) program where inputs are delivered to farmers through input suppliers. The FISP on the other hand has been implemented using a mixed approach of DIS and the electronic voucher system (e-voucher). The size and scope of the e-voucher vs DIS as part of the FISP varied over seasons but the government moved back toward more DIS and away from e-voucher in recent years. However, there is renewed momentum to scale up the electronic voucher system, especially as it is linked to World Bank and IMF economic management conditionalities for debt restructuring.
iv. Beginning in 2020 the Government of Zambia proactively engaged in efforts to try and combat rising fertilizer prices.
    a. In 2020 they recapitalized the state-owned Nitrogen Chemicals of Zambia (NCZ) to increase production of NPK. Ultimately, NCZ failed to meet the targeted production levels and issued subcontracts to other suppliers to make up the difference. Thus, the recapitalization had limited impacts on lowering fertilizer prices for farmers.
    b. In 2021 the government supported the Bank of Zambia to increase interest rates and commercial bank reserve ratios to shore up the local currency and reduce the Kwacha's depreciation against the dollar. This action was effective at maintaining the Kwacha's value for the short-term, but fertilizer prices continued to increase.
    c. As the prices of fertilizer continued to rise in 2022 the government of Zambia increased the FISP subsidy level to 94 percent of the commercial price as a way of cushioning farmers against the high prices.
    d. In 2023 government envisioned the FISP as part of a Comprehensive Agriculture Transformation Support programme (CATSP), and broke the program into two components. The first part of the program was targeted to larger farmer with more than five hectares of land. The goal was for farmers to more than double their input use, by offering them five 50-kilogram bags of fertilizer at a reduced price. Each beneficiary will be required to be in the program for three years, during which time they will have their benefits gradually reduced and eventually be weaned off of the subsidy program. The second part of the program was run by the ministry of community development and social services. It offered to 50-kilogram bags of subsidized fertilizer to smaller-scale farmers with less than five hectares.

11. It is also clear that inorganic fertilizer use among farmers in Zambia has risen over time and is high relative to other countries in the region. For example, Zambian farmers used an average of 20 kilograms of fertilizer per hectare between 1996 and 2006. However, average fertilizer use increased to 50 kilograms per hectare between 2007 and 2020, reaching a high of 80 kilograms per hectare in 2020. This made Zambia the only country in the region besides South Africa to meet the Abuja declaration's goal of 50 kilograms of fertilizer per hectare (Chapoto et al. 2023). Much of this increased fertilizer use was due to Zambia's FISP program which distributed a large amount of fertilizer to farmers.

12. However, our analysis found that the benefits to subsidizing fertilizer were reduced by an average crowding-out rate of 13%. This meant that every 100 kilograms of subsidized fertilizer acquired by farmers in 2023 only led to 87 kilograms of additional fertilizer applied to their fields. The remaining 13 kilograms were displaced commercial purchases.
    i. While Zambia's crowding out estimate was lower on average than in other countries in the region (e.g. Malawi was 27% on average) the crowding out rate in Zambia rose over time. We estimate that it was just 5% on average in 2010/11, but it rose to 31% in 2013/14 and then rose further to 38% in 2017/18. This finding suggests that the

program administration got less efficient over the previous decade as crowding out increased.

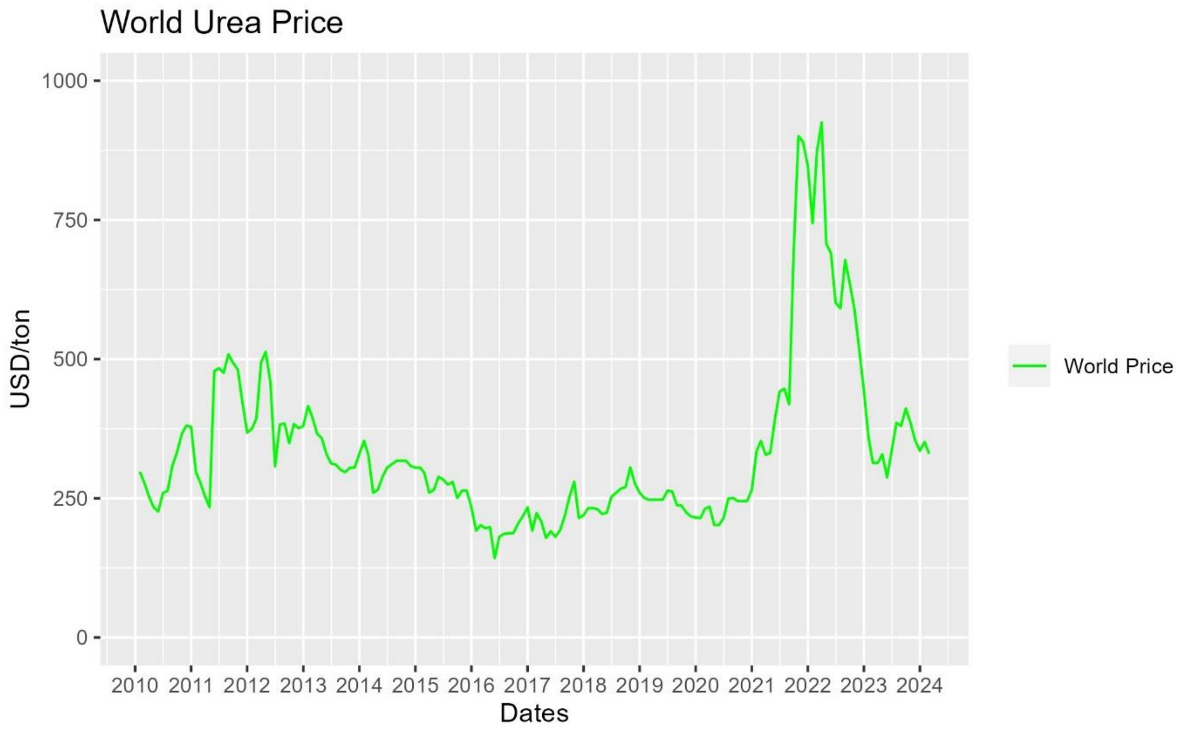
13. When we estimated the returns to commercially priced fertilizer in Zambia, we found that in many years farmers did not break even. This is because of the relatively low price of maize at the farm gate, the relatively high price of commercial fertilizer in rural Zambia, and the low average maize yield response to fertilizer application. On average, Zambian farmers get only 2.97 kilograms of maize per kilogram of fertilizer (Chapoto et al. 2023).

2. Introduction

International fertilizer prices increased and then decreased substantially between 2020 and 2024. The initial global drivers of the increase were disruptions in the global supply chain caused by COVID-19. As a result, China and Russia, two of the largest fertilizer exporters, imposed restrictions on their exports. These restrictions also came at the same time that international coal and natural gas prices, key inputs in the production of fertilizer, were rising. Fertilizer prices increased further in early 2022, due to the fallout from the Ukraine crisis. Russia and Ukraine are major fertilizer exporters, and Russia's invasion of Ukraine greatly reduced the global fertilizer supply during the initial months of the war. At the same time that fertilizer prices increased, prices of staple foods increased as well. This increase in input and output prices had important implications for smallholder farmers, small-scale traders, and consumers in Zambia as it did in many other countries of sub-Saharan Africa (SSA). This is not surprising because Zambia imports virtually all its fertilizers from the international market. Figure Z.1 shows the world price of urea, between 2010 and 2024 in nominal USD per metric ton (MT). The figure shows that before the price spike of 2021/22, the price of urea had declined from a high of about USD 500/MT in 2013 to a low of about USD 250/MT in 2020 before the spike began. The world price of urea then spiked beginning in early 2021 reaching a high of USD 925/MT in March of 2022. The price then dropped during the remainder of 2022 before reaching a monthly average of $375/MT in the second half of 2023.

This report analyzes global and national-level urea prices because urea is a consistent type of fertilizer (46% nitrogen) that is traded and used globally. Doing so allows us to make cross-country comparisons. Subsequent figures and analyses compare the price of urea in Zambia with the world price. The difference between the local price, and the world price is called the price wedge. Understanding the factors that affected the fertilizer price wedge before, during, and after the fertilizer price spike of 2021/22 in Zambia is important for developing policies, programs, and strategies to mitigate the effects of future shocks.

Figure Z.1: World urea price



Source: World Bank Pink Sheets. Urea prices were reported for F.O.B. in the Black Sea before 2022 and in the Middle East since.

3. Objectives

This report has several main objectives. The first is to analyse and document what the change in the fertilizer price wedge during the global fertilizer price spike of 2021/22 meant for Zambia. We estimated which factors explained the local price of urea and the price wedge in the country over the past ten years. Second, we assessed how the government, donors, and other multi-lateral organizations in Zambia responded to the price spike. Since subsidizing fertilizer was the major policy response of the Zambia government to the price spike, we estimated the impact of fertilizer subsidies on commercial fertilizer demand, and how effective fertilizer policy was at increasing fertilizer use among smallholder farmers. Third, we estimated the profitability of fertilizer use for farmers in Zambia using data on smallholder farm household data in the country collected by the Indaba Agricultural Policy Research Institute (IAPRI) in the 2010/11, 2013/14, and 2017/18 production seasons. Fourth, we analyzed the return on the government's expenditure on fertilizer subsidies to see if it was a good use of the country's agricultural budget. Finally, based on these analyses we made recommendations that the Government of Zambia, donors, and the private sector can take to increase the returns to fertilizer use among farmers. Ultimately this will help to make the fertilizer sector more resilient and better prepared for the next time fertilizer prices rise drastically.

4. Methodology

The study applied the following methodology: 1) a qualitative and quantitative econometric analysis of the factors that affected the fertilizer price wedge before, during and after the fertilizer price spike in Zambia; 2) a review of the fertilizer market structure that was conducted by key informant interviews with important actors in the fertilizer sector, and review of relevant background documents; 3) a scoping review of the literature and available databases on fertilizer subsidy policies in Zambia and fertilizer prices, both global and national, before, during and after the fertilizer price spikes of 2021/22;; and 4) an analysis of the farmer survey conducted by IAPRI. Using these data we analysed fertilizer demand, including i) how Zambia's fertilizer subsidy program affected demand for commercial fertilizer for both the average household and along the distribution of assets and landholding, ii) how fertilizer purchasing behavior over time was associated with farm household characteristics, iii) how fertilizer profitability was affected by the price spike and the benefit-cost analysis of subsidizing fertilizer as impacted by rising fertilizer and maize prices during the price spike.

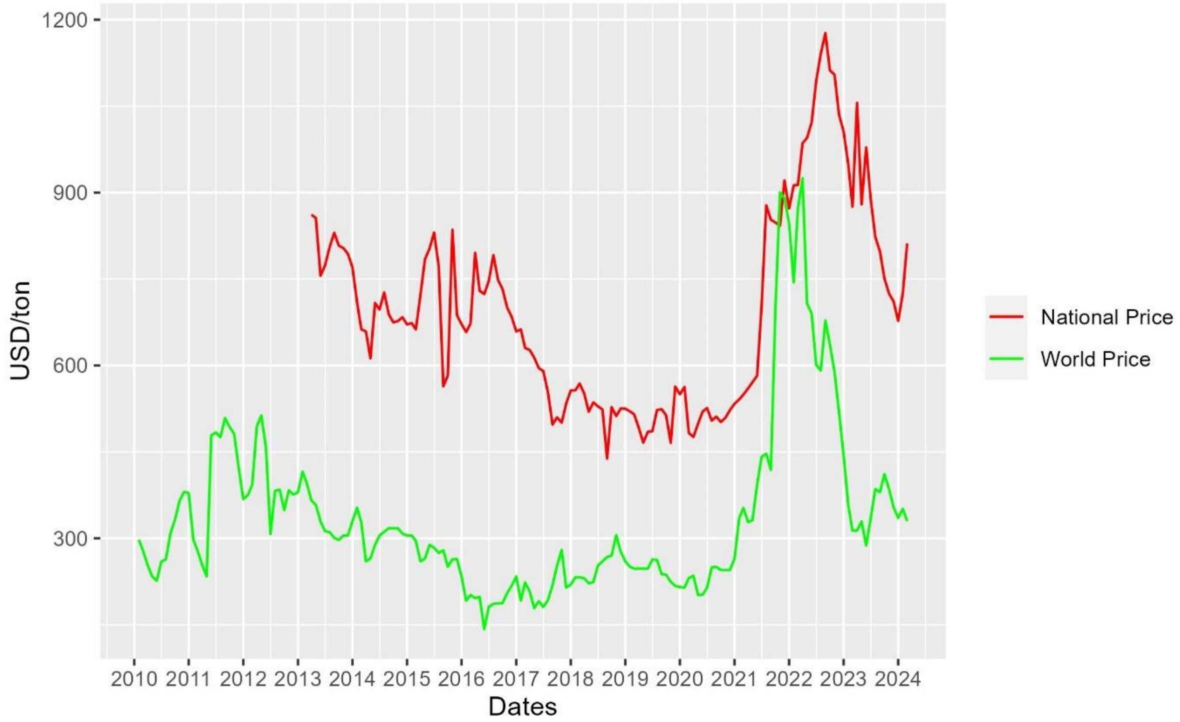
5. Results and Discussion

i) The fertilizer price wedge in Zambia

Figure Z.2 shows the nominal price of urea in Zambia between May 2013 and December 2023 in USD in red and how it compares to the world price of urea in green. The figure indicates that the price of urea in Zambia was always above the world price before the price spike of 2021/22. This is not surprising, given Zambia's landlocked position as a fertilizer importer. However, urea prices in Zambia trended downward during that pre-spike time, meaning that the wedge got smaller as prices went from a high of over USD 900/MT in 2014 to about USD 500/MT at the end of 2020. The wedge also shrunk in real terms prior to the price spike. This suggests that fertilizer use was becoming more profitable for farmers during that period, in US dollar terms, prior to the price spike.

The world urea price rose before the local price did in Zambia starting in 2021. As a result, the wedge was negative for a brief period in early 2022. Though the world price peaked at about USD 900/MT in early 2022, the price in Zambia continued to rise, reaching a high of nearly USD 1,200/MT near the end of that year. The world price had dropped down to an average of USD 375/MT in the second half of 2023, but the local price in Zambia stayed higher for longer and only reached a low of around USD 700/MT at the end of 2023. The decline in urea price in Zambia from its peak at the end of 2021 to the end of 2023 was 42%, but the price of urea in Zambia remained high compared to the world price. By the end of 2023, the wedge between the price of urea in Zambia and the world price was still between USD 300-350/MT. This meant that the price of urea in Zambia was still double the world price.

Figure Z.2: Retail prices of Urea in Zambia and the world price in USD/MT



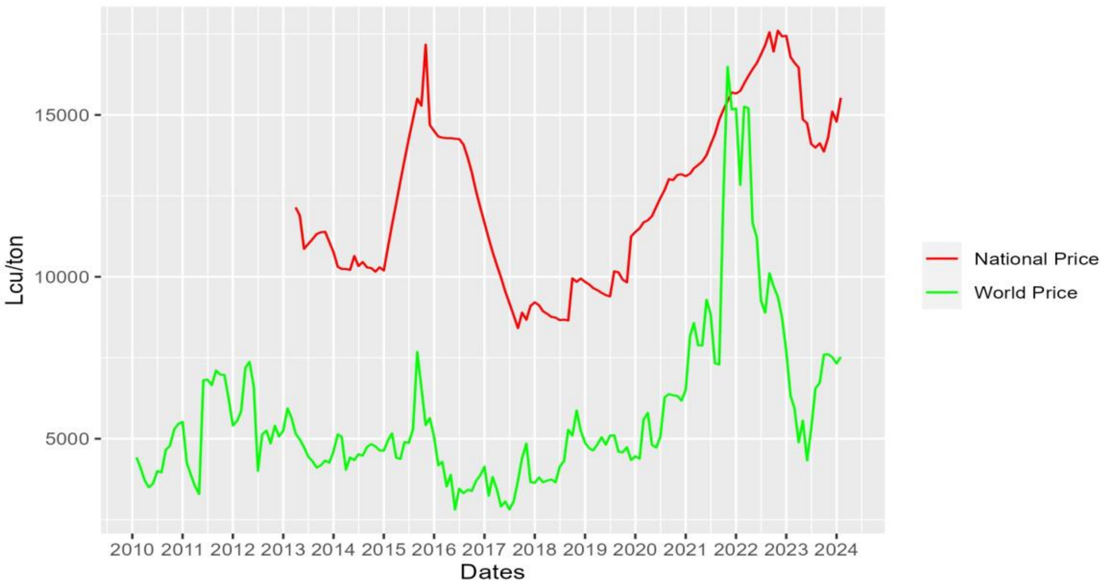
Notes: Price Wedge = Local urea price (US$/Ton) – World Price (US$/Ton); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Zambia began in 2013.

Figure Z.3 presents the same relationship between the price of urea in Zambia and the world price, but this time both price series are measured in nominal local Zambian Kwacha. When urea is denominated in Kwacha the price of urea and the price wedge is much more volatile than it was when the price was denominated in USD. In Figure Z.3 the price of urea was close to ZMW 17,500/MT in 2015, but dropped to about ZMW 9,000/MT in 2018. The price of urea in Zambia began to rise in 2020, which was before the sharp rise in the world price and before the rise in prices in Zambia when the fertilizer was denominated in USD. This speaks to the Zambian Kwacha's depreciation against the USD that occurred during that time, as the exchange rate rose from about nine Kwacha per USD in 2018 to over 20 Kwacha per USD at the end of 2020.

Just as when urea was USD denominated, in late 2021, the world price of urea was higher than the price in Zambia for a brief period. This caused the wedge to go negative. However, the world price dropped quickly from there, reaching a low of about ZMW 5,000/MT by the end of 2023. Conversely, the local price of urea remained high, only dropping slightly from about Kwacha 17,500/MT at the end of 2022 to Kwacha 15,000/MT by the end of 2023. This was equivalent to a 14% decline. Recall that the price drop of urea in Figure Z.2 was 42% when the fertilizer was denominated in USD. Thus, urea prices dropped much more in dollar terms than they did in Kwacha terms after the spike. This meant that fertilizer prices remained high for Zambian farmers. Part of the reason for the difference in price between dollars and Kwacha was due to further depreciation of the Kwacha which declined to 26 Kwacha per dollar by the end of 2023.

The next sub-section discusses the results of our quantitative results on factors that affect the price of urea and the price wedge in Zambia.

Figure Z.3: Retail prices of Urea in Zambia and the world price in Kwacha/MT



Notes: Price Wedge = Local urea price (ZMW/Ton) – World Price (ZMWTon); local prices are an average of monthly prices available from AfricaFertilizer.org; World price is from World Bank Pink Sheet; price data from AfricaFertilizer.org for Zambia began in 2013.

ii) Quantitative analysis of factors affecting the fertilizer price wedge over time and across countries.

Results by Variable for Price Level Model in Kwacha

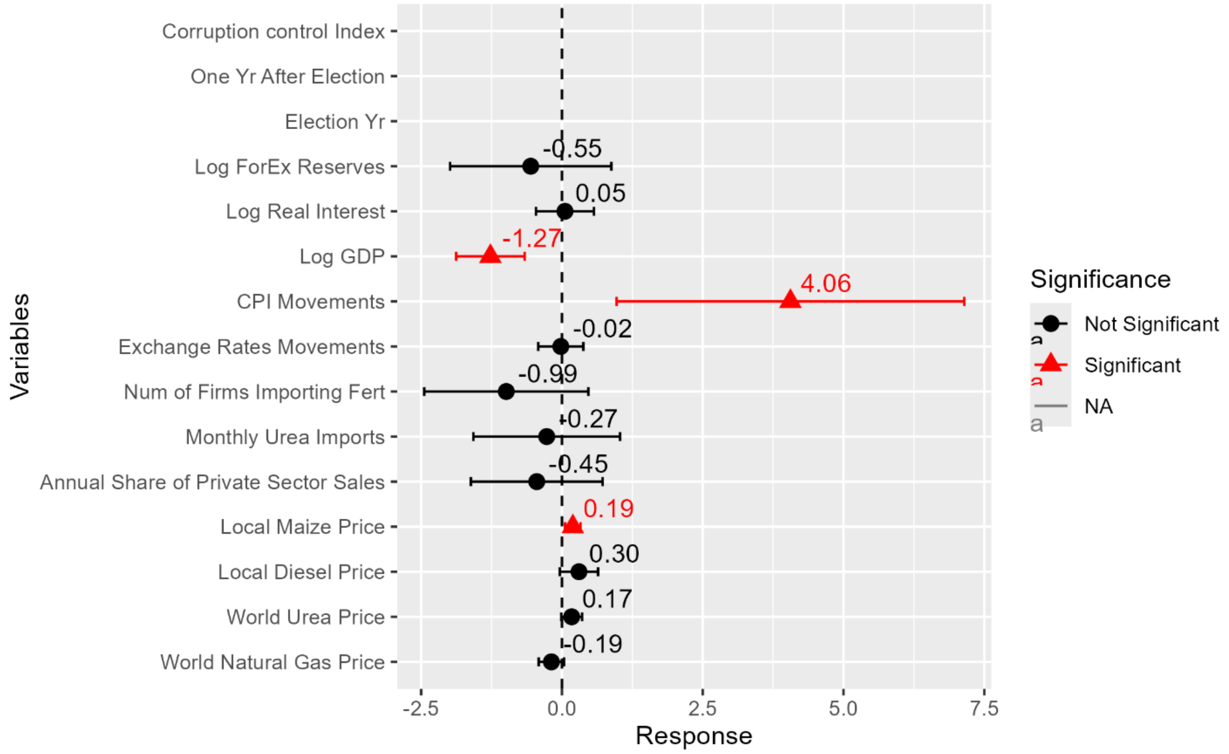
Figure T.4 presents the box and whiskers plot for the factors that affected the price of urea in Zambia between 2010 and 2023. This figure is based on a time series regression of monthly urea prices collected by AfricaFertilizer.org. The urea price was regressed against a set of factors that were hypothesized to affect them; the factors were the same ones used in the cross-country panel model.

The variable *Log GDP* was negative and statistically significant, meaning a 1% increase in GDP was associated with a 1.27% decrease in urea prices on average. This suggests that economic growth, which improves infrastructure and market efficiency, reduces fertilizer prices.

CPI Movements was positive and statistically significant. It indicated that a 1 percentage point increase in CPI was associated with a 4.06% increase in urea prices on average. This reflects the impact of inflationary pressures pushing fertilizer prices higher.

Lagged Maize Price was positive and statistically significant. This suggested that a 1% increase in last month's maize prices was associated with a 0.19% increase in urea prices on average. Higher maize prices can signal greater anticipated demand for fertilizer, leading to higher urea prices.

Figure Z.4. Factors affecting Urea prices in Zambia from 2013-2023 in Kwacha/MT



Notes: Results are from a linear regression model of 138 monthly observations of nominal urea price levels in Zambia denominated in kwacha from AfricaFertilizer.org. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into kwacha to correspond to the impacts in local markets. Models include year fixed effects.

Results by Variable for Price Wedge Model in Kwacha

Figure G.5 presents the box and whiskers plot for the factors that affected the price wedge in Zambia between 2013 and 2023. This figure is based on a time series regression of the monthly price wedge, defined as the difference between the urea price in Zambia and the world price, both in LCU. The wedge was regressed against a set of factors hypothesized to affect it, similar to those used in the cross-country panel model.

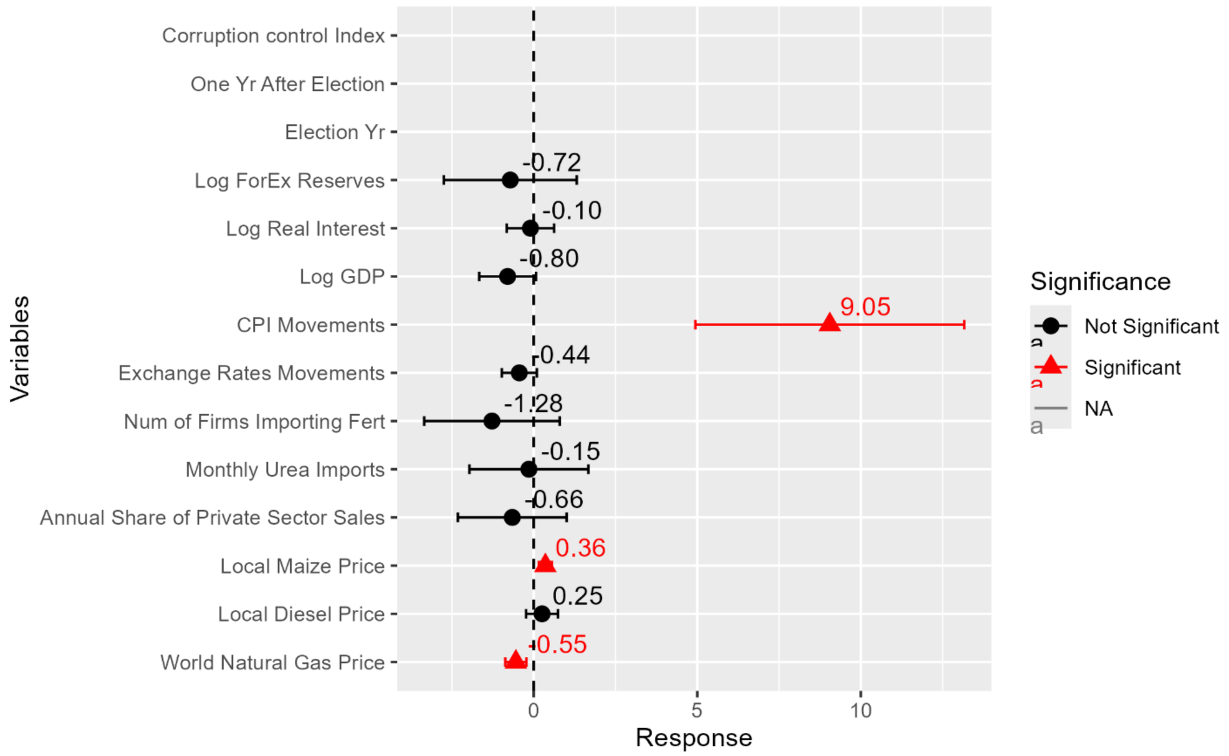
The variable *CPI Movements* was positive and statistically significant. It indicated that a 1 percentage point increase in CPI was associated with a 9.05% increase in the price wedge on average. This reflects the impact of inflationary pressures on fertilizer prices, widening the gap between local and world prices.

Lagged Maize Price was positive and statistically significant. It suggested that a 1% increase in maize prices was associated with a 0.36% increase in the price wedge on average. Higher maize prices, indicating greater anticipated demand for fertilizer, push up local prices relative to world prices.

World Natural Gas Price was negative and statistically significant. It indicated that a 1% increase in the natural gas index was associated with a 0.55% decrease in the price wedge on average. This was at odds with our expectation since natural gas is a major cost factor in the production of urea. We likely picked up some spurious correlation between this variable and the wedge.

Figure Z.5: Factors affecting Urea price wedge in Zambia 2013-2023 in Kwacha/MT

Dependent variable: urea price wedge asinh(nominal urea price in kwacha – world price in kwacha)



Notes: Results are from a linear regression model of 139 monthly observations of nominal urea price wedges in Zambia. The price wedge is calculated as the price of urea in kwacha in each country obtained from AfricaFertilizer.org minus the world price of urea obtained from the World Bank Pink Sheets converted to kwacha. The triangles and circles are the mean estimates of each variable's effect on urea price. The whiskers are the 95% confidence interval of the mean effect. Estimates that are less than zero denoted that the factor had a negative effect on urea prices, while variables that are greater than zero denoted that the factor had a positive effect on urea prices. Variables with **Red** lines denoted that the variable's mean was statistically different from zero. **Black** lines denoted that the variable's mean was not statistically different from zero at the 5% level. All prices, including World Urea Price and World Natural Gas Price, have been transformed into kwacha to correspond to the impacts in local markets. Models include year fixed effects.

iii) *Analysis of fertilizer market structure in Zambia*

NPK and urea are the main fertilizer blends used by Zambian farmers. The structure of the fertilizer sector in Zambia is heavily influenced by the level of government involvement in the market. Many firms increased or decreased operations in response to government tenders. Uncertainty and inconsistency in the process of government fertilizer procurement and how it communicates its intentions with the private sector and farmers increase risk in the system. This leads to higher fertilizer prices at the last mile of the supply chain. Table Z.1 presents the structure of the fertilizer market in Zambia over the past ten years. It indicates that the fertilizer sector is very concentrated along all stages of the chain. Given its position as a landlocked country with no domestic pool of fossil fuels, Zambia has been producing minimal volumes (less than 50,000 Mt) of compound D fertilizer. That being said, in recent years there have been a number of investments made to increase domestic fertilizer production. Nitrogen Chemicals of Zambia (NCZ) has been one of the major players in fertilizer blending for many years in Zambia and minimal manufacturing of compound D. It is a state-run entity that has continued to receive financial support from the government for recapitalization. The overall view is that NCZ has not operated efficiently, but in early 2023 they announced a USD 6 million investment in a new facility that has the capacity to produce 146,000 MT of NPK per year (Lusaka Times 2023). This has the potential to increase value-added blending and have a big impact in the country as there is a push by the government and donors for more crop-specific and soil-specific fertilizers to be adopted to increase fertilizer use efficiency by small-scale Zambian farmers. Another player is United Capital Fertilizer (UCF) of Zambia. At the end of 2023, UCF announced a USD 300 million investment to set up a production facility that will produce 135,000 MT of urea and 80,000 MT of ammonia. The raw materials, coal, and phosphate are expected to be sourced from Zambia's Southern province and the rest imported. The goal is to supply 80% of the country's urea demand all of which is currently imported, and 60% of its D compound demand to supplement production from NCZ.

There has been a slight increase in the number of firms importing fertilizer in Zambia in the past 10 years. In 2014, only seven firms imported 90% of the fertilizer used in Zambia. This increased to 12 in 2019 just before the spike, declined to nine in 2022 during the spike, and increased to 13 firms in 2023. Local companies include Nitrogen Chemicals of Zambia, Neria Investment, and Nyimba Investments, while multinational companies include Zambian Fertilizer, Omnia, Export Trading Group, Yara, Farmer Rama, Forest Co.

The logistics of importing fertilizer into Zambia is challenging. The main ports to import fertilizer into Zambia are Beira in Mozambique and Dar es Salaam in Tanzania. Once an order is placed for fertilizer to be delivered to Zambia it takes between three and four weeks for that fertilizer to arrive. It can take fertilizer one week to clear the port and between one to two weeks to go from the port to the destination in Zambia. That being said, several new market entrants have imported fertilizers into Zambia in the past few years. These companies brought stocks into the region in bulk, either through Beira or Dar-ES-Salaam. They held their stock at these international ports and then distributed it to either Zambia, Malawi, Mozambique or the Democratic Republic of Congo (IFDC 2024).

In terms of blending, there were four firms that supplied 90% of the Zambian market in 2023. This was up from three in 2022, two in 2019, and one in 2014. In 2014, eight fertilizer wholesalers controlled 90% of the fertilizer in Zambia. That number increased to nine in 2019, before the price spike, and increased to 10 during the spike in 2022. In 2023, 12 companies wholesaled 90% of the fertilizer in Zambia. At the retail level, eight companies controlled 90%

of the fertilizer retailing in 2014. This remained the same in 2019. During the price spike, this rose slightly to nine companies and increased to 10 companies in 2023.

Table Z.1: The number of companies in Zambia that control 90% of the fertilizer that was available at different stages in the supply chain during key years.

Stage	In 2014 (ten years ago)	In 2019 (just before the fertilizer price spike)	In 2022 (during the fertilizer price spike)	In 2023 (last year)
Manufacturing	1	1	1	1
Importing	7	12	9	13
Blending	1	2	3	4
Wholesaling	8	9	10	12
Retailing	100's	100's	100's	100's

Source: Importer Information from Afriqom; other information from International Fertilizer Development Corporation (IFDC)

Our interview with the Zambia Fertilizer Association noted numerous challenges to the market. At the macro-economic level, inflation and exchange rate fluctuations make fertilizer prices volatile and mostly expensive in the Zambian market. The price of fertilizer is also tied to the price of fuel, so fertilizer prices rise as fuel prices rise. The number of small-scale local agro-dealers has gone down over time due to fewer contracts from the government. Currently, the numbers have stabilized and more small-scale retailers are starting to enter the market. This is due to farmers becoming more aware of fertilizer over time and willing to pay for it. However, the margins on fertilizer for agro-dealers are low, estimated at only 2% on average. Many agro-dealers use fertilizer as a loss leader and sell fertilizer to get farmers in their shops where they can sell other products like agrochemicals that have better margins. Many also move into crop trading in the harvest season to increase cash flow during the time of year when they sell fewer inputs. In the previous five years, the margins for agro-dealers were higher at between 5-10%. Margins have declined due to uncertainty in the market. This is caused by price volatility and inconsistent communication from the government and their failure to pay back agro-dealers who sold subsidized fertilizer to farmers. Overall, the fertilizer sector in Zambia is highly concentrated but is becoming slightly less concentrated over time. The major threat to the sector is government involvement in the market, and inconsistent and unclear policies that make it hard for the private sector to effectively plan and strategize. The Zambian government's fertilizer policy before and during the 2021/22 price spike is discussed in the next section.

iv) Analysis of fertilizer policies in Zambia around the fertilizer price spike

Policy Response

It is conventional that when global economic shocks occur that affect domestic commodity supply chains and prices, countries respond with policies to try to mitigate their impacts on their citizens. The policy responses often have protracted impacts well after the global shocks have lessened. Such policy responses might achieve their intended objectives but unintended consequences to other aspects of the economy are often also realized. They also might not necessarily achieve their intended objectives – or they might achieve the short-term objective but cause market distortions that are harmful in the longer term. policy responses often have trade-offs, as countries often face options with differing consequences. It is, therefore, critical that a country's policy responses to economic shocks are guided by its contextual conditions and informed by up-to-date evidence as well as the global and regional dynamics. This section identifies key fertilizer policy interventions in Zambia before and during the recent fertilizer price spikes.

Fertilizer Policy Before Price Spike

The government of Zambia has a long history of engagement in fertilizer markets. The primary policy tools have been to subsidize inorganic fertilizers and maize seed for farmers and to attempt to set a price floor for maize at harvest and a price ceiling for consumers in the lean season through their Food Reserve Agency (FRA). The FRA buys maize from farmers at harvest, stores it in their warehouses, and releases it to the market when prices are high in the lean season. An analysis of the FRA's impact found that it mainly benefited larger-scale farmers who had enough surplus production and access to transportation to deliver maize to FRA. As a result, the agency's maize-buying activities were found to put upward pressure on maize prices (Mason et al. 2015). This was detrimental to Zambian consumers and small-scale farmers, many of whom end up buying maize later in the season, especially in the lean season.

Since the 2002/2003 agricultural season, the Government of Zambia has been providing input subsidies to smallholder farmers through input subsidy programs (ISP). The ISP has been managed by the Ministry of Agriculture to improve farmers' access to agricultural inputs and help increase productivity and production. In the 2002/2003 season, the Government established the Fertilizer Support Programme (FSP) which ran through 2008/2009. The FSP provided inorganic fertilizer and hybrid maize seed at a subsidized price to selected beneficiaries. The level of subsidies varied from year to year moving from 50 percent in 2002/2003 to 60 percent in 2006/2007 (Mason et al., 2015). In 2009/2010, the Fertilizer Support Programme was renamed Farmer Input Support Programme (FISP) which runs to date. Unlike the FSP which focused solely on maize, the FISP has a wider scope and includes legumes as part of the diversification effort.

In terms of delivery modality, the FSP was implemented purely as a direct input supply (DIS) program where inputs are delivered to farmers through input suppliers. The FISP on the other hand has been implemented using a mixed approach of DIS and the electronic voucher system (e-voucher). With the e-voucher system, farmers redeem inputs of their choice through agro-dealers and input suppliers using an electronic system. The e-voucher started as a pilot in the 2015/2016 and 2016/2017 agricultural production seasons. The scale of e-voucher implementation varied across seasons, with the program reaching full scale only in the 2017/2018 agricultural season. However, citing some implementation challenges such as limited access to information technology, telecommunications connectivity, and challenges in the provision of financial services, the government decided to scale down the e-voucher implementation from 100 percent in the 2017/2018 season to 60 percent in the 2018/2019 season, and further down to 40 percent in the 2019/2020 agricultural season. The government reintroduced the e-voucher system in the 2023/2024 farming season and was piloted in two of the 10 provinces; Lusaka and Central province, with the aim of scaling the implementation throughout the country by 2026. During the pilot, the government awarded supply contracts to large input suppliers who then subcontracted agro-dealers in various parts of the country. This model crowds out agro-dealers, who are mostly locally based SMEs and thus have direct impacts on job and wealth creation (IAPRI, 2024).

Fertilizer policy during the price spike

Beginning in 2020 the Government of Zamia proactively engaged in efforts to try and combat rising fertilizer prices. In 2020 they recapitalized the state-owned Nitrogen Chemicals of Zambia (NCZ) to increase production of NPK. Ultimately, NCZ failed to meet the targeted production levels and subcontracts to other suppliers, thus having limited impacts on fertilizer prices.

In 2021 the government supported the Bank of Zambia to increase interest rates and commercial bank reserve ratios to shore up the local currency and reduce the Kwacha's depreciation against the dollar. This action was effective at maintaining the Kwacha's value for the short-term, but fertilizer prices continued to increase.

As the prices of fertilizer continued to rise in 2022 the government of Zambia further recapitalized NCZ to increase its production capacity and produce NPK for the FISP. They also increased the subsidy level to 94 percent of the commercial price. In addition to the direct subsidy from the FISP, the government introduced a loan scheme called the Sustainable Agriculture Financing Facilities (SAFF). The intent was for small and medium-scale farmers who have limited access to affordable financing to be able to obtain credit for agricultural inputs with low interest rates (at 12% versus the commercial rate of 28%). The loans were administered by the private sector through financial institutions. Initial results on the success of the SAFF have been mixed. Some banks only partially disbursed the funds that the government made available. The key challenge was a lack of sensitization, as not many farmers were aware of the program. It is also possible that the banks wanted to keep the money and invest it in other more profitable opportunities.

In 2023 government envisioned the FISP as part of a Comprehensive Agriculture Transformation Support Programme (CATSP), and broke the program into two components. The first part of the program was targeted to larger farmer with more than five hectares of land. The goal was for farmers to more than double their input use, by offering them five 50-kilogram bags of fertilizer at a reduced price. Each beneficiary will be required to be in the program for three years, during which time they will have their benefits gradually reduced and eventually be weaned off of the subsidy program. The second part of the program was run by the Ministry of Community Development and Social Services. It offered to 50-kilogram bags of subsidized fertilizer to smaller-scale farmers with less than five hectares.

Overall, FISP remains one of the key strategies of the Zambian government to increase agricultural productivity and reduce rural poverty before, during, and after the fertilizer price spike of 2021/22. The FISP has provided fertilizer to slightly over 1 million smallholder farming households out of the estimated 1.6 million smallholder farming households in Zambia (IAPRI, 2020). However, despite the heavy investment of public resources in the FISP, evidence points to inputs distributed under the program tending to be targeted to the least poor rural households, relatively more in areas with high agricultural potential and households with connection to traditional leadership (Jayne et al., 2018; Mason et al., 2020; Mason et al., 2013; Mason & Smale, 2013). This is due to elite-capture, cronyism, political favoritism, and the general ability of better-off households to access government benefits like subsidized fertilizer. Further, despite substantial agricultural budgetary allocation to FISP rural poverty remains high at 76.5 percent in 2015 and 79% in 2022 (Central Statistical Office, 2015; Zambia Statistics Agency; 2023), while the Ministry of Agriculture annual crop forecast survey data show maize yields have remained stagnant and low at about 2 Mt/ha This points to the limited success of FISP in achieving its goal of reducing poverty. In addition, numerous studies found substantial diversion and leakage of FISP fertilizer (e.g., Jayne et al., 2013; Mofya-Mukuka & Kuteya, 2018; Mason & Tembo, 2015; World Bank *Forthcoming*).

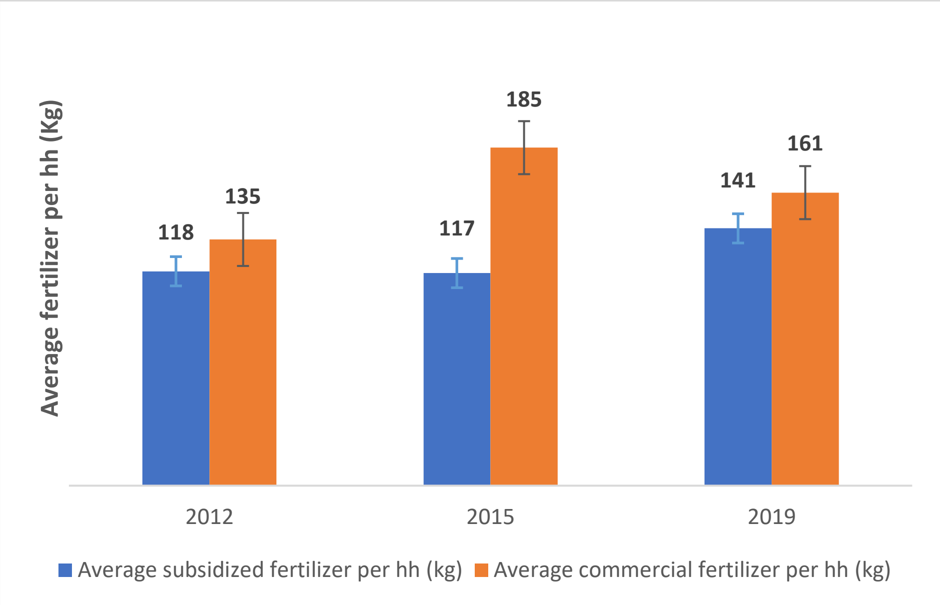
Other fertilizer program responses

Since 2000, the Zambian government has supported the vulnerable but viable farmer households with agricultural inputs including fertilizer (D compound and Urea) and seed for cereals and legumes under the Food Security Pack (FSP) Programme, implemented by the Ministry of Community Development and Social Services (MCDSS). The FSP is purely a social welfare initiative aimed at improving household food security among vulnerable poor farming households. Several donor organizations have been involved with supporting fertilizer use among farmers in Zambia since the price spikes of 2021/22. The African Development Bank (AfDB) has been supporting smallholder farmers in Zambia with subsidized fertilizer and seed in response to rising fertilizer prices through the African Emergency Food Production Facility. The AfDB facility helped 45,000 vulnerable but viable smallholder farmers access fertilizer. In addition, the USAID Bureau for Resilience and Food Security supported the Accelerated Innovation Delivery Initiative (AID-I) implemented by CIMMYT and IFDC to provide inputs including fertilizer through a market system approach aimed at reducing last mile delivery cost. The project has helped scale up input credit facility (including fertilizer) for One Acre Fund, a last-mile fertilizer delivery NGO, in the Central province. The African Fertilizer and Agribusiness Partnerships (AFAP) began a fertilizer distribution program in 2023 that targets farmers who do not qualify for the FISP.

v) *Fertilizer demand impacts*

Inorganic fertilizer use among farmers in Zambia is generally considered to have risen over time and to be high relative to other countries in the region. For example, Zambian farmers used an average of 20 kilograms of fertilizer use per hectare between 1996 and 2006. However, average fertilizer use increased to 50 kilograms per hectare between 2007 and 2020, reaching a high of 80 kilograms per hectare in 2020. This made Zambia the only country in the region besides South Africa to meet the Abuja declaration's goal of 50 kilograms of fertilizer per hectare (Chapoto et al. 2023). This outcome is consistent with the analysis of smallholder fertilizer sourcing fertilizer use based on three waves of the Rural Agricultural Livelihood Survey (RALS) panel data conducted by IAPRI. Figure Z.6 indicates that Zambian smallholder farmers acquired significant amounts of inorganic fertilizer from both the government and subsidized channels, and the FISP distributed a meaningful amount of fertilizer to farmers on average in the past decade. On average farmers acquired 118 kilograms of subsidized fertilizer in 2011/12 (2012 survey), 117 kilograms in 2013/14 (2015 survey), and 141 kilograms in 2017/18 (2019 survey). Average commercial fertilizer use was also high in Zambia. On average farmers purchased 135 kilograms of commercial fertilizer in 2011/12 (2012 survey), 185 kilograms in 2013/14 (2015 survey), and 161 kilograms in 2017/18 (2019 survey).

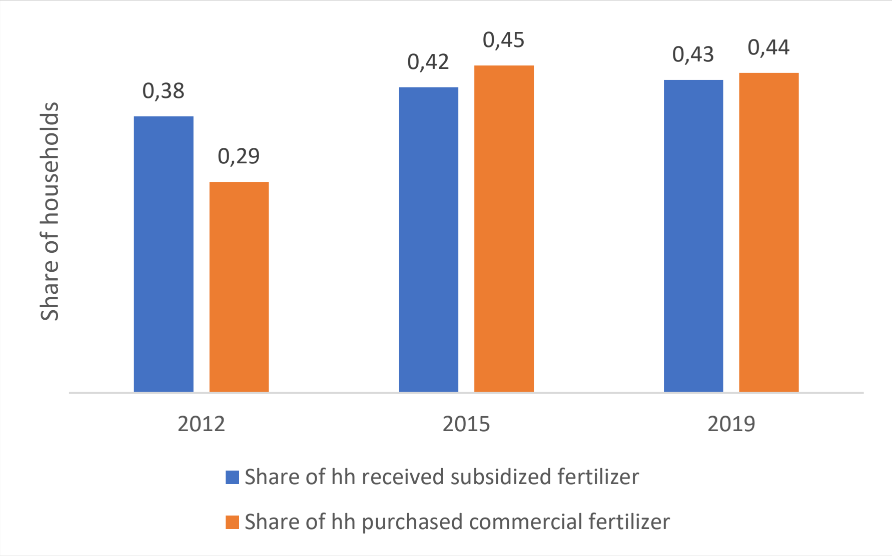
Figure Z.6. Average subsidized fertilizer and commercial procured per household by survey year.



Source. RALS (2012, 2015, and 2019)

Consistent with relatively high average fertilizer use, a reasonable share of farmers acquired subsidized fertilizer during the past decade in Zambia. Figure Z.7 shows this participation rate. In the 2011/12 (2012 survey) 38% of farmers acquired subsidized fertilizer, in 2013/14 (2015 survey) 42% acquired subsidized fertilizer and 43% did so in 2017/18 (2019 survey). In the 2011/12 (2012 survey) 29% of farmers purchased commercial fertilizer, in 2013/14 (2015 survey) this rose to 45% purchasing commercial fertilizer. This percentage remained relatively constant in 2017/18 (2019 survey) at 44%.

Figure Z.7. Share of households who procured subsidized and commercial fertilizer by survey year.



Source. RALS (2012, 2015, and 2019)

Table Z.2 presents the crowding out rates of commercial fertilizer by subsidized fertilizer that we calculated from the RALS data that was collected during the 2010/11, 2013/14, and 2017/18 growing seasons. We found that the crowding-out rate of commercial fertilizer by Zambia's subsidy program was 13% on average. This meant that every 100 kilograms of subsidized fertilizer acquired by farmers in 2023 only led to 87 kilograms of new fertilizer applied to their fields. The remaining 13 kilograms were displaced commercial purchases.

Table Z.2 also shows the crowding out rates estimated by year, area cultivated, and assets. Panel 1 shows that the crowding out rate was highly variable across years, at 5% in 2010/11, rising to 31% in 2013/14 and then rising further to 38% in 2017/18. This finding suggested that the program administration got less efficient over the previous decade as crowding out increased. Panel 2 showed that the crowding out rate for the 20% of the sample with the smallest area cultivated was 16% on average. The second quintile of landholding had the highest crowding out rate at 86% on average. The third landholding quintile had a crowding out rate of 8%. It was 21% for the fourth quintile and 15% for the largest quintile on average. Panel III showed that the crowding-out rate for the poorest 20% of the sample in terms of assets was 11% on average, and that declined to 1% on average for the second poorest quintile. The middle asset quintile had the highest crowding out rate at 29% on average. It was 10% for the fourth asset quintile and 15% for the richest asset quintile on average. Part of the reason for the higher crowding out of commercial fertilizer by the subsidy at lower ends of the landholding and asset distribution could have been issues with targeting the appropriate farmers who did not buy fertilizer commercially. Evidence suggests that despite the heavy investment of public resources in the FISP, inputs distributed under the program tend to be targeted to the least poor rural households, relatively more in areas with high agricultural potential and households with connection to traditional leadership (Jayne et al., 2018; Mason et al., 2020; Mason et al., 2013; Mason & Smale, 2013).

Table Z.2: Crowding out by year, area cultivated, and assets

Category	Average crowd-out	P-value	Category average
Overall	-0.13	(0.000)	
I. Year			
2010/11	-0.05	(0.00)	
2013/14	-0.31	(0.00)	
2017/18	-0.38	(0.00)	
II. Area cultivated			Ha/HH
Smallest 20%	-0.16	(0.12)	0.49
20 - 40%	-0.86	(0.01)	1.52
40-60%	-0.08	(0.04)	2.55
60 - 80%	-0.21	(0.00)	4.309
Largest 20%	-0.15	(0.00)	14.29
III. Asset quintile			USD/HH
Smallest 20%	-0.11	(0.02)	40
20 - 40%	-0.01	(0.03)	236
40-60%	-0.29	(0.07)	1,280
60 - 80%	-0.10	(0.00)	1,910
Largest 20%	-0.15	(0.00)	2,275

Source. RALS (2012, 2015, and 2019)

vi) *Fertilizer user demographics*

Table Z.3 presents the characteristics of farming households who purchased commercial fertilizer in every agricultural survey year in the RALS data (2010/11, 2013/14, and 2017/18) those who bought in some years and not others, and those who never bought it. The table shows that 16% of smallholder farmers in the sample purchased commercial fertilizer in every survey year, while 48% bought fertilizer in some survey waves, but not in others. Additionally, 36% of households never bought commercial fertilizer during the three survey years.

Table Z.3: Percentage of households that bought commercial fertilizer in every survey year, in some survey years, and none of the waves.

Group	% of the Sample in the group
% of the sample who purchased commercial fertilizer in every survey year	16
% of the sample who purchased commercial fertilizer in some of the survey years but not all.	48
% of the sample who never purchased commercial fertilizer in any survey year	36
Total	100

Source. RALS (2012, 2015, and 2019)

Given that less than 50% of Zambian farmers use fertilizer in a given year and the fact that fertilizer use seems to be distributed unevenly, we broke down the landholding distribution of farmers into three categories: i) those with less than two hectares of land, ii) those with between two and five hectares, iii) those with between five and 10.0 hectares, iv) those with between 10.0 and 20.0 hectares, and v) those with more than 20 hectares. We also disaggregated these categories region of the country where the household resides. The results are shown in Table Z.4. Column 6 indicates that farms with less than two hectares made up 39% of all farms nationally, while column 4 indicated that these small farms acquired the least amount of fertilizer on a per-household basis (102 kilograms per household on average). However, in column 3 when we divided commercial fertilizer purchases by landholding it is clear that smaller farms across Zambia used the input more intensively than did larger farms. For example, farms less than 2.0 hectares purchased 120 kilograms of fertilizer per hectare, while farms between 2.0 and 5.0 hectares acquired 46 kilograms per hectare, farms between five and 10.0 hectares acquired 34 kilograms per hectare on average, farms between 10 and 20.0 hectares acquired 25 kilograms per hectare on average, and farms greater than 20.0 hectares acquired just 14 kilograms per hectare on average, even though these larger-scale farmers acquired more fertilizer in total than did smaller-scale farms. These results in Zambia were similar to those in many other focus countries in this analysis including neighboring Malawi and Tanzania. It indicates that small-scale farmers in Zambia used less fertilizer overall, but farmed more intensively than larger farms and acquired more fertilizer on a per hectare basis.

Table Z.4: Landholding and Location Demographics for Households Purchasing Commercial Fertilizer in Zambia

(1) Province	(2) Landholding category	(3) Mean landholding in group (Ha)	(4) Total commercial fertilizer purchased (Kg)	(5) Fertilizer purchased per hecatre (Kg)	(6) Percent of sample in group
Central	Less than 2 ha	1.1	148.0	149.3	29.0
	Between 2 and 5 ha	3.2	258.2	81.2	32.2
	Between 5 and 10 ha	6.9	420.8	60.9	23.1
	Between 10 and 20 ha	13.3	867.6	66.2	10.9
	Greater than 20 ha	42.9	1453.8	47.3	4.8
Eastern	Less than 2 ha	1.2	109.6	111.3	39.4
	Between 2 and 5 ha	3.1	146.1	49.4	42.9
	Between 5 and 10 ha	6.7	271.4	40.4	13.7
	Between 10 and 20 ha	12.9	407.5	31.1	3.4
	Greater than 20 ha	31.2	372.8	14.7	0.7
Northern	Less than 2 ha	1.1	78.2	86.4	36.3
	Between 2 and 5 ha	3.1	108.8	37.8	30.4
	Between 5 and 10 ha	6.9	144.3	22.0	20.5
	Between 10 and 20 ha	13.2	197.4	14.8	9.1
	Greater than 20 ha	57.5	221.2	6.3	3.6
Southern	Less than 2 ha	1.1	184.7	236.3	32.3
	Between 2 and 5 ha	3.2	195.1	63.5	36.6
	Between 5 and 10 ha	6.9	276.0	42.5	21.2
	Between 10 and 20 ha	13.6	317.1	23.3	8.1
	Greater than 20 ha	42.9	387.6	12.3	1.9
Western	Less than 2 ha	1.0	14.3	16.0	40.8
	Between 2 and 5 ha	3.1	17.2	5.9	36.0
	Between 5 and 10 ha	6.9	78.0	11.9	15.7

	Between 10 and 20 ha	13.4	81.6	7.0	5.9
	Greater than 20 ha	40.7	123.3	3.7	1.7
National	Less than 2 ha	1.1	102.2	119.3	39.7
	Between 2 and 5 ha	3.1	137.4	46.2	35.3
	Between 5 and 10 ha	6.8	227.9	34.2	16.2
	Between 10 and 20 ha	13.3	336.6	25.4	6.4
	Greater than 20 ha	47.8	467.0	14.8	2.4

Source. Authors' calculations based on RALS (2012, 2015, and 2019)

Table Z.5 used linear regression to analyse the factors that were associated with purchasing commercial fertilizer in all three survey years in Zambia (2012, 2015, and 2019) in column 1, and factors associated with not purchasing commercial fertilizer every year in column 2. The results from column 1 indicated that households who acquired subsidized fertilizer were 4 percentage points (pp) less likely to buy commercial fertilizer in every year on average. Conversely, more commercialized farmers were more likely to purchase commercial fertilizer on average. In addition, households with higher assets and who had access to loans were more likely to purchase commercial fertilizer every year, while households who accessed safety nets were less likely to buy fertilizer every year on average. These results speak to the positive relationship that wealth and liquidity have in fertilizer purchases.

Column 2 indicated that households who acquired subsidized fertilizer were 4 pp more likely to not have purchased fertilizer in every survey year. This is consistent with the finding that people who acquired subsidized fertilizer were more likely to have been the ones who bought it commercially in Zambia. In addition, more commercialized households were 21 pp less likely to not buy fertilizer every year on average. Households who had access to loans were 6 pp less likely to not buy fertilizer in every year on average, and households who accessed safety nets were 13 pp more likely to not buy fertilizer every year on average. Again, these results speak to the importance of wealth and liquidity in fertilizer purchases. Contact with extension and distance to markets have a small positive effect on the probability that a household did not purchase fertilizer in every wave. Distance to market also had a small positive effect on the probability that a household bought fertilizer in every year in column 1. These results speak to the importance of market access in smallholder's decisions to purchase commercial fertilizer.

Table Z.5: Demographic characteristics of households who bought commercial fertilizer in every survey year and those who did not buy in every survey year in Zambia

Variable	(1) Bought fertilizer in all the years	(2) Did not buy in all the years
Received subsidized fertilizer	4 percentage point negative effect	4 percentage point positive effect
Price per kg of basal dressing fertilizer (ZMW/Kg)	NSS	NSS
Price per kg of top dressing fertilizer (ZMW/Kg)	NSS	Very small positive effect

Male headed household (male = 1)	NSS	NSS
Level of education of hh head in years	NSS	NSS
Number of prime age adults (15 to 59)	NSS	Very small negative effect
Count of hh members	NSS	1 percentage point positive effect
Farm size (ha)	NSS	NSS
Crop commercialisation index	12 percentage point positive effect	21 percentage point negative effect
Number of different traders came to village to buy maize at peak season	NSS	NSS
Log of value of productive assets	Very small positive effect	Very small positive effect
Hh accessed loan from any source	3 percentage point positive effect	6 percentage point negative effect
Distance to Ministry of Agric Extension Office (Km)	NSS	Very small positive effect
Received fertilizer from the safety net program	5 percentage point negative effect	13 percentage point positive effect
HH is non-maize buying	2 percentage point positive effect	5 percentage point negative effect
Distance to the nearest market for inputs and output (Km)	Very small positive effect	Very small positive effect
Distance to the district business center (Km)	Very small positive effect	Very small positive effect
Seasonal average rainfall for previous season (mm)	Very small positive effect	Very small positive effect

Source. Authors' calculations based on RALS (2012, 2015, and 2019); ; NSS means that the factor was not found to be statistically significant in a regression model

vii) Maize-to-fertilizer response rates impacts

The Maize-to-fertilizer response rate measures the kilograms of maize or other crops that farmers obtain from a kilogram of fertilizer. It is an important measure for understanding how much an additional kilogram of fertilizer contributes to food security and the profitability of fertilizer for farmers. It is crucial to note that fertilizer is one input into the production of food and farmers must have sufficient amounts of complimentary inputs, such as seed, land, labor, soil fertility, water, and farm management ability for fertilizer use to be effective. Estimates of maize-to-fertilizer response rates in Zambia conducted on research experiment stations indicated that farmers could get 9.83 kilograms of additional maize per kilogram of fertilizer they applied on average(Chapoto et al. 2023).[20] Thus if a farmer used the recommended rate of ~80 kilograms of fertilizer per acre (200 kilograms per hectare) in Zambia, he or she could obtain an additional ~785 kilograms of maize per acre (~1,965 kilograms per hectare) compared to a farmer who did not use inorganic fertilizer.

However, this estimate can be an upper-bound estimate for the maize-to-fertilizer response rate. A review of the literature on response rates in Zambia from surveys that used farmers' field-level data from the early 2000's found that response rates were only about 3.0 kilograms of maize per kilogram of fertilizer (Xu et al. 2009; Chapoto et al. 2023). This means that ~80 kilograms of fertilizer only added ~240 kilograms of additional maize per acre (~600 per hectare). The 545 kilogram /acre (~1,365) per hectare yield gap between a potentially optimal response to fertilizer on experiment stations, and the more realistic response rate in Xu et al. has major implications for food security and fertilizer profitability in Zambia. This low productivity despite the increase in fertilizer use from 20 kilograms per acre in the late 1990s and early 2000s to 80 kilograms per hectare in 2020 suggests that simply subsidizing fertilizer to increase use is not enough and that agricultural policies also need to focus on efficient use of fertilizer. Thus, inorganic fertilizer use needs to be combined with a mix of good agricultural practices, sufficient labor, and extension services, so that farmers can come closer to reaching their full yield potential when they apply fertilizer.

Based on these findings, it is worth asking the question of what enables farmers to use fertilizer relatively more efficiently, meaning that they obtain the most maize from a kilogram of fertilizer used? Xu et al. (2009) found that yield response varied widely depending on whether the geographic area was "remote" or "accessible". The importance of accessibility points likely points to the ability of farmers to access complementary inputs such as seed, labour, extension services, and output markets that make fertilizer profitable to use. Additionally, Burke et al. (2017) found that fertilizer response rates, and subsequently fertilizer profitability in Zambia were higher on less acidic soils that had higher pH levels. This also speaks to the need for farmers to better understand soil fertility and to take steps to manage it. For example, promoting lime to reduce acidity is an important and under-utilized input. Furthermore, using organic manure, intercropping maize with legumes, and practicing agroforestry are important practices that can increase fertilizer use efficiency (Chapoto et al. 2016). Unfortunately, the adoption of these practices among Zambian smallholders remains low. In addition, the government of Zambia makes blanket recommendations on using NPK and urea across the country. For a vast country like Zambia, the lack of soil and site-specific fertilizer recommendations likely also contributes to limited maize response to fertilizer.

viii) Fertilizer profitability impacts

This subsection considers the profitability of fertilizer use in Zambia. The intention is to understand if the financial returns to Zambia's fertilizer subsidy program justified its cost in recent years and to understand if fertilizer was profitable for Zambian farmers when valued at the commercial price that they paid. The profitability of fertilizer is affected by three main factors: 1) the price of fertilizer, 2) the price of maize (or other staple crop), and 3) the maize-to-fertilizer response rate. the Maize-to-fertilizer response rate was discussed in the previous sub-section and the overall finding from previous studies is that Zambian farmers do not use fertilizer efficiently on a per kilogram basis to the yield response to fertilizer in the country is low. This causes maize yields in Zambia to not reach their full potential, thus reducing fertilizer profitability, as we will discuss below.

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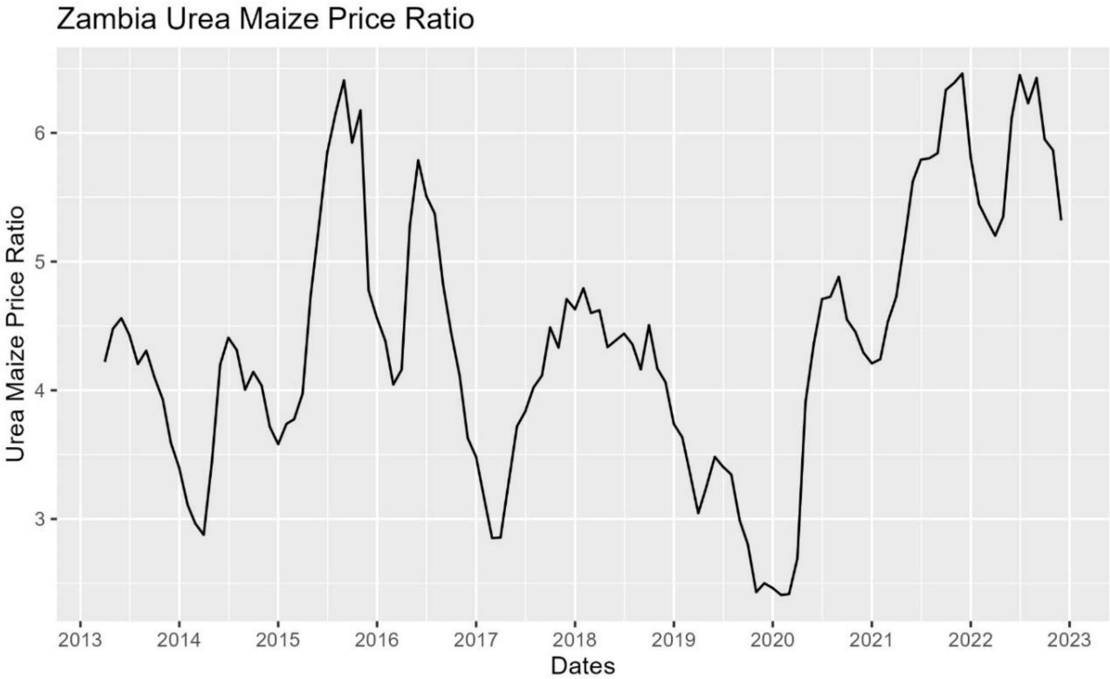
[20] Chapoto et al. (2023) estimate this response rate in Nitrogen equivalents. Thus, their response rate was 29.5 kilograms of maize per kilogram of nitrogen. We converted this to total fertilizer equivalents by dividing 29.5 by 3 to get a response rate of 9.83 kilograms of maize per kilogram of fertilizer.

The other component of fertilizer profitability is the relationship between fertilizer prices and maize prices. This is known as the input/output price ratio, and this relationship between urea and the wholesale maize price in Zambia between 2013 and 2023 is shown in Figure Z.8. A lower ratio means that fertilizer is more profitable, as the price of fertilizer is going down (i.e. the numerator in the ratio getting smaller) or the maize price is going up (i.e. the denominator is getting bigger).). Figure Z.8, indicates that the input/output price ratio before 2020 was highly variable and ranged from a high near 6.5 to a low around 3.0. For reference at a urea/maize price ratio of 6.5 a farmer would need to get 6.5 kilograms of maize per kilogram of fertilizer to break even on their purchase. Since the average response rate was only about 3.0 kilograms of maize per kilogram of fertilizer, on average fertilizer was not profitable when maize was valued at farmgate prices before the price spike. The urea/maize price ratio dropped to about 2.5 briefly in early 2020 before spiking upwards in 2020, 2021, and 2022. The ratio reached a high near 6.5 at the end of 2021, dropped to just over 5 in early 2022, rose to 6.5 again by mid-2022, and was back at 5.5 at the end of 2022. Overall, this ratio suggested that urea prices were very high compared to maize prices for most of the ten-year period between 2013 and 2022, undermining the profitability of fertilizer among smallholders there.

Figure Z.8: Urea / Farmgate maize price ratio in Zambia 2013-2022



Note: Urea prices from AfricaFertilizer.org; Maize prices were retail prices from FAOSTAT. We deducted 20% from the retail price to compute a farm-gate price.

Table Z.4 presents both the financial benefit-cost ratio of Zambia's fertilizer subsidy program in different years and the profitability of fertilizer for farmers when the input is valued at subsidized and commercial prices. The return that farmers obtain from a kilogram of fertilizer valued at its commercial price is the marginal value-cost ratio (MVCR). The MVCR is calculated as follows:

$$\text{MVCR} = \frac{\{\text{incremental maize output (kgs of maize/kilograms of fertilizer)} * \text{maize price per kg}\}}{\text{fertilizer price per kilogram.}}$$

An MVCR that is greater than one indicates that using fertilizer generated a positive and profitable return for farmers. A ratio equal to one is break-even, meaning that the farmer made no profits using fertilizer and a ratio less than one is a loss. However, whether or not fertilizer is likely to be profitable depends on outcomes that are uncertain when fertilizer decisions are made, as well as costs associated with the use of fertilizer that are unknown to the researcher. The types of risks that farmers face when using fertilizer at planting to increase staple crop yields at harvest include the chance of low yields due to adverse weather, and output prices at harvest being lower than expected. In the face of these uncertainties and unobserved costs, an MVCR of at least 2.0 (meaning a risk premium of one) has been recommended in the literature to be required in order for fertilizer to be profitable (Xu et al., 2009; Sauer and Tchale, 2009; Sheahan et al. 2013).

This also applies to the BCR for fertilizer subsidy programs. A BCR of a subsidy program equal to 1.0 means that the economy broke-even on it, essentially that the program was equal to giving farmers cash. A BCR greater than 1.0 indicates a gain for the economy from the subsidy program, while, a BCR less than 1.0 indicates a loss for the economy. Again, a break-even BCR of 1.0 assumes zero transactions costs of implementing the subsidy program. Thus 2.0 may be a better break-even point for subsidies as a rule of thumb.

The key rows of interest in Table Z.4 are row P, row U, and row V, all highlighted in grey. Row P shows the financial benefit-cost ratio (BCR) of Zambia's fertilizer subsidy programs for the years for which we had data on the costs of the program (2017/18-2022/23). All other rows associated with the costs and benefits of the subsidy are highlighted in green. The results in row P indicated that the financial BCR from the subsidy was less than 1.0 in all years of the analysis. The lowest return was 0.18 in 2017/18 and the highest return was just 0.89 in 2020/21. That meant that at best the Zambian government only gained 0.89 kwacha for every kwacha spent on the fertilizer subsidy program. The returns to subsidized fertilizer were low for several reasons. First, Incremental fertilizer from the subsidy was reduced by diversion and side-selling of fertilizer (row D), which we set at -33% following Mason and Jayne (2013). Second, the crowding-out ratio of subsidized fertilizers was -12.5% on average, following Table Z.2. This reduced the amount of incremental fertilizer that went on the ground as a result of the subsidy (row E). third, the maize-to-fertilizer response rate was lows at 2.94 kilograms of maize per kilogram of fertilizer (Chapoto et al. 2023). This meant that on average Zambian farmers did not obtain much of a return to a kilogram of fertilizer. Fourth, the price of maize was not that high in Zambia so the value of the return to the subsidy program was not sufficient to cover its costs.

Row U shows the MVCR of urea for farmers at the subsidized price that they paid for the input. Since the subsidized price of urea, shown in row Q, that farmers paid was 90% or more off of the commercial price (shown in row R), the benefits to farmers who participated in the subsidy program was very high. For example, row U of Table Z.4 shows that the MVCR of fertilizer priced at the subsidized rate was between 5.98 in 2022/23 and 8.89 in 2018/19. Thus, at subsidized prices, Zambian farmers obtained between a 498-789% return on their fertilizer investment.

The fertilizer profitability results were completely different when fertilizer was priced at its commercial value. Row V shows that the average farmer never broke even on a kilogram of fertilizer at its commercial value. The highest MVCR was just 0.82 in 2018/19 and the lowest MVCR was 0.59 in 2019/20. The reasons for this low MVCR were the low average maize-to-fertilizer response rate, set at 2.94 following Chapoto et al. (2023), and the unfavorable urea-to-maize price ratio that was very high over the years of the study. The high profitability of fertilizer at subsidized prices and the low profitability of fertilizer at commercial prices on average helped to explain why the Zambian fertilizer sector is so dependent on and influenced by government involvement in the market. Overall, these results mean that fertilizer use among smallholders in Zambia is not profitable on average and the country needs to seriously question what they are getting from its fertilizer subsidy program and why they are still funding it. The maize-to-fertilizer response rate is too low and the price of fertilizer is too high relative to the price of maize for the program to come close to break-even. The conclusion section discusses some ways to address the challenge of inefficient fertilizer subsidies and lack of fertilizer profitability in Zambia.

Table Z.4: Financial Benefit-Cost Ratios of Fertilizer Subsidy Program and Marginal Value Cost Ratio for Farmers in Zambia (Using national-level maize and fertilizer prices)

Production Year		2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
	Estimated program costs to Gov. and farmers						
	Kwacha/US$	9.9418	12.8809	18.2603	19.1881	16.3713	17.782
A	Gov. Total FISP expenditure (Kwacha.)	2,805,168,247	1,857,017,894	1,428,000,000	1,111,840,201	5,372,670,495	3,600,000,000
B	Gov. Total FISP expenditure ($)	282,158,990	144,168,334	78,202,439	57,944,257	328,176,168	202,451,918
C	GS Fert distributed (MT)	256,109	257,718	262,456	306,610	328,265	307,330
D	Diversion Rate based on Mason and Jayne (2013)	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33
E	Crowding out estimate	-0.125	-0.125	-0.125	-0.125	-0.125	-0.125
F = C*((1+D)*(1+E))	Incremental Fertilizer use (MT)	150,144	151,087	153,865	179,750	192,445	180,172
	GS Fert redemption price (Kwacha/50kg)	400	400	400	400	400	400
G	GS Fert redemption price ($/50kg)	2.40	2.33	2.59	2.30	3.34	5.65
H	GS Fert redemption cost ($/MT)	48	47	52	46	67	113
I = (C*H)	Farmer incremental. cost (Mil. $)	12,293,232	12,009,659	13,595,221	14,104,060	21,928,102	34,728,290
J = (B+I)	Government + Farmer Cost(Mil. $)	294,452,222	156,177,993	91,797,660	72,048,317	350,104,270	237,180,208
	Estimated incremental benefits						
K[i]	Yield response (Maize Kg/ Nitrogen kg)	8.9	8.9	8.9	8.9	8.9	8.9
L = (0.33*K)	Yield response (Maize Kg/ Fertilizer kg)	2.94	2.94	2.94	2.94	2.94	2.94
M = (F*L)	Incremental maize output from subsidy (MT)	440,973	443,743	451,901	527,926	565,212	529,166
N[ii]	Average Harvest Season Farmgate Maize price ($/MT): (June-July)	121	141	114	122	171	230
O = (M*N)	Value of incremental maize from subsidy (Mil. $)	53,357,689	62,567,769	51,516,715	64,406,982	96,651,254	121,708,131
P = (O/J)	Financial BCR of Subsidy program	0.18	0.40	0.56	0.89	0.28	0.51
Q	Subsidized pr. of fertilizer for farmers ($/MT)	48	46.6	51.8	46	66.8	113
R[iii]	Commercial pr. of fertilizer for farmers ($/MT)	565	508	564.8	501	729	1,063
S = Q / N	Subsidized Input/Output price ratio (fertilizer pr. /maize pr.)	0.40	0.33	0.45	0.38	0.39	0.49
T = R / N	Commercial Input/Output price ratio (fertilizer pr. /maize pr.)	4.67	3.60	4.95	4.11	4.26	4.62
U = (N*L)/Q	Marginal Value Cost Ratio of Fertilizer at subsidized price	7.40	8.89	6.46	7.79	7.52	5.98
V = (N*L)/R	Marginal Value Cost Ratio of Fertilizer at commercial price	0.63	0.82	0.59	0.72	0.69	0.64

Note:[i] yield response from Chapoto et al. (2023); [ii] Maize prices were retail prices from FAOSTAT. We deducted 20% from the retail price to compute a farm-gate price; [iii] urea prices from AfricaFertilizer.org (2024).

6. policy recommendations

Based on the results of this report we make the following recommendations for Zambia to better prepare for and address fertilizer price spikes to better ensure a response that benefits farmers and creates a more profitable and resilient supply chain.

i. The FISP has helped Zambian smallholders reach a relatively high level of fertilizer use and use rate. This is good from the perspective of meeting the goal to increase use, but this is heavily driven by subsidies and the current subsidy rate of 94% is very high. The focus of fertilizer policy should be to help farmers use fertilizer more efficiently. This will enable them to obtain more maize from a kilogram of fertilizer, rather than just continuing to increase fertilizer use. Increasing efficiency involves shifting investment towards improving soil health and fertility, climate change adaptation, encouraging the adoption of improved maize varieties, and perhaps most importantly extension. The large annual public budgets devoted to fertilizer subsidy programs over the past several decades compete with funding for these other important agricultural public goods investments. Hence, we believe that Zambian farmers may be able to access fertilizers and use it more profitably under commercial terms if the Government were able to devote the funds necessary to appreciably strengthen the performance of its national agricultural research and extension system. service provision.

ii. There is a particular need to identify effective ways of helping Zambian farmers raise their yield response to the use of fertilizers – doing so will make fertilizer use more profitable and increase the effective demand for fertilizers even when crop/fertilizer price ratios take an unfavorable turn, up to a point at least. Helping farmers to raise the efficiency with which they use fertilizers will entail a more effective farmer extension system linked up to an effective agricultural research system.

iii. Re-examine FISP targeting criteria so that the problem of crowding out is alleviated. The electronic voucher systems for delivering the FISP presents an opportunity for agro-dealers to invest in input supply, and create jobs and local wealth. However, the government has been awarding supply contracts directly to large input suppliers who are crowding out the agro-dealers are mostly small and medium local. The government needs to consider a balanced approach involving both large input suppliers and agro-dealers.

iv. It is important for Zambia to manage the macroeconomic conditions in the country. Our model indicated that higher foreign exchange reserves led to lower urea prices. Likewise, when the Kwacha appreciates against the dollar, fertilizer prices go down in the country. Consistent and reliable macroeconomic policies are essential for fertilizer to remain profitably priced for smallholder farmers who purchase the input in Kwacha. Keeping inflation under control and not running a large trade deficit will help a country avoid experiencing exchange rate depreciation and a run-up in imported fertilizer prices.

v. Given the high and volatile prices of fertilizer in Zambia it is understandable that there is interest in scaling up domestic production. However, the cost-effectiveness of producing fertilizer domestically using coal as a fuel source should be evaluated next to the alternative of using coal for alternative uses such as electricity generation and importing urea as is currently done. Zambia imports roughly 25% of its coal, and the profitability of domestic production could decline rapidly if economic conditions change in the country. In addition, the desire to scale up domestic fertilizer production could further de-couple Zambia from the global market and increase fertilizer price volatility.

vi. We also found that there is a relationship between elections and fertilizer prices in Zambia. Prices were lower in presidential election years in Zambia. Politics should be taken out of fertilizer policies.

vii. Given the low yield and variable maize productivity among smallholders, it is essential to promote livelihood diversification, especially enabling many farmers move away from maize into other crops that generate higher returns. One option could be to drop the FISP's maize/fertilizer focus and make the t general to other crops (e.g., groundnuts, soya, etc).

viii. The government also needs predictable policies on fertilizer subsidies and these policies need to be communicated to the private input supply sector and farmers. The major challenge agro-dealers in Zambia face is inconsistent and unclear policies related to the government's involvement in the fertilizer market.

ix. Considering that the government is likely to continue operating fertilizer subsidy programs, then it would be important to implement them in ways that do not restrict competition and lead to greater concentration at various stages of the fertilizer supply chain. Past research has shown that giving tenders to one or two private sector firms has led to a decline in the number of wholesalers and/or retailers operating in the country. The goal is to take actions that increase the density of rural agro-dealers operating in the country to improve farmers' access to fertilizers continuously. Such actions include investing in last-mile road infrastructure linking villages to small towns and implementing subsidy programs in a way that does not cause some wholesalers to exit the market because they are not awarded tenders under the subsidy program and cannot compete against those that do.

1. Private investment in fertilizer supply channels will also rise with the effective demand for fertilizers, which will depend on the range of interventions already mentioned to improve farmers' yield response to fertilizer use -- mainly improved functioning of national agricultural research and extension systems. In this way, ensuring farmer access to fertilizer in crisis years requires continuous public investments today that build a strong ecosystem in all its dimensions and therefore enable farmers to withstand shocks better when they do come. They also require private investments to build stronger fertilizer supply chains, but government policies and public investments play a decisive role in determining which countries private firms choose to invest in. For these reasons, government policies and the regulatory environment are arguably the most important determinants of whether their country's farmers are able to access fertilizer during global shocks.

7. References

Burke, W. J., Jayne, T.S. & Black, J.R. 2017. "Factors explaining the low and variable profitability of fertilizer application to maize in Zambia." *Agricultural Economics* 48, 115–126.

Chapoto, A., Chabala, L. M. & Lungu, O. N. 2016. "A Long History of low productivity in Zambia: Is it time to do away with blanket recommendations?" *Zambia Social Science Journal*, 6, 6.

Chapoto, A., L. Tiemann , A.M. Akyoo , J. Bonabana , N.F. Faye , M. Kalaba , I.K. Kanyama , L. Kirimi , G. Mandlhate , S. Mbai , E. Mwakiwa , C. Nyondo , I. Ogunbayo , N. Mebeelo , T.S. Jayne. 2023. "Farmer's risks and economic use of fertilizer in Africa South of the Sahara." ANAPRI Policy Report

Lusaka times 2023. "Nitrogen Chemicals to build USD 6 million blended fertilizer plant." Lusaka Times, 22 December 2023. https://www.lusakatimes.com/2023/12/22/nitrogen-chemicals-to-build-us-6-million-blended-fertilizer-plant/

Mason, N. Jayne, T., 2013. "Fertilizer subsidies & smallholder commercial fertilizer purchases: Crowding out, leakage, & policy implications for Zambia." *J. Agric. Econ.* 64(3), 558–582.

Jayne, Thomas, S., Mather, D., Mason, Nicole, M., & Ricker-Gilbert, J. 2013. "How do fertilizer subsidy programs affect total fertilizer use in sub-Saharan Africa? Crowding out, diversion, and benefit/cost assessments." *Agricultural Economics*, 44(6), 687–703. https://doi.org/10.1111/agec.12082

Mason, N. M., Jayne, T. S., & Mofya-Mukuka, R. 2013. "A Review of Zambia's Agricultural Input Subsidy Programs : Targeting , Impacts , and the Way Forward." IAPRI Working Paper, Issue 77.

Mason, N.M., T.S. Jayne, and R. J. Myers 2015. "Smallholder Supply Response to Marketing Board Activities in a Dual Channel Marketing System: The Case of Zambia." *Journal of Agricultural Economics* 66(1):36-65

Mason, M.N and S.T. Tembo. 2015. "Do Input Subsidy Programs Raise Incomes and Reduce Poverty among Smallholder Farm Households? Evidence from Zambia." IAPRI Working Paper No. 92. Lusaka, Zambia.

Mason, N. M., & Smale, M. 2013. "Impacts of subsidized hybrid seed on indicators of economic well - being among smallholder maize growers in Zambia." *Agricultural Economics*, 44(6), 659–670.

Mofya-Mukuka, R., & Kuteya, A. 2018. "Structure of the Zambian Fertilizer Market." National Symposium on Fertilizer, July.

Mulenga B.P., A. Banda and A. Chapoto. 2020. "Securing Food Systems and Trade in Zambia During the COVID-19 Pandemic." IAPRI Policy Brief. IAPRI, Lusaka, Zambia.

Sauer, J., Tchale, H., 2009. "The economics of soil fertility management in Malawi. Applied Economics Perspectives and Policy." 31 (3), 535–560.

Sheahan, M., Black, R., & Jayne, T. S. 2013. "Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research." Food Policy, 41, 39-52.

Snapp, S., T.S. Jayne, W. Mhango, T. Benson, and J. Ricker-Gilbert. 2014. "Maize-Nitrogen Response in Malawi's Production Systems." Presentation at the LUANAR/IFPRI Policy Workshop titled "Eight Years of FISP: Impact and What's Next?" Lilongwe, Malawi. July 14-15.

United Capital Fertilizer 2023. "New USD 300 million fertilizer plant to cut prices by 40%." https://unitedcapitalfertilizer.com/new-300m-fertilizer-plant-to-cut-prices-by-40/

Xu, Z., Guan, Z., Jayne, T. S., & Black, R. 2009. "Factors influencing the profitability of fertilizer use on maize in Zambia." *Agricultural economics*, 40(4), 437-446.

VII. Study Limitations

We conducted a comprehensive assessment of the factors affecting fertilizer prices and the price wedge during the 2021/22 price spike and its impact on farmers. However, our study had the following limitations :

1. Limited data availability.
   i. This was particularly a problem for maize prices in many markets in many countries was a challenge. We originally hoped to estimate the urea price, and price wedge models in different markets within the focus countries. However, limited data on fertilizer prices within countries made this impossible. Even at the country level, we noted that there were missing observations. As detailed in section d. of Appendix 1, we did our best to impute these values straightforwardly and accurately. Malawi and Tanzania did not have a retail fertilizer price series beyond 2020, so we were limited in our analysis of factors affecting urea prices and the price wedge to the period before the 2021/22 price spikes.
   ii. In addition, the household data were mostly collected in the previous decade and did not cover the fertilizer price spike of 2021/22. The only exceptions were the last round of the LSMS panel survey in Nigeria collected by phone in 2022/23 and the phone survey conducted by Ricker-Gilbert et al. (2024) in Kenya in 2023. In the other four countries, we had to use results from older data to calculate and predict impacts of the fertilizer price spikes.

2. Our analysis focused on estimating and calculating the average impacts on important measures like crowding out/crowding in, maize-to-fertilizer response rates, MVCRs of fertilizer use, and BCR of fertilizer subsidy programs. These results do not represent the results for all farmers in the respective countries. Future work could measure returns for farmers at different points in the distribution of these measures, such as the median.

3. In both the MVCR and BCR calculations, we measured the benefits of total fertilizer use, rather than just the benefit to using nitrogen. This allowed us to compare the benefits to the cost of using urea on a standardized per kilogram basis. This is a simplification as farmers use other fertilizers besides urea, but urea is 46% nitrogen, and nitrogen is usually the limiting nutrient in African soils (Snapp et al. 2014).

4. We also estimated an average MVCR and BCR assuming that the maize-to-fertilizer response rate was linear. While this was also a simplification as response rates must decline after a certain level of fertilizer use. However, response rates have often been found to be linear at the levels of fertilizer that most African smallholders applied it.

VIII. Conclusions

The “price wedge” between global and national fertilizer prices in a well-functioning market reflects the costs of transport from global supply points to inland markets plus other costs such as financing, port costs, and normal profits to fertilizer companies. Where markets perform well, this price wedge should be relatively constant as world and national prices rise and fall in tandem according to changes in global conditions.

The rapid spike in inorganic fertilizer prices that started globally in 2021 and continued into 2022 was a major shock to the world’s agricultural and food sectors. The spike was particularly pronounced and prolonged in much of sub-Saharan Africa (SSA). The world price of fertilizer peaked in mid-2022 but then declined from there and was back to pre-spike levels by the end of 2023. But in the six African countries examined in this analysis, fertilizer prices rose significantly higher than the world price did in 2021 and 2022, and prices stayed higher for longer and had not returned to their pre-spike levels by the end of 2023. This is especially so when denominating fertilizer prices in local currency units, which reflect the prices that farmers actually paid.

This decoupling of the local price of fertilizer from the world price reflects a serious problem for African farmers and may indirectly affect the welfare of most of Africa's population because of the importance of food prices in national food security. This decoupling of world and local prices was the motivation for this report. We used monthly urea price data from AfricaFertilizer.org and regression analysis to understand the factors that affected urea prices and the price wedge in six focus countries of SSA: Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia. We also identified features of the market structure in each of these countries and government policy responses or lack thereof that may have affected urea prices and the price wedge during the spike. We then analyzed household survey data collected on smallholder farm households in each of the focus countries to understand how government subsidy policies affected commercial fertilizer demand among farmers. We also identified the characteristics of farmers who were more likely to buy commercial fertilizer over time. We reviewed existing studies to estimate how efficiently farmers in the focus countries use fertilizer and obtained their maize-to-fertilizer response rates. With this information, we then estimated the returns to fertilizer subsidy policy and assessed the profitability of fertilizer use for the average smallholder farmer in each country when the input was valued at both it subsidized and commercial price. Finally, we made recommendations for policy action that we believe can and should be taken to make fertilizer use more profitable for smallholder farmers in SSA. Doing so will make the fertilizer supply chain more resilient and sustainable the next time the price of fertilizer spikes in the region.

Overall, we found that the results and implications of the 2021/22 fertilizer price spike are still unfolding in our six focus countries. The major factors that affected the price of urea and the price wedge in local markets were 1) macroeconomic factors like exchange rates, and GDP growth. When a country's currency appreciated against the dollar and when GDP grew, urea prices and the price wedge went down.; 2) increasing control of government corruption was associated with lower urea price, 3) fertilizer prices were either lower in the year of presidential elections in our cross-country urea price model, 4) previous month's maize price led to higher urea prices, likely because these indicators were associated with increased demand for fertilizer. Thus, macro-economic factors, government corruption, election politics and increased demand were the main drivers of urea prices.

We also found that most governments were slow to react to fertilizer price increases. Also, international fertilizer-importing companies were concerned with other markets, so were not quick to procure additional fertilizer for SSA when prices began to rise. When governments reacted to the prolonged fertilizer price spike it was a year or more later. This delay along with unclear and poorly implemented fertilizer subsidy policies made it difficult for the private sector to react and respond to meet fertilizer demand.

We also found that the fertilizer market structure in the focus countries is highly concentrated in the six countries above the retail level. There are some examples of competition increasing and new companies entering the market for importing, blending, and wholesaling. Governments should facilitate increased competition in this space and countries like Nigeria, Kenya, and Tanzania, need to consider ending their bulk procurement restrictions that award contracts to a small number of firms. Doing so will lead to innovative new blends of fertilizer and lower prices for farmers at the "last mile" of the input supply chain. In the retail sector, profit margins for inorganic fertilizer are low for agro-dealers at 2-5% on average. Many of them view fertilizer as a "loss leader" to get farmers into the shop where they can buy products with better margins like pesticides and herbicides. Private sector actors consistently said that inconsistent and unclear government fertilizer policies were the biggest threat to their operations. In addition, they also highlighted that local currency depreciation against the dollar was another challenge that made it difficult to maintain their business and plan any future expansion. They also stressed that if fertilizer subsidy policies were clear and exchange rates were stable they could adapt and survive. This was even the case if they were excluded from government subsidy programs and even if depreciation was high, so long as it was stable.

We also found that fertilizer use was not profitable on average for farmers in the landlocked countries of Malawi and Zambia. The average farmer in those countries did not use fertilizer efficiently, obtaining too low of a maize-to-fertilizer response rate, to break even on a kilogram of fertilizer at commercial prices. In addition, the price of urea was too high relative to the price of maize in those countries for fertilizer to be profitable on average. As a result, we found that the fertilizer subsidy programs in both countries lost money in all years of our analysis. As a result, both countries need to consider why they are subsidizing fertilizer and whether or not the money spent on subsidized fertilizer could be better spent elsewhere. The coastal countries of Ghana, Kenya, Nigeria, and Tanzania had more favorable fertilizer-to-maize price ratios so fertilizer was somewhat more profitable and their subsidy programs generated a positive return on average over the years of our analysis. That being said, all countries in our analysis have room to improve the efficiency of fertilizer use for their smallholder farming population. Farmers need support with complementary inputs to fertilizer so that they can use it profitably during a price crisis. Such support includes increased access to quality public sector and private sector extension and advisory services. Farmers need training on soil fertility management, erosion control, climate change adaption, and use of appropriate fertilizer blends, and proper timing of fertilizer application. The need for liming should also be investigated and supported where it would prove effective. Improving soil fertility is essential for farmers to get more output from a kilogram of fertilizer but improving soil takes time and investment from farmers and government. The challenge is that the return on investment for improved soil health is not immediately observable, but it is essential to help farmers recognize the benefit of using fertilizer so they continue to purchase it and use it profitably the next time fertilizer prices spike.

IX. References

(Note: these references are for the references that are not in the individual country reports)

Adzawla, W., I.N. Kissidue, E. Martey, P.M. Etwire, W.K. Atakora, A. Gouzaye, and P.S. Bindraban. 2021. “Baseline Study on Fertilizer Use and Food/Nutrition Security in Sudan Savannah, Guinea Savannah, and Transitional Zones of Ghana.” IFDC FERARI Research Report No. 5.

Aragie, E., Artavia, M. and Pauw, K. 2019. “Strategic Public Spending: Scenarios and Lessons for Ghana.” IFPRI Discussion Paper 01852.

Arias-Granada, Y. Ricker-Gilbert, J. 2024. “Estimating the Effectiveness of Public versus Private Distribution Systems: Insights from a Fertilizer Policy Reform in Malawi.” Working paper. Department of Agricultural Economics, Purdue University.

Ariga, J., and Jayne T. 2011. “Fertilizer in Kenya: Factors Driving the Increase in Usage by Smallholder Farmers.” In Yes Africa Can: Success Stories from a Dynamic Continent, edited by Chuhan-Pole, P., and M. Angwafo, 269–288. Washington DC: World Bank.

Chapoto, A., L. Tiemann , A.M. Akyoo , J. Bonabana , N.F. Faye , M. Kalaba , I.K. Kanyama , L. Kirimi , G. Mandlhate , S. Mbai , E. Mwakiwa , C. Nyondo , I. Ogunbayo , N. Mebeelo , T.S. Jayne. 2023. “Farmer’s risks and economic use of fertilizer in Africa South of the Sahara.” ANAPRI Policy Report.

Jayne, T.S., D. Mather, N. Mason, and J. Ricker-Gilbert. 2013. “How do Fertilizer Subsidy Programs Affect Total Fertilizer Use? A Synthesis of the Evidence on “Crowding in/out” in sub-Saharan Africa.” Agricultural Economics 44(6):687-703.

Ricker-Gilbert, J., Olwande, J., Mather D.A., Maredia, M., Bin Khaled, N. 2024. “Farm-level Outcomes of the Kenya National Fertiliser Subsidy Programme (NFSP) In 2023.” Working Paper, Department of Agricultural, Food and Resource Economics, Michigan State University.

Sauer, J., Tchale, H. 2009. “The economics of soil fertility management in Malawi. Applied Economics Perspectives and Policy.” 31 (3), 535–560.

Shah, M. 2024. “Three Essays on Development Economics.” Dissertation Prepared for the Faculty in Agricultural Economics. Purdue University. West Lafayette IN. USA.

Sheahan, M., Black, R., Jayne, T. S. 2013. “Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research.” Food Policy, 41, 39-52.

Sitko, N., Jayne, T.S., 2014. "Exploitative Briefcase Businessmen, Parasites, and Other Myths and Legends: Assembly Traders and the Performance of Maize Markets in Eastern and Southern Africa," World Development, Elsevier, vol. 54(C), pages 56-67.

Xu, Z., Guan, Z., Jayne, T. S., & Black, R. 2009. “Factors influencing the profitability of fertilizer use on maize in Zambia.” Agricultural economics, 40(4), 437-446.

X. Appendices

i. Appendix 1

a. Cross-country model

As mentioned in the Methodology and data section, we employ a panel linear model with individual fixed effects to examine the relationship between urea local urea prices and urea local-global price wedge and various explanatory variables across time. Panel regression models allow for the average effect of each factor to be estimated across many individual countries. Panel models are advantageous in that they smooth out noisy relationships that can be difficult to measure country by country. We have monthly urea price data from AfricaFertlizer.org (with some gaps) between 2010-2023 for Nigeria, Ghana, and Kenya. We have the same data between 2014-2022 for Zambia and from 2010-2020 for Malawi and Tanzania. As a result, we run an unbalanced panel model that uses the available data from each country for the analysis.

1. Local Price Panel Model

The local price model is specified as follows,

1) $\text{local price}_{it} = \alpha_i + \beta_1 x_{1,it} + \cdots + \beta_k x_{k,it} + u_{it},$

where the coefficients and explanatory variables are defined as in the wedge model, but the dependent variable in this analysis is the local fertilizer price.

2. Wedge Price Panel Model

The wedge price model is specified as follows,

2) $\text{wedge}_{it} = \alpha_i + \beta_1 x_{1,it} + \cdots + \beta_k x_{k,it} + u_{it},$

where y_{it} is the dependent variable for country i at time t, α_i is the individual specific intercept for country i, $\beta_1, \cdots, \beta_k$ are the coefficients on the independent variables, $x_{1,it}, \cdots, x_{k,it}$ are the explanatory variables for country i at time t, and u_{it} is the error term for country i at time t. Notice that in this model we get a country-specific fixed effect, α_i, but the coefficients on the explanatory variables represent the average response of the price wedge to the explanatory variables across countries. We also added yearly dummies so in total we have both country and year fixed effects in this modell specification. This model may allow us to draw some general conclusions that are true across most countries. For example, having a higher control of corruption reduces the price wedge. The country specific models will allow us to uncover variation in how different countries respond to our explanatory variables.

b. Country-Specific Models

We also provide country-by-country ordinary least squares estimates of the local price and wedge models. That way, if there are any striking differences in responses across countries, we will uncover those with the country-specific models.

1. Local Price Model

3) $local\ price_t = \alpha_{\square} + \beta_1 x_{1,t} + \cdots + \beta_k x_{k,t} + u_t$

where the coefficients and explanatory variables are defined as in the country-specific wedge model, but the dependent variable in this analysis is the local fertilizer price.

2. *Wedge Model*

The country-specific wedge model is specified as follows,

4) $wedge_t = \alpha_{\square} + \beta_1 x_{1,t} + \cdots + \beta_k x_{k,t} + u_t,$

where the coefficients and variables are defined as before but all coefficients and variables get a country index i, indicating that we will get a model with fully separate estimates for each country with this specification. For most countries this will be urea price as in the cross-country models, but for Kenya we fit a model for urea and DAP, and for Nigeria we fit a model for urea and NPK since both are important fertilizers for those countries.

c. Explanatory Variable Specification Details

For each explanatory variable we determine if it is stationary or not and if it is stationary, we include it in the models in levels, and if it is non-stationary (and stationary in differences) we include it in the models in differences. In most cases we use log of fertilizer price and log of the dependent variables so that coefficients can be interpreted as elasticities.

We found *CPI Movements* and *Exchange Rate Movements* to be non-stationary so we differenced them. Further, since we wish to be able to interpret the coefficients as elasticities to be consistent with most other variables, we use the inverse hyperbolic sine transformation. This transformation is commonly used in this case where we have differenced variables that will take on negative values, making the log transform impossible to use.

Additionally, the variable *Corruption Control Index* obtained from the World Bank is range bound from [-2, 2]. Taking log of this variable is impossible, and we decided to leave this variable untransformed in our regression specification. So, estimated coefficients on this variable will be interpreted as a typical log-linear specification. I.e., if β is an estimated coefficient on *Corruption Control Index*, we will interpret it as: %ΔDependent Variable = exp(β*Standard Deviation$_{CorruptionControl}$). In other words, the percent change in the dependent variable when *Corruption Control Index* goes from 0 to 0+1 standard deviation is given by exp(β*Standard Deviation$_{CorruptionControl}$).

d. Discussion of Missing Data in the Urea Price and Urea Price Wedge Model

Africa Fertilizer Organization collects data from agro-dealers in a number of target countries within Africa. Data collection has been ongoing since 2010, resulting in a relatively long time series of fertilizer prices at a number of locations within countries covered. However, there is a significant proportion of observations missing in the primary data. The tables below record the proportion of the sample of monthly data from September 2010 to December 2022 that are missing for each location in the dataset. The tables show that in each country there are only a few locations that have a low proportion of missing observations. If we consider how many locations there are in each country with less than half observations missing, Kenya has three locations, Malawi has two, Nigeria has thirteen, Ghana has two, and Zambia and Tanzania have no locations with less than half of observations in the time frame missing.

To recover a viable fertilizer price series for each country, we aggregate prices at the locations up to one country level series. For every date in our range of study, we average the fertilizer prices of every location in the country that had a price observation that month. This produces the most complete country level series possible from aggregation alone given the missingness in the location components. While this method produces the most complete country-level series we can get from aggregation alone, we still are faced with a high proportion of missing data in the country-level series, ranging from 6% missing in the case of Nigeria and 43% missing in the case of Zambia.

Country-level maize prices are the only explanatory variable in our model that has a challenge of some missing data. We collect country level maize prices from FAO from 2010-2023 for all countries in our study. For most countries, there is only a small proportion of the sample that is missing. For Kenya, though, we have 65% of the FAO maize price is missing. As we did with the country fertilizer prices, we used simple interpolation to fill in missing data.

Table A.1: Proportion Missing Country Urea and Maize Prices

Country	Urea Price Proportion Missing	Maize Price Proportion Missing
Ghana	0.15	0.00
Kenya	0.15	0.65
Malawi	0.27	0.00
Nigeria	0.06	0.09
Tanzania	0.32	0.01
Zambia	0.42	0.00

Since our main analysis relies on a panel regression model, we are constrained by the series with the most missingness because missing data in one series will cause data from all other countries at that time point to be dropped from the estimation. Considering that Zambia has 43% missing observations, this would be severely constraining.

The solution we opted for is to use linear interpolation to generate synthetic data to fill in missing observations. This method draws a line between the observations on either side of the missing point(s) and fills in synthetic data along this line. If the real unobserved prices followed a fairly linear path, this method will work well. However, if the real unobserved prices rose and fell in a non-linear way, the linear interpolation will produce biased estimates in our statistical model. Unfortunately, we do not have a good way to tell which is the case for our situation.

Additionally, in each country there are significant stretches of time where data collection seemed to be paused resulting in several months of missing data in a row for most (or sometimes all) countries. In the years of 2015 to 2017 it appears that data collection completely stopped in all countries, e.g. We used linear interpolation to fill in missing observations for these periods as well.

Implications of Missing Data on Study Findings

Using linear interpolation on such a large number of observations and proportion of the sample could lead to biased estimates in our statistical findings. While the dataset is the most comprehensive available anywhere for fertilizer prices in Africa, caution should be used in interpreting the statistical results because we cannot guarantee that the interpolated data follow a similar path of the true, but unobserved, price data.

Table A.2: Kenya Proportion Missing by Location

Location	Missing %	Location	Missing %	Location	Missing %	Location	Missing %
Nairobi	0.17	Bungoma	0.75	Keroka	0.89	Kapcherop	0.98
Kisumu	0.39	Saboti	0.75	Webuye	0.89	Kilifi	0.98
Embu	0.46	Murangâ€™a	0.76	Lower Kabete	0.90	Karura Kanyungu	0.98
Mombasa	0.51	Nyahururu	0.78	Wamumu	0.90	Malaba	0.98
Eldoret	0.54	Thika	0.79	Nyamira	0.90	Maragua	0.98
Narok	0.56	Sagana	0.79	Nkubu	0.92	Msambweni	0.98
Kakamega	0.57	Githunguri	0.81	Ol Ngâ€™arua	0.92	Sotik	0.98
Kiambu	0.61	Mumias	0.82	Ainamoi	0.92	Taveta	0.98
Naivasha	0.62	Mwea	0.83	Karatina	0.93	Wote	0.98
Busia	0.65	Timau	0.83	Litein	0.93	Kibwezi	0.99
Nakuru	0.65	Kerugoya	0.85	Homa Bay	0.94	Kwale	0.99

Kisii	0.68	Loitokitok	0.85	Asumbi	0.95	Makutano	0.99
Kitale	0.68	Wanguru	0.85	Bondo	0.95	Kapenguria	0.99
Malindi	0.71	Kilgoris	0.86	Kapsoit	0.95	Kianyaga	0.99
Gatundu	0.71	Kimilili	0.86	Migori	0.96	Makueni	0.99
Meru	0.72	Molo	0.87	Vihiga	0.96	Sirende	0.99
Machakos	0.73	Kimende	0.87	Chebara	0.97	Wundanyi	0.99
Voi	0.73	Kitengela	0.87	Nzoia	0.97		
Mariakani	0.74	Tenwek	0.88	Siaya	0.97		

Table A.3. Tanzania Proportion Missing by Location

Location	Missing %	Location	Missing %	Location	Missing %
Dar es Salaam	0.55	Bunda	0.89	Kasulu	0.98
Morogoro	0.60	Kilosa	0.89	Maswa	0.98
Arusha	0.63	Vwawa	0.91	Moshi Urban District	0.98
Siha	0.71	Mbarali	0.91	Mpanda	0.98
Musoma	0.73	Iringa Rural District	0.92	Namtumbo	0.98
Rombo District	0.74	Mangula	0.92	Nyangâ€™hwale	0.98
Tarakea	0.74	Kiteto	0.92	Ifakara	0.98
Mvomero	0.74	Ludewa	0.92	Igunga	0.98
Mbeya	0.75	Itumba	0.93	Tunduma	0.98
Songea	0.75	Mlale	0.93	Ushetu	0.98
Njombe	0.76	Kinondoni	0.93	Sumbawanga	0.98
Geita	0.77	Kahama	0.93	Babati	0.99
Chimala	0.80	Simanjiro	0.94	Kilolo	0.99
Dodoma	0.81	Rujewa	0.94	Kimbande	0.99
Mwanza	0.81	Kilombero	0.96	Mahenge	0.99
Mbozi	0.83	Bariadi	0.96	Malangali	0.99
Moshi Rural District	0.84	Ileje	0.97	Mlimba	0.99
Morogoro Urban	0.84	Biharamulo	0.97	Nzega	0.99
Kongwa	0.86	Shinyanga	0.97	Tabora	0.99
Nyamagana District	0.87	Bukombe	0.98		
Tarime	0.88	Chato	0.98		

Table A.4. Ghana Proportion Missing by Location

Location	Missing %	Location	Missing %	Location	Missing %
Ho	0.40	Bawku	0.94	Nkawkaw	0.99
Tamale	0.49	Kumasi	0.94	Old Buipe	0.99
Navrongo	0.57	Takoradi	0.94	Samreboi Nkwanta	0.99
Kpandu	0.59	Koforidua	0.95	Sandema	0.99
Sege	0.67	Asamankese	0.96	Sefwi Wiawso	0.99
Mankesim	0.68	Guschiegu	0.96	Yapei	0.99
Tarkwa	0.68	Akim Oda	0.97	Yendi	0.99
Nkoranza	0.70	Chana	0.97	Agona	0.99
Dunkwa	0.75	Kintampo	0.97	Akatsi	0.99
Sunyani	0.76	Lawra	0.97	Atebubu	0.99
Techiman	0.81	Swedru	0.97	Bechem	0.99
Fumso	0.84	Cape Coast	0.98	Chereponi	0.99
Accra	0.84	Nyankpala	0.98	Kadjebi	0.99
Gwallu	0.86	Wa	0.98	La Nkwantanang Madina	0.99
Nsawam	0.88	Adanse Asokwa	0.98	Nante	0.99
Elmina	0.89	Bogoso	0.98	Okrajei	0.99
Hohoe	0.90	Akropong	0.99	Tano South	0.99
Kasoa	0.90	Bibiani	0.99	Tema	0.99
Bolgatanga	0.91	Goaso	0.99	Tuobodum	0.99
Winneba	0.92	Kpasa	0.99		
Ejura	0.93	Nalerigu	0.99		

Table A.5. Malawi, Zambia, and Nigeria Proportion Missing by Location

Location	Malawi Missing %	Location	Zambia Missing %	Location	Nigeria Missing %
Lilongwe	0.35	Lusaka	0.51	Ilorin	0.29
Mchinji	0.44	Mkushi	0.56	Benin City	0.29
Ntcheu	0.51	Chipata	0.59	Wuse	0.33
Dwangwa	0.58	Kapiri Mposhi	0.63	Akure	0.36
Mponela	0.60	Chibombo	0.65	Minna	0.37
Mangochi	0.67	Choma	0.65	Awka	0.38
Lizulu	0.73	Mumbwa	0.66	Gboko	0.38
Karonga	0.80	Lundazi	0.68	Asaba	0.39
Mpingu	0.81	Petauke	0.68	Ikeja	0.39
Mzimba	0.86	Mansa	0.68	Gwagwalada	0.43
Malobvu	0.86	Kabwe	0.72	Sabon Gari	0.48
Jenda	0.88	Kitwe	0.72	Abagana	0.48
Dedza	0.89	Mpongwe	0.73	Tudun Wada	0.49
Kamwendo	0.93	Mazabuka	0.73	Buruku	0.53
Dowa	0.94	Monze	0.78	Ibadan	0.62
Blantyre	0.95	Chisamba	0.79	Kaduna	0.83
Kasungu	0.95	Luanshya	0.80	Jalingo	0.83
Mzuzu	0.95	Katete	0.81	Jimeta	0.84
Nkhata Bay	0.95	Kalulushi	0.82	Bwari	0.89
Area 25	0.96	Isoka	0.83	Kano	0.91
Lobi	0.96	Mufulira	0.85	Idah	0.92
Mitundu	0.96	Lufwanyama	0.85	Kwali	0.92
Mtambalika	0.97	Kalomo	0.85	Ado-Ekiti	0.94
Nkhotakota	0.97	Nyimba	0.86	Bida	0.94
Mkwinda	0.99	Solwezi	0.87	Iwo	0.94
		Chikankata	0.88	Gombe	0.94
		Namwala	0.88	Babura	0.95
		Siavonga	0.88	Kwale	0.95
		Serenje	0.89	Lafiagi	0.95
		Kasama	0.92	Katsina	0.96
		Mpika	0.93	Ogbomoso	0.96
		Kaoma	0.94	Wukari	0.97
		Sinda	0.94	Mubi	0.98
		Chakwe	0.95	Kuje	0.99
		Kapiri	0.98	Suleja	0.99
		Mushindamo	0.99	Gwarzo	0.99
				Iluju	0.99

e. Model of commercial fertilizer demand

As mentioned in the methodology and data section, we used smallholder panel survey data from each of our six focus countries to individually estimate the factors that affect demand for commercial fertilizer. Details of the datasets used in the analysis are available in the individual country reports. Our model of fertilizer demand in each country for household *i* in year *t* as follows:

5) $log\ F_{\ it} = \alpha_1\ log\ P_{it}\ + \beta_1\ S_{it}\ \boldsymbol{log\ X_{it}\delta} +\ \mu_{it}$

We F represents the quantity of inorganic fertilizer demanded by the farm household through the commercial market. Demand is affected by numerous factors that we intend to model. This includes the price of fertilizer on the local market which is represented by P, with α_1 as the parameter to estimate. The coefficient estimate of $\hat{\alpha}_1$ gives us a direct estimate of the price elasticity of demand for fertilizer when the model is estimated in log form. In addition, S represents the quantity of subsidized fertilizer that a household acquires in year t. Thus, $\hat{\beta}_1$tells us the extent to which a kilogram of subsidized fertilizer affects demand for commercial fertilizer on average. A negative sign on $\hat{\beta}_1$ indicates crowding out, while a positive sign on $\hat{\beta}_1$ indicates crowding in. Other factors that affect fertilizer demand are represented by X, and α_h is the set of parameters to estimate. These included output prices for staple crops and other input prices such as seed and labor. In addition, households' assets, credit access, distance to fertilizer markets, whether or not households are selling their crops under contract, and access to subsidized fertilizer are included in X. The coefficient estimates on $\hat{\alpha}_h$ tell us how fertilizer demand responds to these different factors. This is useful for understanding which types of households have the most sensitive response to fertilizer price increases, for example, those with the lowest assets, those that are credit-constrained. those that live furthest to fertilizer dealers, and or those that are net-buyers or sellers of staple crops. The error term is denoted by μ_{it}. We deal with the potential correlation between μ_{it} and the variables in equation 3 by following Ricker-Gilbert, Jayne and Chirwa (2011).

f. Model of maize yield response to fertilizer.

Next, as discussed in the methodology and data section, we use estimates on maize response to fertilizer taken from previous studies to understand fertilizer use efficiency. We used estimates on fertilizer use efficiency from Chapoto et al. (2023) for Kenya, Nigeria, Tanzania and Zambia. We used estimates from Shah et al. (2024) for Malawi, and from Adzawla et al. (2021) for Ghana. These studies estimated how many kilograms of maize that farmer i in each of our focus countries can obtain from a kilogram of fertilizer applied to plot j in year t as follows:

6) $logY_{ijt} = \rho_1 logF_{ijt}\ +\ \beta_2 logP_{ijt} +\ logX_{ijt}\beta_h +\ \varepsilon_{ijt}$

We Y represents yield in staple crop output per hectare. We estimate how yield is affected by numerous factors in the model including the quantity of fertilizer F, with β_1 as the parameter to estimate. The coefficient estimate of $\hat{\rho}_1$ gives us a direct elasticity estimate of how responsive staple crop yields are to fertilizer use. Other factors that affect yields are the price of maize represented by P. The other factors that affect yields are represented by X, and are the same as in equation 3 and β_h is the set of parameters to estimate. These include households' assets, credit access, distance to fertilizer markets, and access to subsidized fertilizer as in equation 5). The coefficient estimates on $\hat{\beta}_h$ tell us how fertilizer demand responds to these different factors similar to the previous equation The error term is denoted by ε_{it}.