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Maize Price Shocks, Food Expenditure and the Mediating Role of Access to Market in Ghana

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ABSTRACT

The existing empirical literature on the impact of food price shocks on food consumption has primarily concentrated on market-purchased foods, offering limited insights into home-produced foods and food quality. Addressing this gap, our study employs panel data from Ghana to investigate the relationship between exposure to positive maize price shocks and price variability and household consumption patterns of nutrient-dense and less nutrient-dense diets, considering both market purchases and home production. Our findings indicate that maize price shocks lead to a reduction in households' consumption of purchased nutrient-dense and less nutrient-dense food groups, while increasing the consumption of home-produced nutrient-dense food groups. The effects of maize price shocks on diet consumption vary across household types, primary crop cultivation, and wealth status. Additionally, access to markets emerges as a crucial mechanism through which maize price shocks influence households' consumption of nutrient-dense and less nutrient-dense diets. The implications of our study underscore the significance of enhanced market access and policy interventions aimed at mitigating food price increases to improve food nutrition security.

Keywords: maize price shocks; food consumption; nutrient-dense diets; market access; Ghana

JEL Classifications: D1; D6; Q1; Q18.

EXECUTIVE SUMMARY

The existing literature extensively investigates the correlation between food price shocks and food expenditure, particularly in the context of developing countries where seasonal fluctuations in food prices contribute to heightened food insecurity. Several studies have explored different constructs of food price shocks on food security. However, there is limited evidence on how cumulative price shocks influence food expenditure, considering both market purchases and home production.

Using three waves of the Ghana Socioeconomic Panel Survey (GSPS) that spans from 2009-2019, geocode data for markets and farmers, and monthly district-level maize prices, the study pursues three main objectives. First, the study examines the effect of household exposure to maize price shocks on expenditures for nutrient-dense and less nutrient-dense diets. Second, the study investigates how these effects vary across heterogenous groups. Lastly, the study provides evidence on the potential mechanism underlying the relationship between food price shocks and household expenditure on nutrient-dense and less nutrient-dense diets.

The study uses a household fixed-effects model to obtain the following results. First, we find a strong association between food price shocks and food expenditure. Specifically, food price shocks lead to a decrease in household consumption of purchased nutrient-dense food groups and an increase in the consumption of home-produced nutrient-dense food groups. Second, we find evidence of the effect of price shocks vary across heterogenous groups. For instance, in the presence of price shocks, wealthier households are more likely to decrease their consumption of nutrient-dense diets from market purchases than middle and poor households. Lastly, we find market access as a potential mechanism through which price shocks influence food expenditure. The results show that farm households located farther from the markets tend to rely more on home-produced nutrient-dense foods than on nutrient-dense foods purchased from the market.

Based on the heterogeneity results, the study recommends government-led food policy responses to be directed toward regions characterized by high poverty levels. Also, based on the market access mechanism results, we support policies aimed at enhancing market access through improved market infrastructure and roads.

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ACRONYMS AND ABBREVIATIONS

SSA	Sub-Saharan Africa
GSPD	Ghana Socio-economic Panel Data
CPI	Consumer Price Index
SDG	Sustainable Development Goal
FAO.	Food and Agriculture Organization
GSPS	Ghana Socio-economic Panel Survey
CV	Coefficient of Variation
CPS	Cumulative Price Shock
FE-OLS.	Fixed Effects-Ordinary Least Squares.

I. Introduction

The past two decades have witnessed several instances of global food price hikes, notably in 2007-2008, 2010-2011, and 2021-2022. These increases may stem from seasonal factors associated with agricultural production cycles (Kaminski et al., 2014) or result from unforeseen events such as climate change, war, drought, political instability, supply chain disruptions, and global pandemics. The impacts of both anticipated and unanticipated fluctuations in food prices have far-reaching consequences on various aspects of household welfare (Amolegbe et al., 2021; Swinnen and Squicciarini, 2012; Stephens and Barrett, 2011).

Food commodities like maize, cereals, wheat, and rice are particularly susceptible to the impacts of global food price fluctuations (World Bank, 2019). The 2007-2008 crisis saw a drastic increase in the international prices of key food commodities, including wheat, maize, and rice, with some prices more than doubling by mid-2008 (von Braun, 2008). Similarly, during the 2010-2011 crisis, the global price of maize surged by 44 percent (World Bank, 2019). These commodities serve as primary staples for many households in sub-Saharan Africa (SSA). This study specifically focuses on maize prices, given that maize is a major staple in Ghana and is predominantly produced and consumed by smallholder farmers.

The impact of food prices is not uniform across households, with some experiencing more significant effects on their food choices. Variations in the effects of food prices on food consumption can depend on factors such as a household's economic status (Amolegbe et al., 2021; Harttgen and Klasen, 2012), location in a rural or urban area (Robles and Keefe, 2011; Swinnen and Squicciarini, 2012), and whether a household is a net seller or net buyer (Amolegbe et al., 2021; Stephens and Barrett, 2011). For instance, rising food prices may benefit net-selling households more than net-buying ones, as increased farm incomes could enhance the affordability of a healthy diet, potentially reducing malnutrition. Swinnen and Squicciarini (2012) suggest that a food price shock may create winners and losers among rural communities, while urban dwellers who are net buyers may face a negative impact. Additionally, the effects of food prices on household welfare and nutritional outcomes are highly context-specific, varying across countries based on pricing policies, trading policies, and dietary patterns. Conducting a country-level analysis of the impact of food price shocks on household welfare and food security outcomes is crucial, considering the diverse factors at play. Seasonality and limited market access can further exacerbate the extent of these shocks.

The level of market access may play a crucial role in explaining variations in households' food consumption (World Bank, 2012). Improved market access enhances farm incomes, enabling agricultural households to not only purchase an adequate quantity of food but also to buy and consume a variety of foods (Usman and Haile, 2019; Abay and Hirvonen, 2017). Distance to the market can hinder access to diversified foods by increasing transportation costs (Minten, 1999). The impact of food price shocks on household food expenditure is exacerbated for households located farther away from a market compared to those closer to a market. Previous research has underscored the vital role of market access in the commercialization and food security of households (Hirvonen et al., 2017; Koppmair et al., 2017; Ogutu et al., 2019; Sibhatu & Qaim, 2017). Headey et al. (2019) found that children in proximity to markets selling more non-staple food groups have more diversified diets. Nandi et al. (2021) also demonstrated that the relationship between market access and dietary diversity is not universally positive and can be context-specific. Therefore, we hypothesize that the distance to the market could moderate the effect of food price shocks on household food consumption.

Several studies, employing diverse countries, methodologies, and time periods, have concurred that escalating prices and seasonality adversely impact welfare outcomes (Amolegbe et al., 2021; Wossen et al., 2018; Hasan, 2017; Matz et al., 2015; Akter and Basher, 2014; Minot and Dewina, 2015; Ferreira et al., 2013; Alem and Söderbom, 2012). A considerable body of research has demonstrated that the effects of rising food prices can vary among different sub-groups of the population (Amolegbe et al., 2021; Matz et al., 2015; Vergez, 2007). For example, Amolegbe et al. (2021) found that the decline in dietary diversity due to increases in rice prices differs between rich and poor households, with a more substantial decrease observed among affluent households. Seasonality and market access are pivotal factors in income and food security studies (Usman and Haile, 2019; Abay and Hirvonen, 2017; Sibhatu et al., 2015; Chamberlin and Jayne, 2013) and livelihood diversifications (Usman and Callo-Concha, 2021; Jacoby and Minten, 2009). Bonuedi et al. (2022) demonstrated that agricultural seasonality induces significant fluctuations in household dietary diversity and food security. They also found that households with better market access exhibit more diverse diets and greater food security in both lean and non-lean seasons compared to more remote households. Despite these insightful findings, many of the reviewed studies focused on short-term price shocks and their impact on welfare outcomes. Additionally, most of these studies did not elucidate the mechanism through which price shocks affect household expenditure on nutrient-dense and less nutrient-dense diets. Lastly, these studies did not decompose food expenditure into purchased and self-produced categories. We are aware of only two studies that have decomposed food dietary diversity into purchased and self-produced categories (Bonuedi et al., 2022; Muthini et al., 2020).

In this study, we address existing research gaps using panel data from Ghana. We contend that farm households, who are also consumers, face constraints in their food group choices. The key determinant for the selection of a specific food group is the relative price change or affordability. Households primarily engaged in maize production may experience either positive or negative effects due to maize price shocks compared to households focused on other crops. With this foundation, we pursue three main objectives. First, we examine the association between household exposure to maize price shocks and expenditures for nutrient-dense and less nutrient-dense diets. Second, we investigate how these associations vary across heterogeneous groups, including household type (net buyer/net seller), wealth status, principal crop cultivation, and distance to market. Finally, we provide evidence on the potential mechanism underlying the relationship between food price shocks and household expenditure on nutrient-dense and less nutrient-dense diets. This is achieved by exploring market access as a potential mechanism. To fulfil these objectives, we leverage three main datasets: the Ghana Socio-economic Panel Data (GSPD), geocodes of output markets, and historical maize prices. Our findings indicate a negative association between maize price shocks and expenditure on purchased nutrient-dense diets, a positive association with expenditure on home-produced nutrient-dense diets, and highlight access to the market as a crucial pathway through which maize price shocks influence food expenditures.

The subsequent sections of the paper are organized as follows. Section 2 provides a contextual overview of the agricultural and food systems in Ghana. Section 3 outlines the data used in the study. Section 4 details the empirical strategy, and Section 5 presents and discusses the results. Finally, Section 6 concludes the study, summarizing key findings and discussing policy implications.

II. Background: Ghanaian Context

Smallholder farmers in Ghana predominantly cultivate food crops such as maize, rice, and cassava, alongside cash crops like cocoa. This study focuses on maize, considering its significance as a primary crop among smallholder farmers in Ghana. Maize is one of the key staples in the country, with the government designating it as a food security crop. Its importance extends beyond human consumption to include use as animal feed. Maize contributes substantially to cereal production, accounting for approximately 50-60% in Ghana (Obuor et al., 2022). Notably, around 80% of the total maize production occurs in the Forest-Savannah transition zone (Wognaa et al., 2019). Over the years, there has been a notable increase in maize consumption, with the annual per capita estimate reaching about 62 kg, compared to 42.5 kg in 2000 (Bua et al., 2020; Darfour and Rosentrater, 2016).

Despite the crucial role played by smallholder farmers in Ghana's efforts toward achieving food security and mitigating undernourishment, they encounter various challenges. These challenges include insufficient access to markets with associated rigidities, inadequate infrastructure like good roads and storage facilities, limited access to capital, a lack of improved inputs and technology, and the impact of climate variability (Ankrah et al., 2021; Assan et al., 2018; Abokyi et al., 2020). Additionally, smallholder farmers grapple with issues such as high postharvest losses, high inflation, and exchange rate fluctuations. For instance, Ghana witnessed a 17% increase in the food Consumer Price Index (CPI) between February 2021 and February 2022. The COVID-19 pandemic and the on-going Russia-Ukraine war have further exacerbated challenges, leading to increased inflation, rising fertilizer prices, reduced cultivation area, high food prices, and diminished food security. This, in turn, adversely affects household welfare and the consumption of diverse foods from the market.

Given the integration of domestic markets in Ghana with international markets, any positive price shocks experienced in international markets are transmitted to domestic markets. Market access is a critical factor with a mediating role in nutrition outcomes. Despite facing challenges, Ghana has made significant strides in reducing the prevalence of undernourishment, a crucial aspect of achieving Sustainable Development Goal (SDG) 2, aiming for zero hunger by 2030. The average prevalence of undernourishment as a percentage of the total population in Ghana decreased from 11.2% to 4.1% between 2004-2006 and 2019-2021 (FAO et al., 2022). However, despite this reduction in undernourishment, the number of moderately or severely food-insecure individuals in Ghana increased from 10.7 million to 11.4 million between 2014-2016 and 2019-2021 (FAO et al., 2022). Additionally, around 61% of the population (19 million people) are unable to afford a healthy diet (FAO et al., 2022). The primary obstacle to Ghana's progress in achieving SDG 2 is food insecurity in terms of access, quantity, and quality, primarily driven by limited incomes that hinder the affordability of a nutrient-dense diet. Addressing these challenges is crucial, and this study contributes by exploring how markets could play a mediating role in the consumption of nutrient-dense diets, especially in the presence of price variability.

III. Data and Summary Statistics

Data

To address the objectives of the study, our research utilized three primary datasets: household panel data, historical price data of maize, and geocodes of markets.

Household Survey Data

Our study relied on data from three waves of the Ghana Socioeconomic Panel Survey (GSPS). The first wave of data collection spanned six months, from November 2009 to April 2010. The second wave covered six months, from October 2013 to March 2014. The third wave, however, extended over 10 months, from February 2018 to November 2019. The GSPS data encompasses all ten regions of Ghana, representing the country at the regional level. The sampling was conducted based on the ten regions existing at that time. Each region was assigned a proportionally allocated number of enumeration areas, determined by the 2009 population share for each region. Due to the smaller proportions of the Upper East and Upper West regions, oversampling was carried out to ensure a reasonable number of households for interviews. The households were reinterviewed in 2013/2014 and 2018/2019, maintaining the same data collection approach. A structured questionnaire was used to collect data across various sections of the survey. The GSPS data tracks 5,009 households over three waves, with 2,800 of them being agricultural households. However, the number of households surveyed in each round varies, and the GSPS also tracked and interviewed households that moved out of their original primary sampling unit.

We explore the timing of data collection to create a seasonality variable capturing the planting, post-planting, and post-harvest periods. The planting season spans from May to July, the post-planting period extends from September to November, and the post-harvest season covers December to April. In addition to seasonality, we categorize households into two types (net buyer and net seller) and three wealth statuses (poor, middle, and wealthy). Drawing from the insights of Minot and Dewina (2015) and Bellemare and Barrett (2006), we define a household as a net buyer at the baseline if the value of sales is less than the value of food purchased and a net seller if the value of sales is greater than the value of food purchased. Typically, smallholder farmers are net buyers of staple food crops, relying on remittances, labour income, and petty trade to cover the cost of food purchases, while net sellers benefit from higher food prices, often being medium and large-scale farmers (Minot and Dewina, 2015). We used the approach provided by Rutstein (2015), Howe (2009) and Mckenzie (2005) to compute the wealth index at the baseline. Binary variables included in the factor analysis encompass household utilities (type of roof, floor, wall materials, and available room), lighting and cooking fuel, electricity access, ownership of a landline, computer, mobile phone, source of water, type of toilet, and mode of refuse disposal. The resulting wealth index is then categorized into wealth terciles, where the first, second, and third terciles represent poor, middle, and wealthier households, respectively.

We derived three food expenditure measures comprising both market purchases and home production. The initial measure, expenditure on nutrient-dense food, is computed as the sum of expenditures on cereals, starchy items, vegetables, fruits, eggs, dairy, meat, and pulses (refer to Table A1 for the list of nutrient-dense food groups). The second measure evaluates expenditure on food groups contributing solely to calories, excluding micronutrients (Leroy et al., 2015). Monthly expenditure on less nutrient-dense diets is the third measure, comprising the sum of expenditures on beverages, sweets, oils, spices, and others (see Table A2 for the list of nutrient-dense food groups). The study, despite acknowledging the complementarity in household food consumption from both home production and market purchases, focuses on the component of food expenditures most impacted by maize price shocks. Additionally, our interest lies in identifying the specific food group more affected by these price shocks. Tables A3 and A4 present lists of market-purchased and home-produced nutrient-dense and less nutrient-dense food groups, categorized by wealth status. The data reveal that wealthier households allocate a higher proportion of their expenditure to nutrient-dense food groups compared to poor households.

Geocodes of Markets

In constructing market access, we employed geocode data for both markets and farmers. The market geocode data delineate the locations of markets accessible to farming households for selling and/or purchasing food, while the farmer geocode data indicate the locations of farmers' homesteads. The geocodes of 20 district markets were linked to farmer geocodes using longitudes and latitudes, facilitating the calculation of the Euclidean distance from farmers' residences to the nearest markets. District markets were selected for the analysis due to the availability and access to historical district price data, which was unavailable for rural markets.

Domestic Maize Price Data

Our study concentrated on local maize prices. We acquired monthly data on domestic maize prices from Esoko, an online agricultural marketing and messaging service in Ghana. Esoko provides market data and other information to individuals, agribusinesses, and government agencies. The price series covered the period from 2008 to 2022. Due to the absence of local-level price data, we utilized district-level data as a proxy for the local markets where farmers operate. The prices were adjusted for inflation to represent real prices.

We adopted the methodology outlined by Amolegbe et al. (2021) with some adjustments, particularly in detrending the price before calculating the price shocks (referred to as cumulative price shocks i.e. months with positive price shocks) and price variability (coefficient of variation). To capture exogenous price shocks affecting household food expenditure, our analysis concentrates on the three-year prices leading up to the data collection periods (2009/2010, 2014/2015, and 2018/2019). Assuming that the deflated nominal maize price (real price), denoted as P, exhibits a trend (δ), seasonal (ϑ), and a stochastic error component (representing non-seasonal price volatility, ε), then $P = f(\delta, \vartheta, \varepsilon)$. To completely isolate the unanticipated price volatility, we detrend the real maize price series. First, we generated a continuous time variable, $t_{m,y}$, such that:

$$t_{m,y} = \begin{cases} 1 \text{ for Jan. } 2006 \\ 2 \text{ for Feb. } 2006 \\ \vdots \\ 204 \text{ for Dec. } 2022 \end{cases} \text{ where m = months and y} = 2006 - 2022 \quad (1)$$

The deflated maize price ($P_{g,m,y}$) for month m, year y and market g regressed on $t_{m,y}$ is as follows:

$$P_{g,m,y} = \theta_g + \gamma_g t_{m,y} \quad (2)$$

We obtained the linear projection of deflated maize price (fitted price values) $\hat{P}_{g,m.y}$ and subtract $\hat{P}_{g,m.y}$ from the observed prices of maize to obtain the detrended deflated price, $D_{g,m,y}$ as follows.

$$D_{g,m,y} = P_{g,m,y} - \hat{P}_{g,m.y} \quad (3)$$

Cumulative Maize Price Shocks

We computed the cumulative maize price shocks before the survey years based on the detrended maize prices. Initially, the detrended price ($D_{g,m,y}$) was standardized. Subsequently, the positive price shock was computed as the standardized detrended price above zero. Finally, we counted the number of months with positive price shocks for a specific market demoted as g, within the reference month (m) and year (y), resulting in the cumulative price shock ($CPS_{g,m,y}$). The cumulative price shock variable was then linked to the household survey data using market as the unique identifier.

Maize Price Variability

We computed maize price variability prior to the survey years using the coefficient of variation (CV). Various studies (Krah, 2023; Abokyi et al. 2018; Huchet-Bourdon, 2011) have used CV to gauge price variability in agricultural outputs and food price volatility. However, in our context, the CV is constructed as exogenous shock (before the data collection period) at the market level for a reference year. The $CV_{g,m,y}$ in market, g for a specific month (m) and year (y) is computed as:

$$CV_{g,m,y} = \left(\frac{\sigma_{g,m,y}}{\mu_{g,m,y}}\right) \quad (4)$$

where $\sigma_{g,m,y}$ and $\mu_{g,m,y}$ are the standard deviation and the mean per kilogram price of maize in market, g and in a given month (m) and year (y) for the preceding years. The $CV_{g,m,y}$ variable was linked to the household survey data using market as the unique identifier.

A puzzling question arises: How do households reduce their reliance on markets in the face of uncertain maize price trends, and how does their share of the food consumption portfolio change? The response of households may hinge on whether they are net buyers or sellers and their wealth status (poor, middle, and wealthy). Would a net seller decrease the cultivated area under uncertain maize prices, reallocating it to crops with more stable market prices and emphasizing commercialization in the short term? Conversely, would a net buyer household expand the cultivated area to self-insure against high maize price variability, thereby reducing market participation? We address these questions in the following sections.

Summary Statistics

Table 1 presents the summary statistics of the explanatory variables of interest, disaggregated by the period of data collection (first, second, and third waves). The sampled farmers experienced 11-35 months of positive maize price shocks and an average maize price variability between -1.66-2.44 prior to the study periods (2009/2010, 2014/2015, and 2018/2019). The proportion of males interviewed remained constant across the years. The age of the respondents at baseline (2009/2010) was 47 years. The proportion of married household heads, household size, the number of males and females above 15 years, years of education, and the number of household members attending school were nearly identical across the survey years. The farm size at baseline was 2.17 hectares but decreased to 1.02 hectares in 2014/2015 and increased to 3.87 hectares in 2018/2019. The tropical livestock unit (i.e., livestock numbers converted to a common unit) is less than two. Household income per capita for waves I, II, and III was GHS32, GHS143, and GHS211, respectively. The average distance to the market is 46 kilometres and remains consistent across the survey years.

Table 1. Summary statistics of explanatory variables

	Wave I (2009/2010)			Wave 2 (2014/2015)			Wave 3 (2018/2019)	
Variables	Mean	SD		Mean	SD		Mean	SD
Months with positive shocks	35.45	5.06		11.45	9.25		18.65	7.99
Price variability	0.27	4.67		-1.66	7.54		2.44	15.78
Sex (1=male)	0.84	0.37		0.84	0.37		0.84	0.37
Age (years)	47.12	14.30		51.12	14.30		55.12	14.30
Marital status (1=married)	0.72	0.45		0.66	0.47		0.68	0.47
Household size	4.75	2.68		4.62	2.53		4.28	2.57
Males above 15 years	1.18	0.76		1.26	0.82		1.24	0.88
Females above 15 years	1.31	0.83		1.29	0.81		1.29	0.84
Years of education	4.99	5.08		4.33	4.91		5.15	5.30
Number of HH members attending school	2.69	2.01		2.57	2.03		2.73	1.98
Farm size (hectare)	2.17	5.49		1.02	1.17		3.87	8.86

	Wave I		Wave 2		Wave 3	
	(2009/2010)		(2014/2015)		(2018/2019)	
Tropical livestock unit	0.91	2.02	1.66	4.18	1.33	2.64
Income per capita	32.08	39.80	142.75	149.77	210.51	200.33
Shallow soil (1=yes)	0.27	0.44	0.27	0.44	0.27	0.44
Distance to market (kilometres)	45.66	28.11	45.66	28.11	45.66	28.11
Observation	1,522		1,522		1,522	

Note: SD is standard deviation

Table 2 presents the baseline summary of food expenditures by household wealth status. In Column 1, it is evident that middle-wealth households spend more on both nutrient-dense and less nutrient-dense food groups compared to poor households. Column 2 shows that wealthier households allocate a greater portion of their expenditure to nutrient-dense diets compared to poor households. There is no statistically significant difference between wealthier and middle-wealth households in terms of the consumption of nutrient-dense food groups (Column 3). These findings suggest that wealthier households are more likely to invest in healthy diets. However, it is important to note that these results are only indicative, and we further test this hypothesis in the subsequent sections.

Table 2. Baseline summary of food expenditures measure by household wealth status.

	Between-group difference		
	(1)	(2)	(3)
	Poor-Middle	Poor-Wealthy	Middle-Wealthy
Panel A. Purchased food expenditures			
Total food purchases	-308.38***	-421.48***	-113.09
	(55.25)	(87.44)	(90.87)
Nutrient-dense	-275.78***	-372.83***	-97.05
	(49.21)	(77.70)	(81.03)
Less nutrient dense	-32.60***	97.49***	-16.04
	(8.80)	(14.33)	(16.63)
Observation	1,336	977	663
Panel B. Home-produced food expenditures			
Total home-produced food	-111.53**	-3.98	107.57
	(46.57)	(71.33)	(84.44)
Nutrient-dense	-110.34**	-21.40	88.95
	(43.74)	(66.44)	(82.33)
Less nutrient dense	-1.19	17.43	18.62*
	(12.46)	(21.54)	(10.58)
Observation	1,336	977	663

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). *** p<0.01, ** p<0.05, * p<0.1.

Figure 1 illustrates household monthly food expenditures, detailing spending on nutrient-dense and less nutrient-dense diets derived from market purchases. The overall expenditure on nutrient-dense diets exceeds that on less nutrient-dense diets. In Figure 2, the expenditure on home-produced nutrient-dense diets surpasses that on home-produced less nutrient-dense diets. Furthermore, the figures indicate that, overall, households allocate more resources to purchased diets compared to home-produced ones. Based on wealth status, Figures A1 and A2 in the supplementary material provide details on monthly home-produced and purchased food expenditure. Broadly, households, particularly those with higher wealth, tend to allocate more expenditure to market-purchased food groups than to home-produced ones.

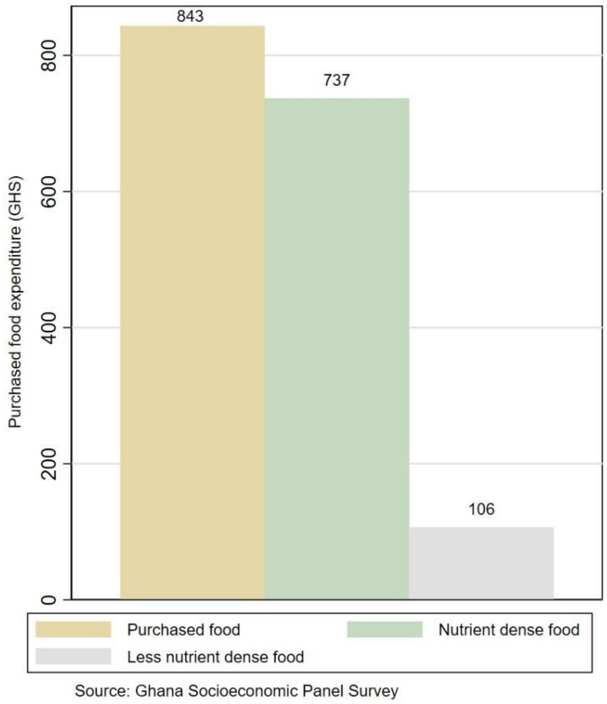

Fig. 1. Purchased food expenditures

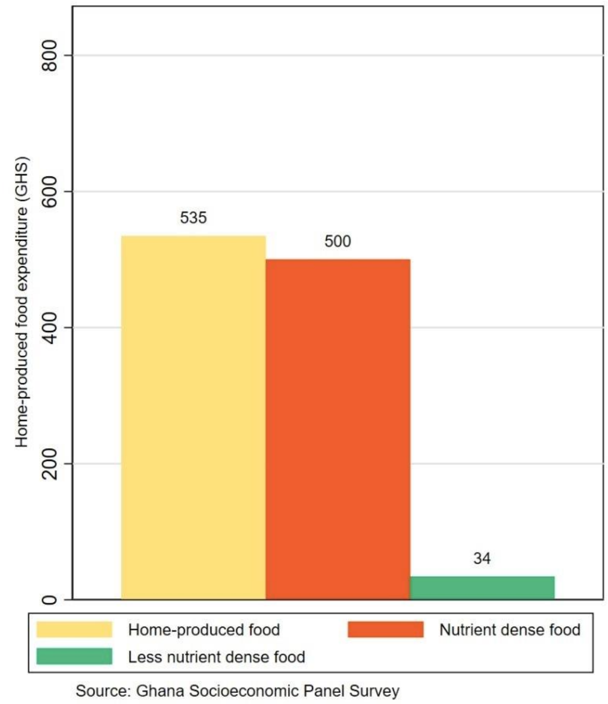

Fig. 2. Home-produced food expenditures

Figure 3 depicts the trend of cumulative maize price shocks and price variability of maize over an 11-year period (2009 to 2019). Notably, the cumulative maize price shocks (months with positive maize price shocks) dominate the observed maize price variability throughout the study period. The trend in both maize price shocks exhibits fluctuations, with the maize price variability showing both positive and negative trends, indicative of negative and positive maize price shocks. Specifically, the months with positive price shocks peak between May 2010 and June 2010, while the highest price variability occurs between December 2015 and May 2018.

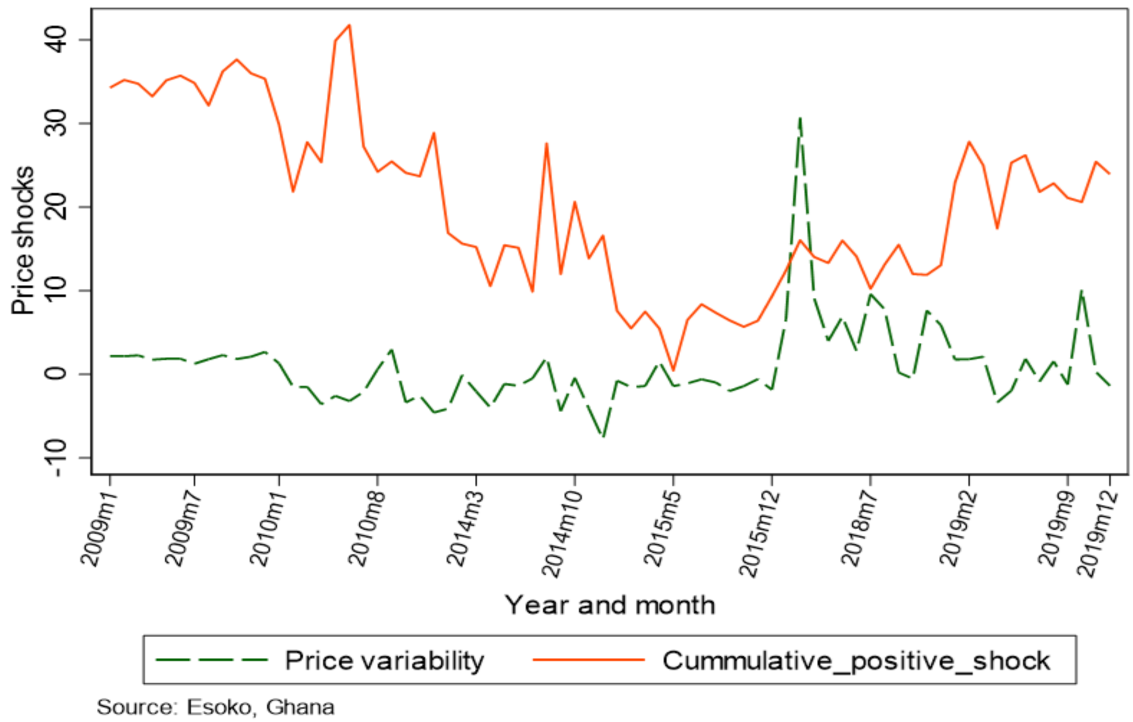

Fig. 3. Cumulative maize price shock and maize price variability

IV. Empirical Strategy

We utilize a household fixed-effects model to examine the relationship between cumulative maize price shocks and maize price volatility on household food expenditures. The initial model, focusing on the relationship between cumulative maize price shocks and food expenditures, is specified as follows:

$$Y_{h,m,y} = \gamma_1 + \beta CPS_{g,m,y} + \Omega D_{h,m,y} + \tau_h + \delta_m + \eta_y + \varepsilon_{h,g,m,y} \tag{5}$$

where $Y_{h,m,y}$ is food expenditures (total food expenditure, nutrient-dense and less nutrient-dense diets) for household h, in month m of year y. $CPS_{g,m,y}$ refers to cumulative maize price shock in reference market, g and in a given month, m and year, y. $D_{h,m,y}$ is a vector of control variables (age, sex, marital status, household size, education, farm size, and tropical livestock unit); τ_h is the household fixed effects; δ_m is seasonal fixed effects; η_y is year fixed effects; $\varepsilon_{h,g,m,y}$ is the idiosyncratic error term. Ω is a vector of parameters associated with each of the household characteristics. The parameter of interest β, measures the effect of the previous year's cumulative maize price shock on household $h's$ expenditures on nutrient-dense and less nutrient-dense diets; β can either be positive or negative depending on the objective and how the farmer reacts to price shock.

The effect of $CPS_{g,m,y}$ on food expenditures depends on household type (net buyer versus net seller), wealth status (poor, middle, wealthy), market access (near average, and far), and household main crop (maize versus other crops). According to Krah (2023), a net seller household might respond to a positive maize price shock by increasing the land under cultivation of maize, while a net buyer may expand the area under maize cultivation to hedge against high and volatile consumer prices. There is a possibility of reallocating land towards commodities with positive market price shocks, subsequently influencing food expenditure. We further analyse the association between maize price variability ($CV_{g,m,y}$) and expenditures on nutrient-dense and less nutrient-dense diets. The model is specified as:

$$Y_{h,m,y} = \gamma_1 + \phi CV_{g,m,y} + \Omega D_{h,m,y} + \tau_h + \delta_m + \eta_y + \varepsilon_{h,g,m,y} \qquad (6)$$

where the parameter of interest, ϕ captures the short-term effect of maize price shocks on household food expenditures (nutrient-dense and less nutrient-dense diets). As mentioned earlier, the direction of the effect depends on household type, wealth status, market access, and the household's main cultivated crop. Therefore, we hypothesize that price variability may either improve or worsen household food expenditure (i.e., $0 < \phi < 0$). We test these hypotheses by estimating equations (5) and (6) based on household type, wealth status, and household's main cultivated crop.

The threat to the identification strategy is that we are unable to make causality claims due to the fact that unobserved variables may be correlated with both household food expenditure and maize price shocks. While the fixed effect model can account for time-invariant unobserved variables, it is inadequate in addressing time-varying unobservable factors (Wooldridge, 2010). To mitigate this concern, we cluster the standard errors at the enumeration area level. We suspect potential reverse causality between food expenditures and price shocks (cumulative price shock and price variability). High reported food expenditures by households might lead to adjustments in production decisions, such as changes in the land allocated to food crop cultivation in the subsequent season, thereby influencing prices. To address this potential bias, we use three years of maize prices prior to the survey periods to construct the price shocks. In this way, we treat the price shocks as purely exogenous, allowing us to examine changes in household crop production acreage following the observed price shocks.

Finally, the study explores the heterogeneity effects of maize price shocks on food expenditures, considering variations in market access (close, far, and farther market access). The hypothesis under examination is whether households reduce their reliance on markets when confronted with maize price shocks.

V. Results and Discussion

This section commences with the estimation of the association between cumulative maize price shock and household food expenditures distinguishing between nutrient-dense food and less nutrient-dense food (equation 5). Following this, the section proceeds to examine the association between price variability and total household food expenditures on diets (equation 6). Subsequently, we present the heterogeneity analysis based on household type, household main crop type, wealth status, and market access. The section concludes with a mediation analysis exploring how maize price shocks influence food expenditures on nutrient-dense and less nutrient-dense diets.

Cumulative Maize Price Shock and Price Variability on Food Expenditure

Table 3 reports results of the association between cumulative maize price shock and food expenditures (nutrient-dense and less nutrient-dense diets), distinguishing between purchased and home-produced food (for the complete results, refer to Table A5 in the supplementary materials). The associations are reported for total purchased food (Column 1), purchased nutrient-dense diets (Column 2), and purchased less nutrient-dense diets (Column 3). Columns 4, 5, and 6 display the effects of cumulative maize price shocks on total expenditure on home-produced food, home-produced nutrient-dense diets, and home-produced less nutrient-dense diets, respectively.

The results suggest that cumulative maize price shocks make household worse-off by reducing their consumption of purchased food, while simultaneously increasing their expenditure on home-produced food. Specifically, an additional month of exposure to a positive maize price shock is associated with a GHS7.552, GHS6.240, and GHS1.312 decrease in expenditure on total purchased food, purchased nutrient-dense diets, and purchased less nutrient-dense diets, respectively. This indicates that households experiencing positive price shocks are more likely to cut back on their spending on purchased food. Interestingly, the reduction in expenditure is more pronounced for purchased nutrient-dense diets compared to purchased less nutrient-dense diets in the presence of a positive maize price shock. The increase in the market price of a major staple like maize may act as a disincentive for households to engage in market transactions, leading to a reduction in the allocation of their budget to food consumption. In terms of expenditure on home-produced food, an additional month of exposure to a positive maize price shock shows a positive but non-significant effect on both home-produced food and home-produced nutrient-dense diets.

In a distinct examination of household-level consumption in urban Ethiopia, Alem and Söderbom (2012) observed that food price shocks had detrimental effects on the consumption patterns of households with limited assets. Their findings also revealed variations in the effects of food price shocks based on household characteristics, such as those led by casual workers, urban poor, and households with numerous children. In a parallel context within Ethiopia, Matz et al. (2015) identified a negative association between short-term cereal price shocks and certain food security indicators, including instances of households reporting a reduced number of meals and a shift towards less preferred food choices. Additionally, Amolegbe et al. (2021) demonstrated that seasonal food prices contribute to a decline in household food security in Nigeria, with varying effects observed across households according to their wealth status.

Table 3. Cumulative maize positive price shock and expenditure on healthy and unhealthy diets

	Food expenditure - purchase (GHS)			Food expenditure – home (GHS)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Total	Nutrient	Less nutrient	Total	Nutrient	Less nutrient
Cumulative maize positive price	-7.552***	-6.240***	-1.312***	0.783	0.987	-0.204
	(2.208)	(2.029)	(0.334)	(2.146)	(2.071)	(0.272)
Mean of dependent variable	[843]	[737]	[106]	[535]	[500]	[34]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,557	4,557	4,557	4,557	4,557	4,557
R-squared	0.151	0.142	0.114	0.096	0.094	0.012

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. See Table A5 in the supplementary materials for the complete results. *** $p<0.01$.

Maize Price Variability and Food Expenditure

Results examining the relationship between maize price variability (uncertainty) and food expenditures, while controlling for household, season, location, and year fixed effects, are presented in Table 4 (refer to Table A6 in the supplementary materials for the complete results). The findings demonstrate the effect of maize price variability on various aspects of food consumption: purchased food (Column 1), purchased nutrient-dense diets (Column 2), purchased less nutrient-dense diets (Column 3), home-produced food (Column 4), home-produced nutrient-dense diets (Column 5), and home-produced less nutrient-dense diets (Column 6). A unit increase in maize price variability or uncertainty is significantly associated with a decrease in the consumption of purchased nutrient-dense diets but positively associated with an increase in the consumption of home-produced nutrient-dense and less nutrient-dense diets. These results suggest that maize price variability prompts households to rely more on home-produced food, discouraging the consumption of market-purchased food. Farmers, in response to price uncertainty, may allocate more land to staple crops to ensure a consistent food supply, as illustrated in Figure A3 in the supplementary materials. This aligns with the findings of Wossen et al. (2018), who established that both price and climate variabilities adversely affect the income and food security of households in Ghana and Ethiopia.

Table 4. Maize Price variability and expenditure on healthy and unhealthy diets

	Food expenditure - purchase (GHS)				Food expenditure – home (GHS)		
	(1)	(2)	(3)		(4)	(5)	(6)
Variables	Total	Nutrient	Less nutrient		Total	Nutrient	Less nutrient
Maize Price variability	-2.874	-3.278*	0.404		5.229***	4.464***	0.765*
	(1.844)	(1.664)	(0.340)		(1.610)	(1.499)	(0.401)
Mean of dependent variable	[843]	[737]	[106]		[535]	[500]	[34]
Other controls	Yes	Yes	Yes		Yes	Yes	Yes
Household FE	Yes	Yes	Yes		Yes	Yes	Yes
Season FE	Yes	Yes	Yes		Yes	Yes	Yes
Year FE	Yes	Yes	Yes		Yes	Yes	Yes
Observations	4,557	4,557	4,557		4,557	4,557	4,557
R-squared	0.151	0.142	0.114		0.096	0.094	0.012

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. See Table A6 in the supplementary materials for the complete results. *** p<0.01, ** p<0.05, * p<0.1.

Differential Effects of Maize Price Shocks on Food Groups

Table 5 shows the differential associations of cumulative maize positive price shocks on monthly expenditures for purchased (Panel A) and home-produced (Panel B) nutrient-dense diets. In Panel A, the findings reveal a negative association between maize price shocks and the consumption of nutrient-dense diets, primarily driven by cereals, vegetables, and pulses. Specifically, an additional month of exposure to a positive maize price shock is linked to declines of GHS1.457, GHS0.822, and GHS1.098 in expenditures on purchased cereals, vegetables, and pulses, respectively. Notably, cereals emerge as the most affected purchased food group due to the positive price shock of maize, considering maize's significance as the main staple for the majority of sampled households. However, this positive price shock tends to reduce the consumption of other nutrient-dense food groups, possibly indicating a reduction in household real income. In Panel B, the results indicate that the positive association between cumulative maize positive price shocks and the consumption of home-produced nutrient-dense food is explained by starchy and vegetable food groups. Consistent with theoretical expectations, there is a reduction in the expenditure on cereals due to the positive price shock. However, the combined effect on starchy and vegetable food groups outweighs the effect on cereals. These findings suggest that a positive shock in the price of maize increases household consumption of home-produced nutrient-dense diets relative to market-purchased nutrient-dense diets, as home-produced food becomes more affordable.

To enhance the insights gained from our study, we examine the effect of maize price variability on the number of home-produced food groups using fixed effects and Poisson models (refer to Figure A4 for comprehensive results). The outcomes from both FE-OLS and Poisson models indicate that a one-unit increase in price variability corresponds to an increase in the number of home-produced food groups by 0.047 for middle-wealthy households and 0.031 for poor households. However, we observe no statistically significant effect on market-purchased food groups (see Figure A5 for complete results).

Table 5. Maize Price variability and expenditure on nutrient-dense diets

	Monthly expenditure on nutrient-dense diets (GHS)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	**Cereals**	**Starches**	**Vegetable**	**Fruits**	**Egg**	**Diary**	**Meat**	**Pulses**
Panel A: Purchased food								
Maize Price variability	-1.457***	0.343	-0.822*	0.194	0.179	-0.038	-0.578	-1.098**
	(0.549)	(0.358)	(0.449)	(0.179)	(0.118)	(0.032)	(0.543)	(0.535)
Mean of dependent variable	[84]	[90]	[247]	[27]	[19]	[5]	[116]	[150]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,557	4,557	4,557	4,557	4,557	4,557	4,557	4,557
R-squared	0.046	0.074	0.116	0.054	0.054	0.040	0.064	0.078
Panel B: Home produced								
Maize Price variability	-1.003**	3.468***	0.945***	0.355	-0.043	0.001	-0.002	0.744
	(0.388)	(1.109)	(0.327)	(0.306)	(0.149)	(0.001)	(0.202)	(0.608)
Mean of dependent variable	[61]	[186]	[61]	[33]	[18]	[0.1]	[27]	[113]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,557	4,557	4,557	4,557	4,557	4,557	4,557	4,557
R-squared	0.108	0.068	0.021	0.050	0.024	0.009	0.025	0.035

Notes. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6 presents the differential associations of cumulative positive price shocks on monthly expenditures for purchased (Panel A) and home-produced less nutrient-dense diets (Panel B). In line with the results in Table 4, we observe that months with positive price shocks do not yield differential effects on the consumption of less nutrient-dense diets. However, the positive association between months with positive maize price shocks and home-produced less nutrient-dense diets is primarily influenced by expenditures on home-produced oil.

Table 6. Maize Price variability and expenditure on less nutrient-dense diets

	Monthly expenditure on less nutrient-dense diets (GHS)				
	(1)	(2)	(3)	(4)	(5)
Variables	**Beverage**	**Sweets**	**Oil**	**Spices**	**Others**
Panel A: Purchase					
Maize Price variability	0.382	-0.034	-0.132	0.167	0.021
	(0.243)	(0.031)	(0.113)	(0.154)	(0.063)
Mean of dependent variable	[32]	[8]	[30]	[14]	[22]
Other controls	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4,557	4,557	4,557	4,557	4,557
R-squared	0.049	0.029	0.054	0.046	0.058
Panel B: Home produced					
Maize Price variability	0.026	0.002	0.110*	0.625	0.002
	(0.019)	(0.005)	(0.065)	(0.386)	(0.002)
Mean of dependent variable	[2]	[0.2]	[5]	[0.2]	[26]
Other controls	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4,557	4,557	4,557	4,557	4,557
R-squared	0.008	0.008	0.020	0.010	0.008

Notes: Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Heterogeneity analysis

Table 7 shows the relationship between price variability and food consumption (both purchased and home-produced), categorized by net buyer-net seller status. Panels A and B present the findings for net buyers and net sellers, respectively. Among net buyers, a unit increase in maize price variability is linked to a GHS6.580 and GHS5.526 rise in the consumption of home-produced food and home-produced nutrient-dense diets, respectively. No significant effect is observed on purchased food, nutrient-dense, and less nutrient-dense diets. These results suggest that net buyers of maize smooth out their consumption by relying on home-produced food when faced with price uncertainty. One possible mechanism could be the allocation of more land to maize production as a hedge against price variability (refer to Figure A3 in the supplementary materials for supporting evidence of land allocation).

Table 7. Price variability and food expenditures – net buyer/seller

Variables	Purchase Food expenditure (GHS)			Home Food expenditure (GHS)		
	(1)	(2)	(3)	(4)	(5)	(6)
	Total	Nutrient	Less nutrient	Total	Nutrient	Less nutrient
Panel A: Net buyer						
Price variability	-2.912	-3.640	0.728	6.580***	5.526***	1.054
	(2.439)	(2.224)	(0.501)	(1.847)	(1.612)	(0.636)
Mean of dependent variable	[831]	[726]	[105]	[481]	[446]	[36]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,802	2,802	2,802	2,802	2,802	2,802
R-squared	0.149	0.143	0.100	0.104	0.102	0.018
Panel B: Net seller						
Price variability	-1.288	-1.606	0.319	1.189	1.023	0.166
	(2.748)	(2.408)	(0.433)	(2.765)	(2.666)	(0.423)
Mean of dependent variable	[863]	[754]	[109]	[619]	[588]	[32]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,755	1,755	1,755	1,755	1,755	1,755
R-squared	0.160	0.148	0.126	0.103	0.102	0.017

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 8 presents the relationship between price variability and food expenditure based on households producing maize and those cultivating other crops. Among maize-producing households, exposure to a positive shock in maize price for one additional month is linked to a GHS6.083 and GHS5.685 increase in the consumption of home-produced food and nutrient-dense diets, respectively, with no significant effect on purchased food. This suggests that maize-producing households respond to positive price shocks by allocating more land to maize cultivation, as depicted in Figure A3 in the appendix. This strategy aims to enhance revenue from maize commercialization and make home-produced nutrient-dense diets more affordable. Conversely, for households primarily cultivating other crops, a one more month exposure to a positive shock in maize price reduces the consumption of purchased nutrient-dense diets by GHS3.898. However, it increases the consumption of home-produced nutrient-dense and less nutrient-dense diets by GHS3.792 and GHS0.955, respectively. Despite maize not being their primary crop, these households may still allocate a portion of their land to maize cultivation to hedge against positive price shocks, allowing them to maintain their consumption bundle through resource reallocation.

Table 8. Price variability and food expenditures – maize HH analysis

Variables	Purchase Food expenditure (GHS)			Home Food expenditure (GHS)		
	(1) Total	(2) Nutrient	(3) Less nutrient	(4) Total	(5) Nutrient	(6) Less nutrient
Panel A: Maize households						
Price variability	-3.381	-3.375	-0.006	6.083***	5.685***	0.398
	(2.544)	(2.357)	(0.261)	(1.967)	(1.905)	(0.296)
Mean of dependent variable	[699]	[614]	[86]	[468]	[443]	[25]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,672	1,672	1,672	1,672	1,672	1,672
R-squared	0.133	0.131	0.067	0.090	0.092	0.014
Panel B: Other crops households						
Price variability	-3.356	-3.898**	0.542	4.747**	3.792*	0.955*
	(2.170)	(1.893)	(0.474)	(2.242)	(2.066)	(0.566)
Mean of dependent variable	[928]	[809]	[119]	[574]	[534]	[40]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,876	2,876	2,876	2,876	2,876	2,876
R-squared	0.152	0.143	0.125	0.108	0.103	0.021

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 9 presents the distinct effects of maize price variability on purchased and home-produced food expenditures based on wealth status. The results indicate that a one-unit change in maize price variability is linked to an increase in the consumption of additional home-produced food groups for poor and middle-wealthy households, while it leads to a decrease in the consumption of additional purchased food groups for wealthier households. Notably, middle wealthy households experience a more substantial reduction in the consumption of home-produced food groups compared to poor households. Wealthier households, known for their inclination toward purchased nutrient-dense diets, are more likely to curtail their consumption of purchased healthy diets in response to maize price variability, possibly due to an income effect.

Wossen et al. (2018) demonstrate that the effect of price variability varies across household types, particularly based on wealth status, with poor households being more significantly affected, thereby exacerbating inequality between poor and rich households. Aligning with our observations, Matz et al. (2015) discover that affluent households in Ethiopia are more adept at smoothing consumption in the face of price increases compared to their less affluent counterparts. Maize price variability correlates with a decline in real income, prompting increased expenditure on food, especially among impoverished households. Our findings resonate with Engel's law, positing that the proportion of income spent on food diminishes rapidly as households ascend from lower to higher income levels. This aligns with the findings of Amolegbe et al. (2021), who establish that a decrease in real income disproportionately affects the food share of the poorest households compared to the wealthiest.

Table 9. Price variability and food expenditures – wealth status

	Purchase Food expenditure (GHS)			Home Food expenditure (GHS)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Total**	**Nutrient**	**Less nutrient**	**Total**	**Nutrient**	**Less nutrient**
Panel A: Poor						
Price variability	-2.059	-2.514	0.455	3.821**	3.165**	0.656
	(2.059)	(1.814)	(0.337)	(1.545)	(1.461)	(0.432)
Mean of dependent variable	[683]	[597]	[85]	[506]	[470]	[36]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,441	2,441	2,441	2,441	2,441	2,441
R-squared	0.120	0.115	0.099	0.115	0.112	0.021
Panel B: Middle						
Price variability	-1.240	-1.654	0.415	11.664***	10.278***	1.386***
	(2.727)	(2.617)	(0.519)	(3.826)	(3.735)	(0.444)
Mean of dependent variable	[990]	[864]	[126]	[584]	[550]	[34]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,589	1,589	1,589	1,589	1,589	1,589
R-squared	0.144	0.135	0.093	0.118	0.117	0.015
Panel B: Wealthy						
Price variability	-8.762*	-9.996**	1.234	0.405	-0.039	0.444
	(4.794)	(4.755)	(1.132)	(3.257)	(3.282)	(0.274)
Mean of dependent variable	[1260]	[1099]	[161]	[562]	[534]	[29]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	394	394	394	394	394	394
R-squared	0.234	0.216	0.212	0.147	0.144	0.066

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Price Variability and Shares of Food Expenditure

Figure 4 shows the relative effect of price variability on the shares of market purchased nutrient dense and home-produced diets. The findings indicate a significant association between price variability and an augmented (diminished) share of market-purchased less nutrient-dense (nutrient-dense) food groups. This implies that uncertainties in prices lead to a reduction in household spending on nutrient-dense diets, prompting a shift towards less nutrient-dense alternatives. However, the result is statistically nonsignificant for home-produced diets.

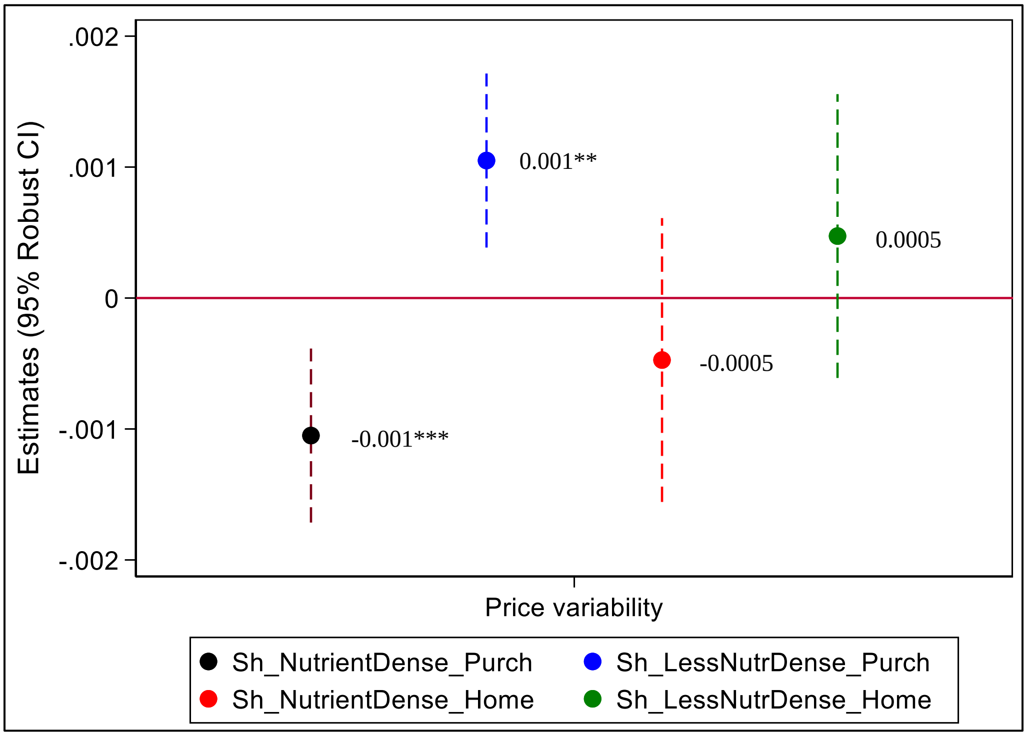

Fig. 4. Fixed effects estimate of price variability and share of food expenditure.

Notes: Other controls include socio-demographics, farm, and tropical livestock unit. *** p<0.01, ** p<0.05.

Potential Channel Analysis

Broadly, markets serve as conduits for transmitting price shocks to both consumers and farmers, contingent on whether households operate as net buyers or net sellers. However, access to a diverse array of foods in a market can potentially assist consumers in mitigating the impact of a price shock by facilitating easier substitutions from affected items to those less influenced. Untangling the predominant effect empirically poses a significant challenge. Due to the constraints of our data, our study concentrates on markets primarily as transmission mechanisms for price shocks to farmers.

We examine the influence of maize price shocks on food consumption, considering access to market as a potential mechanism (Table 10). We interact the months with positive price shocks with access to market variable. In Columns 1-3, each unit increase in months with positive maize price shocks correlates with reductions of GHS8.12, GHS7.27, and GHS0.85 in total purchased food, nutrient-dense purchased food, and less nutrient-dense purchased food, respectively. Households situated farther from food markets encounter larger reductions in the consumption of total purchased food (GHS16.66), nutrient-dense purchased food (GHS12.11), and less nutrient-dense purchased food (GHS33.43). Columns 4-5 reveal that a unit increase in months exposed to positive maize price shocks is linked to a GHS4.19 decrease in total home-produced food consumption, while the expenditure on home-produced nutrient-dense food sees a GHS0.67 increase. Farm households residing far from the market experience a reduction of GHS4.19 in home-produced food expenditure, whereas those closer to the market increase their spending on home-produced nutrient-dense food by GHS4.56. No statistically significant differences are observed in the consumption of less nutrient-dense food.

Table 10. Channel analysis - Positive price shock (months), market access, and food expenditure

	Purchase Food expenditure (GHS)			Home Food expenditure (GHS)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Total**	**Nutrient**	**Less nutrient**	**Total**	**Nutrient**	**Less nutrient**
Positive price shock	-0.176	0.374	-0.550	4.539	4.830*	-0.292
	(2.679)	(2.440)	(0.509)	(2.894)	(2.786)	(0.299)
Far from market (1/0)	301.046***	272.177***	28.869	145.496*	167.237**	-21.741
	(101.023)	(93.303)	(19.304)	(84.076)	(82.322)	(14.064)
Far market*positive shock	-16.253***	-14.543***	-1.710**	-8.383*	-8.322*	-0.061
	(4.000)	(3.758)	(0.758)	(4.299)	(4.216)	(0.544)
Mean of dependent variable	[843]	[737]	[106]	[535]	[500]	[34]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,557	4,557	4,557	4,557	4,557	4,557
R-squared	0.159	0.150	0.118	0.099	0.097	0.016

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

To assess the robustness of the findings concerning the nature of price shocks, we introduce an interaction term between price variability and market access (Table 11). The results reveal that price variability or uncertainty is not significantly correlated with purchased food expenditure but exhibits a significant association with home-produced food expenditure. Specifically, a unit increase in maize price uncertainty is linked to a GHS6.35 (Column 4) and GHS5.68 (Column 5) increase in the consumption of home-produced food and home-produced nutrient-dense food, respectively. Concerning market access, households residing farther from the market witness an increase of GHS9.07 and GHS9.85 in the consumption of home-produced food and nutrient-dense home-produced food, respectively. In Column 6, households residing far from the market are more likely to reduce their expenditure on less nutrient-dense home-produced food by GHS21.40.

Table 11. Channel analysis - price variability, market access, and food expenditures

	Purchase Food expenditure (GHS)			Home Food expenditure (GHS)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Total**	**Nutrient**	**Less nutrient**	**Total**	**Nutrient**	**Less nutrient**
Price variability	-4.408	-4.202	-0.205	9.373***	8.961***	0.413
	(3.241)	(2.921)	(0.730)	(2.715)	(2.552)	(0.392)
Market distance	3.631	3.778	-0.148	-30.622	-9.223	-21.399***
	(42.961)	(38.849)	(7.150)	(42.938)	(41.862)	(5.285)
Price variability*far market	2.238	1.348	0.890	-6.042*	-6.562**	0.521
	(3.837)	(3.391)	(0.815)	(3.200)	(2.892)	(0.927)
Mean of dependent variable	[843]	[737]	[106]	[535]	[500]	[34]
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,557	4,557	4,557	4,557	4,557	4,557
R-squared	0.145	0.138	0.108	0.099	0.097	0.017

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Consistently, the analyses suggest that households residing farther from food markets are inclined to decrease their dependence on market-purchased food and enhance their reliance on home-produced nutrient-dense food. These findings align with those of Bonuedi et al. (2022), who demonstrated that households residing at a distance from food markets are less likely to participate in markets. This tendency may be attributed to the associated costs of market participation, which diminish households' purchasing power and consequently increase the proportion of the household budget allocated to food produced at home.

The results indicate that market access plays a mediating role in bolstering household food consumption, particularly in the face of high price shocks. Enhanced access to markets empowers households to explore a more diverse range of food options, thus mitigating the impact of escalating food prices. Proximity to markets serves to diminish transportation costs for households, even in the presence of elevated food prices (Minten, 1999). Furthermore, market access exerts a positive influence on household commercialization. Households with improved access to markets are more inclined to expand their maize cultivation and engage in commercial activities, propelled by positive maize price shocks and the relatively lower transportation costs, ultimately resulting in increased income, all else being equal. These findings align with the conclusions of Usman and Haile (2019) and Abay and Hirvonen (2017), underscoring the crucial role of markets in enhancing income and facilitating access to diverse and high-quality foods for farm households. A study by the World Bank (2012) also indicates that market access improves the welfare of households. The results further support the findings of Bonuedi et al. (2022), demonstrating that agricultural seasonality significantly impacts household dietary diversity and food security. They highlighted that households with access to markets achieve higher household dietary diversity scores and greater food security compared to more remote households. Other studies emphasize that proximity to markets increases the time available for suitable feeding, care practices, and the demand for diverse diets (Usman and Callo-Concha, 2021; Johnston et al., 2018; Komatsu et al., 2018; Ruel & Alderman, 2013). According to Fafchamps and Hill (2005), a reduction in transaction costs and improved relative market prices are associated with closer proximity to market access.

VI. Conclusion and Recommendations

The existing literature extensively investigates the correlation between food price shocks and food expenditure, particularly in the context of developing countries where seasonal fluctuations in food prices contribute to heightened food insecurity. Several studies have explored different constructs of food price shocks on food security. However, there is limited evidence on how cumulative price shocks influence food expenditure, considering both market purchases and home production. This study examines the relationship between maize price shocks (cumulative price shock and price variability) and household expenditure on nutrient-dense and less nutrient-dense diets, utilising data from the GSPS, historical monthly maize price data, and market geocodes. The availability of maize price data from 20 district markets gives a substantial regional variation in price shocks and the market geocodes offers a more objective measure of distance to the market compared to subjective measures based on recall. The study investigates three outcome indicators based on purchased and home-produced diets: total household food expenditure, household expenditure on nutrient-dense and less nutrient-dense diets. Price variability is measured using the coefficient of variation, and cumulative price shock is measured as the number of months during which a household experiences positive maize price shock.

We find a strong association between food price shocks and food expenditure. The findings indicate that both cumulative maize price shocks and price variability are linked to a decrease in household consumption of purchased nutrient-dense food groups (cereals, starchy items, vegetables, fruits, eggs, dairy, meat, and pulses). However, both cumulative maize price shocks and price variability are positively associated with the consumption of home-produced nutrient dense food groups. The results suggest that positive price shocks and price uncertainty negatively impact households by reducing their consumption of diversified diets from the markets. We conclude that food price shocks are more likely to influence the consumption of diversified diets based on market purchases than home-produced foods, as expected.

Furthermore, the results reveal that the effects of price shock household consumption of nutrient-dense and less nutrient-dense diets varies among heterogeneous groups. The reduction in the consumption of additional market-purchased food groups is more pronounced for net buyers compared to net sellers. Additionally, wealthier households are more likely to decrease the consumption of nutrient-dense diets from market purchases than middle and poor households. However, poor and middle-wealth households are more likely to consume home-produced nutrient-dense diets than the wealthiest households. Wealthy households tend to smooth out their food consumption when confronted with food price shocks relative to their poorer counterparts. Consistent with Bennett's law, wealthy households in Ghana exhibit greater dietary diversity than less affluent households. A real income decrease resulting from a positive maize price shock would have a more substantial effect on the food share of the poorest households compared to the wealthiest ones. The study reveals compelling evidence supporting market access as a potential mechanism through which price shocks influence food expenditure. Specifically, farm households located farther from markets tend to rely more on home-produced nutrient-dense food than on nutrient-dense food purchased from the market.

The study has two main implications. First, the wealth heterogeneity in food consumption dynamics must be accounted for in the design of national response strategies to external shocks. Government-led food policy responses, including fiscal measures such as off-farm employment programmes, must be directed toward regions characterized by high poverty levels, those within the middle wealth distribution, and net buyers of food. Strengthening and broadening existing social safety net programs, particularly among poor households, are critical for enhancing overall food security. Second, proximity to food markets improve household consumption of nutrient-dense diets through market purchases. Proximity to markets can alleviate seasonal fluctuations in household dietary diversity and food consumption by promoting market participation and income generation. Distant markets are associated with higher transportation costs and food prices for buyers, as well as higher production costs and income for sellers, leading to reduced food expenditures. Policies aimed at enhancing market access through improved market infrastructure and roads should be actively pursued, as they can significantly contribute to both food consumption smoothing and the consumption of nutrient-dense diets.

Our study is not without limitations. First, the few available historical maize price data prior to the survey period was not enough thus, restricted our ability to construct a comprehensive measure of price shocks. Nevertheless, we were able to assess the impact of medium-term price shocks on food expenditures. Second, due to the unavailability of historical price data for rural markets, we relied on district market data. However, we assume that markets are sufficiently integrated, allowing shocks in district markets to be transmitted to rural markets, albeit with potentially different adjustment speeds. While our study captures substantial variation at the district level, incorporating more markets could have enhanced the district-level variation in food price shocks. Future studies can explore additional sources of variation, including different market types (rural, urban, and international) and various crop types (food and cash).

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Supplementary Materials

List of Tables

Table A1. Nutrient-dense food groups (purchased and home-produced) by net buyer/seller at baseline.

	Pooled		Net buyer		Net seller	
	Mean	SD	Mean	SD	Mean	SD
Panel A. Purchased food						
Cereals	83.81	158.30	90.12	180.44	73.74	113.82
Starch	90.06	167.95	88.38	165.37	92.75	172.09
Vegetables	246.61	273.31	238.84	264.71	259.01	286.29
Fruits	26.85	88.77	24.67	73.02	30.33	109.30
Eggs	18.69	65.95	17.00	74.33	21.38	49.67
Diary	4.71	12.63	4.70	12.25	4.72	13.22
Meat	116.12	321.75	115.83	381.11	116.57	192.47
Pulses	149.93	216.99	146.34	206.40	155.68	232.97
Panel B. Home-produced food						
Cereals	61.18	137.12	63.20	146.77	57.952	120.171
Starch	185.56	453.31	145.43	306.61	249.644	614.218
Vegetables	61.17	143.72	58.00	154.85	66.235	123.852
Fruits	33.20	135.02	28.07	129.50	41.376	143.119
Eggs	19.75	57.20	16.73	50.45	24.568	66.331
Diary	0.08	1.79	0.05	1.08	0.126	2.546
Meat	26.83	170.97	22.52	173.24	33.721	167.200
Pulses	112.52	323.37	111.57	354.09	114.040	267.389
Observations	1,519		934		585	

Note: SD is standard deviation.

Table A2. Less nutrient-dense food groups (purchased and home-produced) by net buyer/seller at baseline.

	Pooled		Net buyer		Net seller	
	Mean	SD	Mean	SD	Mean	SD
Panel A. Purchased food						
Beverages	32.48	87.53	31.63	92.45	33.85	79.11
Sweet	7.98	21.54	8.40	21.55	7.32	21.52
Fats and oil	29.77	57.91	29.79	65.45	29.76	43.27
Other	22.45	78.23	21.46	78.26	24.02	78.21
Spices	13.81	25.14	13.61	27.31	14.12	21.24
Panel B. Home-produced food						
Beverages	2.21	21.40	2.24	25.19	2.148	13.290
Sweet	0.22	2.75	0.11	1.03	0.396	4.241
Fats and oil	5.26	17.31	4.74	15.13	6.106	20.281
Other	26.45	206.03	28.66	252.08	22.928	93.804
Spices	0.18	1.42	0.14	1.20	0.236	1.717
Observations	1,519		934		585	

Note: SD is standard deviation.

Table A3. Nutrient-dense food groups (purchased and home-produced) consumed by wealth status at baseline

	Poor		Middle		Wealthy		Between-group difference		
Variable	Mean	SD	Mean	SD	Mean	SD	Poor-Middle	Poor-Wealthy	Middle-Wealthy
Panel A. Purchased food									
Cereals	82.56	170.18	80.69	142.41	99.77	150.43	1.87	-17.21	-19.08
Starch	66.24	147.94	116.39	186.00	134.01	195.04	-50.15***	-67.78***	-17.63
Vegetables	202.94	222.31	289.30	321.52	326.46	301.77	-86.36***	-123.52***	-37.16
Fruits	19.27	83.35	36.91	99.64	36.62	82.06	-17.64***	-17.35**	0.29
Eggs	14.27	78.52	22.91	44.72	29.65	53.66	-8.65***	-15.38**	-6.73
Diary	3.38	10.45	5.60	13.40	8.44	17.70	-2.22***	-5.06***	-2.84b
Meat	88.72	360.06	146.19	249.99	158.26	325.05	-57.47***	-69.54**	-12.07
Pulses	125.16	203.61	180.32	238.59	182.15	203.02	-55.15***	-56.99***	-1.83
Panel B. Home-produced food									
Cereals	79.32	148.23	39.35	124.25	35.21	99.97	39.97***	44.11	4.14
Starch	136.41	311.09	248.13	521.64	241.82	760.79	-111.72***	-105.42***	6.30
Vegetables	58.89	97.06	66.54	198.31	54.45	142.32	-7.66	4.44	12.10
Fruits	27.03	130.53	47.49	157.91	21.61	67.22	-20.46**	5.42	25.88**
Eggs	21.02	58.62	17.15	47.28	20.25	75.39	3.86	0.77	-3.10
Diary	0.13	2.38	0.03	0.62	0.00	0.00	0.11	0.13	0.03
Meat	26.74	123.09	31.49	244.03	12.58	88.57	-4.75	14.16	18.91
Pulses	110.61	335.83	120.30	341.18	95.62	190.33	-9.69	14.99	24.68
Observations	825		511		152		1,336	977	663

Note: SD is standard deviation. Poor-Middle is the mean difference between the poor and middle wealthy households; Poor-Wealthy is the mean difference between the poor and wealthiest households; Middle-Wealthy is the mean difference between the middle wealthy and wealthiest households. *** p<0.01, ** p<0.05.

Table A4. Less nutrient-dense food groups (purchased and home-produced) consumed by wealth status at baseline

	Poor		Middle		Wealthy		Between-group difference		
Variable	Mean	SD	Mean	SD	Mean	SD	Poor-Middle	Poor-Wealthy	Middle-Wealthy
Panel A. Purchased food									
Beverages	26.80	69.87	36.44	79.44	50.99	167.53	-9.64**	-24.19***	-14.55
Sweet	7.59	15.94	8.74	29.03	6.96	13.27	-1.14	0.63	1.77
Fats and oil	26.77	57.94	33.55	63.78	33.90	36.35	-6.78**	-7.12	-0.35
Spices	14.58	30.34	12.65	16.58	12.99	15.58	1.93	1.59	-0.34
Panel B. Home-produced food									
Beverages	1.48	10.09	3.35	34.17	2.27	9.12	-1.87	-0.79	1.08
Sweet	0.31	3.07	0.13	2.66	0.05	0.44	0.18	0.26	0.08
Fats and oil	5.22	15.67	5.90	21.32	2.98	8.99	-0.68	2.24*	2.92
Spices	0.22	1.66	0.17	1.24	0.00	0.00	0.04	0.22	0.17*
Observations	825		511		152		1,336	977	663

Note: SD is standard deviation. Poor-Middle is the mean difference between the poor and middle wealthy households; Poor-Wealthy is the mean difference between the poor and wealthiest households; Middle-Wealthy is the mean difference between the middle wealthy and wealthiest households. *** p<0.01, ** p<0.05.

Table A5. Cumulative positive price shock and expenditure on healthy and unhealthy diets

	Food expenditure - purchase (GHS)			Food expenditure – home (GHS)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Total	Nutrient	Less nutrient	Total	Nutrient	Less nutrient
Positive shock (months)	-7.552***	-6.240***	-1.312***	0.783	0.987	-0.204
	(2.208)	(2.029)	(0.334)	(2.146)	(2.071)	(0.272)
Sex	49.316	24.430	24.886*	145.472***	150.304***	-4.832
	(69.256)	(59.857)	(14.054)	(50.745)	(48.305)	(13.690)
Age	-7.309***	-6.505***	-0.804***	-4.467***	-3.946***	-0.521
	(1.554)	(1.439)	(0.240)	(1.335)	(1.239)	(0.468)
Marital status	-45.302	-44.320	-0.982	-62.247	-75.775**	13.529
	(53.157)	(46.686)	(9.455)	(40.741)	(36.733)	(15.227)
Household size	-12.585	-10.115	-2.470	9.935	10.453	-0.518
	(10.127)	(9.164)	(1.809)	(8.468)	(8.701)	(1.530)
Males above 15yrs	26.375	14.970	11.405***	8.695	10.941	-2.247
	(22.105)	(20.299)	(4.294)	(23.162)	(22.805)	(2.874)
Females above15yrs	67.322***	61.119***	6.203	-0.282	-4.316	4.034
	(21.438)	(19.311)	(4.298)	(24.319)	(23.322)	(4.892)
Education (years)	13.379**	12.522**	0.856	6.941*	6.465*	0.476
	(5.633)	(5.024)	(0.846)	(3.662)	(3.614)	(0.823)
Educated members	107.467***	96.587***	10.880***	68.989***	66.715***	2.274
	(12.940)	(11.502)	(2.170)	(10.596)	(10.257)	(1.596)
Farm size (hectare)	-1.903	-1.836	-0.067	-0.881	-0.520	-0.360***
	(2.223)	(1.989)	(0.305)	(1.701)	(1.677)	(0.115)
Tropical livestock unit	-6.701	-6.475*	-0.226	1.847	2.070	-0.223
	(4.052)	(3.701)	(0.645)	(3.504)	(3.552)	(0.453)
Shallow soil	40.982	32.332	8.649	59.510	40.923	18.587
	(48.684)	(43.318)	(8.923)	(49.547)	(44.871)	(14.916)
Income	1.789***	1.483***	0.306***	1.198***	1.137***	0.061*
	(0.380)	(0.338)	(0.050)	(0.201)	(0.202)	(0.032)
Post-planting	12.507	10.378	2.129	-1.435	-4.229	2.794
	(35.979)	(33.448)	(6.231)	(30.559)	(29.608)	(4.033)
Postharvest	-68.490*	-56.201	-12.289*	63.612*	45.299	18.313*
	(40.369)	(35.723)	(7.256)	(33.196)	(30.991)	(10.048)
Wave 1	-171.156***	-137.455***	-33.701***	-87.271***	-89.611***	2.340
	(39.303)	(35.085)	(5.899)	(23.484)	(23.308)	(3.388)
Wave 2	-337.309***	-274.829***	-62.480***	-119.246***	-129.778***	10.532
	(52.770)	(47.667)	(9.744)	(41.443)	(39.209)	(8.515)
Constant	917.978***	811.665***	106.314***	259.971***	235.080**	24.891*
	(104.835)	(97.901)	(17.327)	(98.137)	(97.135)	(13.220)
Observations	4,557	4,557	4,557	4,557	4,557	4,557
R-squared	0.151	0.142	0.114	0.096	0.094	0.012

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A6. Price variability and expenditure on healthy and unhealthy diets

	Food expenditure - purchase (GHS)			Food expenditure – home (GHS)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Total**	**Nutrient**	**Less nutrient**	**Total**	**Nutrient**	**Less nutrient**
Price variability	-2.874	-3.278*	0.404	5.229***	4.464***	0.765*
	(1.844)	(1.664)	(0.340)	(1.610)	(1.499)	(0.401)
Sex	29.327	6.140	23.186	157.227***	160.944***	-3.717
	(69.880)	(60.106)	(14.294)	(50.982)	(48.568)	(13.264)
Age	-7.755***	-6.898***	-0.857***	-4.286***	-3.775***	-0.510
	(1.568)	(1.446)	(0.247)	(1.340)	(1.249)	(0.464)
Marital status	-49.831	-48.163	-1.668	-61.228	-74.728**	13.500
	(53.961)	(47.363)	(9.566)	(41.697)	(37.627)	(15.226)
Household size	-12.916	-10.484	-2.433	10.487	10.925	-0.438
	(10.338)	(9.331)	(1.821)	(8.533)	(8.768)	(1.546)
Males above 15yrs	23.000	12.179	10.821**	9.056	11.392	-2.336
	(22.614)	(20.756)	(4.278)	(22.939)	(22.604)	(2.870)
Females above15yrs	63.177***	57.019***	6.158	3.836	-0.717	4.553
	(21.967)	(19.845)	(4.257)	(24.485)	(23.467)	(5.045)
Education (years)	13.528**	12.781**	0.747	6.186*	5.832	0.353
	(5.532)	(4.942)	(0.817)	(3.632)	(3.595)	(0.783)
Educated members	110.454***	99.288***	11.165***	67.402***	65.267***	2.136
	(12.990)	(11.601)	(2.153)	(10.758)	(10.416)	(1.626)
Farm size (hectare)	-1.890	-1.765	-0.125	-1.215	-0.798	-0.417***
	(2.202)	(1.968)	(0.307)	(1.693)	(1.671)	(0.115)
Tropical livestock unit	-6.965*	-6.740*	-0.225	2.132	2.318	-0.186
	(4.090)	(3.757)	(0.626)	(3.540)	(3.577)	(0.457)
Shallow soil	42.148	33.900	8.248	56.093	38.037	18.055
	(48.860)	(43.364)	(8.979)	(49.412)	(44.873)	(14.685)
Income	1.796***	1.490***	0.306***	1.192***	1.131***	0.061*
	(0.379)	(0.337)	(0.050)	(0.201)	(0.202)	(0.031)
Post-planting	10.635	9.812	0.823	-6.595	-8.423	1.828
	(35.394)	(33.066)	(6.214)	(30.470)	(29.570)	(3.769)
Postharvest	-82.229**	-67.192*	-15.037**	63.066*	45.461	17.605*
	(40.977)	(36.183)	(7.397)	(33.445)	(31.328)	(9.801)
Wave 1	-173.925***	-139.471***	-34.454***	-88.466***	-90.477***	2.012
	(39.166)	(34.906)	(5.970)	(23.591)	(23.377)	(3.279)
Wave 2	-347.523***	-283.424***	-64.098***	-117.335***	-127.737***	10.402
	(53.946)	(48.423)	(10.017)	(41.887)	(39.617)	(8.463)
Constant	822.205***	733.261***	88.944***	265.918***	244.296***	21.623*
	(97.893)	(92.509)	(16.316)	(86.447)	(85.819)	(11.848)
Observations	4,557	4,557	4,557	4,557	4,557	4,557
R-squared	0.145	0.138	0.107	0.098	0.096	0.013

Notes. Total refers to total expenditure on nutrient-dense and less nutrient-dense diets. Nutrient-dense refer to monthly expenditure on high nutrient-dense food groups (cereals, starchy staples, vegetables, fruits, egg, diary, meat, and pulses. Less nutrient-dense diets refer to monthly expenditure on low nutrient-dense food groups (beverages, sweets, oil, and spices). Other controls include socio-demographics, farm, and tropical livestock unit. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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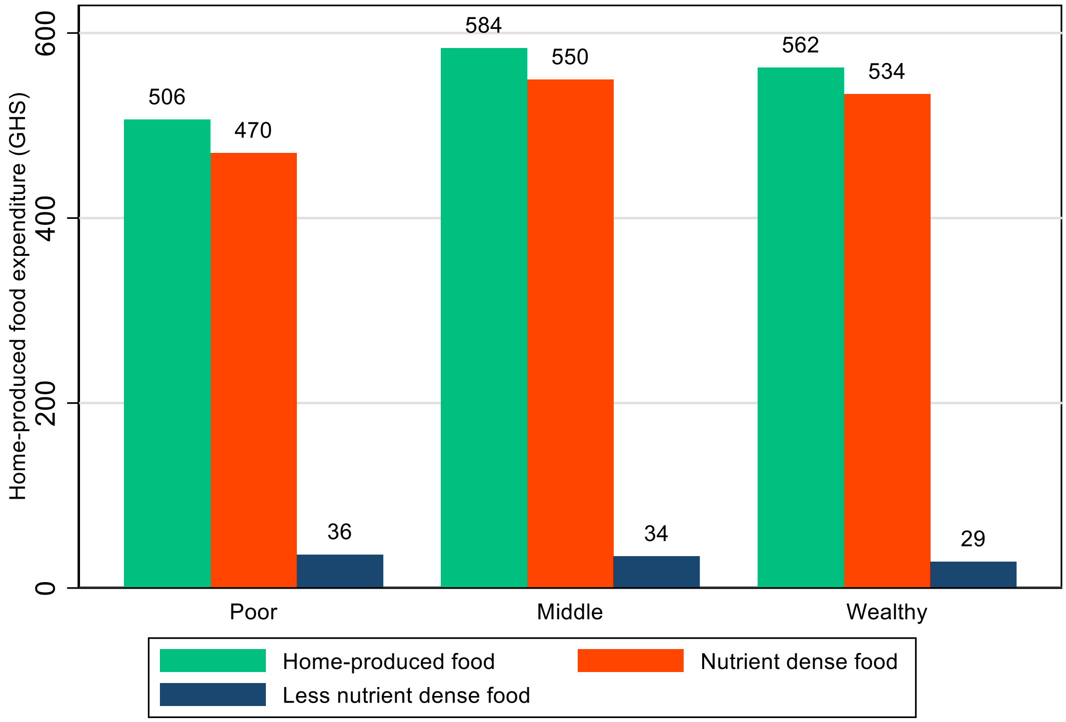
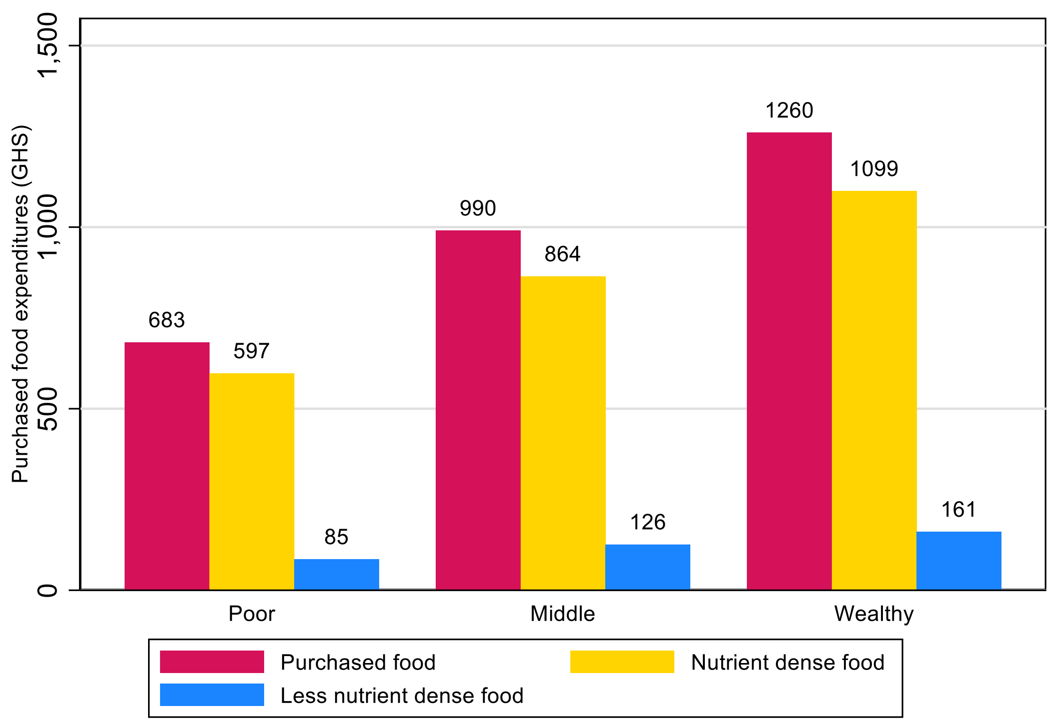


Source: Ghana Socioeconomic Panel Survey

Figure A1. Baseline home-produced food expenditure by wealth status



Source: Ghana Socioeconomic Panel Survey

Figure A2. Baseline purchased food expenditure by wealth status

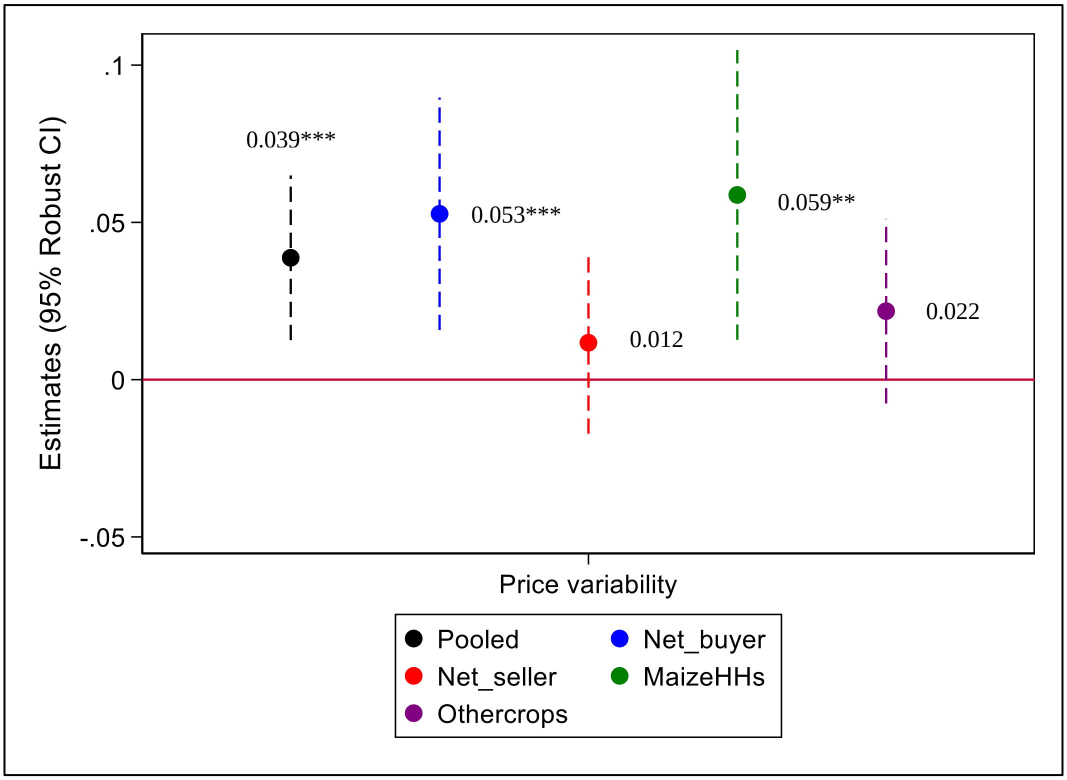


Figure A3. Fixed effects estimate of price variability and land allocation (hectares) to cereal crop.

Notes: Other controls include socio-demographics, farm, and tropical livestock unit. *** p<0.01, ** p<0.05.

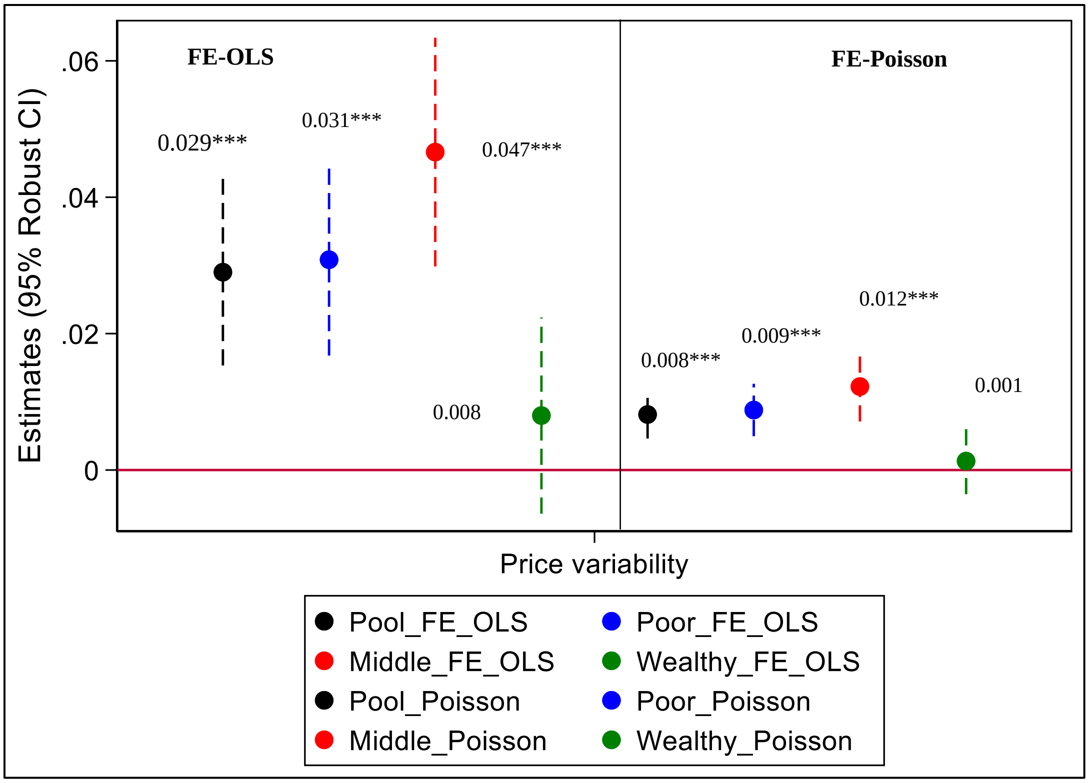


Figure A4. Fixed effects and Poisson estimates of price variability and home-produced food groups.

Notes: Other controls include socio-demographics, farm, and tropical livestock unit. *** p<0.01.

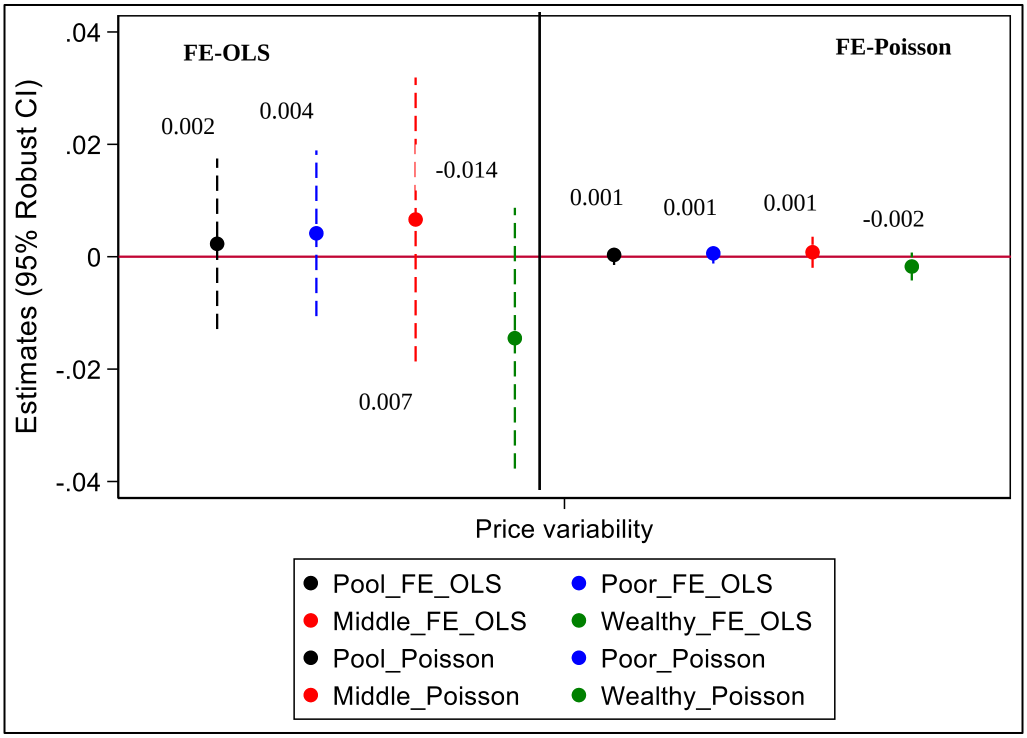


Figure A5. Fixed effects and Poisson estimates of price variability and purchased food groups.

Notes: Other controls include socio-demographics, farm, and tropical livestock unit. *** p<0.01.