Maize Price Shock, Agriculture Production and

Children Nutrition Outcomes in Tanzania

by Mkupete Jaah, Dieter Von Fintel, and Ronelle

Burger

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Abstract

This study used the three waves of the Tanzania National Panel Survey to analyze how a maize price shock affects the nutrition outcomes of children under five . We distinguished between households who produce food and those that do not. The results show that maize prices negatively significantly affected the linear growth of children from food nonproducers households. The effect is positive for children from food producers households. We find that girls suffer more than boys when maize prices increase. Moreover, we find that children aged 24-35 months stopped breastfeeding and began eating on the same plate as other adults in the households to be more vulnerable to shock than other age groups. We also find that the impact of maize price on children nutrition works through differential effects on household micronutrient consumption. The results imply that food production has a protective effect in the presence of a price shock, at least in events when the price increase is not caused by climate change. Investment in climate-smart agriculture for sustainable food production can offer an alternative to ensure that these gains persist in a changing climate .

Keywords: Maize Price Shock, Child Nutrition Status, Agriculture, Food production and, Tanzania

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1. Introduction

Food price shocks have become an important feature in current policy debates due to potential implications on children and the poor. Prior to the 2008-09 food crisis, low food prices were considered unacceptable (Swinnen and Squicciarini, 2012) because it hurt the poor rural farmer households who depended on agriculture as their primary source of income. The declining food prices trend observed from 1974 to the mid-2000s raised concerns about the lower returns of agriculture and the likelihood for farmer households to escape poverty. However, the 2008 food crisis accompanied by high food prices forced policymakers to change their perspectives regarding high prices. The welfare and nutrition indicators that deteriorated because of the crisis (Alexander, 2010; Tiwari and Zaman, 2010; Akter et al., 2013; Attanasio et al., 2013; Rajmil et al., 2014), made multilateral organizations revisit policy recommendations for developing countries in particular.

Globally, high food prices have resulted in a food price dilemma due to mixed effects on different population sub-groups (Lustig, 2012). World Bank (2008) and Bibi et al. (2010) show that children are at higher risk of being affected by high food prices over the short and long run. The extent to which children are affected by high food prices is still unclear (Arndt et al., 2016) and is likely to be context-specific. The literature documents several potential channels through which food prices can affect children health. The most direct impact is the first-order effect operating via the quantity and quality of food consumed.

The evidence of the impact on the poor and on smallholders farmers is scant despite the size and the importance of this stakeholder group (Ivanic and Martin, 2008). Data insufficiency limits a rigorous investigation of the nutritional consequences of higher food prices (Torlesse et al., 2003; Zaki et al., 2014). As a result, many existing studies in Africa underestimate the impact of food price on nutrition and poverty (Compton et al., 2010). The current understanding is that the effect differs depending on the household net buyer(seller) market position (Ivanic and Martin, 2008). Higher prices are expected to improve the welfare and nutrition of the smallholders' farmers that can produce enough for their families and have surplus left over to sell. Income earned from such sales can be used to buy a more diversified diet even in high food shortage seasons. On the other hand, those who suffer are rural net buyers with no other source of income than agriculture and the urban poor. They spent more than half of their income on the food they buy from the market to meet their daily caloric intake requirement. High prices, therefore, erode the purchasing power of the poor households and force them to adjust their basket of food to include more affordable items, which often comes at the cost of micro-nutrients (Zaki et al., 2014). Due to a combination of low meal frequency and insufficient micro-nutrients, children can become malnourished and suffer from a weak immune system, which increases their vulnerability to infectious diseases.

The current study aim to examine the impact of maize price shock on the growth of children from food producers and food nonproducers. We hypothesize that high maize prices do not negatively impact the children from food nonproducers households than children from food producers households. This hypothesis is guided by the evidence that food producers can benefit from agriculture through income earned by selling the food and the diversified diet from consuming what they produce (Ruel et al., 2013). However, the open question is whether the current level of subsistence production provides the children from food producers households with a buffer against the adverse effects of maize price hike?

In particular, the interest is in the reduced form as well as the structural coefficients to establish a causal association. The analysis was performed in steps where the reduced form equation was estimated using OLS for pooled sample in the first step and control function for the endogenous switching regression by Murtazashvili and Wooldridge (2016) in the second step. The control function accounts for the endogeneity in food production decision which is not random across households. We first estimated the structural equation that links HAZ and maize price. We then separately estimated the second equation that links HAZ and measures for diet diversity and share of calories of maize consumed. In the Tanzania context, we use the share of calories of maize as a proxy for low diet diversity. When prices are high, households are likely to increase consumption of energy-rich foods, and in the most basic case, maize, to calm their hunger; because maize remained relatively cheaper when the price of other staples also rise. Given that maize is the cheapest staple, there is no substitution options thus impact of price hike

This study, similar to Yamauchi and Larson (2019), find an increase in maize price reduce the growth of children from food nonproducers and increase the growth of children from food producers. However, our study makes multiple additional contributions to the literature. Firstly, unlike Yamauchi and Larson (2019), we provide age and gender-specific analysis of the impact of soaring prices on the growth of children who produced food and those who did not. We find evidence for gender bias disfavouring girls from food nonproducers, supporting Becker (1981) assertion that households treat children differently conditional on gender depending on the economic conditions. While no research explicitly assess how the gender of a child influences feeding practices in the household, the evidence for son preferences are documented in many parts of Tanzania (Msuya, 2019; Mwageni et al., 2001; Mulema, 2014). The cultural norms which view a son as an asset and a girl as a liability has, over overtime, influenced household investment in children in favour of boys, with a detrimental impact on the girls mental and physical health (Msuya, 2019).

Exploring the age-specific effect of maize price, we find that the negative impact of maize price on growth is significant among children aged 24-35mo from food nonproducers households. Tanzania, most children stop breastfeeding at this growth stage and begin to eat on the same plate as other adults in the household. One possible reason for this age-specific effect is that the diet children consume when prices are high lacks essential micronutrients available in breast milk to continue support growth beyond two years. Another reason could be related to cultural norms. In rural Tanzania, households members eat from the same plate, which may negatively affect the nutritional intake of younger children who often eat slowly (FAO, 2008). Thus, with increased food price and reduced food availability, children in the transition from breastfeeding to solid food become vulnerable because they can not keep pace with older children and adults in the household.

Thirdly, we examine the mechanism of the growth effect of maize price shock. Specifically, we test whether a different price effect across producers and nonproducers work through the differential effects on household micronutrient consumption [4]. We establish the mechanism is through changes in micronutrients and diet diversity. The food producers consumed less energy-rich foods and increased consumption of micronutrients when the

[4]Many studies on food prices focuses on household expenditure or poverty and their analysis is dominated by the households net food consumption position assessment (Deaton, 1989). While income can mediate the association between food prices and child nutrition, a rigorous analysis of the impact of price volatility on diet diversity across net-buyer(sellers) households could be useful (Headey and Masters, 2019). However, we do not follow the net-buyer(sellers) classification approach because it limits our broader understanding of the role of own production; being a food producer can have an impact on its own. Moreover, a household may not necessarily be a net-buyer (seller) of food. Still, consumption of own production can reduce the risk of food insecurity and malnutrition, particularly when food prices are high. Moreover, the household net food consumption is hardly accurately measured in household surveys which impose systematic errors (Headey and Fan, 2010).

prices are high. In contrast, food nonproducers increased consumption of energy-rich food (proxied by share of maize consumption) and cut back the consumption of micronutrients rich food.

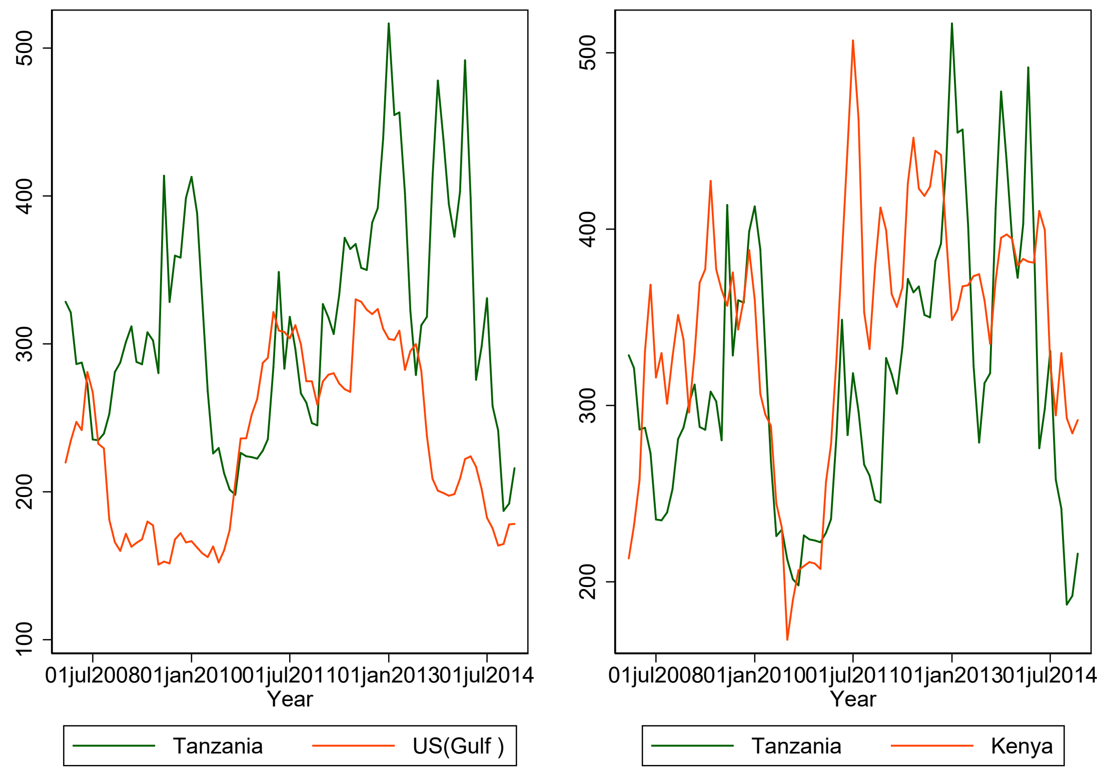
In the next sections, we present the background of the maize production and price trend in Tanzania, describe the data and specify the model. The last two sections provide the results and discussion, and conclusion for the study.

2. Country Context

Maize is the main staple in Tanzania with a per capita consumption of 80-135kg/person and contributes about 80 percent to total caloric intake (USDA, 2018; FEWS NET, 2018). Maize production accounts for about 41 percent of the total cultivated land during the long rain season and 47 percent during the short rain season (MAFAP, 2013). The large proportion, about 80 percent, of maize is produced by small holders farmers where 65-80 percent serves for family consumption, and 25-40 percent is traded (Wilson and Lewis, 2015; USDA, 2018).

Unlike many countries that experience immediate price increase on the main food staples during 2008 and 2011 food crisis, the transmission to Tanzania was comparatively small and slow to feed through the system. The domestic prices increased but at a slower rate, while international prices were rising from mid-2007 to March 2008 and continue to increase when the international prices are decreasing (Macharia et al., 2009). The data for Tanzania also indicate that the maize price fluctuate and deviate from the international prices in the analyzed period 2008-2013 (Figure 1). However, of much interest in this study is a maize price shock marked by a huge spike in the last quarter of 2012 to the second quarter of 2013 (see Figure 1). While regional trade movements are often linked to large domestic price swings, factors such as seasonality, unpredictable trade policies and intervention through the National Food Reserve Agency (NFRA) (Rashid and Minot, 2010; Baffes et al., 2017). Seasonality on its own causes about two-thirds of the domestic price volatility (Baffes et al., 2017).

Maize trade is mostly used as an intervention tool through export bans to stabilize price in the major consumption market in Tanzania (World Bank, 2004). For example, for the period between 2006 and 2012, the ban was imposed and lifted at least ten times (Stryker



Source: Author. Data sources: FAOSTAT

Figure 1: Monthy Maize Price Trend, Tanzania, Kenya and US (Gulf)

and Amin, 2013). Export bans are, however, reported to be less effective to lower the prices rather than being disruptive (Diao and Kennedy, 2016). The analysis of the export bans imposed during 2005-2010 shows that the objective of the ban was only partly achieved. During the ban period, the maize could not be moved from surplus to the deficit markets where the price is high and instead distorted the profit of the farmers in the surplus zones (MAFAP, 2013). Baffes et al. (2017) also show that the prices decrease only temporarily when the ban is imposed but return to a higher level when the ban is lifted.

3. Data and Methods

This study uses the three waves of the Tanzania National Panel Survey (TNPS); 2008-2009, 2010-2011, and 2012-2013 which collect various information on living standards. The data is part of the Living Measurement standard Study (LSMS) by the World Bank, which follows a stratified, multistage cluster sampling design. The sample size for wave I, II, and III are 3,265 households, 3924 households, and 5,010 households, respectively. Attrition across surveys is low, with 96 percent of original households successfully maintained. The focus of this study is children under the age of five, and thus we exclude from the analysis all other household members that do not meet our criteria. We also dropped observations with missing information on child height and age, which left us with a working sample of 3, 187 observations for 2008, 2,865 observations for 2010 and 2,736 observations for 2012 surveys (Table 1). We classified a child as from a food producer household based on the self-reported food consumption information[5].

The maize prices were computed directly from the households food expenditure section that reports the quantity of food purchased and its monetary value. The prices were obtained by dividing the total value of the maize purchased and its quantity purchased by a household. The prices were then aggregated at the district level, the lowest possible administrative division, and the median, instead of unit values, were used in the analysis. The surveys also collect price data at the community level from community centres, shops, and markets reported in the community section. Still, they could not be used due to many missing values. To ensure that we are using the correct prices, we conducted a correlation analysis between the constructed prices and community level prices for the districts with price information, which show that the two prices do not differ substantially.

The outcome variable used in this study is child height-for-age z-score (HAZ) as per 2006 WHO growth standards. The z-scores calculated are age and sex-specific. Children with biologically implausible scores below -6 and above +6 standard deviation were excluded. z-score below zero indicate poor growth; scores between 0 and -2, - 2 and -3 and below -3 is referred respectively to mild, moderate and severe stunting conditions. Similarly, we define a child as stunted if the z-score lies below -2SD of the WHO standard median.

Table 1 reports the characteristics of the sample and descriptive statistics of the variables used in the study. The first column presents the statistics for the pooled sample, and columns (2) - (4) present wave specific statistics. On average, child HAZ has improved over six years while the mean price for maize has not substantially increased substantially over the same period[6]. While the mean number of households accessing health care has increased by 35

[5] We do acknowledge the possible error that might arise due to misclassification of producers into nonproducers if a particular household has nothing in stock during a time of survey.

[6] It could be possible that the changes we observe are driven by changes in sample across waves of the panel.Comparing the same children across waves is difficult because they cross the 5 years cut-off. The increase in the average values of other variables such as households ownership of assets and mothers years of

Table 1: Sample Characteristics

	Pooled Sample		2008		2010		2012	
Producer	mean	sd	mean	sd	mean	sd	mean	sd
HAZ	-1.590	1.525	-1.788	1.461	-1.489	1.525	-1.529	1.558
HDDS	7.557	2.344	7.414	2.307	7.694	2.306	7.551	2.396
Share Calories (Maize)	0.678	0.311	0.696	0.311	0.668	0.304	0.673	0.315
Maize Price	7.162	0.244	7.017	0.151	7.075	0.157	7.338	0.248
maizeprod	34.130	28.604	32.885	27.280	33.943	29.052	35.188	29.151
Consumption (log)	14.708	0.724	14.449	0.640	14.644	0.675	14.949	0.744
Household size	7.915	5.444	7.389	4.719	8.075	5.972	8.168	5.465
Mother's Education	5.386	3.321	5.150	3.236	5.315	3.329	5.615	3.363
Head Education	4.821	3.682	4.893	3.392	4.756	3.640	4.819	3.911
Head Gender	0.839	0.368	0.838	0.369	0.844	0.363	0.836	0.370
Head Age	44.419	14.299	43.495	13.837	44.625	14.238	44.925	14.651
0-6mo	0.078	0.268	0.054	0.226	0.087	0.282	0.088	0.284
6-23mo	0.306	0.461	0.309	0.462	0.324	0.468	0.290	0.454
24-35mo	0.210	0.407	0.204	0.403	0.201	0.401	0.221	0.415
36-60mo	0.406	0.491	0.434	0.496	0.388	0.488	0.401	0.490
Market(Distance)	88.492	54.738	89.424	53.576	89.725	55.726	86.818	54.753
Share Calories (nutsseeds)	0.010	0.029	0.011	0.038	0.009	0.022	0.010	0.027
Share Calories (vegetables)	0.004	0.006	0.003	0.009	0.004	0.004	0.004	0.004
Share Calories(fruits)	0.008	0.025	0.008	0.026	0.010	0.030	0.007	0.019
Share Calories(meatfish)	0.003	0.009	0.003	0.007	0.003	0.012	0.003	0.007
Share Calories(dairy)	0.006	0.019	0.004	0.011	0.005	0.014	0.008	0.026
Observations	5254		1508		1674		2072	
Non Producer								
HAZ	-1.215	1.536	-1.374	1.499	-1.041	1.526	-1.252	1.559
HDDS	9.204	2.196	9.371	2.108	9.243	2.202	9.043	2.248
Share Calories (Maize)	0.616	0.282	0.614	0.284	0.610	0.275	0.623	0.287
Maize Price	7.187	0.227	7.014	0.112	7.122	0.118	7.375	0.229
maizeprod	13.612	18.365	9.950	11.891	13.411	18.977	16.547	21.131
Consumption (log)	15.110	0.730	14.913	0.705	15.120	0.710	15.249	0.734
Household size	5.909	2.908	5.775	2.640	6.297	3.217	5.661	2.776
Mother's Education	7.498	3.413	7.297	2.982	7.521	3.582	7.629	3.556
Head Education	7.254	4.171	7.188	3.853	7.251	4.329	7.305	4.261
Head Gender	0.777	0.417	0.802	0.399	0.759	0.428	0.773	0.419
Head Age	39.829	12.740	40.401	13.169	40.286	12.316	38.989	12.766
0-6mo	0.073	0.260	0.030	0.170	0.102	0.303	0.080	0.272
6-23mo	0.340	0.474	0.324	0.469	0.328	0.470	0.363	0.481
24-35mo	0.205	0.404	0.225	0.418	0.180	0.385	0.212	0.409
36-60mo	0.382	0.486	0.421	0.494	0.390	0.488	0.345	0.476
Market(Distance)	47.245	49.997	40.203	44.139	47.742	50.769	52.098	52.845
Share Calories (nutsseeds)	0.018	0.028	0.020	0.027	0.016	0.025	0.019	0.031
Share Calories (vegetables)	0.007	0.006	0.007	0.006	0.007	0.006	0.008	0.006
Share Calories(fruits)	0.004	0.012	0.004	0.011	0.004	0.009	0.005	0.015
Share Calories(meatfish)	0.006	0.008	0.006	0.008	0.007	0.009	0.006	0.007
Share Calories(dairy)	0.006	0.014	0.005	0.014	0.006	0.014	0.006	0.013
Observations	1423		404		482		537	

percent between the first and third wave, the mean number of households with access to clean and safe water has reduced by 22 percent. On average, the number of children born by mothers under the recommended childbearing age of 18 years increased from 53 percent to 70 percent between 2008 and 2012. Early childbearing is associated with the risk of a child born underweight, often resulting in serious health and development problems.

4. Model Specification and Estimation

The empirical specification draws on the influential Grossman (1972) health production theoretical model and the extended hybrid household health production model for children under five years (Rosenzweig and Schultz, 1983; Mwabu, 2007). We estimate the reduced form child health input demand function using OLS and control function for the endogenous switching regression model in the second step.

(a) *Reduced Form Equation*

The empirical reduced form equation is specified as follows:

$$HAZ_{it} = \alpha + \beta_1 MaizePrice_{it} + \beta_2 MaizePrice_{it} \times Producer_{it} + \beta_3 Producer_{it} + \gamma X_{it} + \delta D + \mu_{it} \quad (1)$$

where HAZ_{it} is a height for age child z-score, $\beta' s$ are the coefficients of our primary interest which capture the effects of a maize price shock on the HAZ scores. γ represent a vector of coefficients that capture the effects of non-price variables that are likely to affect child HAZ. D is a vector of community fixed effects and survey specific dummies, and the last term μ_{it} is a well behaved stochastic error term[7].

Estimating Eqn. 1 using OLS allows us to establish a correlation between the variables of interest and the outcome variable. The model was estimated by child gender, age categories, and harvesting seasons sub-samples. In both approaches, we interact with the maize price, a dummy for food producers, to examine whether the effects differ between the two groups. The assumption is that the sensitivity of HAZ to maize price depends on which group a child belongs to. Food producer might be less sensitive since they can consume

schooling is an indication that sample has changed over time

[7] I did not add child or household FE because children are difficult to follow across waves within this very narrow age group of 0-5years

what they produce and purchase only a small share if necessary, while the food nonproducers households purchase everything (Grace et al., 2014).

(b) *Control Function for Endogenous Regression Switching Model*

In any given year, a household decision to produce food crops depends on the expected benefit of producing food crops over other crops. The decision to produce food is not random and may be subjected to selection bias and influenced by unobserved heterogeneity between households and farms specific characteristics. The unobserved heterogeneity is likely to affect both the decision to produce food and the outcome variable and, therefore, lead to biased estimates, particularly when OLS is used. To establish a causal association, We combine the control function and Instrumental Variable (IV) to estimate the endogenous switching regression model. We specifically follow a constant coefficient switching regression model for panel data presented in section 3.1 in Murtazashvili and Wooldridge (2016). We treat the decision to produce food as endogenous switching variable and specify the two regimes as follows:

$$h_{it1}^{(q)} = X_{it1}\beta_q + c_{i1q} + \mu_{it1q}, \quad i = 1, ..., N; \quad and \quad t = 1, ...T \tag{2}$$

where $h_{it1}^{(q)}$ is an outcome variable (HAZ), c_{i1q} is time constant individual-specific unobserved effects, and μ_{it1q} is an idiosyncratic error term in the two regimes represented by q such that q =1 if a household produce food and 0 if do not. X is a vector of endogenous and exogenous explanatory variables such as HDDS, share of calories of maize, household expenditure, maize price, household size, maize producers, and distance to the market. β_q is vector of coefficients in q regimes. β_1 and β_0 are the coefficients of interest where for simplicity we write $\gamma = \beta_1$ - β_0 in a full model specification in the Eqn 3 below.

$$h_{it1} = X_{it}\beta + h_{it3}X_{it}\gamma + \bar{z}_i\rho_0 + h_{it3}\bar{z}_i\rho_1 + \delta_0\hat{gr}_{it3} + \delta_1 h_{it3}\hat{gr}_{it3} + \mu_{it} \tag{3}$$

where $\bar{z}_i = \sum_{t=1}^{T} z_{it}$, is a mean values of the Mundlak devices (z_{it}) which comprises of strictly exogenous variables such as (head gender, head age and mother's education), h_{it3} is an endogenous switching variable, $\hat{gr}_{it3}$ is a generalized residue from the first stage regression, $h_{it3}\hat{gr}_{it3}$ is an interaction between a switching variable and generalized residue, and μ_{it} is an error term. The estimation procedure involves running a probit model of h_{it3} on z_{it} and $\bar{z}_i$ for all N x T observations in the first stage and generate generalized residue $\hat{gr}_{it3}$. In the second step Eqn 3 is estimated by 2SLS using $(\bar{z}_i, h_{it3}\bar{z}_i, \hat{gr}_{it3}, h_{it3}\hat{gr}_{it3})$ as instruments if there is an endogenous explanatory variable in the model, otherwise the second step involves estimation of the standard OLS.

This approach has several advantages over applying the IV or endogenous switching regression model on its own as used in the previous related studies (Salazar et al., 2015; Cawley et al., 2018; Di Falco et al., 2011; Asfaw et al., 2012; Kassie et al., 2018; Ali and Awade, 2019). Applying IV methods or regressing the fitted values $\hat{y}$ obtained in the first stage on y (Adams et al., 2009; Zereyesus et al., 2017) yields inconsistent results, particularly when there are more than one sources of unobserved heterogeneity (Murtazashvili and Wooldridge, 2016). A control function combined with IV account for the correlation between endogenous and exogenous explanatory variables. Including Mundlak (1978) and Chamberlain (1980) devices which is simply the means of time-varying strictly exogenous covariates in the food producer and outcome equation adjusted for the time-constant unobserved heterogeneity. Furthermore, the approach is flexible to allow either the switching variable alone or both switching and other explanatory variables to be endogenous in the model.

4.1. Instrumental Variable (IV)

The decision to produce food is instrumented by the share of maize farmer within a cluster. The instrument meets the identification and exclusion criteria by having a low correlation with the outcome variable but strongly correlating with the decision to produce food. The share of maize farmers within a cluster can represent the suitability of the soil for growing food crops, which in turn affect the decision to produce food. Additionally, the effect can be through information externalities where farmers are expected to learn from their fellow farmers nearby (Holloway et al., 2002; Michelson, 2017; Li and Zhao, 2018). This is also consistent with the work by Zanello et al. (2019) and Dubbert (2019).

The explanatory variables: Diet Diversity Score (HDDS) and share of calories of maize consumption in the HAZ regression can not be exogenous. Feeding practices are heterogeneous across households and can be influenced by the observed and unobserved factors which also affect HAZ. The relationship between HAZ and diet measures run in both directions and thus, estimation of Eqn 3 using OLS estimators are inconsistent. For example, when a household changes the composition of the diet after observing the deterioration in child nutrition, the direction of causality will run from HAZ to HDDS (Frempong and Annim, 2017). We instrument the HDDS and share of calories of maize with the maize price. The effect of maize price on child nutrition is indirect and works through changing the diet composition and, thus, serves as a valid instrument. Maize price averaged at district level was also used to instrument crop diversity in a study by Lovo and Veronesi (2019) in Tanzania.

4.2. Construction of Diet Diversity (HDDS) and Calculation of Calories

Household diet diversity score and calories intake were calculated from the food consumption information reported by the household in the survey. The households were asked to list the food types and quantities they consumed in the last seven days. The construction of the HDDS follows the guidelines by FAO (Kennedy et al., 2011) and other previous works (Chegere and Stage, 2020) where we sum the number of food groups out of 12 food groups: Cereals; Nuts and seeds; White tubers and roots; Vegetables; Fruits; Legumes; Meat; Eggs; Fish and other seafood; Milk and milk products; Sweets; Spices, condiments; Beverages and Oils and fats that a particular household consumed in the last seven days. We also calculated the food-specific and food group kilocalories using conversion units in calories per kg for each 59 food items provided in the National Panel Survey reports (NBS, 2012, 2014).

5. Results and Discussion

5.1. Descriptive Results

Figure 2 presents the distribution of children's HAZ scores over the three surveys. In all the surveys, the scores are skewed to the left, which indicates that a higher number of children are malnourished. Only a small number of the children fall under the mild category, while the majority are either moderate or severely malnourished as their HAZ scores are below minus two standard deviations (-2SD). There is a noticeable shift in the HAZ scores distribution curves to the right after the first survey, which indicates a decline in malnutrition but, no clear difference can be observed between the second and third surveys.

Stunting levels are higher in the rural than in the urban area as seen in Figure 3, where about 47 percent of the children in rural areas compared to 33.2 percent of children in urban areas were stunted in 2008. In 2010 stunting levels decreased by 9.5 percent and 8.2 percent

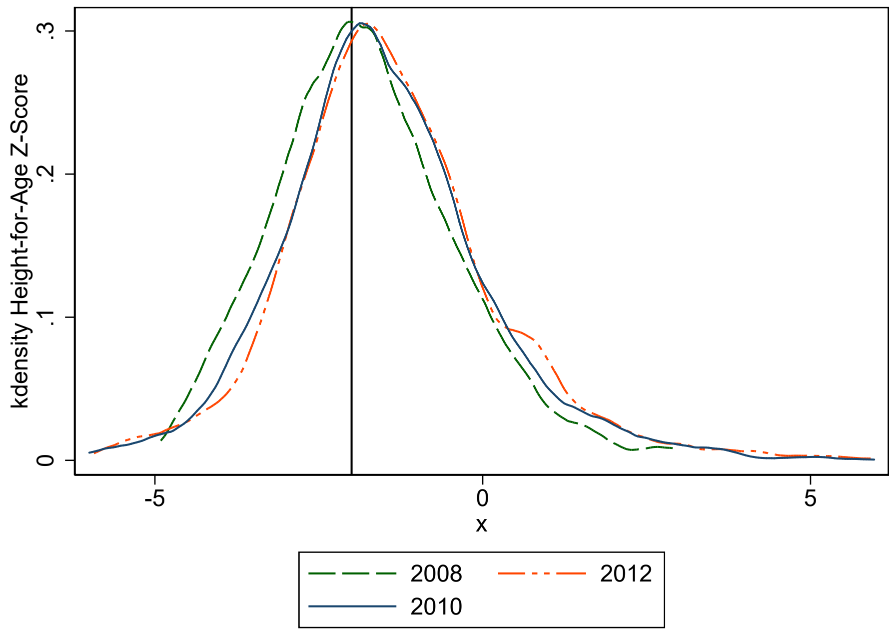


Figure 2: Distribution of Height-for- Age Z- Score 2008-2012

in rural and urban respectively. Despite the higher prevalence of stunting in rural areas, stunting increased by a higher proportion in urban areas in 2012. Stunting increased by about 5.7 percent in urban areas compared to 1.7 percent in rural areas. These patterns are consistent with a maize price shock that hit the economy between 2012 and 2013, as is shown in Figure 1. The levels of stunting were 39.6 percent in rural areas and 30.7 percent in urban areas in the year 2012. Compared to other waves, the baseline stunting levels are also very high, plausibly attributable to the 2007/08 food crisis, which is reported to have doubled the maize price, particularly in urban Tanzania (Rudolf, 2019).

Figure 4 shows a higher stunting prevalence among food producers than food nonproducers in all the surveys. This distribution represents an important aspect of endogeneity in food production; poor households often have shorter children for their age and use food production as a coping strategy. The stunting prevalence substantially declines in 2010 among both food producers and nonproducers but increased by a large proportion among children from food nonproducers than food producers households in 2012. Nearly 7 percent of the children from the nonproducers households became stunted in 2012. This trend indicates that food production increased the relative resilience to price shock for food producers households.

Table 2 shows that during the maize price surge in 2012, the average per capita maize

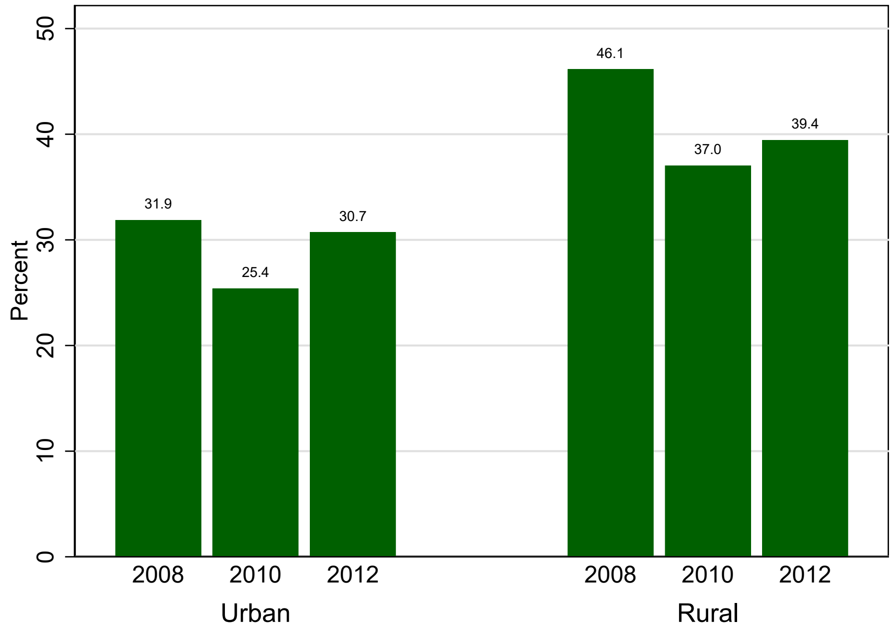


Figure 3: Proportion of Stunted Under-Five Children by Area of Residence

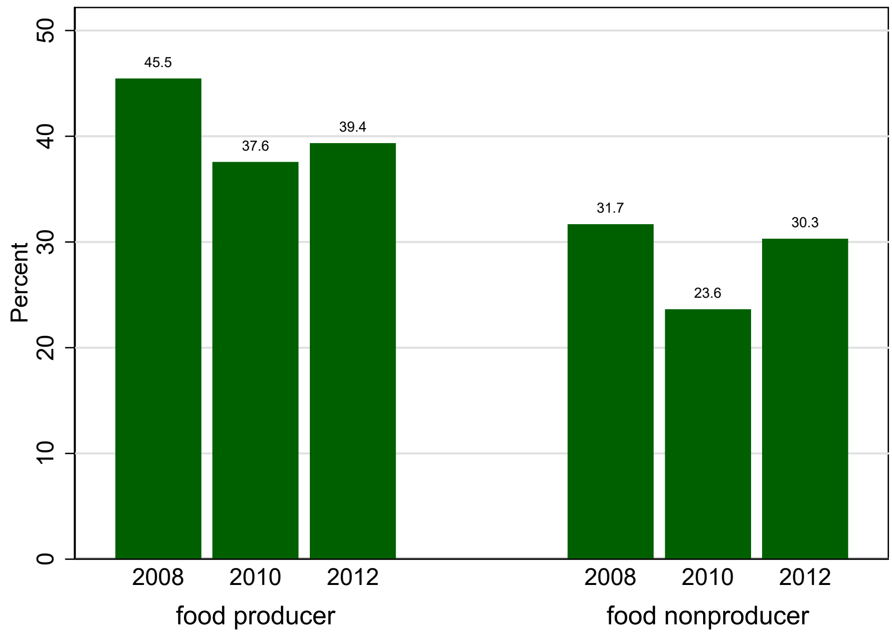


Figure 4: Proportion of Stunted Under-Five Children by Food producers and Non Food producers

consumption declined by 22 and 3 percentage points among food producers and food non-producers respectively. This differential drop in maize consumption have two implications. First, nonproducers are at greater risk of experiencing a reduction in consumption below the critical level given that the consumption is already at low levels before the maize price shock. Second, there is the substitution from maize consumption to other food bought in the market among food producers. It is likely that food producers reduced the share of maize consumption and sell some when prices increased.

Table 2: Average Consumption per Capital of Food in Kg

	Producers			Non- Producers		
	2008	2010	2012	2008	2010	2012
Maize	0.846	0.926	0.704	0.252	0.210	0.172
Observations	2737	2238	2176	455	598	541

Nevertheless, despite higher stunting rate observed, children appear to attain a catch-up growth as they age, particularly in rural areas (Table A.10 in the appendix). The transition matrix in Table 3 also confirms catch up growth among both male and female children, where quite massive movements can be observed. About 47 percent of male and 43 percent of female children who were stunted in 2008 are no longer stunted in 2012. However, it is difficult to tell whether the improvement is from moderate to mild or a completely healthy state with transition matrices alone.

The analysis by age group shows that the movement is only at the margins as a higher proportion of children move from worst to the second-worst category, and that younger children are more likely to be stunted than the older ones(Table A.10 in the appendix). Table 4 also shows that catch-up growth among children is more likely to happen in the urban area than the rural areas. Nearly 60 percent of children in the urban areas are no longer stunted in 2012 compared to the 43 percent in rural areas. Similarly, children in the rural areas are more likely to become stunted than those in urban area. About 23.6 percent of children in the rural area became stunted in 2012, compared to only 14.6 percent in the urban area.

Table 3: Transition Matrix for the Stunted Children by Sex (2008, 2010 and 2012)

	Male			Female		
	Not Stunted	Stunted	Total	Not Stunted	Stunted	Total
Not Stunted	494	136	630	589	155	744
	78.41	21.59	100	79.17	20.83	100
Stunted	240	263	503	197	256	453
	47.71	52.29	100	43.49	56.51	100
Total	734	399	1,133	786	411	1,197
	64.78	35.22	100	65.66	34.34	100

Table 4: Transition Matrix for Stunting in Rural and Urban Areas (2008, 2010 and 2012)

	Rural			Urban		
	Not Stunted	Stunted	Total	Not Stunted	Stunted	Total
Not Stunted	771	238	1,009	240	41	281
	76.41	23.59	100	85.41	14.59	100
Stunted	332	439	771	87	61	148
	43.06	56.94	100	58.78	41.22	100
Total	1,103	677	1,780	327	102	429

5.2. *Regression Results*

Table. 5 presents the reduced form results based on the pooled sample. Column (1) shows that maize price is negatively significantly associated with HAZ of the children from food nonproducers and positively significantly associated with HAZ of the children from food producers. Previous literature pointed out that the relationship between child nutrition and other potential covariates can be driven by seasonality, highlighting the need to account for seasonality in the estimation (Bevis et al., 2019; Zanello et al., 2019). Lack of storage also determines the food access and availability between harvest and lean season and, thus, the household's nutrition (Basu and Wong, 2015; Omotilewa et al., 2018). Columns (8) and (9) provide estimates for the lean and post-harvest agricultural seasons. As seen in the table, the association between maize price and HAZ appears to persist in both lean and post-harvest agricultural seasons, suggesting that the observed relationship is not driven by seasonality [8]. The results suggest that households can smooth inter-seasonal food consumption by consuming from their stock and selling at a higher price in the lean season, and buying other foods from the market.

In column (2) and (3) we observe a significant negative association between maize price and HAZ only among female children from the food nonproducers. The sign of the coefficient of maize price among male children from food nonproducers is negative but not significant. Similarly, for the children from food producers, we observe a positive association between maize price and HAZ only among female children. Columns (4)-(7) presents the correlation between maize price and HAZ across different age categories. The significant negative association between maize price and HAZ is observed only among older children

[8] The chow test (Table A.12) confirm that the two equations are essentially equivalent.

aged 24-35 months and 36-60 months from food nonproducers households. The association is positive for the children from food producers households but only significant among 24-35 months age group.

The negative and significant coefficient for the dummy for the food production signifies the endogeneity in food production, which was also revealed in the descriptive analysis, justify our choice for the control function to establish causality in the next section. One explanation is that the dummy captures producers of which the majority are rural households with a high proportion of stunted children compared to urban. The negative correlation we observe could be the nutrition status of the severely malnourished group (producers) relative to the reference group, the food nonproducers. Similarly, previous studies in Tanzania also suggests that regions with abundant food production have a higher prevalence of chronic malnutrition than regions with frequent food unavailability (TFNC, 2012).

Table 5: OLS Regression for Height-for-Age z-score

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Child Gender		Age of a Child				Seson	
	Pooled OLS	male	female	0-5mo	6-23mo	24-35mo	36-60	Lean	Post harvest
Maize Price	-0.483***	-0.409	-0.557**	-0.534	-0.386	-1.107***	-0.378	-0.730***	-0.815**
	(0.163)	(0.268)	(0.267)	(0.890)	(0.357)	(0.270)	(0.235)	(0.254)	(0.357)
Producer X Maize Price	0.316*	0.147	0.480	0.981	-0.090	0.743**	0.265	0.688	0.804**
	(0.185)	(0.277)	(0.296)	(0.987)	(0.398)	(0.311)	(0.252)	(0.275)	(0.392)
Consumption(log)	0.331***	0.310***	0.349***	0.283*	0.372***	0.345***	0.281***	0.334***	0.311***
	(0.033)	(0.044)	(0.046)	(0.159)	(0.072)	(0.054)	(0.043)	(0.043)	(0.057)
Household Size	-0.036***	-0.035***	-0.038***	-0.014	-0.007	-0.020**	-0.008	-0.050***	-0.022
	(0.007)	(0.012)	(0.010)	(0.021)	(0.010)	(0.008)	(0.005)	(0.009)	(0.015)
Mother's Education	0.008	0.004	0.012	-0.012	-0.022*	0.029**	0.027***	0.002	0.018**
	(0.006)	(0.008)	(0.009)	(0.023)	(0.012)	(0.011)	(0.007)	(0.007)	(0.008)
Male Headed	-0.065	-0.148*	0.010	-0.114	-0.152	0.060	-0.074	-0.121**	0.004
	(0.050)	(0.077)	(0.066)	(0.282)	(0.101)	(0.094)	(0.061)	(0.058)	(0.081)
Head Age	0.001	-0.001	0.003	-0.008	-0.001	0.004	0.002	0.004**	-0.003
	(0.001)	(0.003)	(0.002)	(0.008)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
Distance to Market	0.000	0.000	0.000	0.000	0.001	-0.001	-0.001	-0.000	0.001
	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Urban	-0.188***	-0.268***	-0.107	-0.421	-0.298***	-0.125	-0.061	-0.223***	-0.130
	(0.049)	(0.089)	(0.074)	(0.274)	(0.098)	(0.112)	(0.069)	(0.076)	(0.085)
Producer	-2.391*	-1.108	-3.644*	-6.912	0.538	-5.390**	-2.109	-1.543	-2.974
	(1.330)	(1.984)	(2.125)	(7.163)	(2.852)	(2.234)	(1.827)	(1.875)	(2.211)
Child Age	0.107***	0.131***	0.087***					0.164***	0.006
	(0.022)	(0.040)	(0.030)					(0.028)	(0.040)
Child=Male				0.197	0.224***	0.228***	0.089**	0.199***	0.113*
				(0.168)	(0.086)	(0.069)	(0.044)	(0.046)	(0.058)
Constant	-2.711**	-2.886	-2.464	0.179	-4.105*	0.578	-3.008*	-3.763**	-2.302
	(1.175)	(1.873)	(1.952)	(6.798)	(2.388)	(2.018)	(1.778)	(1.755)	(2.193)
Observations	6827	3387	3440	524	2151	1429	2723	4110	2717

Notes: The standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.01. All specifications includes time and community fixed effects.

To disentangle the differential causal effects of a maize price shock on food producers and nonproducers we estimated a control function by fitting a probit regression for the decision to produce food in the 1^{st} Stage and subsequently estimate 2 stages and 2SLS re-

Table 6: Probit and Second Stage Control Function Regression Results

	(1) Probit	(2) HAZ	(3) HDDS	(4) Maize Calories
Maize Price		-0.541***	-1.651***	0.292***
		(0.164)	(0.207)	(0.027)
Producer X Maize Price		0.362*	0.715***	-0.143***
		(0.185)	(0.237)	(0.034)
Consumption(log)	-0.618***	0.291***	1.946***	0.053***
	(0.059)	(0.039)	(0.042)	(0.010)
Household Size	0.138***	-0.005	-0.108***	-0.008***
	(0.014)	(0.006)	(0.008)	(0.001)
Mother's Education	-0.038***	0.003	0.030***	-0.001
	(0.010)	(0.006)	(0.008)	(0.001)
Male Headed	0.531***	-0.056	0.209***	-0.041***
	(0.082)	(0.052)	(0.072)	(0.014)
Head Age	0.015***	0.002	-0.012***	-0.002***
	(0.003)	(0.002)	(0.002)	(0.000)
Child Age	0.002	-0.012***	-0.001	-0.000*
	(0.002)	(0.001)	(0.001)	(0.000)
Child=Male	-0.036	0.172***	0.057	0.001
	(0.063)	(0.033)	(0.049)	(0.009)
Distance to Market	0.012***	0.001	-0.003***	-0.001***
	(0.001)	(0.001)	(0.001)	(0.000)
Urban		-0.155***	0.170	-0.330***
		(0.048)	(0.149)	(0.030)
Producer		-2.917**	-6.051***	1.676***
		(1.350)	(1.705)	(0.239)
Resid		0.098	0.243*	-0.278***
		(0.095)	(0.147)	(0.026)
Resid X Producer		0.081	0.913***	-0.203***
		(0.111)	(0.159)	(0.023)
Maizeprod(IV)	0.013***			
	(0.003)			
Constant	7.493***	-1.545	-7.560***	-2.220***
	(0.837)	(1.262)	(1.507)	(0.215)
Observations	6827	6827	6827	6795
p-val: $\hat{\beta}_{Maize} + \hat{\beta}_{MaizeXProducer} = 0$		0.040	0.000	0.000

Notes: All specifications are controlled for survey year and community fixed effects.
The standard errors (in parentheses) * p<0.10, ** p<0.05, *** p<0.01

gressions. The results are presented in Table 6 and Table 9. Table 6 shows that all the variables, including our instrument in the probit regression in column (1), are statistically significant and have expected signs. Column (2) shows the control function where I allow our switching indicator to interact with the maize price. As suggested by Murtazashvili and Wooldridge (2016), we estimated Eqn 3 using OLS after obtaining the generalized residue from the first stage probit regression since the maize price variable is exogenous in the model.

We find a negative statistically significant effect of maize price on HAZ among children from food nonproducers and a significant positive effect on HAZ among children from the food producers households. The results confirm the findings of the previous works by Yamauchi and Larson (2019) in Indonesia and Cogneau and Jedwab (2012) in *Côte* d'Ivoire. Deducing from the main and interaction effect coefficients, We argue that the impact of high maize price is only less positive for food producers for food producers compared to the food nonproducers(-0.179), and it can, therefore, be interpreted as a protective effect.

Table 7: Second Stage Control Function Regression for HAZ

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Child Gender		Age of a Child				Seson	
	male	female	0-5mo	6-23mo	24-35mo	36-60	Lean	Post harvest
Maize Price	-0.418	-0.558**	-0.524	-0.353	-1.069***	-0.308	-0.735***	-0.770**
	(0.270)	(0.269)	(0.869)	(0.358)	(0.279)	(0.229)	(0.257)	(0.362)
Producer X Maize Price	0.159	0.475	1.007	-0.102	0.730**	0.199	0.684**	0.703*
	(0.278)	(0.299)	(0.971)	(0.396)	(0.326)	(0.249)	(0.261)	(0.398)
Consumption(log)	0.305***	0.371***	0.274	0.334***	0.298***	0.237***	0.318***	0.211***
	(0.052)	(0.052)	(0.173)	(0.076)	(0.061)	(0.045)	(0.047)	(0.078)
Household Size	-0.034***	-0.041***	-0.015	-0.002	-0.014	-0.001	-0.048***	-0.006
	(0.012)	(0.010)	(0.024)	(0.010)	(0.009)	(0.005)	(0.010)	(0.017)
Mother's Education	0.004	0.013	-0.012	-0.026**	0.023*	0.021***	0.001	0.011
	(0.008)	(0.009)	(0.026)	(0.012)	(0.013)	(0.007)	(0.007)	(0.009)
Male Headed	-0.146*	-0.005	-0.118	-0.117	0.112	-0.018	-0.105*	0.059
	(0.077)	(0.070)	(0.293)	(0.109)	(0.102)	(0.064)	(0.060)	(0.086)
Head Age	-0.001	0.002	-0.007	0.001	0.005*	0.003*	0.005***	-0.001
	(0.003)	(0.002)	(0.008)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
Distance to Market	0.000	0.000	0.000	0.001	-0.000	-0.000	0.000	0.002**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Urban	-0.264***	-0.118	-0.429	-0.085	0.182	0.183	-0.214***	-0.103
	(0.088)	(0.076)	(0.513)	(0.217)	(0.233)	(0.135)	(0.079)	(0.086)
Producer	-1.237	-3.488	-7.227	0.231	-5.880**	-2.021	-1.526	-3.506
	(2.008)	(2.147)	(7.118)	(2.830)	(2.403)	(1.811)	(1.878)	(2.242)
Resid	0.038	-0.068	0.226	0.185	0.285	0.088	0.005	0.343**
	(0.105)	(0.117)	(0.479)	(0.179)	(0.215)	(0.162)	(0.109)	(0.157)
Resid X Producer	-0.036	-0.024	-0.496	0.142	0.187	0.406***	0.132	0.024
	(0.159)	(0.147)	(0.503)	(0.194)	(0.190)	(0.135)	(0.139)	(0.174)
Child Age	0.130***	0.089***					0.163***	-0.000
	(0.040)	(0.030)					(0.029)	(0.040)
Child=Male			0.187	0.226***	0.229***	0.091**	0.199***	0.110*
			(0.168)	(0.085)	(0.068)	(0.044)	(0.046)	(0.058)
Constant	-2.719	-2.815	0.447	-3.760	1.053	-2.954*	-3.642**	-0.906
	(1.957)	(2.006)	(6.744)	(2.372)	(2.126)	(1.774)	(1.759)	(2.360)
Observations	3387	3440	524	2151	1429	2723	4110	2717

Notes: All specifications are controlled for survey year and community fixed effects. The standard errors (in parentheses) * p<0.10, ** p<0.05, *** p<0.01

Moreover, maize price creates a gender bias against female children as it is seen in Table 7. The effect of maize price is negative and significant among female children from food nonproducers, while the effect on male children is insignificant. The results suggest that the observed effects may be associated with the biological differences between male and female children and social-cultural gender bias in intra-household food allocation in favour of males over female children. A large body of literature indicates that male children are prioritized in terms of food consumption when food becomes scarce (Mangyo, 2008; Aurino, 2017). In India, Behrman (1988) found that male children were eating better among farming households than female children in the lean agricultural seasons when food insecurity is high. However, most of this evidence is from Asian countries with little evidence from Sub-Saharan Africa. A negative and positive statistically significant effect of maize price on HAZ is detected only for the age category 24-35 months. The possible explanation for this might be that most children are weaned at this age and eat on the same plate as the other adults in the households (Mosha et al., 1998; Branson et al., 1999). Evidence also shows that children in this age group have an increased physiological demand for nutrients and are more susceptible to diseases such as diarrhoea (Stoltzfus et al., 1997; Nyaruhucha et al., 2006) and thus, increasing the likelihood of being affected when prices increase.

In the next step, we explore the mechanisms through which food price can affect children growth by paying particular attention to the quality and quantity of diet consumed in the household conduit. Households response to high food prices is likely to be heterogeneous across food producers and food nonproducers households. Since food producers can eat from their basket, the food elasticities certainly differ between the two groups. In columns (3) and (4) of Table 6, we provide evidence of the heterogeneous effect of maize price on the diet diversity and share of calories of maize consumed in food producers and food nonproducers households. Maize price has a statistically significant negative effect on the diet diversity score of food nonproducer households and a positive effect on the diet diversity score of food producers households. These results suggest that a maize price shock reduces the quality of diet intake among children from food nonproducers and improves the quality of the diet of children from food producers. These findings are supported by the summary statistics, which show a slight decline in the average diet diversity for food nonproducers from 9.3 in 2008 to 8.9 in 2012 and an increase from 7.3 to 7.5 in the same period for the food producers (Table A.11 in the appendix).

In column (4), we observe an increase in the share of calories from maize consumption among food nonproducers and a decrease among food producers. The high share of calories of maize consumption reflects a low level of diet diversity in the household. These findings suggest that food nonproducers could have been trapped in a situation that prevented them from substituting maize with other staples, cereals or micronutrient-rich food since their prices also increased, unlike the food producers who could consume from their own production.

It is also likely that food producers reduced their share of maize consumption and sold part for cash income to buy other types of food. This pathway cannot be undermined, particularly in areas with good access to markets where increasing income can significantly impact the household quality of diet. A study from Tanzania (Rudolf, 2019) shows that doubling income, proxied by expenditure, increases diet diversity by 1.3 units. The descriptive analysis reveals that about 53 per cent of the food producers reported selling food crops as their primary source of income and 11 per cent as their second source of income. The average quantity of maize sold increased from 454kg in 2008 to 781kg in 2012, which generated a more than a hundred per cent increase in the average real sale revenue (Table A.11 in the appendix). A similar observation was documented in Burkina Faso, where the increase in the price of the major staples improved the welfare of the farmers by a factor ranging from 2 and 6 percentage points in 2006 and 2011 due to agricultural price shock (Nakelse et al., 2018).

Changes in the price of main consumed staples can potentially affect the consumption of micronutrients (Ecker and Qaim, 2011). The analysis of the cross-price effect of maize on the consumption of micronutrient-rich food presented in Table 8 shows an improvement in diet quality among food producers when maize price increased. Specifically, maize price significantly increased the consumption of vitamin A, Meat and Fish, Nuts and seeds among food producers households and decreased their consumption among food nonproducers. The consumption of fruits significantly declined among food nonproducers, while the effect is not significant among food producers. When examined together with the results in column (4) in Table 6, it can be argued that food nonproducers households adjusted the consumption of micronutrient composition to maintain a higher calories intake. The find-

Table 8: Second Stage Estimates: Effect of Maize Price on Consumption Shares of other Food(in calories)

	(1) Vitamin	(2) Meat and Fish	(3) Nuts and Seeds	(4) Vegetables	(5) Fruits
Maize Price	-0.028***	-0.008***	-0.024***	0.001**	-0.002*
	(0.005)	(0.001)	(0.003)	(0.001)	(0.001)
Producer X Maize Price	0.015***	0.005***	0.015***	-0.001	-0.003
	(0.005)	(0.001)	(0.003)	(0.001)	(0.002)
Consumption(log)	0.006***	0.001***	0.001*	-0.000**	0.001*
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
Household Size	0.000**	0.000	-0.000***	-0.000**	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother's Education	0.000*	0.000***	0.000	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male Headed	-0.001	0.000	-0.000	0.000	0.001
	(0.002)	(0.000)	(0.001)	(0.000)	(0.001)
Head Age	0.000	-0.000	0.000***	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Child Age	-0.000	0.000	0.000**	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Child=Male	0.001	0.000	-0.000	-0.000*	0.000
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
Distance to Market	-0.000***	-0.000***	-0.000***	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Urban	0.011***	0.002***	0.005***	-0.001***	0.003***
	(0.002)	(0.000)	(0.001)	(0.000)	(0.001)
Producer	-0.136***	-0.042***	-0.120***	-0.001	0.018
	(0.034)	(0.006)	(0.023)	(0.005)	(0.013)
$Resid_1$	0.010***	0.001***	0.001	0.003***	0.002***
	(0.002)	(0.000)	(0.001)	(0.000)	(0.001)
$Resid_1$ X Producer	0.005	0.002***	0.000	-0.001*	0.003*
	(0.003)	(0.001)	(0.002)	(0.000)	(0.001)
Constant	0.160***	0.050***	0.166***	0.006	0.008
	(0.033)	(0.006)	(0.022)	(0.005)	(0.011)
Observations	6795	6795	6795	6795	6795

Notes: All specifications are controlled for survey year and community fixed effects. The standard errors (in parentheses) * p<0.10, ** p<0.05, *** p<0.01

ings are in line with the study by Romano and Carraro (2015) in Tanzania, which found a decline in consumption of macro and micro-nutrients among vulnerable urban households, which constitutes most food nonproducers in our sample.

Turning to the causal effects of diet diversity, columns (1) and (2) in Table 9 presents the final stage regression results for the impact of diet quality on child growth. As seen on the table, higher diet diversity has a statistically positive effect on the children HAZ. In-

Table 9: Final Stage Control Function Regression Results

	(1) HAZ	(2) HAZ
HDDS	0.221^{***}	
	(0.074)	
Maize Calories		-1.494^{***}
		(0.504)
Consumption(log)	-0.131	0.383^{***}
	(0.138)	(0.048)
Household Size	0.019^{**}	-0.018^{**}
	(0.009)	(0.007)
Mother's Education	-0.004	0.001
	(0.006)	(0.007)
Male Headed	-0.087	-0.109^{*}
	(0.060)	(0.062)
Head Age	0.005^{**}	-0.001
	(0.002)	(0.002)
Child Age	-0.011^{***}	-0.012^{***}
	(0.001)	(0.002)
Child=Male	0.160^{***}	0.174^{***}
	(0.034)	(0.041)
Distance to Market	0.002^{**}	-0.000
	(0.001)	(0.001)
Producer	-0.261	0.586
	(0.211)	(0.409)
Urban	-0.022	-0.529^{**}
	(0.100)	(0.222)
$Resid_1$	0.081	-0.316^{*}
	(0.116)	(0.185)
$Resid_1$ X Producer	-0.006	-0.120
	(0.127)	(0.178)
$Resid_2$	-0.171^{**}	1.446^{***}
	(0.076)	(0.530)
$Resid_2$ X Producer	-0.053^{**}	0.134
	(0.021)	(0.165)
Constant	-1.312	-5.852^{***}
	(1.380)	(0.526)
Observations	6827	6795

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

creasing the share of maize on household food consumption is shown to affect child growth negatively. Higher maize consumption share implies that children eat a less diversified diet which leads to faltering growth. The traditional variety of maize consumed by a large number of households have broadly shown to contain insufficient protein (Nuss and Tanumihardjo, 2010) which is essential for child growth and development (Henley et al., 2010; Akalu et al., 2010). Increasing consumption of quality protein maize can significantly improve the growth of children (Gunaratna et al., 2010).

6. Conclusion and Policy Recommendations

While a growing literature suggests that children are more vulnerable to high food prices, there is a paucity of evidence of whether the impact is heterogeneous across households that produce food and those who do not. Yamauchi and Larson (2019) is probably the only study that provides evidence of the differential impact of food price on the growth of children from food producers and food nonproducers households. We add to this literature by estimating a control function for endogenous switching regression using National Panel Survey data; 2008, 2010 and 2012. We empirically test the potential heterogeneous effect of high maize prices on children height-for-age z-score for the food producers and food nonproducers households in Tanzania.

The findings of this study show that children from food nonproducers experience a reduction in linear growth due to a maize price shock, unlike their counterparts from food producers who experience positive growth. We cautiously interpret the positive effect of maize as an increase in linear growth; instead, we consider it as a protective effect due to a slight significance and size of the coefficient and also the proportion of children that fell into a stunted condition in the year 2012 when the maize price peaked.

A maize price shock also generated negative gender bias against female children from food nonproducers, highlighting an important socio-cultural aspect of intra-household resource allocation, particularly during a crisis. Differential treatment of children was also evidenced in Uganda and Vietnam, where parents were found to reduce investment in education for the female children in response to income shock (Björkman-Nyqvist, 2013; Behrman, 1988). In terms of age, children who stop breastfeeding and begin to eat the same food as other household members eat appear to be more vulnerable to high maize price.

Moreover, high maize prices generated opposite effects on the households diet diversity score and share of calories of maize consumption. Food nonproducers reduced the diversity of their diet and increased the share of calories intake of maize which suggests a reduction in the quality of food intake for the children. On the contrary, food producers increased their diet diversity and reduced consumption of maize in the share of the food consumed in the same period. We find the same pattern in the consumption of micronutrient-rich food where a negative cutback was observed among food nonproducers while the effect was positive among food producers households. These findings provide suggestive evidence that food production can offer protection against food price shocks except if food price shocks are caused by climate change, which will reduce this shock immediately. Furthermore, children growth appear to improve when a household consumes a more diversified diet than increasing the consumption share of calories of maize. This evidence has important policy implications on food aid and transfer programs; the aim should be to enhance the diversity of a household's diet rather than focus on quantity alone.

The findings of this study enabled the identification of the group of children who are vulnerable to price shocks and highlight a potential entry point for social protection programs. Food safety net and cash transfer intervention programs that proved effective elsewhere in Sub-Saharan Africa (Bhalla et al., 2018; Dietrich and Schmerzeck, 2019) can be targeted to vulnerable children. Given that producers can benefit when producer prices spike above the average indicates the need for efficient government interventions to reduce fictions in the market by regulating what the middle man extracts. Export bans often used in Tanzania, and frequent and unanticipated minimum price announcements by the government should be avoided because they prevent farmers from exploiting the gains of the free market due to the distortions created in the economy. Notably, if not handled with great care, price regulations can sometimes bring unintended outcomes (Ecker and Qaim, 2011). Intervention through the National Food Reserve Agency (NFRA) should target the areas with relatively higher prices to ensure that subsidisation does not crowd out consumption of other micronutrients when the price is too low. Evidence from Malawi shows that the government maize subsidization program crowded out the consumption of Vitamin A and D (Ecker and Qaim, 2011).

The study has a few limitations. Food producer and nonproducer classification are based on the food consumption information in the last seven days. The producers could be erroneously misclassified into nonproducers if a particular household has nothing in stock during a survey (Yamauchi and Larson, 2019). Similarly, the data used in the analysis are not recent as the patterns could have changed since the last survey. More recent data might be insightful to explore the current trend.

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Appendices

A.

Table A.10: Proportion of Stunted Children in different HAZ categories by age

Year = 2008	Rural					Urban				
age group	HAZ<-2	-2<=HAZ<0	0<HAZ<2	HAZ>2	Total	HAZ<-2	-2<=HAZ<0	0<HAZ<2	HAZ>2	Total
6-23mo	214	192	36	3	445	69	64	18	3	154
	48.09	43.15	8.09	0.67	100	44.81	41.56	11.69	1.95	100
	30.75	28.7	28.57	37.5	29.69	38.55	22.46	25.35	42.86	28.41
24-60mo	482	477	90	5	1,054	110	221	53	4	388
	45.73	45.26	8.54	0.47	100	28.35	56.96	13.66	1.03	100
	69.25	71.3	71.43	62.5	70.31	61.45	77.54	74.65	57.14	71.59
Total	696	669	126	8	1,499	179	285	71	7	542
	46.43	44.63	8.41	0.53	100	33.03	52.58	13.1	1.29	100
	100	100	100	100	100	100	100	100	100	100
Year = 2010										
	HAZ<-2	-2<=HAZ<0	0<HAZ<2	HAZ>2	Total	HAZ<-2	-2<=HAZ<0	0<HAZ<2	HAZ>2	Total
	249	285	73	11	618	50	88	35	5	178
6-23mo	40.29	46.12	11.81	1.78	100	28.09	49.44	19.66	2.81	100
	33.74	29.66	43.2	61.11	32.77	35.97	29.24	46.05	71.43	34.03
	489	676	96	7	1,268	89	213	41	2	345
24-60mo	38.56	53.31	7.57	0.55	100	25.8	61.74	11.88	0.58	100
	66.26	70.34	56.8	38.89	67.23	64.03	70.76	53.95	28.57	65.97
	738	961	169	18	1,886	139	301	76	7	523
Total	39.13	50.95	8.96	0.95	100	26.58	57.55	14.53	1.34	100
	100	100	100	100	100	100	100	100	100	100
Year = 2012										
	HAZ<-2	-2<=HAZ<0	0<HAZ<2	HAZ>2	Total	HAZ<-2	-2<=HAZ<0	0<HAZ<2	HAZ>2	Total
	310	278	85	16	689	85	111	38	9	243
6-23mo	44.99	40.35	12.34	2.32	100	34.98	45.68	15.64	3.7	100
	34.52	24.98	42.93	76.19	30.9	39.91	30.25	37.62	81.82	35.12
	588	835	113	5	1,541	128	256	63	2	449
24-60mo	38.16	54.19	7.33	0.32	100	28.51	57.02	14.03	0.45	100
	65.48	75.02	57.07	23.81	69.1	60.09	69.75	62.38	18.18	64.88
	898	1,113	198	21	2,230	213	367	101	11	692
Total	40.27	49.91	8.88	0.94	100	30.78	53.03	14.6	1.59	100
	100	100	100	100	100	100	100	100	100	100

Table A.11: Changes in HDDS, Revenue and Quantity of Maize Sold (Averages)

Year		2008	2012	diff(p-value)
nonproducer	HDDS	9.3	8.9	0.0015
producer		7.3	7.5	0.0139
Maize	Quantity Sold	454.2	781.9	0.0016
	Revenue	102211.9	275939.6	0.0000

Table A.12: Chow Test

	df	F	P>F
Season	1	0.21	0.6465
Season X Maize Price	1	0.39	0.5314
Season X Producer X Maize	1	1.07	0.3017
Season X Consumption(log)	1	0.25	0.6146
Season X Household Size	1	1.77	0.1828
Season X Education	1	0.57	0.4491
Season X Head Age	1	0.63	0.4275
Season X producer	1	1.1	0.2935
Season X Male headed	1	0.04	0.84
Overall	9	1.54	0.1284
Denominator	6827		