Food and Agriculture Organization of the United Nations

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## Highlights

- El Niño induced drought affecting Southern Africa in 2015-2016 has triggered a rise of food prices in the region, especially those of cereals.
- The impact of the price increase of cereals is borne disproportionately by poorer and less endowed households.
- In order to maintain cereal consumption in vulnerable households in Lesotho, every percentage increase in the price of cereals would have to be matched by a 0.4 percent increase in total income.
- Assuming that increases in total income were to come only from the Child Grants Programme and that all other sources of income remained stable, the amount of the cash transfer would have to increase by 2% for every percentage point increase in the price of cereals.

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# 1. The macro context

The main staple food in Lesotho is maize, which is accessed through production and market purchases. Less than half of the domestic demand for staple foods is satisfied by the country's own production, while the rest is imported from South Africa. Lesotho is currently facing one of the worst droughts that hit the region in 35 years due to El Niño (WFP, 2015). Most small scale farmers relying exclusively on rains for irrigation will be out of business due to a failure in food production. Even for large scale farmers, planting has taken place only in exceptional cases, particularly in the lowlands and Senqu River Valley. The combination of the drought and the high reliance on rain-fed agriculture in Lesotho implies that many households will rely on purchases for food for most of the time during 2016 into 2017. Therefore, changes in food prices are critical for Lesotho as they have significant implications for household food security, particularly among poor and vulnerable households.

The overall consumer price index (CPI), which refers to the general retail price level, presents an upward trend throughout 2015, as does the food CPI. However, the food CPI is significantly higher than the overall CPI. In November 2015, the overall CPI had increased by 0.3 percent compared to the previous month, and 4.8 percent compared to last year; while the food inflation had increased by 3.0 percent compared to last month and 8.9 percent compared to last year. This implies that the prices of foods are increasing at a higher rate compared to the overall basket that is being monitored (Lesotho Bureau of Statistics, 2015). Food is the main driver of inflation as it counts for about 40 percent weight in the CPI.

Lesotho's Disaster Management Authority (DMA), which monitors trends in staple food prices, reports in its December 2015 market update that maize meal prices have kept increasing throughout the year and are currently above both last year's average and the last five years' average. Price increases ranged from 20 percent in the Qacha's Nek district to 32 percent in Butha Buthe from December 2014 to December 2015. The year on year change in maize price was 11 percent in Mohale's Hoek and 14 percent in Quthing. In the other districts, prices have gone up by less than 7 percent, while in the district of Leribe maize prices have remained relatively stable. This is likely only the beginning of a series of price increases at the retail level as wholesale prices increases in South Africa might add further inflationary pressure to retail prices (FAO, 2105).

The main factor contributing to local price increases in Lesotho and South Africa has been the tightening of maize supplies because of the production failure caused by the El Niño-induced drought. The depreciation of the Rand and expectations of reduced production continuing through 2016 have also put inflationary pressure on food prices. The drought is affecting the whole southern Africa region, especially South Africa and the two states that neighbour Lesotho: Free State and KwaZulu Natal. South Africa saw maize prices increase by an average of 58 percent from January-November 2015 compared with the same period in 2014. The price of wheat, the closest substitute for maize, is also increasing in both countries as a result of the drought.

Climate forecasts have predicted that El Niño would begin to decline in the spring of 2016, a period that is usually associated with below-normal rainfall in Lesotho (WFP, 2015). If it were possible to plant crops from August to November, the next harvest would be expected in May and June 2017. Given the persistent dry weather during the last crop planting season and the expected low performance in the agriculture sector in the coming months, the wholesale prices in the region and retail food prices are expected to increase even further during the next months until production and supply recover.

This continued rise in food prices will most likely reduce consumer purchasing power and will certainly lead to a deterioration of the food security situation in Lesotho. The aim of this report is to quantify by how much food consumption may decline in the country and to determine which of the most vulnerable segments of its population will suffer the most.

## 2. Micro implications

Under normal circumstances, producers are expected to reap some benefits from food price increases. In the case of Lesotho, however, producers are likely to suffer the same repercussions from the drought as do consumers in terms of food security. Usually, food-selling households benefit from higher incomes owing to price increases and this may compensate for the rise in the cost of foods they must purchase. Yet in Lesotho, most farmers barely produce enough for themselves. This indicates that net food-buying households, which generally make up most of the population in Lesotho and many other developing countries, will be adversely affected by any crisis in staple prices.

The nature and size of price effects on households that are both producers and consumers have important policy implications. Income from crop and livestock production, in addition to agricultural and non-agricultural wages and any other transfers, serves as the basis for decisions about consumption. Therefore, in theory, the overall price effect on household consumption is a traditional demand response, whereby demand decreases as a result of a price increases, and a supply response, which may lead to an increase in household production and possibly consumption.

In this report, we look at both the demand response and the supply response to a given increase in the price of different commodities. To do so, we adopt the Augmented Multimarket Approach proposed by Ulimwengu and Ramadan (2009). The multimarket framework incorporates both the production and the consumption sides. We estimate own- and cross-price supply elasticities from a system of four commodity groups - maize, wheat, sorghum and legumes – which represent the staple commodities in Lesotho. An increase in agricultural prices would normally create an incentive for farmers to produce more and would increase both the value of production and value of income from sales. However, given the current climate-induced generalized failure in production, we present the supply side of the analysis only for completeness.

On the demand side, we estimate own- and cross-price demand elasticities from a quadratic Almost Ideal Demand System (AIDS) of nine commodity groups (cereals, tubers, meat, milk, eggs, fats and oils, fruits and vegetables, legumes, miscellaneous). The aim of the latter estimation is to gauge by how much consumption may decrease in each food category given an increase in prices. The estimation is carried out separately for the group of the Child Grants Programme (CGP) beneficiary households and for the households used as control group in the CGP evaluation. We expect the cash transfer to act as a buffer against negative shocks in the households' purchasing power. Our working hypothesis is that the beneficiary group as a whole should display a higher elasticity of demand to the current price surge compared to the control group. Similarly, on the supply side, we would expect the treated group to be more reactive to the stimulus provided by the price increase and produce more in response. The cash transfer can be used to expand the scale of production (by using more inputs) or to increase its efficiency (through hiring mechanized tools and using better seeds and fertilizers) in ways that might have otherwise been impossible. In fact, previous research on the CGP has shown that beneficiary farmers do increase their consumption and production more than the control group (Daidone et al., 2014; Taylor et al., 2014; Dewbre et al., 2015). As noted above, this report mainly focuses on the demand side, namely, on estimating how much the current inflation in food prices undermines the purchasing power of poor households and determining how much the social cash transfers would need to increase to maintain the intended protection levels.

Economic shocks such as falling income in a recession or dramatic increases in food prices can lead to changes in purchasing behavior that are not necessarily predicted by elasticity estimates calculated with data collected under normal market conditions or different type of market stressors. It is important to understand the effects of such economic circumstances on diet quality, particularly in low-income groups. Our data were collected in 2011 and 2013, thus any extrapolation of the findings to the current situation must be interpreted with care, bearing in mind that some of the observed and unobserved characteristics of the sample may have changed in the meantime. This observation is especially critical on the supply side because a positive supply reaction to the price increases is unlikely, given the general production failure in production expected to result from the prolonged drought in Lesotho and in the neighboring countries. Moreover, the effects of food price increases may vary widely across districts or demographic groups in Lesotho. These heterogeneities have practical implications in terms of policy responses. In this report, we break down the impact of the price surge by demographic characteristics in order to ascertain which groups of the population might be hit harder than others.

## 3. Data

This study uses data from the household survey carried out to evaluate the impact of the CGP - an unconditional social cash transfer targeted to poor and vulnerable households. According to its original design the CGP transfer provided the equivalent of about 20 per cent of the monthly consumption expenditures of an eligible household. The program evaluation study involved 508 villages spread over 80 electoral divisions (EDs). The survey for the impact evaluation collected information for 747 eligible households in treatment EDs and 739 households in control EDs for a total sample size at baseline of 1486 units. To complete the longitudinal design the follow-up survey took place in the same period of the year, exactly 24 months after baseline, between June and August 2013. More details about the program and its evaluation can be found in Pellerano *et al.* (2014).

A brief overview of households' characteristics included in the study is shown in

Table, in which baseline and follow-up data have been pooled. The two treatment arms are quite similar on most demographic characteristics, such as household size, composition, main features of the household head, geographic distribution and labour constraints. The only noticeable difference concerns the share of cultivated area under irrigation, which is 6.7 per cent for CGP beneficiaries and 1.8 per cent for the households in the control group. Overall, households comprise 5.7 members on average, with around 2.5 adults of working age and a dependency ratio slightly below 3. The sample is equally split between male and female headed households, with the head being on average 52 years old. The protection of orphan and vulnerable children (OVC) is one of the objectives of the programme, thus it is not surprising to have a large number of orphans in the sample – 1.4 per household on average. The sample households are generally asset-poor, as evidenced by the amount of operated land, on average less than one hectare, and by the amount of livestock they own: 0.6 Tropical Livestock Units (TLUs), which equals around 6 goats/sheep or 1.1 cattle.[1]

[1] Sometimes there is a need to use a single figure that expresses the total number of livestock present, irrespective of the specific breeds. In order to do this, the concept of an 'exchange ratio' has been developed, whereby different species can be compared and described in relation to a common unit. This is a Tropical Livestock Unit (TLU).

**Table 1** **Sample household characteristics**

| | Controls | Treated | All |
|---|---|---|---|
| Operated land, ha | 0.7 | 0.9 | 0.8 |
| Area irrigated (%) | 1.8 | 6.7 | 4.4 |
| TLUs owned | 0.6 | 0.7 | 0.6 |
| Female-headed (%) | 52.8 | 49.2 | 50.9 |
| Household (HH) size | 5.5 | 5.9 | 5.7 |
| Dependency ratio | 2.9 | 2.8 | 2.9 |
| Age head HH | 52.0 | 52.0 | 52.0 |
| Educ head HH (years) | 4.2 | 4.0 | 4.1 |
| Highest educ HH (years) | 7.7 | 7.6 | 7.6 |
| Single-headed (%) | 58.8 | 55.4 | 57.0 |
| Sex ratio | 1.2 | 1.2 | 1.2 |
| Member 0-5ys | 0.8 | 0.9 | 0.8 |
| Member 6-12ys | 1.1 | 1.2 | 1.2 |
| Member 13-17ys | 0.8 | 0.8 | 0.8 |
| Males 18-59ys | 1.1 | 1.2 | 1.2 |
| Females 18-59ys | 1.2 | 1.3 | 1.3 |
| Males >60ys | 0.1 | 0.2 | 0.2 |
| Females >60ys | 0.3 | 0.3 | 0.3 |
| No. orphans | 1.4 | 1.4 | 1.4 |
| Widow-headed (%) | 49.6 | 45.5 | 47.5 |
| Elderly head (%) | 38.3 | 37.7 | 38.0 |
| Leribe (%) | 21.5 | 22.7 | 22.1 |
| Berea (%) | 29.8 | 26.5 | 28.1 |
| Mafeteng (%) | 24.4 | 26.5 | 25.5 |
| Qacha's Nek (%) | 4.9 | 4.2 | 4.6 |
| Labor unconstrained (%) | 68.2 | 68.2 | 68.2 |
| Moderately labor constrained (%) | 20.5 | 21.9 | 21.2 |
| Severely labor constrained (%) | 11.3 | 9.9 | 10.6 |
| HH sold crop in market (%) | 5.8 | 6.6 | 6.2 |
| Adult equivalents HH members | 2.9 | 3.0 | 3.0 |

## 4. Results

### Supply elasticities

Table 1 and Table 2 show supply elasticities for the treated and the control group, respectively, for maize, wheat, sorghum and legumes. The estimate in row *r* and column *c* refers to the percentage change in the supply of good *r* to a 1 percent change in the price of good *c*. The bolded numbers in the main diagonal of the tables refer to the own-price supply elasticity while the off-diagonal elements are the cross-price elasticities. For example, the entry in the first row and in the first column shows the own-price elasticity for maize, indicating that a 1 percent increase in the price of maize would be accompanied by an increase in production of maize of just 0.1 percent. The reason for this may be the low degree of commercialization among smallholders. When farmers do not engage in market transactions but tend to be self-sufficient, it is harder for changes in market price to translate into production stimuli. The entry in the first row and in the second column shows that an increase in the price of wheat of 1 percent would make this commodity relatively more profitable for farmers to grow compared to maize, whose production would therefore fall by 0.3 percent.

**Table 1** Supply elasticities for CGP beneficiaries

| | Maize | Wheat | Sorghum | Legumes |
|---|---|---|---|---|
| Maize | **0.1** | -0.3 | 0.1 | -0.1 |
| Wheat | -1.2 | **1.0** | 0.0 | 0.2 |
| Sorghum | -0.8 | 0.0 | **0.6** | 0.1 |
| Legumes | -0.9 | 0.1 | 0.2 | **0.3** |

**Table 2** Supply elasticities for the control group

| | Maize | Wheat | Sorghum | Legumes |
|---|---|---|---|---|
| Maize | **-0.4** | -0.1 | 0.2 | -0.1 |
| Wheat | -0.9 | **0.7** | 0.0 | 0.0 |
| Sorghum | -0.6 | 0.0 | **0.4** | 0.1 |
| Legumes | -0.9 | 0.1 | 0.2 | **0.5** |

As can be seen in Table 2, the price elasticity of maize's supply for the control group is negative. However, this is not necessarily an indication of the economic irrationality of the farmers. Households that do not produce enough food for their own needs may not want to sell their product in the face of price increases, because they might not be able to make enough money to purchase food in the market. Another explanation could be that transaction costs and general constraints to investment in agricultural production prevented farmers from engaging in the market. The rest of the own-price elasticities are positive for both the treated and the controls. For the treated, the own-price elasticity of supply is almost unity for wheat and 0.6 for sorghum. These numbers are consistently higher than the corresponding estimates for the controls; the reason may be that the treated are better equipped to respond to a price stimulus for these commodities thanks to the cash transfers that may allow them to carry out the necessary purchases of inputs, labor and tools they need to expand production and access the market. Finally, Table 3 reports the element-by-element difference in elasticities between the treated and the control group.

**Table 3** Inter-group differences in supply elasticities

| | Maize | Wheat | Sorghum | Legumes |
|---|---|---|---|---|
| Maize | **0.6** | -0.2 | -0.2 | 0.0 |
| Wheat | -0.3 | **0.3** | 0.0 | 0.1 |
| Sorghum | -0.2 | 0.0 | **0.1** | 0.0 |
| Legumes | -0.1 | -0.1 | 0.1 | **-0.2** |

## Demand elasticities

Table 4 and

| Elasticity of good r to price c | Cereals | Tubers | Meat | Milk | Eggs | Fats/oils | Fruits/ vegetab | Legumes | Rest |
|---|---|---|---|---|---|---|---|---|---|
| Cereals | **-1.0** | 0.1 | 0.1 | 0.1 | 0.0 | -0.1 | 0.1 | 0.0 | 0.0 |
| Tubers | 6.8 | **-1.4** | -7.8 | 4.1 | -1.6 | 3.0 | -1.7 | -1.2 | 6.2 |
| Meat | 2.5 | 0.6 | **-3.0** | 2.3 | -0.7 | 1.6 | -2.0 | -1.4 | 1.3 |
| Milk | 11.5 | 0.4 | -1.2 | **-8.7** | 0.4 | -5.6 | 2.7 | 8.8 | -9.5 |
| Eggs | -0.2 | -1.7 | -1.8 | 1.3 | **2.0** | -7.4 | 2.6 | 7.2 | -4.5 |
| Fats and oils | -0.8 | -0.1 | 0.4 | -0.3 | 0.0 | **-1.1** | 0.2 | 0.1 | -0.1 |
| Fruits and veg | -0.2 | -0.2 | -0.2 | -0.3 | -0.2 | 0.0 | **-1.0** | 0.0 | -0.1 |
| Legumes | -0.4 | -0.3 | 0.3 | -0.6 | -0.2 | 0.0 | 0.9 | **-1.4** | -0.2 |
| Rest (fish, sweet, bread, misc) | 0.6 | -0.6 | 0.2 | -0.9 | 0.2 | 0.2 | -0.8 | 0.3 | **-0.9** |

| Elasticity of good r to price c | Cereals | Tubers | Meat | Milk | Eggs | Fats/oils | Fruits/ vegetab | Legumes | Rest |
|---|---|---|---|---|---|---|---|---|---|
| Cereals | **-1.1** | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | 0.2 |
| Tubers | -1.0 | **-0.5** | 0.1 | -1.8 | -5.1 | -1.2 | -0.3 | 0.2 | -3.2 |
| Meat | 0.9 | -0.1 | **-1.2** | -0.2 | -0.4 | -0.1 | 1.1 | -0.1 | 0.0 |
| Milk | -9.2 | 2.9 | -3.7 | **11.9** | -12.0 | 10.7 | -7.4 | -1.6 | -25.6 |
| Eggs | 2.1 | -1.8 | -1.5 | -1.1 | **-4.6** | 1.2 | 8.8 | 0.2 | 4.4 |
| Fats and oils | -0.6 | 0.1 | 0.1 | -0.2 | 0.7 | **-1.0** | -0.5 | 0.2 | 0.3 |
| Fruits and veg | -0.2 | -0.1 | -0.1 | -0.1 | -0.3 | -0.1 | **-0.8** | 0.0 | 0.1 |
| Legumes | 0.1 | -0.2 | -0.3 | -0.1 | 2.5 | 0.0 | -0.3 | **-0.9** | -0.3 |
| Rest (fish, sweet, bread, misc) | 2.2 | -0.5 | 0.4 | 0.5 | -1.8 | -0.3 | -0.7 | 0.0 | **-3.0** |

Table 5 illustrate the uncompensated price elasticities of demand for the treated and controls, respectively[2], while

Table 6 shows results for the full sample. The bolded numbers in the main diagonal of each

| Elasticity of good r to price c | Cereals | Tubers | Meat | Milk | Eggs | Fats/oils | Fruits/ vegetables | Legumes | Rest |
|---|---|---|---|---|---|---|---|---|---|
| Cereals | **-1.0** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 |
| Tubers | 2.9 | **-0.5** | -1.6 | 1.3 | -2.1 | 2.3 | -0.3 | 1.4 | -3.5 |
| Meat | 1.3 | 0.3 | **-1.8** | 0.0 | 0.2 | 0.4 | 0.0 | -0.1 | 0.4 |
| Milk | 1.7 | 2.1 | -1.7 | **2.9** | -7.4 | 4.8 | -1.9 | 1.0 | -12.7 |
| Eggs | 1.3 | -1.6 | -2.0 | 0.3 | **-0.8** | -0.8 | 5.3 | 2.3 | 0.5 |
| Fats and oils | -0.6 | -0.1 | 0.3 | -0.2 | 0.2 | **-1.1** | -0.1 | 0.1 | 0.1 |
| Fruits and veg | -0.2 | -0.1 | -0.2 | -0.2 | -0.2 | -0.1 | **-0.9** | 0.0 | 0.0 |
| Legumes | 0.0 | -0.3 | -0.2 | -0.2 | 0.8 | 0.1 | 0.3 | **-1.0** | -0.3 |
| Rest (fish, sweet, bread, misc) | 1.4 | -0.5 | 0.4 | 0.0 | -0.4 | -0.3 | -0.8 | 0.0 | **-1.8** |

table refer to the own-price demand elasticity while the off-diagonal elements are cross-price elasticities. For example, the entry in the first row and in the first column shows that a 1 percent increase in the market price of cereals will automatically translate into a 1 percent decrease in

[2] See the methodological appendix for an explanation of compensated and uncompensated price elasticity.

the quantity of consumed cereals. The cross-price elasticities in the first column show changes in the quantity consumed of a good as a result of a one percent increase in the price of cereals. Looking, for instance, at the first column of Table 7, an increase in the price of cereals would cause households to substitute away from this good and increase consumption of tubers, meat and milk, as demonstrated by the positive cross-price elasticities on these goods. On the other hand, the cross-price elasticity of vegetables and fruits and of tubers is almost null, indicating that households would stick to the consumption of vegetables and tubers to substitute for the reduction in cereals.

A large price elasticity indicates that people are not vulnerable to increases in the price of a given commodity (Deaton, 1997). In our context, a price elasticity higher than unity implies that the percentage reduction in quantities consumed will be higher in magnitude than the percentage increase in price, leading to a reduction in the expenditure on that commodity. On the other hand, households with less than unity in price elasticity will be unable to substitute away from the good as it becomes more expensive and will have to increase expenditure on the good. This will probably put these vulnerable households into dire straits because they are already allocating 65 percent of their total expenditure to food.

It should be noted that for cereals, the main staple in Lesotho and the good that absorbs half of the households' budget (

Table 7), there are no significant differences in the own-price elasticity between treated and controls households. This is also true for fats, fruits and vegetables, legumes and the foods in the residual category that, together with cereals, make up almost 90 percent of household food expenditure. It may be that the cash transfer is not large enough to substantially influence the behavioral parameters of the consumption function. Moreover, as expected, cereals, oil and fruits and vegetables have smaller own-price elasticities (almost unity) because these are the goods that households rely upon most heavily.

The last row of

Table 7, which shows the average share of total expenditure allocated to each good, substantiates this point. Unsurprisingly, half of food consumption is concentrated on cereals and 20 percent on fruits and vegetables with minor shares devoted to animal products. Investing in cereals and vegetable production technologies and training could help households to reduce one of their core expenses, possibly liberating some part of the available cash for other needs[3].

[3] This idea finds empirical support in a previous report from Dewbre et al. (2015). The authors evaluated a combination of a social protection programme - the CGP – and an agricultural intervention - the FAO-Lesotho Linking Food Security to Social Protection Programme (LFSSP). The LFSSP combined training on homestead gardening and nutrition with the distribution of vegetable seeds to 799 CGP-eligible households. The report finds that households more than tripled their carrot, beetroot, and onion harvests (all three of which were included in the LFSSP package) over the study period and experienced significant increases in the production of peppers, tomatoes, and other types of vegetables not included in the LFSSP package. In particular, an additional year of CGP in combination with the LFSSP achieved many positive outcomes, which two years of receiving the CGP alone did not. This suggests that additional cash in combination with the LFSSP has the potential to positively

On the other hand, the own price elasticity of tubers and meat is considerably higher for the treated compared to the control group. Finally, the own price elasticity of eggs in the treated group and the one of milk in the control group are positive, which, in theory may indicate that these foods behave like Giffen goods in our context.[4] However, we attribute the "anomaly" to outlier individual level elasticities that pull up the sample average.

A certain increase in income does not translate entirely into an equal increase in consumption of a certain food item. Expenditure elasticity of demand indicates the change in the quantity demanded of a good for a given change in total expenditure. Expenditure elasticity is often used as a proxy for income elasticity since it is easier to obtain a reliable estimate for total expenditure from household surveys than for total income.

Table 7 reports expenditure elasticity estimates by food group and treatment arm. For both treated and control households, an increase of 1 percent in expenditure/income translates approximately into a 0.8 percent increase in consumed cereals.

**Table 4 Uncompensated demand elasticities for CGP beneficiaries**

| Elasticity of good r to price c | Cereals | Tubers | Meat | Milk | Eggs | Fats/oils | Fruits/ vegetab | Legumes | Rest |
|---|---|---|---|---|---|---|---|---|---|
| Cereals | **-1.0** | 0.1 | 0.1 | 0.1 | 0.0 | -0.1 | 0.1 | 0.0 | 0.0 |
| Tubers | 6.8 | **-1.4** | -7.8 | 4.1 | -1.6 | 3.0 | -1.7 | -1.2 | 6.2 |
| Meat | 2.5 | 0.6 | **-3.0** | 2.3 | -0.7 | 1.6 | -2.0 | -1.4 | 1.3 |
| Milk | 11.5 | 0.4 | -1.2 | **-8.7** | 0.4 | -5.6 | 2.7 | 8.8 | -9.5 |
| Eggs | -0.2 | -1.7 | -1.8 | 1.3 | **2.0** | -7.4 | 2.6 | 7.2 | -4.5 |
| Fats and oils | -0.8 | -0.1 | 0.4 | -0.3 | 0.0 | **-1.1** | 0.2 | 0.1 | -0.1 |
| Fruits and veg | -0.2 | -0.2 | -0.2 | -0.3 | -0.2 | 0.0 | **-1.0** | 0.0 | -0.1 |
| Legumes | -0.4 | -0.3 | 0.3 | -0.6 | -0.2 | 0.0 | 0.9 | **-1.4** | -0.2 |
| Rest (fish, sweet, bread, misc) | 0.6 | -0.6 | 0.2 | -0.9 | 0.2 | 0.2 | -0.8 | 0.3 | **-0.9** |

impact the food security and welfare of poor families. Most of the impacts related to small-scale homestead gardening practices are a consequence of the LFSSP and CGP.

[4] A Giffen good is a product that – contrary to the law of demand – people consume more of as the price rises and less of as the price falls. A Giffen good is typically an inferior product with no readily available substitutes. As a result, the income effect dominates the substitution effect.

**Table 5 Uncompensated demand elasticities for the control group**

| Elasticity of good r to price c | Cereals | Tubers | Meat | Milk | Eggs | Fats/oils | Fruits/ vegetab | Legumes | Rest |
|---|---|---|---|---|---|---|---|---|---|
| Cereals | **-1.1** | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.2 |
| Tubers | -1.0 | **-0.5** | 0.1 | 1.8 | -5.1 | 1.2 | -0.3 | 0.2 | -3.2 |
| Meat | 0.9 | -0.1 | **-1.2** | -0.2 | -0.4 | 0.1 | 1.1 | 0.1 | 0.0 |
| Milk | -9.2 | 2.9 | -3.7 | **11.9** | -12.0 | 10.7 | -7.4 | -1.6 | -25.6 |
| Eggs | 2.1 | -1.8 | -1.5 | -1.1 | **-4.6** | 1.2 | 8.8 | 0.2 | 4.4 |
| Fats and oils | -0.6 | 0.1 | 0.1 | -0.2 | 0.7 | **-1.0** | -0.5 | 0.2 | 0.3 |
| Fruits and veg | -0.2 | -0.1 | -0.1 | -0.1 | -0.3 | -0.1 | **-0.8** | 0.0 | 0.1 |
| Legumes | 0.1 | -0.2 | -0.3 | -0.1 | 2.5 | 0.0 | -0.3 | **-0.9** | -0.3 |
| Rest (fish, sweet, bread, misc) | 2.2 | -0.5 | 0.4 | 0.5 | -1.8 | -0.3 | -0.7 | 0.0 | **-3.0** |

**Table 6 Uncompensated demand elasticities for the full sample**

| Elasticity of good r to price c | Cereals | Tubers | Meat | Milk | Eggs | Fats/oils | Fruits/ vegetables | Legumes | Rest |
|---|---|---|---|---|---|---|---|---|---|
| Cereals | **-1.0** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 |
| Tubers | 2.9 | **-0.5** | -1.6 | 1.3 | -2.1 | 2.3 | -0.3 | 1.4 | -3.5 |
| Meat | 1.3 | 0.3 | **-1.8** | 0.0 | 0.2 | 0.4 | 0.0 | -0.1 | 0.4 |
| Milk | 1.7 | 2.1 | -1.7 | **2.9** | -7.4 | 4.8 | -1.9 | 1.0 | -12.7 |
| Eggs | 1.3 | -1.6 | -2.0 | 0.3 | **-0.8** | -0.8 | 5.3 | 2.3 | 0.5 |
| Fats and oils | -0.6 | -0.1 | 0.3 | -0.2 | 0.2 | **-1.1** | -0.1 | 0.1 | 0.1 |
| Fruits and veg | -0.2 | -0.1 | -0.2 | -0.2 | -0.2 | -0.1 | **-0.9** | 0.0 | 0.0 |
| Legumes | 0.0 | -0.3 | -0.2 | -0.2 | 0.8 | 0.1 | 0.3 | **-1.0** | -0.3 |
| Rest (fish, sweet, bread, misc) | 1.4 | -0.5 | 0.4 | 0.0 | -0.4 | -0.3 | -0.8 | 0.0 | **-1.8** |

Income support measures can help to counteract a fall in consumption resulting from the erosion of purchasing power caused by inflation in food prices. In microeconomic theory, the impact of price changes on consumer welfare is generally analyzed by the compensating variation (CV) method (Deaton, 1989), which represents the amount of money required to reimburse a household after a price change so that it can keep the same level of utility as before the change occurred. The compensating variation for simulated price shocks in cereals of +20 percent, +40 percent, +60 percent is computed following formula 10 in the methodological appendix (page 21). Results are shown for the treated, the controls and for the full sample in the fourth row of

Table 9, Table 10 and Table 11, respectively. Focusing on the full sample results, we see that to counteract a 20 percent increase in the price of cereals the necessary increase in total income in order to keep utility unchanged is 8.7 percent. For cereal price increases of 40 and 60 percent, total income has to increase by 15.3 and 20 percent, respectively. Therefore, on average for every 1 percent increase in the price of cereals, total income would have to increase by 0.4 percent to keep utility unchanged.

Further, let us assume that the necessary increase in total income to keep utility unchanged would derive from the exogenous component of income represented by the cash transfer while all other sources of income (crop, livestock, non-farm enterprise and wage labour) remained stable. In this scenario, the amount of the cash transfer, which represents only a fifth of total monthly expenditure, would have to increase by 0.4%*5=2% for every percentage point increase in the price of cereals in order to keep the utility of the latter from falling. The actual increase registered thus far in Lesotho's retail maize price, i.e. approximately 15 percent at the national level, would call for a 30 percent top-up of the amount of the CGP cash transfer.

We have estimated the impact of each of the simulated cereal price increases on three chosen poverty indicators: the "Head Count Ratio" (HCR), the "Poverty Gap" (PG) index and the Sen poverty index. The HCR is the percentage of the population living below the poverty line; the PG is the mean income shortfall with respect to the poverty line, expressed as a percentage of the poverty line. The Sen Index considers simultaneously both the HCR and the PG while taking into account the underlying distribution throughout the Gini coefficient of the income distribution of the poor. The higher the percentage/index, the worse the poverty outcome. The individual poverty line here is set at $1.90 a day (2011 PPP). The three indicators are first computed for the actual prices and incomes (benchmark scenario). After the shock, households face a new poverty line, which is household-specific and is obtained by adding the amount of the compensating variation for each household to the original poverty line. We use this new poverty line to assess the impact of a price shock on welfare represented by the three poverty measures.

Table 9, Table 10 and Table 11 show the simulation results for the beneficiaries, the control group and the full sample, respectively. Regardless of the price scenario, all poverty measures are slightly higher for the control group. For instance, the HCR in the benchmark scenario is 85.7 percent for the treated and 86.4 percent for the control. Also, the cereal price increases lead to a deterioration of all poverty indicators for both treated and controls. However, the increase in the head count ratio, for example, is higher among the controls, as expected.

**Table 7 Demand elasticities with respect to expenditure**

| | Cereals | Tubers | Meat | Milk | Eggs | Fats/oils | Fruits/ vegetables | Legumes | Rest |
|---|---|---|---|---|---|---|---|---|---|
| Treated | 0.8 | 2.3 | -3.6 | 10.8 | 16.4 | 1.8 | 1.9 | 2.6 | 0.4 |
| Controls | 0.6 | 5.0 | -2.3 | 34.3 | 1.1 | 1.6 | 2.0 | 1.9 | 1.7 |
| Full sample | 0.7 | 4.1 | -2.2 | 17.6 | 6.7 | 1.8 | 1.9 | 2.1 | 1.1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Expenditure share | 0.49 | 0.02 | 0.08 | 0.01 | 0.01 | 0.06 | 0.20 | 0.06 | 0.06 |

**Table 8** **Impact of simulated cereals' price shocks on poverty measures: treated**

| | Benchmark | 0.2 | 0.4 | 0.6 |
|---|---|---|---|---|
| HCR | 0.857 | 0.862 | 0.864 | 0.866 |
| PG | 0.404 | 0.408 | 0.412 | 0.415 |
| Sen | 0.507 | 0.513 | 0.516 | 0.519 |
| CV | | 0.088 | 0.155 | 0.203 |

**Note**: for tables 9 to 11, HCR stands for head count ratio, PG is poverty gap and CV is compensating variation.

**Table 9** **Impact of simulated cereals' price shocks on poverty measures: control**

| | Benchmark | 0.2 | 0.4 | 0.6 |
|---|---|---|---|---|
| HCR | 0.864 | 0.878 | 0.882 | 0.883 |
| PG | 0.408 | 0.416 | 0.420 | 0.422 |
| Sen | 0.504 | 0.518 | 0.522 | 0.525 |
| CV | | 0.086 | 0.151 | 0.195 |

**Table 10** **Impact of simulated cereals' price shocks on poverty measures: full sample**

| | Benchmark | 0.2 | 0.4 | 0.6 |
|---|---|---|---|---|
| HCR | 0.860 | 0.870 | 0.873 | 0.874 |
| PG | 0.406 | 0.412 | 0.416 | 0.418 |
| Sen | 0.506 | 0.515 | 0.519 | 0.522 |
| CV | | 0.087 | 0.153 | 0.200 |

## Vulnerability analysis

The rest of our analysis is dedicated to tracing a profile of the households that are most vulnerable to an increase in the price of cereals. To do so, we computed the own-price cereal demand elasticity for each household and compared the characteristics of the households with price elasticities below and above the average. Figure 1 presents a scatter plot of household level own-price elasticity of cereal demand (on the y axes) against the own-price elasticity of maize supply (x axes). The red lines represent the average price elasticity of demand (horizontal) and the average price elasticity of supply. The average price elasticity of supply is driven by positive outliers since most of the sample lies below the average. Average price elasticity of demand splits the sample in half. According to Ulimwengu and Ramadan (2009), the most vulnerable to a food price increase (the "losers") are those households with a below average demand elasticity and a below average profit elasticity (here we use the supply elasticity instead of the profit elasticity). As mentioned above, households with a low price elasticity of demand are the most vulnerable to a price increase while those with a low price elasticity of supply are less likely to benefit from a price increase. Here we compared only the households below the average price elasticity of demand with those above the average because the elasticity of supply is much less informative.

**Figure 1** **Household level elasticities**

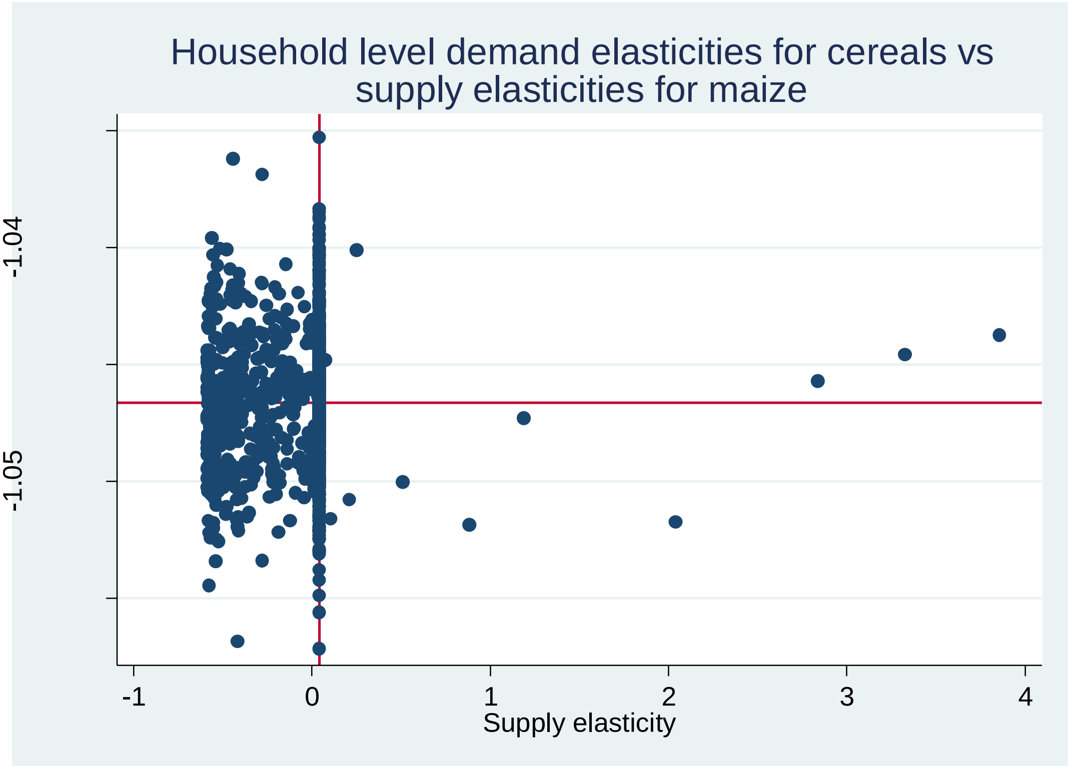


Table 11 shows the sample average of a set of observed characteristics for the two subsamples defined by the horizontal red line in Figure 1. The more vulnerable households have a smaller area of operated land, a smaller number of TLU and a higher dependency ratio. This finding clearly indicates that the most vulnerable households are less endowed with factors of production (land, livestock and labor). They are also less likely to be beneficiaries of the cash transfer, more likely to be female-headed, single-headed, widow-headed or severely labor-constrained. They are also less likely to participate in the output markets, either through selling or bartering part of their produce.

**Table 11** Average sample characteristics by level of uncompensated own-price demand elasticity of maize

| | High demand elasticity | Low demand elasticity |
|---|---|---|
| Treatment group (%) | 0.6 | 0.5 |
| Operated land, ha | 1.5 | 0.8 |
| Area irrigated (%) | 0.0 | 0.1 |
| TLU owned | 1.1 | 0.5 |
| Female-headed (%) | 0.4 | 0.5 |
| HH size | 5.7 | 6.2 |
| Dep ratio | 2.7 | 2.8 |
| Age head HH | 53.7 | 52.2 |
| Educ head HH (years) | 4.0 | 3.8 |
| Highest educ HH (years) | 7.8 | 7.4 |
| Single-headed (%) | 0.5 | 0.6 |
| Sex ratio (males to females) | 1.3 | 1.1 |
| Members 0-5ys | 0.8 | 1.0 |
| Members 6-12ys | 1.1 | 1.3 |
| Members 13-17ys | 0.8 | 0.8 |
| Males 18-59ys | 1.3 | 1.2 |
| Females 18-59ys | 1.3 | 1.4 |
| Males >60ys | 0.2 | 0.2 |
| Females >60ys | 0.4 | 0.3 |
| No. orphans | 1.0 | 1.4 |
| Widow-headed (%) | 0.4 | 0.5 |
| Elderly head (%) | 0.4 | 0.4 |
| Leribe (%) | 0.2 | 0.2 |
| Berea (%) | 0.3 | 0.3 |
| Mafeteng (%) | 0.3 | 0.3 |
| Qacha's Nek (%) | 0.0 | 0.1 |
| Labour unconstrained (%) | 0.7 | 0.7 |
| Moderately labor constrained (%) | 0.2 | 0.2 |
| Severely labor constrained (%) | 0.1 | 0.1 |
| HH sold crop in market (%) | 0.1 | 0.0 |
| Adult equivalents HH members | 3.0 | 3.1 |

# 5. Conclusions

At the moment, Lesotho is experiencing a large increase in the price of maize, the main staple food in the country. Two factors are likely to deteriorate the food security in the coming months. First, the current drought induced by El Niño is increasingly affecting countries in Southern Africa, especially South Africa, which is the main source of cereal imports for Lesotho. Wholesale prices for cereals are increasing in South Africa and are likely to be transmitted to Lesotho in the short-term. Second, the current depreciation of the Rand, to which Lesotho's Maloti currency is currently pegged *vis-à-vis* the US dollar, will make imports from other countries more expensive.

Regardless of the causes of food prices inflation, its most unwelcome effect is clear: a decrease in the consumption of staple foods. Rising food prices reduce consumer access to food. This effect is most severe among poor households, who spend a higher share of their income on food. This is a stylized fact as in a sample of nine developing countries, 88 percent of rural and 97 percent of urban poor households were net buyers of food (FAO 2008).

For the study, we used a demand system to simulate the effects of an increase in the price of food commodities. We based our analysis on data collected for the evaluation of the Child Grants Programme, which offers unconditional cash transfers to poor households with orphans and vulnerable children. The data represent the community councils where the pilot of the programme was implemented and were an extremely useful tool for assessing the likely impacts of a price surge on the poorest segments of the population.

The price increase had very diverse impacts on different socio-economic groups. The direct and first-order impacts of the price shock were borne disproportionately by the poorest and least endowed households. As for the possible policy measures to contrast the impacts of the current price surge we observed that, in order to maintain household utility unchanged, every percentage increase in the price of cereals would need to be matched by a 0.4 percent increase in income. If increases in total income would have to come only from the exogenous component given by the cash transfer while other sources remain stable, the amount of the cash transfer would have to increase by 2 percent for every percentage point increase in the price of cereals. The increase registered thus far (December 2015) in the retail maize price is approximately 15 percent at the national level, which would call for almost 30 percent increase of the amount of the cash transfer.

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## Methodological appendix

Following Singh et al. (1986), we consider a sequential basic decision-making process model of agricultural household where, first, the production decisions are determined by maximizing agricultural profit; and second, the consumption is determined by estimating a complete demand system. Let's assume a multi-output and multi-input household producer. A given household, that produces *n* outputs using *m* inputs, chooses the optimal level of output *i* ($y_i$) and input *j* ($x_j$) to maximize a profit function, given the output prices $p_i$ *i*={*1..n*} and the input prices $q_j$ *j*={*1..m*}:

$$\pi(p,x) = \sum_{i=1}^{n} p_i y_i - \sum_{j=1}^{m} q_j x_j \tag{1}$$

Assuming a logarithmic functional relationship between profits and the vector of output prices and input quantities, we can maximize the above profit function with respect to the output prices and the fixed quantities of inputs. This process yields the following output and fixed input share equations:

$$S_i = a_{i0} + \sum_h a_{ih} lnp_h + \sum_j c_{ij} lnx_j + \varepsilon_i \tag{2}$$

$$R_j = b_{j0} + \sum_k a_{jk} lnx_k + \sum_i c_{ij} lnp_j + \omega_j$$

where $S_i$ is the share of the output *i* in the revenue while $R_j$ is the share of input *j* in the total cost and the constant terms are modeled as linear indexes of observed characteristics as $a_{i0} = X'\beta_S$ and $b_{j0} = X'\beta_R$ and *X* includes a column of ones. We control for household size, female headship, area of operated land, number of TLUs owned and dependency ratio. In order to identify all the parameters, some cross-equations constraints need to be imposed on system (2), specifically, adding up constraints, homogeneity constraints and symmetry constraints (see Ulemwengu and Ramadan, 2009; Wadud 2006).

We compute the elasticity of commodity *i* with respect to price of commodity *h* by the following standard formula that uses the share of the outputs and estimated coefficients of system (2):

$$es_{ih} = S_h + \frac{a_{ih}}{S_i} - \delta_{ih} \tag{3}$$

where $\delta_{ih}$ is the Kronecker delta, which is unity if $i$=$h$, and zero otherwise ($\delta_{ih} = 1[i = h]$).

As pointed out earlier, we augment the traditional multimarket approach with demand elasticities derived from the AIDS, based on expenditure function (Deaton and Muellbauer 1980). For the estimation of the Almost Ideal Demand System and the related compensated and uncompensated demand elasticities we follow Lamber et al. (2006). The presentation here is brief; for an in-depth analysis of consumer behaviour and demand-system analysis, see the classic monographs by Deaton and Muellbauer (1980). We consider a consumer's demand for a set of *k* goods for which the consumer has budgeted *m* units of currency. The quadratic AIDS model of Banks, Blundell, and Lewbel (1997) is based on the indirect utility function:

$$lnV(\boldsymbol{p},m) = [\left\{\frac{lnm - lna(\boldsymbol{p})}{b(\boldsymbol{p})}\right\}^{-1} + \lambda(\boldsymbol{p})]^{-1} \tag{4}$$

where $\boldsymbol{p}$ is a vector whose i-th element is $p_i$, the price of good i for i = 1, . . . , k, $\ln(a(\boldsymbol{p}))$ is a transcendental price index given by the linear combination of the commodities price and all their possible interactions, $b(\boldsymbol{p}) = \prod_{i=1}^{k}(p_i)^{\beta_i}$ and $\lambda(\boldsymbol{p}) = \lambda_i lnp_i$. Lowercase Greek letters represent parameters to be estimated. Let $Q_i$ denote the quantity of good i consumed by a household, and define the expenditure share for good *i* as $w_i = p_i Q_i$/m. Applying Roy's identity to (1), we obtain the expenditure share equation for good *i*:

$$w_i = \alpha_i + \sum_{j=1}^{k}\gamma_{ij} lnp_j + \beta_i \ln\left(\frac{m}{a(\boldsymbol{p})}\right) + \frac{\lambda_i}{b(\boldsymbol{p})}\left[\ln\left(\frac{m}{a(\boldsymbol{p})}\right)\right]^2 \quad i = 1,2..k \tag{5}$$

When $\lambda_i$= 0 for all i, the quadratic term in each expenditure share equation drops out, and we are left with Deaton and Muellbauer's (1980) original AIDS model.

Sociodemographic variables are typically incorporated into demand system analysis *via* demographic translation. Demographic translation assumes that the constant terms in the share equations vary across households and that they can be expressed as a linear function of sociodemographic variables. So instead of $\alpha_i$we will have a linear combination of $H$ covariates, $\sum_{j=1}^{H}\alpha_{ij}X_{ij}$.

This set of expenditure share equations requires nonlinear system estimation techniques because of the price index $lna(\boldsymbol{p})$Therefore, we consider a linear approximation based on the Stone index as in Moschini (1995). Instead of using the translog $\ln(a(\boldsymbol{p}))$, we replace it with $lna^*(\boldsymbol{p})$

$$\ln\big(a^*(p)\big) = \sum_{i=1}^{n}\bar{w}_i \ln(p_i) \tag{6}$$

where $\bar{w}_i$ is the average budget share of good i over all households. Second, we set $b(\boldsymbol{p})$=1 to avoid nonlinearity in the $b(\boldsymbol{p})$. These two assumptions make our system of equations linear in parameters.

One of the econometric challenges in the analysis of consumption survey data is to properly handle the large number of "zero" purchases. Some households may never consume the good. The zero purchase may simply reflect a corner solution or the good was too pricey during the week the survey was conducted. Shonkwiler and Yen (1999) developed a two step strategy to handle the censoring problem which we follow here. In order to derive an equation for the observed budget share $BS_i$, an analytical expression for the unconditional expectation of $BS_i$ is required. The unconditional mean accounts for both the probability of observing a positive consumed amount of a certain good and the quantity actually consumed. The unconditional mean is defined as the conditional mean value multiplied by the probability of a positive observation. If we denote the density and the cumulative functions of the standard normal distribution by $\varphi(.)$ and $\Phi(.)$, respectively, the unconditional mean of $BS_i$, is:

$$E[\,BS_{ih}] = \Phi(z'_{ih}\kappa_i)w_{ih} + \theta_i\,\varphi(z'_{ih}\kappa_i) \tag{7}$$

where $h$ indexes households. Equation (7) provides the basis for the censored quadratic AIDS budget share system.

The first step consists of estimating the parameters $\kappa_i$, which are directly related to the binary decision of whether to purchase. Consistent estimates of $\kappa_i$ can be obtained by using the probit model to explain the binary outcome. By replacing $\kappa_i$ with its estimate, we then recover the parameters in system 7**.** There is no need to delete one equation from the system and the whole n equation system is estimated with the SUR procedure.

Finally, we present the formulas for the elasticities for the quadratic AIDS model with demographic variables. The uncompensated (Marshallian) price elasticity of good *i* with respect to changes in the price of good *j* is

$$ued_{ij} = \frac{\mu_{ij}}{E[BS_i]} - \delta_{ij} \text{ where } \mu_i = \frac{\partial E[BS_i]}{\partial \ln(p_j)} \; and \; \delta_{ij} = 1[i = j] \quad (8)$$

The expenditure (income) elasticity for good *i* is

$$xed_i = \mu_i / E[BS_i] + 1 \text{ where } \mu_i = \partial E[BS_i] / \partial \ln(m) \quad (9)$$

Compensated (Hicksian) price elasticities are obtained from the Slutsky equation as $ced_{ij} = ued_{ij} + xed_i E[BS_j]$ .

If the own-price elasticity of demand, either compensated or uncompensated, is equal to 1 (ed=1), the demand is defined as being unit elastic while the demand is defined as being elastic if ed>1 and inelastic if ed<1. Ed=1 means that a price increase of 1% will reduce demand for a good by 1%. The expense on a good will, however, remain the same when the demand is unit elastic. If the demand is inelastic a price increase means that the decrease in the purchased quantity will be relatively smaller than the increase in price. So the consumer's total expense for the good in question increases. The opposite is the case at a price increase of a good where the demand is elastic.

Income elasticity shows the percentage increase in the demand for a given good as a result of a percentage increase in income. Generally, the income elasticity for necessities is smaller than for luxury goods. Economic theory predicts that income elasticity of food decreases as households move up the income distribution, as demand for agricultural commodities responds less to income increases. An increase in the price of one good has both a substitution effect and an income effect. The substitution effect will cause households to demand less of the good that has become relatively more expensive. The income effect goes in the same direction since it implies a general reduction in purchasing power caused by the price increase.

The compensated own-price elasticity is numerically smaller than the uncompensated version (general own-price elasticity). The cause for this is that the uncompensated elasticity is found by looking at the percentage change in the price for a maintained income level, whereas the compensated own-price elasticity is calculated by maintaining the utility level. The difference between the two elasticities corresponds exactly to the total proportion of budget which the consumer uses on good $i$. That is, the bigger the proportion of the budget being used on good $i$, the more the consumer is affected by a price increase on good $i$. The same argumentation could also explain why the compensated cross-price elasticity is numerically bigger than the non-compensated one.

The fundamental difference between the Hicksian demand function and the general or Marshallian demand function is that when you consider the change in the Hicksian demand at a price increase on a good the consumer should have the same utility level before and after the price increase. Therefore, we assume that the consumer is compensated for the price increase through a rise of income. Consequently, the income effect is disregarded so that only the substitution effect is left. The opposite applies to the Marshallian demand, i.e. the income is constant while the utility level might change. For a normal good, the Hicksian demand curve is less responsive to price changes than is the uncompensated demand curve – the uncompensated demand curve reflects both income and substitution effects, while the compensated demand curve reflects only substitution effects.

In microeconomic theory, the impact of price changes on consumer welfare is generally analysed by the compensating variation method. The compensating variation represents the amount of money required to compensate the household after a price change occurs and such that the household keeps the same level of utility as before the change in price. The compensating variation per each household is computed here as a second-order Taylor series expansion approximation (Friedman and Levinsohn, 2001):

$$\Delta \ln(CV_h) \approx \sum_{i=1}^{n} w_{ih} \Delta \ln(p_{ih}) + 0.5 \sum_{i=1}^{n} \sum_{i=1}^{n} w_{ih} ued_{ij} \Delta \ln(p_{ih}) \Delta \ln\left(p_{jh}\right) \quad (10)$$

Thus, in order to understand these effects better we take the poverty line as given. After the shock, individuals face a new poverty line. This poverty line is individual-specific and is obtained by adding the amount of the compensating variation for each individual to the original poverty line. We use this new poverty line to assess the impact of a price shock on welfare by using some poverty measures. In this study we refer to three indicators: (i) the "Head Count Ratio" (HCR); (ii) the "Poverty Gap" (PG) index and (iii) the Sen (1976, 1997) poverty index. The HCR is the percentage of the population living below the poverty line; the PG is the mean income shortfall with respect to the poverty line, expressed as a percentage of the poverty line (households above the poverty line are not considered): $PG = 1/G \sum_{i=1}^{G} (\frac{p-y_g}{p})$, where G is the total population of poor, p is the poverty line and $y_g$ is the income of poor household g. The Sen Index considers simultaneously both the HCR and the PG while taking into account the underlying distribution throughout the Gini coefficient of the income distribution of the poor. The higher the percentage/index, the worse the poverty outcome, Sen = HCR [PG+(1 – PG) Gini].

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