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Rising food prices and undernourishment: A cross-country inquiry

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A B S T R A C T

Households' welfare in developing countries has been hit by dramatic food prices increases which occurred between 2005 and 2008. In this paper, we adopt a partial equilibrium approach to analyze the short-time effects of a staple food price increase on nutritional attainments, as a measure of welfare. The analysis consists of first approximating complete food-demand systems and then performing household level micro-simulations. Instead of focusing on a single country profile, we provide a more complete snapshot by comparing the evidence through a cross-country assessment made possible by the use of nationally representative household surveys. Comparability is assured by the adoption of the same methodological choices in the treatment of the micro data. We find that food price spikes not only reduce the mean consumption of dietary energy, but also worsen the distribution of food calories, further deteriorating the nutritional status of populations. We also discovered that access to agricultural land plays a significant role in ensuring adequate nutritional attainments in rural areas, and surprisingly, even in urban areas.

Introduction

The main objective of this paper is to assess the household-level food security impact of tradable staple food price increases in developing countries. We adopt a partial equilibrium approach by simulating the food demand response of households to a price shock, thus considering mainly short-term effects or direct effects on consumers and producers.

The motivation for this paper stems from the recent upward trends in global food prices, concerning overall many staple commodities between 2005 and 2008.[1] Although by early 2009, most food prices had fallen from their peaks, they remained well above 2005 levels. In this context, the major source of concern is clearly related to the possible reduction of consumption levels: households may be forced to reduce both their food consumption, in response to the price surge, and other longer-term expenditures, such as education, in order to meet basic needs. However, the impact of soaring food prices on welfare is likely to be very diverse, depending upon which commodity prices change and the structure of the economy. Governments may play an important role by setting specific market and trade policies with the aim of protecting domestic markets and calming down the internal effects of price fluctuations.[2] This may come at the risk of increasing international volatility. Further, the overall effect of price increases on poverty depends also on the distribution of net buyers and net sellers of food among low-income households, i.e. it depends on whether the gains to poor net producers offset the adverse effects on poor consumers (Aksoy and Izik-Dikmelik, 2008).

In this kind of study, the monetary value of food consumption or total expenditure is generally used as a measure of living standards. Ul-Haq et al. (2008) and Brambila et al. (2009), for example, estimate an Almost Ideal Demand System (AIDS), which serves as a basis for their simulation exercise respectively for Pakistan and Zambia. Ivanic and Martin (2008) use an expenditure function to characterize household consumption and factor supply behavior and a profit function to represent household production activities in ten low-income countries; this yields an expression for the welfare impacts of small price changes.

This paper instead focuses on food security for several reasons: (a) from an academic point of view, nutrition is of particular interest as a proximate determinant of human growth, which may have functional consequences for health, labor productivity, cognitive development and personality, which in turn may influence socio-economic conditions (Steckel, 1995); (b) as shown below, poverty and undernourishment do not exactly correlate, and therefore have different determinants; and (c) from an institutional point of view, eradication of extreme hunger together with poverty are among the targets of the first Millennium Development Goal.

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[1] For example, the price of maize rose by 80% between 2005 and 2007, wheat by 70%, and rice by about 25%.

[2] There is a broad literature covering this topic. We refer for instance to Ravalion and Walle (1991), Jensen and Manrique (1996), and Ravallion and Lokshin (2004).

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The nutritional analysis we undertake is commonly considered as part of the food security literature, which has become increasingly relevant to policy makers. Food security is essentially a three-dimensional concept: it embodies availability (food supply), access (the economic capacity to attain food), and utilization (food safety, micro-nutrient sufficiency, etc.). These dimensions are hierarchical, with the first concept of availability necessary but not sufficient for the other two. All countries considered here are food-secure with respect to availability (average dietary energy supply is well above minimum dietary energy requirements[3]), which justifies this paper's focus on access; measured here through undernourishment (specifically dietary energy deficiency) as the indicator. Most household-level food security indicators are relatively simple indicators of diet quantity and/or diet quality.[4] In this study, a household is defined as undernourished if its dietary energy consumption (caloric intake) falls below its minimum dietary energy requirement (MDER). For exposition purposes, in this paper we interchangeably use the concepts of undernourishment and food insecurity, while acknowledging that the latter encompasses the former.

The analysis presented below is similar to the more common poverty analysis present in the literature. Both ask similar questions (who are the poor/food insecure? what are the causes and consequences of their poverty/food insecurity?); both share the same approach, requiring a measure of welfare to compare households/individuals (expenditure vs. dietary energy consumption) and a threshold by means of which households can be classified (poverty line vs. energy requirements). The main difference regards the way how the caloric threshold is measured. We estimate energy requirements accounting for both household composition in terms of age, sex and presence of pregnant women; and the country-specific biometric distribution. The other significant difference is that given the relative size of the poverty and food security literature, we know a much more about the former.

Our contribution to the empirical food security literature lies first in the usage of household-specific energy thresholds, which blends into the micro-analysis of undernourishment the best available guidelines regarding dietary energy requirements, FAO (2004). Also, we offer a novel cross-country assessment made possible by using national living standards household surveys. Instead of focusing on a single country profile, by first computing a food demand system and then performing a micro-simulation, we provide a more complete snapshot, comparing the evidence over an extended set of countries. In order to accomplish this task and keep consistency, we adopt the same methodological choices in the treatment of the micro data. Further, instead of using food demand elasticities from different non-comparable studies, we decided to use demand parameters from the cross-country study of Seale et al. (2003), which provides comparable, "conservative" estimates, while consistent with what is found in the literature. We further complemented the available own-price elasticities with computed cross-price elasticities consistent with consumer theory, following the technique suggested by Beghin et al. (2003), to account for mitigating substitution effects.

The paper is organized as follows. Section 2 describes the use of household surveys for food security analysis and the main methodological choices taken. In Section 3 we discuss our food price simulation approach, while in Section 4 we present the food security profile of eight selected countries. We proceed by presenting simulation results and a study of the determinants of food security. Finally, we provide some conclusions.

Methodology

The total dietary energy consumed by individuals depends on the quantity of food consumed and its caloric content:

$$E = \sum_j c_j \cdot x_j(\mathbf{p}, \mathbf{y}) \tag{1}$$

Food consumption is usually measured at the household level, so we define x_j as the per-capita demand of food item j, c_j is the energy content of the edible part of food item j, and E is the total dietary energy intake, measured in kilocalories per capita per day. As the energy conversion factors are fixed, as they depend on the nutritional content of food, the changes in dietary energy consumption are given by the changes in food consumption

$$dE = \sum_j c_j \cdot dx_j(\mathbf{p}, \mathbf{y}) \tag{2}$$

Food consumption will change as a result of food price variations, due to both a change in real income, and indirectly by changing nominal household income if the household is a producer of food

$$dx_j = \frac{\partial x_j(\mathbf{p}, \mathbf{y})}{\partial p_i} \cdot dp_i + \frac{\partial x_j(\mathbf{p}, \mathbf{y})}{\partial y} \cdot \frac{\partial y}{\partial p_i} \cdot dp_i, \tag{3}$$

In (3) income y is the sum of the different goods and services (including labor supplied) produced by the household, valued at their market prices, that is, $y = \sum_i p_i y_i$, and hence $\partial y / \partial p_i = y_i$. We can multiply and divide terms to re-write Eq. (3) as:

$$d \ln x_j(\mathbf{p}, \mathbf{y}) = [\varepsilon_{\mathbf{ji}} + \gamma_{\mathbf{i}} \cdot \eta_{\mathbf{j}}] \cdot \mathbf{d} \ln \mathbf{p_i},$$

which shows that as a result of a price change of food item i, the percentage change in each food item j consumed will vary proportionally to the percentage change in the price food item i multiplied by the cross (or own) price demand elasticity (ε_{ji}) and the income demand elasticity η_j of food item j multiplied by the share in disposable income of the value of the production of the food item i, $\gamma_i = p_i y_i / y$.

The change in total dietary energy consumed, as a result of an increase in the price of food item i will be given by:

$$\frac{dE}{E} = \frac{dp_i}{p_i} \sum_i \beta_j \cdot [\varepsilon_{ji} + \gamma_i \cdot \eta_j], \tag{4}$$

where β_j is the share of good j in total dietary energy consumption: $c_i x_j(p, y) / \sum_i c_i x_i(p, y)$. Eq. (4) presents a key relationship; in it, the economics given by (3) get limited by the nutritional constraints given by (1). For example, for countries with a less diverse diet, where the staple accounts for a large share of food consumption, the bulk of the change in dietary energy consumption will be given by the changes in the consumption of the staple foods, which account for a larger share of dietary energy intake. Even if some food items suffer large proportional changes, their impact on dietary energy will be lower than smaller proportional changes in the consumption of the staple.

Many choices have to be made in order to arrive to an empirical estimate of household and individual level dietary energy intake. These choices include: how to deal with outliers, which food composition table to use, how to add the energy equivalent of expenditures on food eaten away from home, etc. It is beyond the scope of this paper to explain these in detail, but we refer the reader to Smith and Subandoro (2007), which constitutes an excellent handbook on how to use household surveys to obtain food security indicators; Sibrián et al. (2008), which is our reference manual on how

[3] Dietary energy supply, available at http://faostat.fao.org/, measures the dietary energy available per capita after accounting production, net of exports and imports, and subtracting non-food uses of crops (like seeds and feedstock).

[4] See (Smith and Subandoro, 2007) for a more detailed illustration of the main household-level food security indicators.

to convert food quantities into dietary energy intake; and to the methodological appendix available online.

In the exercise presented below, the goal is to simulate the short-term impact of a price spike of tradable cereals (rice, maize, and wheat), such as that observed during the food, oil, and financial crisis of 2008. Therefore, the simulated price is not necessarily that of the main staple, which could be a non-tradable product, but the price of the main tradable staple. Hence, in this exercise only short-term effects are captured. In the medium and longer term, the rise in tradable foods causes inflation of other goods including other food items. Also, wages may adjust reflecting the change in the profitability of sectors. These second-stage general equilibrium effects are not captured in this analysis.

Surveys and countries considered

In this study we estimate the effects of rising food prices using household surveys from eight different countries, namely: Bangladesh, Guatemala, Nepal, Cambodia, Tajikistan, Vietnam, Kenya, and Malawi. The selection of these countries, from the twenty-eight countries included in the RIGA household survey database (Davis et al., 2010), was based on data quality and the aim of having illustrative samples from different developing regions, and examples of the dietary differences in the main tradable staple foods. While obviously not a statistically representative sample of the developing world, in this small group Kenya and Malawi, for example, not only reflect the development realities of sub Saharan Africa, but the dietary characteristics of maize-consuming countries of Eastern and Southern Africa. Furthermore, all chosen surveys are compatible with food security analysis as they record all sources of food consumption, namely: purchased food, own-production, food received in the form of a gift or a payment, and finally food eaten away from home.

The design of a useful (for nutrition analysis) food consumption survey is not a science because the designer has to compete with conflicting sources of bias.[5] If the recall period is too short you run into problems of "telescoping" or attributing to the recall period recent consumption. If the recall period is too large there will be an increase in the recall error, which is why 1 or 2 weeks is standard practice for surveys that measure consumption. The optimal number of food items to include depends on the diversity of local diets. However, if too few items are included, the survey will miss consumption; if too many are included, the interviewer and interviewee will run into "diary exhaustion" and increase reporting errors. In our sample of surveys, Tajikistan is in the lower limit of what is usually considered the minimum necessary for nutrition analysis, while Cambodia is perhaps above what is normally recommended.

Surveys that measure consumption are usually preferred over those that measure acquisition (purchases), because actual consumption can occur without acquisitions in the reference period, and not all the acquisitions are consumed during the reference period. This leads to acquisition surveys having higher variance of measured dietary energy intake, but nonetheless they produce remarkably close estimates of mean dietary energy intake and expenditures, Smith et al. (2006). It is generally recommended to use long reference periods when measuring acquisition, both to reduce the difference between acquisition and actual consumption, as explained above, and to capture less frequently purchased items, Ohri-Vachaspati et al. (1998). The two surveys in our sample (Nepal and Vietnam) that use acquisition use 1 month as the reference period.

[5] See (Smith et al., 2006) for a more detailed discussion of the issues and biases in food consumption surveys.

Micro-simulation approach

Choice of food demand elasticities

As can be seen from (3) and (4), price and income elasticities play a central role in the outcome of the simulations. Of similar importance are, of course, the population and dietary characteristics contained in the household surveys, such as distribution of dietary energy consumption, food consumption, and demographic characteristics. However, as elasticities are treated as exogenous in our analysis they need to be carefully selected.

Income elasticities obtained from food expenditure/acquisition surveys over-estimate true income elasticities.[6] Wealthier households tend to make larger purchases than what they actually consume, because the wealthy transfer some of their purchased food to lower income groups; buy food that is given to guests and pets; can afford to buy in bulk and usually do; and, in all likelihood, have a higher level of food wastage. The over-estimation can be large: Bouis (1994) showed that the food income elasticities obtained from food expenditure surveys are usually inconsistent with observed nutritional outcomes. It is also known, from early estimations of Engel functions that income elasticities obtained from time-series data is much lower than that observed in cross sections (Tobin, 1950; van Driel et al., 1997).

In his survey of fifteen studies that described food demand elasticities across income groups, Alderman (1986) concluded that "it is widely, if not universally, acknowledged that income elasticities for food items decline with income [p. 35]". The voluminous work that has followed this study has not contradicted this hypothesis. The fact that food income elasticities fall with income is not the same as the well-accepted Engel's law, but it is related. We expect these elasticities to be higher for lower income groups, because their consumption base is lower. Furthermore, this observation is also consistent with the stylized fact that the poor, who consume proportionally more food, devote a larger share of any additional income to buying food items.

The relation between price elasticities and income is less clear. We can start from the well-known Slutsky decomposition:

$$\varepsilon_{ii} = h_{ii} - \alpha_i \cdot \eta_i, \tag{5}$$

which shows that the Marshallian price elasticity (ε_{ii}) is equal to the compensated or Hicksian (constant real income) elasticity (h_{ii}) minus the share of the good in consumption (α_i) times the income elasticity (η_i) of the good. From Engel's law we know that for food overall α falls with income, and for most food items/income groups this is true also. Further, let's accept the above hypothesis relative to income elasticity and wealth, to conclude that if the compensated elasticities were constant, then Marshallian elasticities should fall with income.[7] However, compensated elasticities are not constant. Timmer (1981) started a lively debate in the literature by showing that, in general, food demand compensated elasticities fall with income, and most of the following studies have corroborated this outcome. Thus, if both compensated and income elasticities decline with income, then Marshallian elasticities would also decline with income as (5) implies.[8]

However, the fact both Marshallian and compensated elasticities fall with income is not a universal result. It is not uncommon to find that the poorest have lower own-price elasticities (Marshal-

[6] See for instance (Bouis and Haddad, 1992; Bouis, 1994; Ohri-Vachaspati et al., 1998).

[7] We are talking about price elasticities in absolute values, as is standard practice.

[8] The fact that most demand studies do not consider quality of the goods may lead to under estimation of price elasticities. Prices in cross-section studies are usually obtained from unit values (expenditures divided by quantity), but as wealthier households consume goods of higher quality their effective price is over-estimated, which would lead to the appearance of demand being more inelastic.

lian and compensated) than middle-income groups.[9] If one observes own-price elasticities across countries of different income levels, one will discover that they clearly fall with income: Alderman (1986) does this exercise, or one can examine the cross-country elasticities of Seale et al. (2003) study to confirm that this is the case. Further, most food price demand elasticities fall with income, but in many cases the price elasticity of the staple food in poor countries has an inverted-U shape relation with income (rice in Thailand and coarse grains in Philippines (Alderman, 1986), maize in Malawi, Zanias and Gunjal (2008), for example). This behavior should not come as a surprise; the price elasticity is an implicit indicator of availability of substitutes. Households that are unable to satiate their energy needs would rationally react to increases in the price of the staple by cutting the expenditure of more expensive energy sources, to mitigate the drop in consumption of the staple which is still the cheapest source of energy, as they do not have alternatives/substitutes. Bouis (1996) argues that the inverted-U shape is consistent with food demand being characterized as demand for characteristics (i.e. energy, variety, taste, etc.). There may be other competing explanations for the inverted-U relation found in some food demand studies, standard microeconomic theory does not provide predictions regarding this relation; but in wealthier countries it is very improbable to find evidence contradicting the negative relation between food own-price elasticities and income.

Hence, in choosing the food demand elasticities we take into account what we know about consumer behavior, particularly of poor households, which are those that obviously are more vulnerable to undernourishment and sensitive to the choice of elasticities in our simulations. Instead of using elasticities from different non-comparable studies we decided to use demand parameters from the cross-country study of Seale et al. (2003). In the case of income elasticities, this cross-country study does not suffer from over-estimation discussed above.[10] We account for the different income elasticities of different income groups by using predicted income elasticities. The equation used to predict income elasticities is given by the regression:

$$\eta_{ji} = \underset{\substack{1.45 \\ (0.03)}}{\alpha_i} + \underset{\substack{-0.125 \\ (0.0036)}}{\beta_i} \ln(GDP[PPP]/N)_j + u_{ji}$$

(standard errors in parentheses) which was run with 111 available country (j) observations, and for all eight food groups (i). The eight food groups considered in the (Seale et al., 2003) study and in this one are: 1. cereals (including roots, tubers, and pulses); 2. meat; 3. fish; 4. dairy; 5. oils and fats; 6. fruits and vegetables; 7. other food; and 8. beverages and tobacco. The coefficients described above represent the cereal income elasticities equation, which has a fit of 91% (fits ranged between 84% an 92% for the eight food groups). We predicted income elasticities by income deciles in each country considered, and we use annualized means of per capita expenditures by decile, converted to international PPP currency, as the predictor. This exercise gave us income elasticities that lie well within what has been found in the literature. For example, in the case of cereal demand income elasticities, these varied from 1.065 in the poorest decile in Tajikistan to 0.333 in the wealthiest decile in Guatemala.

In the case of price elasticities, we decided to use national-level estimates provided by the same study.[11] We know that within our sample in Malawi,[12] and probably in Kenya too, the own-price elasticity of the poorest is positively correlated with income, so a linear or log-linear relation between price elasticities and income cannot be assumed. Further, the use of country-level price elasticities from a single study, in addition to providing comparable estimates, has the benefit of relying on national-level data, which should produce more modest estimates of price elasticities. The use of more moderate price elasticities aids us in not over-estimating the effects of food price increases on undernourishment.

Cross-price elasticities

As Eq. (4) suggests, substitution in food consumption can play an important role in mitigating the drop in dietary energy caused by the price hike of a given good, particularly when diets are diversified and substitutes are readily available. In the absence of a complete substitution matrix, we proceed to compute a substitution matrix consistent with the available information: food consumption patterns, and own-price and income elasticities. The elasticities come from Seale et al. (2003), while consumption patterns and aggregate prices for the same food groups considered in the aforementioned study were calculated using disaggregated data from the 2005 round of Purchasing Power Parity surveys, generously facilitated to this study by the World Bank, see (World Bank, 2008).

We calculate cross-price elasticities following the technique suggested by Beghin et al. (2003). The proposed methodology imposes diagonal dominance, to calculate the off-diagonal elements of the Slutsky substitution matrix. The assumption of quasi-concavity of preferences translates into positive semi-definite and symmetric Slutsky matrix. Beghin et al. (2003) further assume that preferences can be expressed with a LINQUAD incomplete (in that it only describes food and not total consumption) expenditure system. The conditions imposed by diagonal dominance exactly identify the set of unknown parameters of a LINQUAD expenditure system, provided that the diagonal elements are known.[13] Thus, what the proposed approach does is to jointly scale the absolute value of all cross-price effects until the concavity (of the expenditure function) sufficient condition is met. In the methodological appendix available online we show the numbers used to calculate cross-price elasticities in Malawi as an example.

Food security profiles

This study identifies as undernourished those individual whose dietary energy consumption falls below the minimum dietary energy requirements (MDERs). We also define as *weakly nourished* those individuals whose dietary energy consumption falls below the average dietary energy requirements (ADERs) and above the MDER. The difference between the two dietary energy requirements is that, in the case of adults, the first is calculated for the individual in the 5th percentile of the national body mass index (BMI) distribution under light physical activity level ($1.55 \times$ BMR [Basal Metabolic Rate]), while the second is calculated for the median individual (50th percentile) in the national BMI distribution assuming moderate physical activity level ($1.85 \times$ BMR). This study takes a conservative approach in measuring undernourishment by using MDER as the relevant threshold[14] – when others suggest that

[9] Alderman, (1986) provides a couple of examples of this behavior, Zanias and Gunjal (2008) provide a more recent example.

[10] Food demand based on consumption and not acquisition would also be more accurate with regards to income elasticities, but in the literature most food demand systems are estimated using food expenditure surveys.

[11] Seale et al. (2003) study does not include Cambodia and Guatemala, we therefore used estimates from Vietnam and Paraguay respectively, as proxies for these countries.

[12] Cf. Zanias and Gunjal (2008).

[13] Another way to impose concavity of the expenditure function is to use the Cholesky decomposition as suggested by Lau (1978).

[14] We try to be consistent with the statistical axiom of minimizing Type I error, which in this case is classifying as undernourished an individual that is not. The under-reporting of consumption that is prevalent among household survey leads to an over-estimation of undernourishment, and justifies the use of a conservative threshold.

Table 1
Poverty and food security indicators.

Country	Year	GDP per capita*	Poverty Headcount**	Under-nourished***	Weakly nourished***	Dietary energy thresholds****	
						MDER	ADER
Bangladesh	2000	901	49.8	15.6	38.2	1720	2158
Cambodia	2004	1296	35.0	31.2	31.4	1746	2212
Guatemala	2000	3966	56.2	18.1	14.2	1622	2015
Kenya	2005	1346	45.8	53.7	17.9	1728	2163
Malawi	2004	650	52.4	26.3	19.0	1678	2088
Nepal	2003	926	30.8	19.0	26.8	1702	2138
Tajikistan	2003	1402	82.8	18.3	33.8	1845	2116
Vietnam	2002	1780	28.9	12.5	31.5	1789	2278

* In per-capita international dollars of 2005.
** % of population, from World Bank Poverty Assessments using the same surveys this study uses.
*** % of population.
**** In kilocalories per capita per day.

the ADER should be used as relevant food security limit[15] – but acknowledges that the population whose consumption lies between requirements is in an exposed situation, vulnerable to food price, income or other types of shocks; hence we accordingly treat them as a separate group from those who are unambiguously food-secure.

An inspection of Table 1, shows that both poverty and undernourishment are negatively correlated with national income, but this correlation is not strong. Further, undernourishment and poverty are correlated; however, this correlation is also not very marked. It is important to highlight that the poverty figures presented in the table, like most poverty numbers, are based on per capita consumption/income, without using age-equivalence scales. This is an important difference with undernourishment, which is based on energy requirements that vary by age and gender, and therefore are implicitly constructed using equivalence scales (in this case energy requirement equivalence). Thus countries with a high proportion of children like Guatemala and Malawi (reflected in the lower mean national dietary thresholds in the table), show large differences between undernourishment and poverty that can be partially explained by the lack of use of equivalence scales in the poverty measures. In the case of Bangladesh, the large difference between poverty and measured undernourishment is partly explained by the fact that this country used the diary method to capture food consumption, which is probably less prone to under-reporting; and also the cumulative distribution of consumption of calories is extremely steep at low values, as reflected by the highest share of weakly nourished in our sample of countries.

In most countries, rural undernourishment is higher than urban undernourishment, as Fig. 1A shows. The exceptions are Bangladesh and Tajikistan: in both countries we observe that in spite of having higher rural poverty rates, they both display lower rural undernourishment as access to food is better in rural areas.[16] This observation highlights that poverty and food security are not the same thing, and therefore do not necessarily share the same main determinants. The figure also shows that those weakly nourished form an even larger group than the undernourished in three of the four Asian countries, the exception being Cambodia. Fig. 1B shows that undernourishment is, as expected, negatively correlated with per capita expenditure levels. The prevalence of weakly nourished, however, has a less marked negative correlation with welfare. Although cross-country comparisons cannot be directly made, mainly because differences in the survey instrument design make measurements not fully comparable, it is remarkable how close our estimates are for the poorest quintile; in all countries roughly four out of every five individuals among the poorest 20% are either undernourished or weakly nourished. The differences between national-level undernourishment rates are, as expected, much larger across countries. Also, the rate at which undernourishment falls across quintiles varies markedly across countries.

[15] For example, WHO/FAO (2002) suggests using the median BMI, which is consistent with ADER and not MDER.

[16] In Bangladesh rural poverty is 53% vs. 37%, and in Tajikistan rural poverty is 65% vs. 59% in the corresponding surveys.

Results

Fig. 2 provides a graphical display of the effect on measured undernourishment of a 10% increase in the price of the main staple (left scale) by expenditure quintiles, together with the observed share of the staple on overall energy consumption (right scale). The figure shows that only in Bangladesh, Cambodia and to a lesser extent in Vietnam the increase in undernourishment is negatively correlated with welfare levels. The increase in observed undernourishment is chiefly driven by three factors, of which only one has a definite correlation with welfare levels. First, reliance on the staple and dietary patterns in general determine the impact of the food price increase. These dietary patterns, in particular the dependence of diets on the main staple, are clearly negatively correlated with welfare levels (as shown in the figures). On the other hand, staple farm income, which helps to cushion the negative real income effects of food inflation, or even completely countervail these effects, is distributed in ways that vary across countries and is not necessarily correlated with income levels. Finally, the concentration of household and individuals around the dietary threshold, or equivalently the size of the average dietary energy surplus of individuals determines how sensitive these groups are to changes in food prices. Again, this surplus is likely to be higher for the wealthiest deciles, but this correlation does not necessarily exist in the poorer and middle income deciles.

In Table 2 the results of the simulation are further disaggregated by welfare quintiles and urban/rural areas. This differentiation is important because most food production is done in rural areas, and therefore we expect important differences in terms of the positive income effects of staple price hikes. We find that the largest increases in undernourishment occur in the middle or lowest quintiles of either rural or urban areas. This result contrasts with what was found by Zezza et al. (2008), who simulated the effects of food price increase on welfare and found consistently in eleven countries that it was the poorest urban consumers who were most negatively affected. In terms of the more afflicted areas there is no clear trend; in half of the countries considered, the increase in undernourishment was higher in rural areas. Also, in some countries (Guatemala, Kenya, and Malawi) in urban areas, the poorest quintiles suffer an increase in undernourishment that is lower than

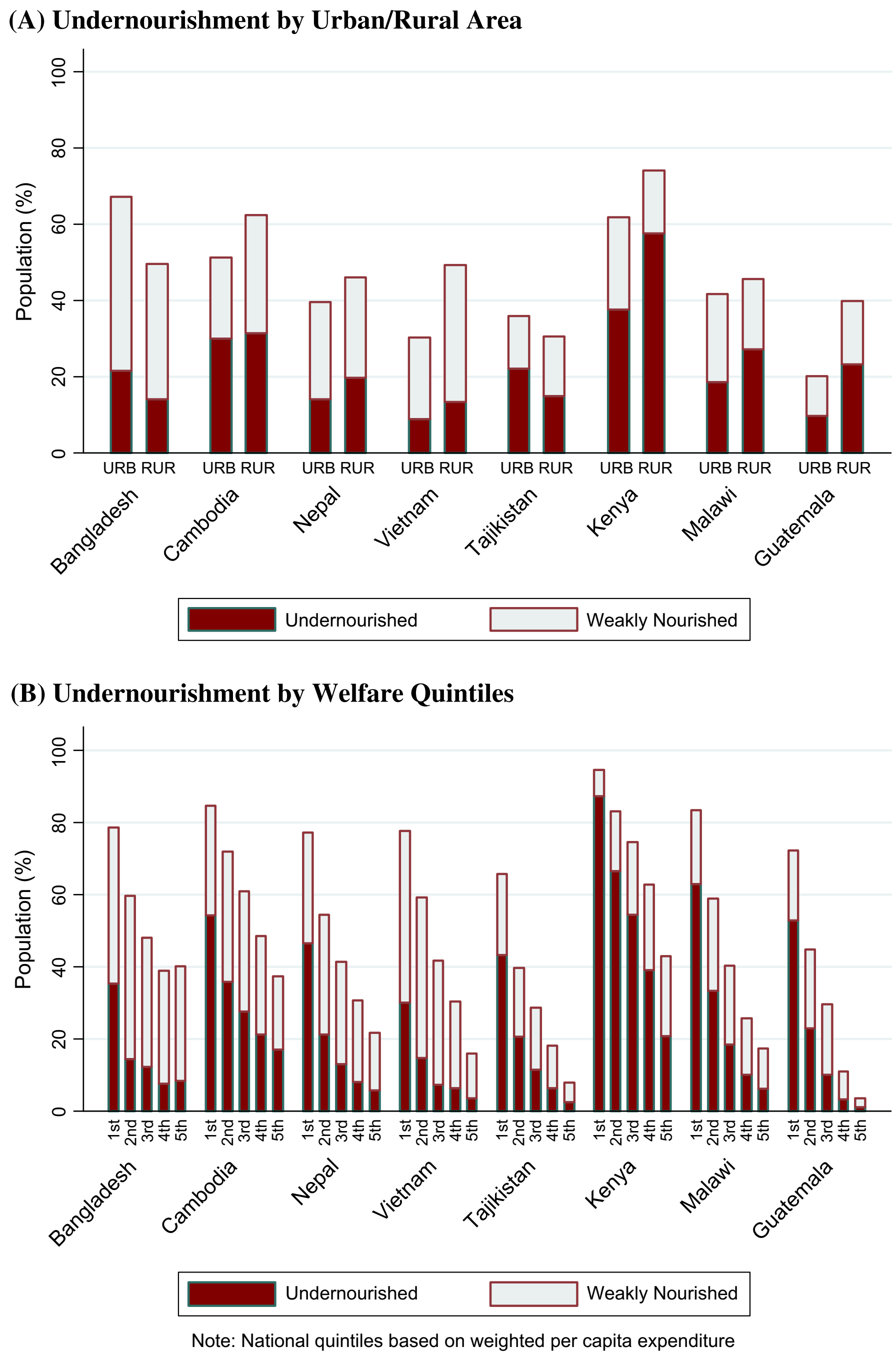

Fig. 1. Undernourishment profile. A. Undernourishment by urban/rural area. B. Undernourishment by welfare quintiles.

that of the quintile (or quintiles in Malawi) above, which most likely is an indicator of increased importance of urban agriculture in these countries.

Decomposing mean and distribution effects

We decompose the estimated increase in undernourishment into two different components; that which can be explained by a change in the mean kcal per capita consumption ([negative] growth component), and that which can be explained by changes in the distribution of dietary energy consumption following (Datt and Ravallion, 1992). This decomposition of the change in undernourishment between t_0 and t_1 can be described with the following equation:

$$U_{t_1} - U_{t_0} = G(t_0, t_1; r) + D(t_0, t_1; r) + R(t_0, t_r; r).$$

The change in undernourishment U, using r as reference year (could be t_0, or t_1) can be separated into three parts: the growth component $G(t_0, t_1; r)$ or change in average dietary energy consumption holding the distribution constant; the distribution component $D(t_0, t_1; r)$, which represents the change in undernourishment that can be attributed to changes in the distribution, holding average food energy consumption constant; and the residual $R(t_0, t_1; r)$, which represents that part of the undernourishment change which cannot be explained by the growth and distribution effect. If the

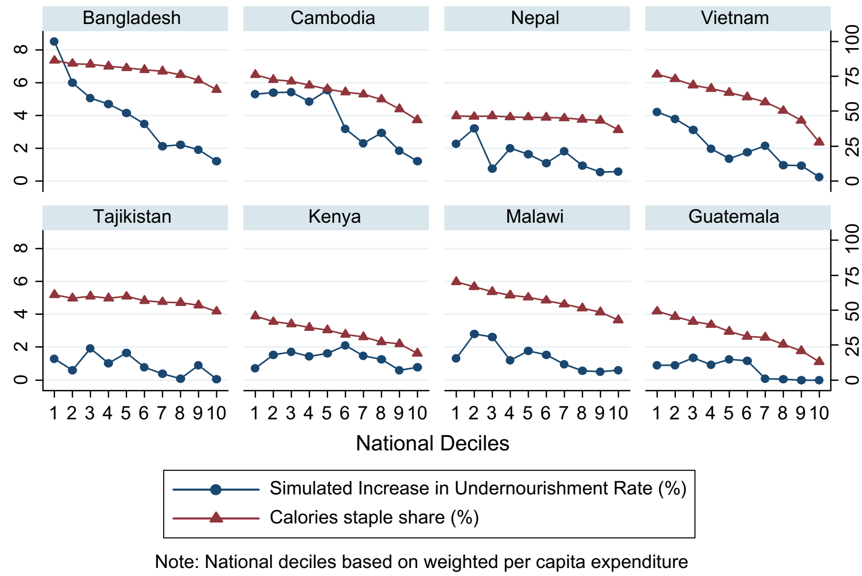

Fig. 2. Simulated increase in undernourishment rate.

Table 2
Simulated undernourishment impact by welfare groups and urban/rural area.

	Bangladesh		Cambodia		Guatemala		Kenya	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Rural quintiles								
Poorest	85.7	6.9	75.0	5.2	48.3	0.8	44.6	1.2
2nd	83.5	4.8	70.9	5.3	45.0	1.4	40.4	1.5
3rd	81.3	3.8	67.6	5.1	40.6	0.8	36.1	1.6
4th	79.2	1.7	63.2	2.6	35.3	0.9	31.9	1.8
Wealthiest	73.6	0.7	56.7	1.9	28.1	−0.1	26.4	0.7
Rural average	80.6	3.6	66.7	4.0	39.5	0.7	35.9	1.4
Urban quintiles								
Poorest	81.1	9.8	64.4	5.0	35.2	0.9	33.5	1.5
2nd	77.4	7.6	54.3	2.8	25.5	1.5	28.2	1.7
3rd	72.5	4.8	45.2	2.8	23.8	0.2	24.8	1.2
4th	67.0	3.0	33.3	1.3	19.1	0.0	22.0	0.3
Wealthiest	60.2	2.1	30.5	0.9	11.8	0.0	15.5	1.4
Urban average	71.6	5.5	45.5	2.5	23.1	0.5	24.8	1.2
	Malawi		Nepal		Tajikistan		Vietnam	
Rural quintiles								
Poorest	69.0	2.0	46.1	2.4	59.4	0.6	75.1	3.8
2nd	62.5	2.1	45.9	1.3	59.0	1.2	69.7	3.1
3rd	58.5	1.5	45.1	1.4	58.8	1.5	64.7	1.6
4th	54.1	0.6	44.1	1.4	56.2	0.1	59.3	1.7
Wealthiest	47.5	0.4	43.0	0.2	53.9	0.6	49.0	0.7
Rural average	58.3	1.3	44.8	1.3	57.4	0.8	63.6	2.2
Urban quintiles								
Poorest	62.8	1.6	53.3	4.2	60.7	2.2	62.8	3.5
2nd	55.5	3.4	48.6	3.5	60.0	1.5	48.1	3.2
3rd	50.5	3.4	42.4	3.3	56.8	1.3	40.8	0.6
4th	45.2	1.3	38.4	0.8	51.9	0.1	31.4	0.7
Wealthiest	35.2	0.0	30.2	0.4	46.6	0.1	21.7	0.1
Urban average	49.8	2.0	42.6	2.4	55.2	1.0	41.0	1.6

Notes: (1) Share (%) of main staple in consumption and (2) change in undernourishment (% points).

components are calculated for initial and final periods (t_0, or t_1) as reference years and then taking averages, the residual disappears, which is what we do in Table 3.

The first result that strikes from the table is that at the national level (with the exception of Guatemala, which displays negative effects), the distributional effects of staple food price increases augment the effect on undernourishment. This result is probably driven by the fact that staple consumption as a share of total energy is negatively correlated with welfare and total dietary energy consumption, as shown above. This observation has important implications for the way the effects of food price spikes are modeled; it is not enough to assume that average consumption falls, unfortunately, the food security analyst who uses parametric methods needs to account for a further deterioration of nutritional

Table 3
Decomposition of the simulated change in undernourishment.

Country	Change in undernourishment	Components			
		Growth		Redistribution	
		Change % points	(%) Of total change	Change % points	(%) Of total change
National					
Bangladesh 2000	3.94	3.55	90.2	0.39	9.8
Cambodia 2004	3.80	3.46	91.0	0.34	9.0
Nepal 2003	2.44	2.23	91.4	0.21	8.6
Vietnam 2002	2.05	1.75	85.5	0.30	14.5
Tajikistan 2003	0.90	0.84	93.2	0.06	6.8
Kenya 2005	1.33	1.32	99.6	0.01	0.4
Malawi 2004	1.39	1.02	73.1	0.37	26.9
Guatemala 2000	0.66	0.67	101.4	−0.01	−1.4
Urban					
Bangladesh 2000	5.45	5.36	98.3	0.09	1.7
Cambodia 2004	2.55	2.17	85.4	0.37	14.6
Nepal 2003	3.92	3.14	80.2	0.78	19.8
Vietnam 2002	1.62	1.21	74.6	0.41	25.4
Tajikistan 2003	1.06	1.25	117.5	−0.19	−17.5
Kenya 2005	1.22	1.23	100.5	−0.01	−0.5
Malawi 2004	1.95	1.65	84.5	0.30	15.5
Guatemala 2000	0.52	0.52	99.6	0.00	0.4
Rural					
Bangladesh 2000	3.56	3.20	89.8	0.37	10.2
Cambodia 2004	4.03	3.78	93.8	0.25	6.2
Nepal 2003	2.19	2.02	92.3	0.17	7.7
Vietnam 2002	2.18	1.80	82.8	0.37	17.2
Tajikistan 2003	0.84	0.76	89.5	0.09	10.5
Kenya 2005	1.35	1.33	98.5	0.02	1.5
Malawi 2004	1.32	0.93	70.3	0.39	29.7
Guatemala 2000	0.75	0.81	107.6	−0.06	−7.6

status due to a worsening of the distribution. The results of the simulations are mostly consistent with what has been found in the poverty literature, (see Datt and Ravallion (1992) and Contreras (2003), for example), which is that the distribution component explains a minor part of the changes in poverty. With the exception of Malawi, this result is mostly confirmed. However, there are important differences between urban and rural populations. In some surveys we find that the share of the growth component is larger in urban areas, while in others the opposite result. Also, at the sub national levels we find that there can be positive distributional impacts (urban Tajikistan and rural Guatemala).

The determinants of the impact on dietary energy consumption

To uncover which types of households are most affected by staple price hikes, we estimate a reduced form equation that explains the proportional change in per-capita calories induced by the price change:

$$\frac{\Delta x_i}{x_i} = f(\text{HH demographics}_i,\ \text{HH Assets}_i, \text{welfare}_i,\ \text{regional characteristics}_i) + u_i \qquad (6)$$

This equation should be interpreted as a multivariate correlation, not necessarily implying causation, because in many cases the causation arrow goes both ways; for example, better educated people are better fed, and because they are better fed they attain a better education. The demographic characteristics included are age of the household head, in both linear and quadratic form to allow for life-cycle hypothesis considerations; the dependency ratio separated by children and elderly (a partition justified by their very different energy requirements); the number of household members, and a dummy identifying households headed by females. We include among the assets of the households, both agricultural and non-agricultural assets. Among the first, we include operated land, livestock holdings, and an index of agricultural assets like machinery, tools, and others measured by a principal components index. With respect to non-agricultural assets, we include human capital identified by the average education of adults in the household, a measure of infrastructure/access to public goods and markets which is a principal components index of several indicators of proximity to services such as, distance to school and/or hospitals, and trash collection services. We use per capita expenditures as the welfare indicator, which is a questionable choice given that expenditures are calculated using the same food consumption data we use to calculate energy intake. We therefore use predicted per capita expenditures, where we use different household characteristics as instruments, but also one main instrument which is an indicator of household wealth (an index of all durables owned by the household, such as cars, motorcycles, and refrigerators). With these predicted per capita measure we are capturing the longer-term per-capita levels as implied by their wealth (and the host of other household and regional characteristics) and not the current levels which are more affected by transient shocks. Finally, we use district/region-level dummies to control for unobservable regional characteristics; and use country-specific household controls, such as religion and use of indigenous language at home, but as these are country-specific we do not present those results here.

The main results of these estimations are presented in Table 4 in the form of partial elasticities (evaluated at the mean). The estimations were done for national, urban, and rural samples separately, for a total of twenty-four different regressions. The separation of samples by area is justified by the nature of the exercise carried out, where staple income is relatively much lower in urban areas, and it can be of significant importance in rural areas. The fit of these equations is not particularly high, with the R^2 rang-

Table 4
Estimated percentage change in caloric intake (partial elasticities).

	Bangladesh 2000	Cambodia 2004	Guatemala 2000	Kenya 2005	Malawi 2004	Nepal 2003	Tajikistan 2004	Vietnam 2002
National sample (obs.)	(7423)	(11,982)	(7257)	(12,979)	(11,280)	(3866)	(4148)	(29,530)
Age of head	0.021	0.029*	−0.098*	0.057**	0.064	−0.002	−0.043**	−0.010
Household size	−0.2*	−0.029	−0.085**	0.021	0.084	−0.107**	0.3*	−0.153***
Share < 15	0.058**	0.040	0.049*	0.035**	0.114***	−0.003	0.141***	0.011
Share > 60	0.018**	0.023***	0.004	0.022***	0.014**	0.034**	−0.022***	−0.002
Female head	−0.005	0.006	−0.034***	0.005	0.019**	0.001	−0.007	−0.021***
Education average (adults)	0.013	0.185***	−0.001	0.121***	0.002	0.105***	−0.076	0.117***
Predicted expenditures per capita	0.145**	0.167**	0.151***	0.150***	0.194***	0.030	0.539***	−0.007
Infrastructure Index	0.009*	0.000	0.000	0.001***	−0.001	−0.011	−0.007***	−0.004
Land operated/owned	0.163***	0.037*	0.000	0.052***	0.236***	0.125***	0.061***	0.230***
Livestock in tropical units	0.126***	−0.023	0.002	0.001	−0.021***	0.424***	−0.010	0.013***
Rural	0.105***	−0.059	0.101***	0.006	0.318***	0.209***	0.263***	0.255***
Rural sample (obs.)	(5031)	(9586)	(3842)	(8382)	(9840)	(2712)	(2629)	(22,621)
Age of head	0.014	0.007	−0.154*	−0.042	0.065	−0.041	0.165***	−0.038
Household size	−0.265***	−0.642**	−0.197***	0.252***	0.073	−0.100	−0.770***	−0.232***
Share < 15	0.065**	−0.049	0.061	0.127***	0.129***	−0.035	−0.534***	−0.006
Share > 60	0.027**	0.030***	0.010	0.026***	0.012	0.021	0.093***	−0.005
Female head	−0.005	−0.008	−0.047***	0.006	0.016	0.004	0.015***	−0.021***
Education average (Adults)	−0.003	0.373***	0.002	0.004	−0.002	0.103***	1.591***	0.146***
Predicted expenditures per capita	0.002	−0.957	0.090**	0.570***	0.189*	−0.057	−2.668***	−0.254***
Infrastructure index	0.000	0.000**	0.000	0.011***	0.000**	0.001	0.000	−0.004***
Land operated/owned	0.237***	0.041*	−0.001	0.062***	0.217***	0.189***	0.113***	0.294***
Livestock in tropical units	0.178***	−0.030	0.001	0.000	−0.021***	0.478***	0.109***	0.020***
Urban sample (obs.)	(2392)	(2396)	(3415)	(4597)	(1440)	(1154)	(1519)	(6909)
Age of head	0.036***	0.038	−0.030	0.111***	0.015	0.040	−0.068**	0.049**
Household size	−0.203***	−0.195*	0.002	0.050**	0.041	−0.138*	0.301**	−0.070*
Share < 15	0.040	0.068	0.043*	0.041**	0.056*	0.013	0.196***	0.004
Share > 60	0.000	0.026*	−0.003	0.005	0.019***	0.059***	0.000	0.001
Female head	−0.003	−0.006	−0.012	0.015**	0.024*	−0.003	−0.031***	−0.016**
Education average (Adults)	0.099***	0.096	0.007	0.138***	0.181***	0.143**	−0.268	−0.002
Predicted expenditures per capita	0.253***	0.062	0.180***	0.197***	0.149	0.119***	0.821***	0.283***
Infrastructure index	−0.005***	0.000	0.000	−0.015***	−0.001	−0.001**	0.000	−0.003
Land operated/owned	0.031**	0.100***	0.000	0.013**	0.247***	0.022**	−0.005***	0.061***
Livestock in tropical units	0.020**	−0.023	0.004**	0.002	−0.007	0.183***	0.005	0.003

* Values significant at the 10% level.
** Values significant at the 5% level.
*** Values significant at the 1% level.

ing from 10% to 30%. Hypothesis testing was done with an adjusted covariance matrix, using White's heteroscedasticity consistent covariance matrix, clustered by each survey's primary sampling units. Below we discuss the salient results of a cross-country comparison of the main elasticities.

The age of head is sometimes positively correlated with the response to higher food prices of dietary energy consumption, and sometimes negatively. Given the quadratic fit, and life-cycle considerations, we find this result plausible, as in older populations like the Tajikistani, age is negatively correlated with the change in consumption, while in younger populations like that of Malawi, the opposite is found (summary statistics of the main regressors are available in the Appendix). To our surprise, household size is not always negatively correlated with the response in caloric consumption. Most poverty studies find a positive correlation between household size and poverty; thus we expected a strong negative correlation between the change in energy consumption and household size. However in Tajikistan and rural Kenya, we observe a strong positive relation. Similarly surprising is the finding that the share of dependents (children and elder) are in most cases positively correlated with the proportional change in dietary energy consumption. Notable exceptions to this general result are the share of children in rural Tajikistan, and the share of elder again in Tajikistan and Vietnam. In general, the gender of the head is not statistically correlated with the change in caloric consumption. However, the two countries, where we observe a negative correlation, Guatemala and Vietnam, the national level results are driven by a stronger negative correlation in the rural samples. This suggests that female headship acts negatively in these countries' households by significant differences in the access to staple (and farm in general) income.

Assets, and access to assets obviously play an important role in determining the vulnerability of households to food price spikes. A first glance at Table 4 suggests that different assets have varying importance across countries and urban/rural landscapes. Human capital, measured in our analysis by the average education of adults is a key asset, not always significant, but if significant it is always positive. In some countries, namely Cambodia, Tajikistan and Vietnam education plays a larger positive role in rural areas, while the opposite occurs in Bangladesh, Kenya, Malawi and Nepal. The ownership of livestock has varying effects on the vulnerability of households to food price spikes. This is explained by the fact that in some countries livestock herding is correlated with poverty (Malawi, Cambodia), while in other countries (Bangladesh, Guatemala) such correlation is not present.

The results in Table 4 also highlight that it is not always the poorest who are most harmed by a food price spike. Households that do not produce food and whose diets are dominated by the staple are the most vulnerable to staple food price increases. The latter characteristic is correlated with poverty (to a lesser extent in rural areas), while the characteristic of being a staple producer does not *a priori* correlate with levels of wellbeing. Table 4 shows that in urban samples, the poorer households are more negatively affected by the rising staple food prices, with the coefficient on (predicted) per capita expenditures being positive in all eight countries (significantly in six). However in rural areas, the same coefficient is negative in four countries, and significantly in two: Tajikistan and Vietnam, which means that all other variables kept constant, the wealthier are more negatively affected by rising food prices. At the national level, the coefficient on per capita expenditures is negative only in Vietnam. This finding is consistent with the results presented by Ivanic and Martin (2008): in their simulation of the impact of rising food prices on poverty, poverty in Vietnam actually falls with an increase in the prices of major food commodities. The evidence presented in Aksoy and Izik-Dikmelik (2008), Ivanic and Martin (2008), and Zezza et al. (2008) and this paper demonstrates that in general the poorer suffer more from higher food prices, given their general net-food buyer position and less diversified diets. However, such a generalization is risky and the characteristics of the poor, what they eat and what they produce need to be known before making accurate predictions about the effects of rising food prices.

Finally, we refer to agricultural land, measured in this study as operated agricultural land. Perhaps among the most important findings of this study was the discovery of the important role that agricultural land plays in food security even in the national samples. In seven out of the eight national samples we found that access to agricultural land has a positive effect on the impact of food price spikes on nutritional intake, and in five of these the relation was statistically significant. This means that access to land plays a major role in ensuring food security not only in rural areas (where the elasticities are obviously larger), but also in urban areas of these developing countries.

Even though this finding that access to land has an impact on the food security of urban households appears surprising, it is consistent with what has been found in the literature, which has shown a large impact of urban agriculture on poor developing countries[17]. For example, Maxwell et al. (1998) found that households (in Kampala, Uganda) involved in urban agriculture had children under five with significantly higher height-for-age and weight-for-age *z*-scores. Similarly, Zezza and Tasciotti (2008) show that access to urban agriculture increases the dietary diversity scores of urban households in twelve out of fifteen countries analyzed (significantly in ten). The reason for this important food security impact of urban agriculture, is that agricultural income is more prevalent in urban households than is generally assumed. Zezza and Tasciotti (2010) show that in a sample of fifteen countries (including Bangladesh, Malawi, Guatemala, Nepal and Vietnam in this study) on average roughly two out of every five urban households earn agricultural income, representing a share of household income ranging between 1% in Panama, and 27% in Nigeria. Consistent with the evidence presented in (Zezza and Tasciotti, 2010), Table 4 shows that Malawi, which displays the highest impact of agricultural land is also the country in our sample with the highest share of agriculture on urban household income: 12%.

Table 4 also highlights the great heterogeneity that exists across countries, which reinforces the need for country-specific food security analyses. The simulations presented in this paper reveal food vulnerability that can and should be mapped, as well as studied in greater depth, and taking into account country-specific conditions.

[17] In most of the literature, as well as in this study the use of urban agriculture refers to agriculture practiced by urban households not necessarily occurring within urban areas.

Conclusions

Global estimates suggest that there are about 1 billion people undernourished in the world, a sobering number that has seen a sharp rise in the last years (FAO, 2009). One of the main reasons for this rise has been the sharp increase observed in food prices in the period 2005–2008. Although most food prices had fallen by 2009, many experts believe that prices will stabilize at higher real levels (see for example (OECD-FAO, 2009)). Under this outlook for food prices, it would be sensible to implement social protection policies that tackle nutritional aspects, which means that a sound understanding of the determinants of undernourishment and the target groups of these policies is necessary.

In this paper we have assessed the possible consequences of staple food price increases on households' food security in eight developing countries. We have undertaken a nutritional analysis by first estimating the energy requirements that account for the household composition, instead of using a fixed threshold for all households as it is often done in the literature. Then for our simulation approach we used demand parameters from the cross-country study of Seale et al. (2003), which provided also national level estimates of own-price elasticities. We further expanded these by estimating cross-price elasticities following the technique suggested by Beghin et al. (2003).

The novel methodology adopted in this study can provide a policy-relevant micro-level instrument for food security analysts and policymakers in developing countries. The results evidence the fact that an increase in staple food-prices does not have an equivalent impact on consumption across households. Saying that the poorest are the most affected may not always be true. At the same time, though, the results highlight that the poor urban/non-farm households with a high share of food expenditures are the most vulnerable. The land-tenure-based policies and investments for increasing agricultural productivity have a crucial role to play in reducing household food insecurity in the developing countries considered in this study. In fact, among the most important findings of this study was that access to land, here measured as operated agricultural land, plays a major role in ensuring adequate nutritional attainments in both urban and rural areas. Access to infrastructure and, to a lesser extent, livestock holdings are also important determinants of the vulnerability of households to food price spikes. While surprisingly, differences in the share of dependents (children and elder) does not affect significantly simulated changes in dietary energy consumption.

Finally the heterogeneity in the results presented in this cross-country approach shows clearly that the country-specific socio-economic, geographic, and institutional factors have to be considered before drawing locally relevant policy conclusions.

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Appendix A. Summary statistics

	Bangladesh 2000		Cambodia 2004		Guatemala 2000		Kenya 2005	
	M	SD	M	SD	M	SD	M	SD
National sample (obs.)	(7423)		(11982)		(7257)		(12979)	
Age of head	44.48	13.41	44.84	13.73^{-}	44.27	15.01^{-}	44.89	15.65^{-}
Household size	5.14	2.19^{-}	4.97	2.00^{-}	5.18	2.53^{-}	5.04	2.73^{-}
Share < 15	0.36	0.22^{+++}	0.33	0.22	0.38	0.25^{-}	0.36	0.25^{-}
Share > 60	0.08	0.17^{+++}	0.08	0.18^{+++}	0.10	0.23^{+++}	0.08	0.21^{+++}
Female head	0.09	0.28	0.22	0.41^{+++}	0.18	0.39^{+++}	0.29	0.45^{+++}
Education average (adults)	3.05	3.34	4.09	2.86^{+++}	4.29	4.02^{+++}	6.63	3.66^{+++}
Predicted expenditures per capita	11,047	7673^{+++}	338,015	302,328^{+++}	649	610^{+++}	43,652	54,425^{+++}
Infrastructure index	0.00	1.00	0.00	1.00^{+++}	0.00	1.00^{+++}	0.01	1.01^{+++}
Land operated/owned	0.27	0.56^{+++}	0.93	2.15	2.97	10.86^{+}	0.60	1.18^{-}
Livestock in tropical units	0.44	0.74^{+++}	0.89	1.05^{-}	0.61	4.98	1.68	20.96^{-}
Rural	0.80	0.40^{+++}	0.85	0.36^{-}	0.57	0.50^{-}	0.75	0.43^{-}
Rural sample (obs.)	(5031)		(9586)		(3842)		(8382)	
Age of head	44.61	13.65	44.53	13.83^{-}	44.06	15.04^{-}	47.21	15.87
Household size	5.16	2.23^{-}	4.95	2.00^{-}	5.64	2.63^{-}	5.40	2.73^{-}
Share < 15	0.37	0.21^{+++}	0.34	0.22	0.42	0.24^{-}	0.38	0.24^{-}
Share > 60	0.08	0.17^{+}	0.08	0.19^{+++}	0.09	0.22^{++}	0.10	0.22^{+++}
Female head	0.09	0.28	0.21	0.41^{+++}	0.15	0.36^{++}	0.31	0.46^{+++}
Education average (adults)	2.58	3.01^{+}	3.76	2.60^{+++}	2.49	2.48^{+++}	5.91	3.42^{++}
Predicted expenditures per capita	9269	4576^{+++}	1,070,455	518,100^{+++}	356	252^{+++}	23,805	14,120^{+++}
Infrastructure index	0.00	1.00^{+++}	0.00	1.00^{+++}	0.00	1.00^{+++}	0.00	1.00^{+++}
Land operated/owned	0.33	0.59^{+++}	1.02	2.28	3.15	10.92	0.78	1.28^{++}
Livestock in tropical units	0.53	0.78^{+++}	0.98	1.05^{-}	0.92	6.39^{++}	2.20	24.21^{-}
Urban sample (obs.)	(2392)		(2396)		(3415)		(4597)	
Age of head	43.94	12.40	46.53	13.06^{-}	44.54	14.97^{-}	38.04	12.72^{-}
Household size	5.04	2.05^{-}	5.12	1.98^{-}	4.58	2.25^{-}	3.97	2.44^{-}
Share < 15	0.33	0.21	0.29	0.22	0.33	0.25^{-}	0.29	0.25^{-}
Share > 60	0.06	0.15^{+++}	0.08	0.17	0.11	0.24^{++}	0.03	0.14^{+++}
Female head	0.10	0.30	0.24	0.42	0.23	0.42^{+++}	0.23	0.42^{+++}
Education average (adults)	4.92	3.90^{+++}	5.97	3.48^{+++}	6.64	4.41^{+++}	8.77	3.54^{+++}
Predicted expenditures per capita	18,251	11,816^{+++}	2,319,306	1,681,138^{+++}	1024	738^{+++}	96,847	78,584^{+++}
Infrastructure index	0.00	1.00^{+++}	0.00	1.00^{+++}	0.61	0.97^{+++}	0.02	1.00^{+++}
Land operated/owned	0.05	0.28^{+}	0.41	0.94^{-}	1.93	10.48	0.08	0.62
Livestock in tropical units	0.08	0.34^{+++}	0.40	0.91^{-}	0.19	1.90	0.17	1.97

	Malawi 2004		Nepal 2003		Tajikistan 2003		Vietnam 2002	
	M	SD	M	SD	M	SD	M	SD
National sample (obs.)	(11280)		(3866)		(4148)		(29530)	
Age of head	42.40	16.42^{-}	45.58	14.16	48.91	14.86^{-}	47.72	13.58^{-}
Household size	4.47	2.32^{-}	5.23	2.56^{-}	6.25	3.08^{-}	5.12	1.87^{-}
Share < 15	0.39	0.24^{-}	0.35	0.22^{-}	0.36	0.22^{+++}	0.29	0.21
Share > 60	0.08	0.21^{+++}	0.09	0.20^{+++}	0.09	0.20^{+++}	0.09	0.18
Female head	0.23	0.42^{+++}	0.20	0.40	0.20	0.40^{++}	0.21	0.40^{+++}
Education average (adults)	4.50	3.47^{+++}	3.22	3.40^{+++}	9.83	2.40^{+++}	7.19	3.10^{+++}
Predicted expenditures per capita	25,499	20,701^{+++}	18,330	23,206^{+++}	52	21^{+++}	3769	3003^{+++}
Infrastructure index	0.00	1.00^{+++}	0.00	1.00^{+++}	0.00	1.00^{+++}	−0.07	0.95^{+++}
Land operated/owned	0.55	0.53	0.60	1.00^{+++}	0.16	0.29^{+++}	0.54	0.91^{-}
Livestock in tropical units	0.29	0.83	1.41	1.33	1.24	2.35^{+++}	43.62	83.14^{-}
Rural	0.88	0.32^{-}	0.83	0.37^{-}	0.66	0.47	0.77	0.42^{-}
Rural sample (obs.)	(9840)		(2712)		(2629)		(22621)	

Appendix A (*continued*)

	Bangladesh 2000		Cambodia 2004		Guatemala 2000		Kenya 2005	
	M	SD	M	SD	M	SD	M	SD
Age of head	43.08	16.69$^{—}$	45.63	14.15	49.35	14.94$^{–}$	47.04	13.55$^{—}$
Household size	4.51	2.31$^{—}$	5.32	2.59$^{—}$	6.91	3.08$^{—}$	5.18	1.85$^{—}$
Share < 15	0.40	0.24$^{—}$	0.36	0.22$^{–}$	0.38	0.20^{+++}	0.31	0.21^{++}
Share > 60	0.09	0.22^{+++}	0.09	0.20^{+++}	0.08	0.17^{+++}	0.09	0.19^{++}
Female head	0.24	0.43^{+++}	0.20	0.40	0.14	0.35	0.16	0.37^{+++}
Education average (adults)	4.05	3.17^{+++}	2.56	2.75^{+++}	9.54	2.06	6.67	2.88^{+++}
Predicted expenditures per capita	22,176	11,905^{+++}	13,103	8742^{+++}	47	15^{+++}	2758	1249^{+++}
Infrastructure index	0.00	1.00^{+++}	−0.30	0.53^{+++}	0.00	1.00$^{—}$	0.00	0.98^{+++}
Land operated/owned	0.60	0.53^{+}	0.66	1.01^{+++}	0.23	0.34^{+++}	0.67	0.97^{+++}
Livestock in tropical units	0.32	0.88	1.61	1.33^{+++}	1.76	2.63^{+++}	51.47	83.74^{+++}
Urban sample (obs.)	(1440)		(1154)		(1519)		(6909)	
Age of head	37.40	13.28$^{—}$	45.34	14.25	48.06	14.69$^{—}$	49.97	13.45$^{—}$
Household size	4.23	2.31$^{—}$	4.78	2.33$^{—}$	4.97	2.64$^{—}$	4.94	1.93$^{—}$
Share < 15	0.34	0.24$^{—}$	0.26	0.22$^{–}$	0.32	0.24	0.24	0.20
Share > 60	0.04	0.15	0.09	0.19^{++}	0.10	0.25^{+}	0.09	0.17
Female Head	0.15	0.36	0.19	0.39	0.30	0.46^{+++}	0.35	0.48^{+++}
Education average (Adults)	7.81	3.79^{+++}	6.53	4.28^{+++}	10.40	2.86^{+++}	8.93	3.16^{+++}
Predicted expenditures per capita	50,882	45,997^{+++}	44,252	42,736^{+++}	62	27^{+++}	7009	4532^{+++}
Infrastructure index	0.00	1.00	0.01	1.00^{+++}	0.00	1.00^{+++}	−0.08	1.01^{+++}
Land operated/owned	0.20	0.36	0.29	0.88	0.02	0.06	0.14	0.48$^{—}$
Livestock in tropical units	0.04	0.19	0.42	0.83	0.24	1.16	17.70	75.55$^{—}$

Notes: Test of the difference of the mean between food secure group and other: $^{—}$Negative at 1%, $^{–}$Negative at 5%, $^{-}$Negative at 10%, $^{+++}$Positive at 1%, $^{++}$Positive at 5%, $^{+}$Positive at 10%. Predicted expenditures per capita in Local Currency Unit.

Appendix B. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.foodpol.2012.02.010.

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