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**The Effect of Food Prices and Own-produced Food on Food Security
of Chinese Rural Households**

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1 Introduction

During the last decades, China is the country that has contributed the most to the worldwide reduction of undernutrition over the last two decades: about two-thirds of hunger population reduction has been attributed to China (FAO, 2013). Despite this widely acknowledged success, there is still a high absolute number of households in China that remain food insecure and undernourished. There were still 134 million undernourished people in China in 2014–2016, accounting for 9.3% of the total population of China and 16.9% of the world's total undernourished population (FAO, 2016). According to UNICEF, 7.2 million children in China are still stunted. Compared to the average level of food consumption in rural China, households in poor counties of rural China consume more grain but much less animal food, which is the main source of quality proteins (Nie, Huang, & Bi, 2014). Micronutrient deficiency is also more prevalent in these areas (Luo et al., 2011; Wong et al., 2014). Most of the stunted children are also living in poor rural areas. Therefore, we chose poor rural areas in China as the research context for its practical significance.

It is the aim of this study to find out to which extent food market prices and income changes drive food insecurity in those regions. For this a food demand model of the QUAIDS type is estimated. Based on these results, we computed nutrient elasticities and simulate the effect of food price and income changes on malnutrition. Our approach contributes to the previous literature in that we explicitly consider the consumption of own-produced food both as a potentially biasing factor in demand estimation as well as in calculating the food security status of the households. This is necessary due to the fact that rural households in China often consume a significant share of their own-produced food the demand, and production decisions of agricultural households might not be separable in case of market failures. Due to our focus on the consumption patterns of rural households and the according need for estimating a system of food demand equations that involve all kinds of nutrient sources, we chose to still focus on the demand side, but add some production side components, (Sadoulet and de Janvry 1995, Tekgüç 2012).

We employ a rich dataset from 2015 consisting of 1368 rural households that covers six poor rural counties in Shaanxi, Yunnan, and Guizhou provinces. The Quadratic Almost Ideal Demand System (QUAIDS) proposed by Banks et al. (1997) is employed using a multi-budgeting approach. In addition, socioeconomic variables of the household,

region as well as variables from the agricultural production side are added as explanatory variables.

The paper is structured as follows. Section 2 gives a brief overview on the literature of rural household nutrient demand with a focus on the implications for Chinese households. In section 3 we describe the economic theory of rural households' nutrient demand and present an outline of the econometric method applied. The employed data is presented in section 4. Section 5 discusses the elasticity estimates of food and nutrients and presents simulation results based on these estimates. The results and its policy implications are discussed in the conclusion section 6.

2 Literature review

Food demand studies for the most vulnerable people living in poor rural areas of China are still sparse. While the rural population's proportion of cash expenditure on food commodity keeps increasing and rose up to 81.8% in 2014, Zheng *et al.* (2015) report that self-produced food consumption is still prevalent in rural China. Because this is particularly true for the poor rural areas, our study takes into account production side characteristics in the estimation of demand elasticities. Engel's Coefficient of residents in poor rural counties is around 50.0%, which is higher than rural average (around 40.0%). Residents in poor rural counties consume much more grains, but much less aquatic products, eggs, and milk. Little difference between vegetables and meat consumption was observed.

Compared to food demand studies, nutrient demand analyses go one step by investigating demand responses directly linked with health outcomes. An increase in food expenditure does not necessarily result in higher nutrient intake or a healthier diet, though (Ye & Taylor, 1995; Tian & Yu, 2013). From the very beginning of the characteristic theory, nutrients have been showcased as attributes of food items, which result in the consumers' choice (Lancaster, 1979). In contrast, Pitt & Rosenzweig (1986) argue that nutrients are not a direct argument of the utility function but that an individual values her health condition, which in turn is dependent -among others- of the nutrient intake of the individual. There is however a vast body of literature showing that consumers do not emphasize nutritional values of food when selecting food, but have other priorities related with consumer's preferences that are more influenced by other food attributes such as taste, appearance, degree of processing etc. (Babu, Gajanan, &

Hallam, 2016; Tian & Yu, 2013). Therefore, the relationship between food demand and nutrient intake is unclear, as has been found for the analysis of nutrient demand and income (Ogundari & Abdulai, 2013). Despite controversial arguments on the strength of the relationship between income and nutrient intake, limited research has yet been done on the relationship between income and key macro and micro nutrients (Ecker and Qaim, 2011; Santeramo and Shabnam, 2015).

In our literature review on calorie-income elasticities in China, we found that estimates range from -0.65 to 1.34. Nie and Sousa-Poza (2016) employ a variety of estimation techniques, including parametric, nonparametric, and semiparametric approaches, for cross-sectional and panel data, finding that the calorie-income elasticities in China are very small, ranging from -0.031 to 0.022. Despite major differences in previous publications, a common trend was observed: poorer households have higher calorie-income elasticities (Ye & Taylor, 1995; Huang & Gale, 2009). Most nutrient studies have focused on undernutrition, measured by energy intake. The existing research of micronutrient demand in China is still sparse, despite the fact that hidden hunger, which is caused by micronutrients deficiency is a major concern. Only two papers estimated multiple nutrient elasticities in China. Huang & Gale (2009) estimated the income elasticities for 28 nutrients of urban residents in China, and they found the values ranged from 0.1-0.5. Tian & Yu (2013) estimated income elasticities for 22 nutrients and found that most nutrients-income elasticities are quite small. They also found that households under poverty line have positive elasticities for protein, carbohydrates, fiber, vitamin B2, B3 and most minerals, while those above the poverty line have significant positive elasticities only for cholesterol and iron. It is because of the known vulnerability to nutrition insecurity of households in poor and remote areas, that we see particular merit to do a study on nutrients in the poor rural study regions.

3 Methodological approach

3.1 Consumption of own produce: relevance and theory

Many households living in rural areas produce food by themselves, and this is also true for the rural area we analyze, where 49% of the households in the 2015 survey had agriculture as their main income source and 84% had at least some agricultural activity. Table 1 shows the relevance of consumption of self-produced food by different food

groups.

Table 1 Percentage of self-produced food of total consumption (2015)

	Mean	Std. Deviation
Grains	.3253	.35827
Beans, bean products and nuts	.1710	.33027
Tuber	.6190	.48306
Vegetable	.6463	.37665
Fruits	.1238	.29893
Aquatic products	.0175	.12993
Meat	.4944	.47335
Eggs	.3077	.45880
Dairy products	.0083	.08977
Oil	.3267	.42356

Number of observations: 1368 households

Conventional food demand analyses assume that production and demand decisions for food producing households are conducted separately. Given this separability assumption, household utility maximization behavior can be seen as a sequential order in which first the household chooses the optimal production levels to maximize profits, and in a second step chooses its demand, given the household's income. Thus, it is sufficient if only the demand side is modelled with the observed household income and market prices.

Under market imperfections, exogenous market prices no longer accurately reflect the full opportunity cost of goods and services. The production and consumption decision of farm households will then become interrelated. One consequence is that income will be not exogenous anymore, as the optimum profit changes with different food price levels. Furthermore, household will base their consumption decision not on the market price but on an endogenous price. In case of farm input market failures, the decision prices of the households indicate the price that would be willing to pay to have the corresponding constraint relaxed by one unit (de Janvry et al. 1991). If e.g. the credit market fails, the household will substitute some of the food item with own-produce, as this saves money and therefore has an easing effect on the credit constraint. Moreover, in order to ease the credit constraint, more products are sold than under perfect market

conditions. Thus food sales are based on an internally determined selling price, which is internally determined by farm characteristics and factors leading to inaccessibility to the credit market. Note that the transaction prices will remain the market price, which is the price recorded in the survey, but is not the price that defined the demand response. This has to be taken into account when estimating the elasticity of the aggregate demand curve.

Another case is when the difference between the sales price and the purchasing price is high enough that the household chooses not to participate in the market and fully produce for own-consumption. This can emerge e.g. from high transaction costs, local monopolies or shallow markets, and might be particularly relevant for bulky products or for perishable products, which often are high in micronutrients or protein like fruits, vegetables or meat (Sadoulet and de Janvry 1995). Food price increase can bring a negative Slutsky effect and a positive income effect (Taylor & Adelman, 2003). Negative Slutsky effect means that when price of a food item (normal good) increases, its demand will decrease because of a negative real income effect¹ and a negative substitution effect². However, as a producer, food price increase will lead to increase of farm production income, pushing the budget constraint outward, giving a positive effect on food demand. If the positive income effect outweighs the Slutsky effect, the food demand of agricultural households increases with the food price. Production and consumption decisions are therefore linked. In the presence of such bias, the estimated price elasticities would be too high (see e.g. Sadoulet and de Janvry 1995). In his food demand study on Turkish households, Tekgüc (2012) demonstrated this by taking into account the budget share of own produced food, which significantly reduced the magnitude of estimated price elasticities. Tekgüc (2012) did not have detailed farm-level data, so his model was a second best test of whether separability holds. Since the survey we analyze has a joint focus on consumption as well as production, we are able to have a deeper look into whether production side factors have an influence on a farm household's demand.

¹ With a fix income or budget, price increase of a good brings decrease of real purchase power, leading to a demand decrease of the good.

² Price increase of a good encourages consumers to buy the substitutes of the good, leading to a demand decrease of the good.

3.2 Econometric method

Food demand elasticities have been estimated with the almost ideal demand system (AIDS). The AIDS generally allows flexible price responses that are in line with demand theory, assuming a utility maximizing household facing a budget constraint. Deaton and Muellbauer (1980) developed the theoretical framework of the AIDS, in which the following budget share demand functions are estimated in a system of equations:

$$w_i = \alpha_i + \sum_{j=1}^k \gamma_{ij} \log(p_j) + \beta_i \log\left(\frac{m}{P}\right) + \varepsilon_i \quad (1)$$

Where w_i is the share of a product i in the total expenditures of the product group, which is milk & milk products composed of $k = 8$ products in our case. On the right hand side, p_j indicates the price of a product j , m represents the total expenditure allocated to the analyzed commodity group, P is a price index defined later, and $\alpha_i, \beta_i, \gamma_{ij}$ are parameters to be estimated and ε_i is the error term for the equation of product i . Demand systems defined as in (1) are linear in the Engel function, and therefore called linear approximated AIDS models (LA/AIDS). In the estimation procedure of the demand system, the following parameter restrictions are imposed in order to get elasticity estimates that are consistent with the behavior of a rational utility maximizing consumer:

$$\text{Adding up restriction: } \sum_i^k \alpha_i = 1; \sum_i^k \gamma_{ij} = 0; \sum_i^k \beta_i = 0 \quad (2)$$

$$\text{Homogeneity restriction: } \sum_{j=1}^k \gamma_{ij} = 0 \quad (3)$$

$$\text{Symmetry restriction: } \gamma_{ij} = \gamma_{ji} \quad (4)$$

While negativity cannot be imposed, it can be checked whether the estimates are consistent by checking the Hicks own-price elasticities.

We complement those data with socioeconomic variables, which allows shifting the level of the demand.

Banks et al. (1997) have shown that for many product groups Engel curves are non-linear, and that in those cases the estimates of the LA/AIDS are biased. For example,

the LA/AIDS does not allow a product to change from a luxury to a necessary good when the consumer's income rises. This inflexibility results in an estimation bias that is particularly significant at low and high ends of the income distribution. In consequence, Banks et al. (1997) developed the quadratic almost ideal demand system (QUAIDS), which lifts this restriction and allows flexible price and income responses. Using their QUAIDS specification and including demographic variables z , the demand equations estimated in this paper are specified as

$$w_i^h = \alpha_i + \gamma'_i p^h + \beta_i \{x^h - a(p^h, \theta)\} + \lambda_i \frac{\{x^h - a(p^h, \theta)\}^2}{b(p^h, \theta)} + u_i^h \quad (5)$$

where $a(p)$ is the translog price aggregator, and $b(p)$ is the Cobb-Douglas price aggregator. They are defined as follows (Banks et al., 1997):

$$a(p^h, \theta) = \alpha_0 + \alpha' p^h + \frac{1}{2} p^{h'} \Gamma p^h \quad (6)$$

$$b(p^h, \theta) = \exp(b' p^h) \quad (7)$$

For adding-up to hold, the additional parameter constraint $\sum_i \lambda_i = 0$ is imposed. The parameter α_0 was set to 1. Typical values reported in QUAIDS literature range between 1 to 10, and we tried different values within that range for α_0 . We found that the choice of α_0 can have a quite significant effect on the estimation outcome. The value 1 was used as it converges quickly and without backup iterations, and it delivers elasticity estimates (at the sample population average) that fulfills the negativity constraint.

The previous section showed that farm level factors can affect the demand side in two ways: 1st the food expenditures are affected by food price movements, and 2nd the observed market prices are not the decision prices and therefore cannot be used to estimate the response of the aggregate demand. To correct this, we use an instrumental variable (IV) approach, treating the price variables as well as the expenditure variable in the AIDS model as endogenous. The IV approach also tackles the effect that when common shocks affect the error terms of the budget share equations and also the total food group expenditure variable, endogeneity is likely to occur and bias the results. The following variables are used to take into account production side characteristics and potential market failures: number of household members working on the farm, livestock number, land rented and land lent, debts of the household, the average selling prices of

plant and of animal products, production quantities of a range of food products, and village dummy variables that capture local production-side characteristics (see data description). In addition to the production side variables, we use the annual net income as instrument for the total expenditure variable. For the sake of brevity, we do not report the results of the nine IV estimations, but they can be requested from the authors.

The estimation is carried out with an iterative procedure that has been implemented in the Stata `aidsills` command provided by Lecocq and Robin (2015). The iterative AIDS approach is computationally quick and can be easily used for instrumenting prices and expenditures. With the `aidsills` command, we computed demand elasticities at group means for the two groups 1) households with agriculture as main income source, and 2) other households.

3.3 Estimation of nutrient demand responses

The abovementioned food demand model estimates price elasticities that are conditional on constant food expenditures. In order to derive unconditional price elasticities and also to estimate income elasticities, we assume that the households follow a multi-stage budgeting process. The first stage of the demand model is specified as a double-log model:

$$\ln q_f = \alpha + \beta_1 \ln p_f + \beta_2 \ln m + \gamma D + \eta \quad (8)$$

Where q_f is the food quantity consumed, p_f is the aggregate food price, m is the household's income, measured as total expenditures, D is a vector of socioeconomic variables, and η is the residual. This equation is estimated with a 2SLS instrumental variable regression, in which the price is instrumented with the same variables as prices in the AIDS. Of relevance are the parameters β_1 , which is the own price elasticity of food ε_f^M , and β_2 , which represents the income elasticity of food e_f^{uc} .¹ These unconditional elasticities e_i^{uc} for each food group aggregate i are calculated as:

$$e_i^{uc} = e_{f,i}^c * e_f^{uc} \quad (9)$$

where $e_{f,i}^c$ is the expenditure elasticity (conditional) for item i within the food group, and e_f^{uc} is the income elasticity for food. The unconditional, uncompensated price elasticity $\varepsilon_{ij}^{M,uc}$ is calculated as

$$\varepsilon_{ij}^{M,uc} = \varepsilon_{ij}^H + e_i^c * w_j \varepsilon_f^M \quad (10)$$

ε_{ij}^H is the compensated price elasticity for item i and price j (conditional); w_j is the budget share of item j in the food budget, and $\varepsilon_f^{M,uc}$ is the unconditional, uncompensated own-price elasticity of food.

The nutrient demand elasticities of energy, protein, iron, zinc, vitamin A and vitamin C have been derived with a variation of the formulas suggested by Ecker and Qaim (2011):

$$\text{Income elasticity: } E_k = \frac{\sum_i n_i e_i^{uc}}{\sum_i n_i} \quad (11)$$

$$\text{Price elasticity: } e_{kj} = \frac{\sum_i n_i \varepsilon_{ij}^{M,uc}}{\sum_i n_i} \quad (12)$$

Where E_k is the income elasticity of nutrient k ; e_{kj} is the price elasticity of nutrient k with respect to a price change of commodity j , and n_i is the nutrient content of the i th food group.

The nutritional heterogeneity in the analyzed food groups is taken into account by computing the nutrient demand elasticities for the individual households' nutrient composition.² Moreover, each household's nutritional minimum nutrient requirement has been calculated based on the age/sex groups living in the household. Given the individual households' daily food purchases and food consumed from own production, it is then evaluated for each of the analyzed nutrients whether the household meets its minimum daily requirement. For the simulation scenarios, the nutrient elasticities are used to estimate the nutritional changes in the individual households' daily food purchases when prices or income changes. Based on this estimate it is then evaluated how many households cross the minimum requirement threshold.

4 Data description

The study uses the 2015 wave of household data gathered from six poor rural counties of three provinces (Shaanxi, Yunnan, Guizhou) in China (Nie et al., 2011). The six counties were first selected from the poorest group of 572 National Poor Counties based on viability. They are located in mountainous areas, where road infrastructure was poor

and economic level of development was lagging behind. Following the selection of the villages, 12 households within each village were randomly selected. In each county, all selected 228 households from 19 villages were interviewed, resulting in a total sample size of 1368 households. The dataset includes comprehensive household information on food consumption, income, expenditure, assets, debts, production, demographics, shocks, and coping strategies. In order to obtain comprehensive data on food demand, the past 30 days was chosen as the recall period.

All specific food items the household consumed in the past 30 days were recorded. There were 180 specific food items in total, which could mainly be divided into coarse grain, rice and its products, maize and its products, flour and its products, beans and its products, tubers, fruit vegetables, leafy vegetables, bean vegetables, other vegetables, fungus, fresh fruits, melons, nuts, aquatic products, poultry, meats, eggs, dairy, and oil. For applying the QUAIDS model, we further aggregated the food items into 8 food categories, which were 1) grains (including coarse grain, rice and its products, maize and its products, flour and its products), 2) bean products and nuts (including beans and its products, nuts), 3) tubers, 4) vegetables (including fruit vegetables, leafy vegetables, bean vegetables, other vegetables, fungus), 5) fruits (including fresh fruits, melons), 6), meats (including meats, poultry, aquatic products), 7) animal products (including eggs, dairy), and 10) oil of plant and animal origin. The unit value of each food category was calculated by aggregated food expenditure of the category divided by aggregated food consumption amount of the same category. Missing values of food price were interpolated by the village average unit value of that food category. Table 2 shows descriptive statistics on the variables employed in the demand model.

Table 2. Descriptive Statistics of Variables in the QUAIDS and the IV regressions

Variable name	Description	Mean	Min	Max
<i>QUAIDS estimation variables</i>				
w1	Budget share: grains, including coarse grains	0.30	0.03	0.84
w2	Budget share: beans, bean products and nuts	0.04	0	0.41
w3	Budget share: tuber	0.05	0	0.48
w4	Budget share: vegetables	0.14	0	0.58
w5	Budget share: fruits	0.06	0	0.38
w6	Budget share: meat and aquatic products	0.23	0	0.87
w7	Budget share: eggs and dairy products	0.06	0	0.69
w8	Budget share: oil of plant and animal origin	0.12	0	0.71
p1	Price: grains, including coarse grains	4.70	1.57	15.75
p2	Price: beans, bean products and nuts	5.44	1.00	41.29
p3	Price: tuber	1.91	0.20	6.00
p4	Price: vegetables	3.61	0.67	18.28
p5	Price: fruits	4.09	0.80	15.38
p6	Price: meat and aquatic products	26.72	4.00	80.00
p7	Price: eggs and dairy products	16.87	3.00	300.22
p8	Price: oil of plant and animal origin	17.11	2.00	64.00
foodexpend	Monthly food expenditures	765.01	50.90	19846
county_1	1 if in Pan (Guizhou), 0 otherwise	0.17	0	1
county_2	1 if in Zhengan (Guizhou), 0 otherwise	0.17	0	1
county_3	1 if in Wuding (Yunnan), 0 otherwise	0.17	0	1
county_4	1 if in Huize (Yunnan), 0 otherwise	0.17	0	1
county_5	1 if in Zhenan (Shaanxi), 0 otherwise	0.17	0	1
county_6	1 if in Luonan (Shaanxi), 0 otherwise	0.17	0	1
gender	1 if household head is female, 0 otherwise	0.06	0	1
children_share	Share of children <= 14 years in total household members	0.16	0	0.75
elder_share	Share of elder household members aged >= 65	0.15	0	1
hhsiz	Household size	3.43	1	11
wealth	Wealth index, computed as principal component on assets	0	-0.86	2.85
type_agri	1 = main income source is agriculture, 0 otherwise	0.49	0	1
shock	1 = natural shock occurred this year, 0 otherwise	0.62	0	1
market	Market distance	6.71	0	150
<i>IV regression variables</i>				
netinc	Monthly net income/1000000	0	-0.03	0.14
debt	Debts/1000000 to the three main credit sources	0.02	0	0.60
landrent	Land rented	22.79	0	422.50
landlend	Land lend	4.00	0	44.30
livestock	Number of livestock, in livestock units	0.98	0	50
agrilabor	Number of household members engaged on the farm	1.66	0	7
saleprice_plant	Average selling price of plant products	4.01	0.70	50.00
saleprice_anim	Average selling price of animal products	17.40	2.00	80.00
prod_grain	Production quantity of grains, including coarse grains	1213	0	24000
prod_beannut	Production quantity of beans and nuts	62.8	0	3000
prod_tuber	Production quantity of tuber	847.4	0	90000
prod_vegetable	Production quantity of vegetables	431	0	63900
prod_fruit	Production quantity of fruits	55.3	0	5000
prod_aquatic	Production quantity of aquatic products	0.70	0	200
prod_meat	Production quantity of meat	583.8	0	58577
prod_eggs	Production quantity of eggs (dairy production negligible)	10.1	0	1000
prod_oil	Production quantity of oil	9.5	0	1200

Village dummy variables were used in IV regressions are not reported here. Prices, expenditure, income and debt enter the equation in logarithmic terms. For values $x \leq 0$, the $\ln(1+x)$ transformation was used.

5 Results

The first stage regression results can be found in the Appendix (tables A1 and A2). Its results show that the income elasticity of food in the study region are at 0.31 for household with agriculture as main income source and 0.21 for the other households. Own price elasticities for total food is -0.62 and -0.68 respectively.

For the sake of space and to keep the focus on the final demand response and food security results, the instrumental variable (IV) regressions as well as the QUAIDS parameters are not being reported but will be summarized briefly here. The R^2 (adjusted R^2) of the IV regressions range from 0.22 (0.14) for the price regression of eggs & dairy products up to 0.63 (0.59) for the price regression of oils. In all price and expenditure regressions, some identifying instruments have been significant, although not the same in the different equations. The inclusion of village dummy variables contributed significantly to the explanatory power of the equations, which is not surprisingly given the remoteness of the villages.

The eight QUAIDS equations had an R^2 ranging from 0.2 (oils) to 0.55 (meats and aquatic products), which we consider as sufficient for a cross-sectional analysis. Interesting patterns are that the budget share of meats and aquatic products (the latter being of little importance) as indicated by a positive and highly significant wealth index (99% significance level), while the opposite is true for grain products. The latter, clearly serving as a staple food, is also the only variable of which the budget share rises when a natural shock has occurred to the household. Grains and tubers also have higher budget shares when the market distance increases, while most other products have significantly reduced budget shares when markets are farer away. With increasing household size, the budget share of grain increases, while the opposite is true for beans & bean products and meats & aquatic products. Household gender does not have any significant effect on the demand pattern, but household composition does. A higher share of children among the household members significantly increases the budget share of fruits, but also reduces the budget share for grains as well as vegetables. Households with agriculture as main income have smaller budget shares spent on vegetables and eggs & dairy products compared to the other households that have less than 50% income from agricultural activities (at 90% significance level). The results discussed above are available on request to the authors.

5.1 Food elasticity estimates

With the parameters obtained from the QUAIDS model, we calculated demand elasticities for the whole sample population as well as at group means for households with agriculture as main income source (now: agricultural households) and other households. Despite this differentiation, it has to be kept in mind that in our sample more than 70% of the other households still have some agricultural activities and produce food.

The results for conditional expenditure and own-price elasticities are shown in table 3. For all groups the compensated own-price elasticities estimates are negative, indicating that negativity holds. Most of the elasticities are different from zero at a high 99% significance level. This is however not the case for eggs & dairy products and beans, bean products & nuts. For the whole sample and its agricultural household subsample, grains demand elasticities are also not significantly different from zero. Grain has the lowest expenditure elasticity, showing that with an increase in food expenditures, the households' budget share in food expenses decreases. Expenditure elasticities higher than 1 indicate that with rising food expenditures, the food budget shares increase. For all household groups, the food categories beans, bean products & nuts and meat & aquatic products have the highest expenditure elasticities with values above 1.3.

Unconditional income and price elasticities (uncompensated) are reported in table 4. In general, income elasticities of agricultural households are on a somewhat higher level than those for other households. In line with recent research on rural China, the income elasticity for grain is the lowest compared to the other food groups (Zheng *et al.*, 2015). Of the price elasticities, the demand response of agricultural households is in 41 cases more elastic and in 23 cases (most of the own-prices) less elastic than other households. The differences are however often very small. While farm households can switch consumption to own produced food if purchasing prices are increasing and thus a more elastic demand than the one of other households could have been expected, it should be beard in mind that these are uncompensated price elasticities for which an income effect also plays a role.

Table 3. Food elasticities estimated by the QUAIDS model (conditional)

	Total households (N=1368)			Agricultural households (N=668)			Other households (N=700)		
	Expenditure elasticity	Uncompst. Own price elasticity	Compenst. Own price elasticity	Expenditure elasticity	Uncompst. Own price elasticity	Compenst. Own price elasticity	Expenditure elasticity	Uncompst. Own price elasticity	Compenst. Own price elasticity
Grain	0.593*** (-0.089)	-0.271* (-0.147)	-0.124 (-0.14)	0.567*** (-0.097)	-0.223 (-0.16)	-0.092 (-0.152)	0.615*** (-0.083)	-0.312** (-0.137)	-0.149 (-0.13)
Beans, bean prod. & Nuts	1.355*** (-0.124)	-0.189 (-0.177)	-0.128 (-0.173)	1.362*** (-0.127)	-0.169 (-0.184)	-0.109 (-0.18)	1.349*** (-0.122)	-0.207 (-0.173)	-0.145 (-0.169)
Tuber	1.115*** (-0.172)	-0.861*** (-0.183)	-0.813*** (-0.181)	1.133*** (-0.188)	-0.846*** (-0.202)	-0.802*** (-0.2)	1.101*** (-0.159)	-0.872*** (-0.168)	-0.821*** (-0.166)
Vegetables	0.823*** (-0.09)	-0.446*** (-0.105)	-0.327*** (-0.1)	0.808*** (-0.097)	-0.410*** (-0.113)	-0.301*** (-0.107)	0.835*** (-0.085)	-0.476*** (-0.099)	-0.348*** (-0.094)
Fruits	1.163*** (-0.098)	-0.600*** (-0.1)	-0.500*** (-0.097)	1.160*** (-0.103)	-0.576*** (-0.106)	-0.481*** (-0.102)	1.166*** (-0.093)	-0.620*** (-0.095)	-0.515*** (-0.092)
Meat & Aquatic products	1.409*** (-0.066)	-0.733*** (-0.094)	-0.381*** (-0.092)	1.348*** (-0.057)	-0.788*** (-0.08)	-0.391*** (-0.079)	1.491*** (-0.078)	-0.660*** (-0.113)	-0.350*** (-0.111)
Eggs & Dairy products	0.958*** (-0.168)	-0.215 (-0.142)	-0.146 (-0.137)	0.941*** (-0.199)	-0.071 (-0.18)	-0.013 (-0.174)	0.970*** (-0.146)	-0.317*** (-0.12)	-0.236** (-0.116)
Oil	0.932*** (-0.103)	-0.559*** (-0.116)	-0.454*** (-0.114)	0.937*** (-0.1)	-0.571*** (-0.113)	-0.463*** (-0.111)	0.927*** (-0.106)	-0.547*** (-0.12)	-0.446*** (-0.117)

Table 4. Unconditional food demand elasticities

	Income	Grain	Beans, bean products & Nuts	Tuber	Vegetables	Fruits	Meat & Aquatic products	Eggs & Dairy products	Oil
Agricultural households (N=668)									
Grain	0.1698	-0.1979	-0.0582	-0.0108	-0.0077	-0.0546	0.0400	-0.1152	0.0344
Beans, bean prod. & Nuts	0.4078	-0.4842	-0.1428	-0.0169	0.1240	0.2334	-0.4345	0.0281	-0.1959
Tuber	0.3394	-0.1815	-0.0043	-0.8338	-0.0938	0.0073	0.0588	-0.0040	0.3117
Vegetables	0.2420	-0.0798	0.0588	-0.0211	-0.3711	-0.0184	-0.0545	-0.0750	0.0338
Fruits	0.3475	-0.3106	0.1241	-0.0089	-0.0816	-0.5243	0.1993	-0.0193	-0.1359
Meat & Aquatic products	0.4035	-0.1415	-0.0625	-0.0036	-0.0766	0.0620	-0.6285	0.0392	-0.0679
Eggs & Dairy products	0.2817	-0.5411	0.0279	-0.0060	-0.1910	-0.0116	0.2285	-0.0430	-0.0776
Oil	0.2805	-0.0133	-0.0549	0.1088	0.0359	-0.0630	-0.0550	-0.0296	-0.5401
Other households (N=700)									
Grain	0.1297	-0.2851	-0.0474	-0.0044	0.0066	-0.0377	-0.0037	-0.0845	0.0280
Bean products & Nuts	0.2842	-0.4721	-0.1832	-0.0178	0.1142	0.2212	-0.4339	0.0264	-0.1932
Tuber	0.2321	-0.1461	-0.0018	-0.8599	-0.0707	0.0135	0.0349	0.0052	0.2586
Vegetables	0.1759	-0.0614	0.0537	-0.0157	-0.4356	-0.0110	-0.0808	-0.0567	0.0266
Fruits	0.2456	-0.2858	0.1121	-0.0078	-0.0756	-0.5688	0.1585	-0.0152	-0.1284
Meat & Aquatic products	0.3141	-0.2340	-0.0996	-0.0128	-0.1365	0.0650	-0.5414	0.0396	-0.1175
Eggs & Dairy products	0.2045	-0.3881	0.0243	-0.0008	-0.1301	0.0012	0.1585	-0.2840	-0.0561
Oil	0.1952	-0.0134	-0.0598	0.1154	0.0369	-0.0681	-0.1060	-0.0268	-0.5229

Note: For the calculation of the unconditional price elasticities, the individual households' price shares were used. The reported elasticities are the averages of the household groups.

Table 5. Nutrient elasticities

	Income	Grain	Bean, bean products & Nuts	Tuber	Vegetables	Fruits	Meat & Aquatic products	Eggs & Dairy products	Oil
Agricultural households (N=668)									
Energy	0.2324	-0.1750	-0.0522	-0.0091	-0.0109	-0.0446	-0.0369	-0.0734	-0.1043
Protein	0.2445	-0.2412	-0.0590	-0.0341	-0.0244	-0.0006	-0.0954	-0.0694	-0.0088
Iron	0.2385	-0.2139	-0.0510	-0.0284	-0.0267	-0.0261	-0.0538	-0.0724	-0.0474
Zinc	0.2349	-0.2206	-0.0519	-0.0314	-0.0279	-0.0264	-0.0632	-0.0751	-0.0156
Vitamin A	0.2838	-0.2283	0.0222	-0.0335	-0.1862	-0.0674	-0.0183	-0.0458	-0.0613
Vitamin C	0.2778	-0.1678	0.0462	-0.1585	-0.2071	-0.1333	0.0281	-0.0540	0.0409
Other households (N=700)									
Energy	0.1707	-0.2090	-0.0513	0.0063	-0.0041	-0.0397	-0.0739	-0.0601	-0.1318
Protein	0.1785	-0.2865	-0.0584	-0.0265	-0.0265	0.0026	-0.1087	-0.0692	-0.0160
Iron	0.1717	-0.2446	-0.0498	-0.0157	-0.0252	-0.0245	-0.0776	-0.0626	-0.0670
Zinc	0.1726	-0.2675	-0.0517	-0.0221	-0.0268	-0.0187	-0.0880	-0.0665	-0.0288
Vitamin A	0.2025	-0.2103	0.0160	-0.0294	-0.2190	-0.0360	-0.0359	-0.1128	-0.0415
Vitamin C	0.1991	-0.1506	0.0470	-0.1509	-0.2451	-0.1362	-0.0001	-0.0492	0.0275

Note: The nutrient elasticities were calculated using the households' individual nutrient composition of the food groups. Reported are averages of the household groups.

5.2 Nutrient demand elasticities

The unconditional elasticities are used to calculate nutrient demand elasticities reported in table 5. Nutrient income elasticities are a bit higher for agricultural households than for other households, although not much. The income elasticities range from 0.23 (energy) to 0.28 (vitamin A) for agricultural households, and from 0.17 to 0.20 for other households. Thus, when income rises, their change in nutrient purchases is a bit more pronounced than the one of other households. This is not generally the case for price changes. Price elasticities of energy, protein, iron and zinc for price changes in grain and meat & aquatic products are smaller than in the other household group. For both household groups the grain price has the most important effect on nutrient demand for energy, protein, iron, zinc and vitamin A, which is not surprising given its status as a staple food. Only for vitamin C it is the price of vegetables that has the highest influence. Other products with important effect on nutrient consumption are tuber and fruits on vitamin C and vegetables on vitamin A.

5.3 Simulation results

The effect of food price and income changes on the nutrient status is simulated using the households nutrient consumption as a basis and deriving the change in purchased nutrients based on the computed nutrient elasticities. To see the effects, we define three scenarios and compare them to the nutrient consumption of 2015 (status quo). In the 1st scenario, an income increase by +100% is assumed, in the 2nd scenario the households are faced with a grain price increase by 100% and in the 3rd scenario the grain price decreases by 50%. As a cautionary note, the elasticities calculated were based on point estimates, and therefore the evaluation of increasing income and price changes come at an increasing extrapolation risk of being off the demand curve. We did not define scenarios with several price changes, in order to not violate the *ceteris paribus* condition of the parameters estimated. ³

Nutrition insecurity is measured at household level, by evaluating the nutritional needs of the age/sex groups within the households and adding their nutritional needs for energy (kcal), protein, iron, zinc, vitamin A and vitamin C to derive a household minimum requirement threshold. If a household's nutrient consumption falls below this

threshold, allocation at least one household member will not meet her nutritional requirement, and this regardless of intra-household allocation. A household not meeting the sum of minimum requirements of its members is thus counted as nutrition insecure.⁴ The household's overall consumption includes its food used for own consumption as well as purchased food. In the scenarios however, the consumption of own produce is fixed, and only the difference in purchased nutrients is evaluated.

Table 6 shows the results of the simulations and compares the scenarios with the status quo. In four columns the results of the status quo and scenario calculations are depicted. The upper section presents results for agricultural households, the middle part for other households and the bottom part for the total sample. The absolute numbers are the number of households considered as food insecure with respect to the nutrient mentioned in the first column.⁵

In the status quo, it can be seen that nutrition insecurity is by far most severe for vitamin A with a prevalence of 88% in the total households. The highest nutrient security is achieved for iron, with just 8% of the households facing undersupply. Other nutrients have prevalence rates from 23% and 38%. Agricultural households have generally a smaller share of insecure households than other households in poor rural areas. Starting from this initial situation, the changes occurring when the income rises by 100% is depicted in the next column. In comparison with the status quo scenario, such a development reduces the number of nutrition insecure total households by 18% for iron, 15% for energy, 14% for zinc and 11% for protein. Vitamin demand has a relatively small response with -8% for vitamin A and only -1% for vitamin C. The income effect is more pronounced for agricultural households than for other households, and this is true for all nutrients.

In the following column the simulated consequences of an increase in grain prices by 100% is depicted. This price effect has considerable negative effects for energy, protein, iron and zinc supply, while both analyzed vitamins are again relatively unresponsive. With respect to grain prices, the group of other households have mostly a much higher nutrient demand responsiveness than agricultural households. This is a result of the higher grain price elasticity (Table 4). For energy, protein and iron the absolute changes are twice as high or higher. As a last scenario, the nutrition situation of households after a grain price decrease by 50% is presented in the last column. Interestingly, for total households such a scenario has a quite similar effect as an income increase of 100%.

Table 6. Nutrition insecurity: status quo (2015) and simulation results

	Status quo			Income +100%		Grain-Price +100%		Grain-Price -50%	
Agricultural households (N=668)									
	below min. reqrm.	% share	below min. reqrm.	% change	below min. reqrm.	% change	below min. reqrm.	% change	
Energy	172	26%	141	-18%	222	29%	148	-14%	
Protein	213	32%	182	-15%	272	28%	181	-15%	
Iron	50	7%	35	-30%	74	48%	36	-28%	
Zinc	124	19%	105	-15%	185	49%	102	-18%	
Vitamin A	584	87%	581	-1%	594	2%	581	-1%	
Vitamin C	263	39%	241	-8%	282	7%	253	-4%	
Other households (N=700)									
	below min. reqrm.	% share	below min. reqrm.	% change	below min. reqrm.	% change	below min. reqrm.	% change	
Energy	219	31%	190	-13%	319	46%	178	-19%	
Protein	245	35%	226	-8%	366	49%	211	-14%	
Iron	53	8%	49	-8%	107	102%	47	-11%	
Zinc	186	27%	162	-13%	286	54%	140	-25%	
Vitamin A	616	88%	604	-2%	628	2%	610	-1%	
Vitamin C	256	37%	235	-8%	273	7%	245	-4%	
Total households (N=1368)									
	below min. reqrm.	% share	below min. reqrm.	% change	below min. reqrm.	% change	below min. reqrm.	% change	
Energy	391	29%	331	-15%	541	38%	326	-17%	
Protein	458	33%	408	-11%	638	39%	392	-14%	
Iron	103	8%	84	-18%	181	76%	83	-19%	
Zinc	310	23%	267	-14%	471	52%	242	-22%	
Vitamin A	1200	88%	1185	-1%	1222	2%	1191	-1%	
Vitamin C	519	38%	476	-8%	555	7%	498	-4%	

6 Conclusion

This study evaluated the effect of income and price changes on the food security status of households in poor rural regions in China. It thereby included own produced food in the demand estimation, in order to correct potential measurement bias when the production and demand decisions become interlinked as it is likely to be for agricultural households in remote areas. For a nutrition analysis, the food groups in the demand models were relatively broadly defined. We did so in order to avoid econometric problems and too little variation when zero consumption values become dominating in smaller food item definitions. However, since we had information on the exact nutrient composition of the broad food groups, we computed individual nutrient elasticities,

calculated the individual nutrient response and food insecurity status of each household. Since the food categories studied here do also have some numbers of zero consumption, it is nevertheless an interesting way to proceed to check whether a demand model that can account for the agricultural household setting and at the same time properly accounts for limited dependent variables would reveal different results. A further promising approach to refine the simulations is to also estimate production side changes and see how own production changes a households' nutrient supply. The estimated food and nutrient elasticities as such are of value for policy analysts to estimate the effects of policies targeted towards those regions, be they income or price related. It was shown that nutrients have generally highest responsiveness to grain price changes. The food security simulations showed the importance of economic development, and particularly of the grain price levels in the food security status of households. While the nutrient elasticity estimates might indicate that income subsidies or grain price policies could be appropriate methods to tackle a vast range of nutrient deficiencies, the simulation results showed a somewhat different picture, as vitamin A and vitamin C undersupply hardly changed even when prices or income have greater movements. We therefore see simulations as a valuable addition to the report of nutrient elasticities.

References

- Babu, S., Gajanan, S. N., & Hallam, J. A. (2016). *Nutrition Economics: Principles and Policy Applications*. Academic Press.
- Banks, J., Blundell, R., & Lewbel, A. (1997). Quadratic Engel curves and consumer demand. *Review of Economics and statistics*, 79(4), 527-539.
- De Janvry, A., Sadoulet, E. & Fafchamps, M. (1991). Peasant Household Behaviour with Missing Markets: Some Paradoxes Explained. *The Economic Journal*, Vol. 101, No. 409, 1400-1417.
- Deaton, A., & Muellbauer, J. (1980). An almost ideal demand system. *The American Economic Review*, 70(3), 312–326.
- Ecker, O., & Qaim, M. (2011). Analyzing Nutritional Impacts of Policies: An Empirical Study for Malawi. *World Development*, 39(3), 412–428.
- Fan, S., Cramer, G., & Wailes, E. (1994). Food demand in rural China: evidence from rural household survey. *Agricultural Economics*, 11(1), 61-69.
- FAO (2013). *The State of Food Insecurity in the World 2013*. The multiple dimensions of food security. FAO, Rome.

- Gao, X. M., Wailes, E. J., & Cramer, G. L. (1996). A two-stage rural household demand analysis: Microdata evidence from Jiangsu Province, China. *American Journal of Agricultural Economics*, 78(3), 604–613.
- Gould, B. W., & Villarreal, H. J. (2006). An assessment of the current structure of food demand in urban China. *Agricultural Economics*, 34(1), 1-16.
- Huang, K. S., & Gale, F. (2009). Food demand in China: income, quality, and nutrient effects. *China Agricultural Economic Review*, 1(4), 395–409.
- Huang, J., & Rozelle, S. (1998). Market development and food demand in rural China. *China Economic Review*, 9(1), 25–45.
- Lancaster, K.J. (1979). *Variety, equity and efficiency*. New York: Columbia University Press.
- Lecocq S. & Robin, J. M. (2015). Estimating almost-ideal demand systems with endogenous regressors, *The Stata Journal* 15(2), 554–573.
- Liu, H., Wahl, T. I., Seale, J. L., & Bai, J. (2015). Household composition, income, and food-away-from-home expenditure in urban China. *Food Policy*, 51, 97–103.
- Luo, R., Wang, X., Zhang, L., Liu, C., Shi, Y., Miller, G., ... Martorell, R. (2011). High anemia prevalence in western China. *Southeast Asian Journal of Tropical Medicine and Public Health*, 42(5), 1204.
- Nie, P., & Sousa-Poza, A. (2016). A fresh look at calorie-income elasticities in China. *China Agricultural Economic Review*, 8(17), 55–80.
- Nie, F., Wadhwa, A., Wang, W., et al. (2011). *Analysis of Food Security and Vulnerability in Six Counties in Rural China*. Beijing: China Agricultural Sciences and Technology Press.
- Nie, F., Huang, J., & Bi, J. (2014). Food Consumption of Households in Poverty-Stricken Areas of West China: The Case of Shaanxi, Yunnan, and Guizhou. In: *Proceedings of 2013 World Agricultural Outlook Conference* (pp. 77–87). Springer.
- Ogundari, K., & Abdulai, A. (2013). Examining the heterogeneity in calorie–income elasticities: A meta-analysis. *Food Policy*, 40(6), 119–128.
- Pitt, M., & Rosenzweig, M. R. (1986). Agricultural prices, food consumption, and the health and productivity of Indonesian farmers. In: *Agricultural household models: Extensions, applications and policy*, 153-82.
- Robles, M., Torero, M., & Cuesta, J. (2010). Understanding the Impact of High Food Prices in Latin America. *Economica*, 10(2), 117–164.

- Sadoulet, E., & De Janvry, A. (1995). *Quantitative development policy analysis*. Baltimore: Johns Hopkins University Press.
- Santeramo, F. G., & Shabnam, N. (2015). The income-elasticity of calories, macro- and micro-nutrients: What is the literature telling us? *Food Research International*, 76(P4), 932–937.
- Shonkwiler, J. S., & Yen, S. T. (1999). Two-step estimation of a censored system of equations. *American Journal of Agricultural Economics*, 81(4), 972–982.
- Singh, I., Squire, L., & Strauss, J. (1986). *Agricultural household models: Extensions, applications, and policy*. The World Bank.
- Taylor, J. E., & Adelman, I. (2003). Agricultural Household Models: Genesis, Evolution, and Extensions. *Review of Economics of the Household*, 1(1), 33–58.
- Tekgüç, H. (2012). Separability between own food production and consumption in Turkey. *Review of Economics of the Household*, 10(3), 423–439.
- Tian, X., & Yu, X. (2013). The demand for nutrients in China. *Frontiers of Economics in China*, 8(2), 186–206.
- Wong, A. Y. S., Chan, E. W., Chui, C. S. L., Sutcliffe, A. G., & Wong, I. C. K. (2014). The phenomenon of micronutrient deficiency among children in China: a systematic review of the literature. *Public Health Nutrition*, 17(11), 2605–2618.
- Ye, X., & Taylor, J. E. (1995). The Impact of Income Growth on Farm Household Nutrient Intake: A Case Study of a Prosperous Rural Area in Northern China. *Economic Development and Cultural Change*, 43(4), 805–819.
- Zhang, X., Mount, T. D., & Boisvert, R. N. (2001). The Demand for Food Grain in China: New Insights into a Controversy. *Agricultural and Resource Economics Review*, 30(1), 1–9.
- Zheng, Z., & Henneberry, S. R. (2010). The impact of changes in income distribution on current and future food demand in urban China. *Journal of Agricultural and Resource Economics*, 51–71.
- Zheng, Z., Henneberry, S. R., Zhao, Y., & Gao, Y. (2015). *Income growth, urbanization, and food demand in China*. Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's (AAEA) Annual Meeting, San Francisco, CA.
- Zuo, X. L., & Zhang, G. S. (2011). Empirical Comparison of Animal Food Consumption between Urban and Rural Residents in Liaoning Province. *Journal of Shenyang Agricultural University (Social Sciences Edition)*, 2, 005.

Appendix

Table A1.1 First budgeting stage: Other households

Instrumental variables (2SLS) regression

Number of obs = 700

Wald chi2(14) = 516.46

Prob > chi2 = 0.0000

R-squared = 0.5393

Root MSE = .41225

(Std. Err. adjusted for 109 clusters in vcode)

ln_q	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
ln_p	-.6958068	.0572591	-12.15	0.000	-.8080325	-.5835811
ln_totexpend	.2107247	.0299162	7.04	0.000	.1520901	.2693593
hhhead_gender	-.139393	.0668494	-2.09	0.037	-.2704154	-.0083706
share_childnumb_0to14	.0261194	.0862139	0.30	0.762	-.1428569	.1950956
share_eldernumb	-.0878559	.0571871	-1.54	0.124	-.1999406	.0242287
hhsize	.1090445	.0128267	8.50	0.000	.0839046	.1341843
wealthindex	.1329102	.0347038	3.83	0.000	.0648919	.2009284
natsho	-.0053095	.0332152	-0.16	0.873	-.0704101	.0597912
market	-.0018924	.0031299	-0.60	0.545	-.0080268	.0042421
county_2	.0026238	.0695933	0.04	0.970	-.1337765	.1390241
county_3	.1749287	.0739385	2.37	0.018	.030012	.3198455
county_4	.132168	.0723895	1.83	0.068	-.0097128	.2740489
county_5	-.0405949	.074406	-0.55	0.585	-.1864279	.1052382
county_6	-.1900056	.0697957	-2.72	0.006	-.3268027	-.0532084
_cons	3.710362	.2201847	16.85	0.000	3.278808	4.141916

Instrumented: ln_p

Table A1.2 First budgeting stage: Agricultural households

Instrumental variables (2SLS) regression				Number of obs = 668		
				Wald chi2(14) = 467.18		
				Prob > chi2 = 0.0000		
				R-squared = 0.5202		
				Root MSE = .40156		
(Std. Err. adjusted for 112 clusters in vcode)						
ln_q	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
ln_p	-.6525361	.0778386	-8.38	0.000	-.805097	-.4999752
ln_totexpend	.2994221	.0327099	9.15	0.000	.2353118	.3635324
hhhead_gender	-.031738	.0859329	-0.37	0.712	-.2001635	.1366874
share_childnumb_0to14	-.0769227	.0975909	-0.79	0.431	-.2681974	.1143519
share_eldernumb	-.1082959	.0698766	-1.55	0.121	-.2452516	.0286598
hhsize	.07321	.0131088	5.58	0.000	.0475173	.0989027
wealthindex	.1103434	.0270423	4.08	0.000	.0573415	.1633454
natsho	-.0125882	.0311929	-0.40	0.687	-.0737251	.0485487
market	-.0021082	.0015069	-1.40	0.162	-.0050617	.0008453
county_2	.0121279	.0569911	0.21	0.831	-.0995726	.1238283
county_3	.2045421	.0561454	3.64	0.000	.0944991	.3145851
county_4	.0953438	.0521806	1.83	0.068	-.0069282	.1976159
county_5	-.0299376	.0721699	-0.41	0.678	-.171388	.1115128
county_6	-.2275332	.0979621	-2.32	0.020	-.4195354	-.0355309
_cons	3.124267	.3085911	10.12	0.000	2.51944	3.729095

Instrumented: ln p

¹ The results of the first budget stage are not shown here, but can be obtained by request to the authors.

² A further step could have been done by estimating a 3rd stage of more detailed food groups. However, with more detailed food groups, there is a considerable number of zero consumption observations which makes the model increasingly unsuitable, as the AIDS assumes a continuous left-hand side variable. A common approach to deal with this is the two step method proposed by Shonkwiler and Yen (1999). This comes at the cost of theoretical consistency as the adding up constraint cannot be imposed, which reduces the applicability for scenario simulations. Moreover, since the number of zero values in the demand variables of the AIDS drastically increases for smaller defined food groups, there is little variation left in our study sample. We therefore argue that it is a more reliable approach to estimate the average demand response to those eight food groups of the 2nd stage.

³ When no price illusion is assumed however, any scenario of income changes can be also seen as a scenario of an according change in all prices in the opposite direction.

⁴ For a thorough analysis of nutrition insecurity all nutrient thresholds need to be considered. A household is then seen as insecure as soon as one nutrient supply is below the minimum requirement. Because of the high numbers of vitamin A insecure households and its little responsiveness to prices and income, such a strict definition does not reveal much new insights.

⁵ Because the households have a varying number of members and that nutritional requirements are different at different ages and for women and men, the absolute numbers in term of nutrients are not very informative.