INTRAHOUSEHOLD ALLOCATION OF DIETARY DIVERSITY IN EAST AFRICAN PASTORALIST HOUSEHOLDS

Kira M. Villa, Cornell University
Christopher B. Barrett, Cornell University
David R. Just, Cornell University

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Abstract

In this paper we explore intrahousehold nutritional allocation in pastoralist households in northern Kenya and southern Ethiopia. A number of previous studies on intrahousehold behaviors have compared income or price elasticities of resource allocation across demographic cohorts as a way of inferring intrahousehold welfare disparities (or lack there of). However, differing elasticities have very different welfare implications depending on the direction of income or price changes and thus cannot be used to make definitive welfare comparisons. To control for this problem we estimate cohort-specific income elasticities separately for when income is below or above the household's intertemporal mean income. Statistical tests show that individuals do exhibit asymmetrical responses to changes in above- or below-mean income. Furthermore, we find that household heads appear to disproportionately bear the nutritional burden when household income is below its mean while other household members appear to disproportionately enjoy nutritional gains when household income is above its mean. Stochastic dominance tests on simulated cohort-specific nutritional distributions show that adult daughters are systematically better off than other household members, sons are systematically worse off, and there seems to be little difference between male household heads and their wives.

I. Introduction

Nutritional welfare is an individual, not household, characteristic. While the average nutritional status of the household can be one of the largest determinants of the well-being of its members, nutritional well-being is individually experienced. Therefore development policies targeting nutrition are typically more concerned with their possible implications for individual welfare than for household-, community- or national-level aggregates. The household, though, may be one of the most important institutions influencing individual nutritional welfare. Consequently, an understanding of how households allocate resources to their individual members is essential in evaluating income generation and pricing policies. Deaton (1997) points out that if members in a household are treated differently, but equality is assumed, then true inequality is understated and social welfare is overstated. Haddad and Kanbur (1990) show that the ranking order of different socioeconomic and geographic groups by their nutritional status can change depending on whether individual- or household-level data are used.

There is a large literature in development economics evaluating whether and to what extent the intrahousehold allocation of food differs according to demographic groups such as gender and age. To make any definitive welfare statements concerning demographic groups within the household, one must not only consider relative levels of nutrient intake, but also the relative volatility of one group's nutrient consumption versus another group's. For example, if one group has a high mean but also a high variance of food intake, then that group may not necessarily be nutritionally better off than another group whose average food intake is lower yet less volatile over time. Thus disparities in mean nutritional intake alone among different household demographic groups do not necessarily signify disparities in nutritional welfare.

II. Intrahousehold Allocation of Nutrition

Food allocation within the household has been a widely studied facet of intrahousehold distribution.[1] Evidence for the existence and extent of intrahousehold inequality in nutritional well-being is mixed. While a number of studies have found a pro-male bias in intrahousehold nutrient distribution, this result has predominately been found in northern India and Bangladesh. Outside of these regions evidence for male bias in food allocation is scarce (Haddad et al., 1996).

In a study of households in Bangladesh, Pitt *et al.* (1990) find that men have both a higher mean and a higher variance of caloric consumption than do women. They also find that adult males are much more likely to participate in energy-intensive activities than are women. Thus, despite adult males' higher average calorie consumption, their high energy expenditure results in a tax on their endowments that exceeds that on adult females. Therefore, the authors conclude that these households appear to be more inequality averse than male-biased or income-maximizing in their intrahousehold food allocation behaviors.

Dercon and Krishnan (2000) examined intrahousehold disparities in Ethiopian households by looking at whether these households engaged in complete risk sharing. They found in all study locations save one that households fully shared the risk of unpredicted illness. The exception was poor households in southern Ethiopia where women were not fully insured against unpredicted illness while men were.

A number of studies have examined the existence and magnitude of intrahousehold inequality by comparing the income and price elasticities of household resource consumption among different demographic groups. If one household demographic group's consumption is more income or price elastic than another's, then this might be indicative of greater volatility in their consumption. Some studies have

[1] For a good review of this literature see Haddad *et al.* (1996).

found that consumption and human capital investment are less price and income elastic for more "favored" demographic groups than less favored ones (Alderman and Gertler 1997, Behrman 1988, Behrman and Deolalikar 1990).

For example, in a study of households in rural South India, Behrman and Deolalikar (1990) find that females' nutrient intake is more price elastic than that of males. The authors conclude that these higher elasticities could leave women and girls vulnerable during times of food shortages. Alderman and Gertler (1997) develop a theoretical model in which human capital investments are more income and price elastic for less favored household demographic groups. They then show empirically that girls' demand for healthcare services is more price and income elastic than that of boys in a study of Pakistani households.

Mangyo (2008), on the other hand, demonstrates theoretically that higher income and price elasticities do not necessarily indicate weaker household status. He explains that as household income increases, the rate at which resource allocation to individuals increases depends on the rates at which the marginal utility and productivity of one household member fall relative to that of others. Among Chinese households, he finds that the nutrient intake of females is less income elastic than that of males when controlling for potentially confounding factors. In fact, he found that prime-age males had the highest income elasticity of all the gender and age groups studied.

Comparing income or price elasticities of consumption among demographic groups within the household has been widely used as a way of making intrahousehold welfare statements. It has often been implied that an individual whose consumption is relatively more price or income elastic is worse off because this indicates that his consumption is more volatile. Certainly, awareness of individual-level income and price elasticities allows for better and more informed evaluations of the welfare impacts of income and price changes. However, elasticities may be inadequate for making any definitive welfare comparisons.

As discussed, Behrman and Deolalikar (1990) found that the nutrient intake of females in their study was more price elastic than that of males. They surmised that while this may mean that females enjoy a disproportionate share of nutritional reward when food prices are falling, it also means that their nutritional burden is greater when food prices are rising during lean seasons and droughts. The authors conclude that this leaves females more vulnerable to malnutrition and starvation.

This highlights an important point. Whether disproportionately high income or price elasticities are a blessing or a curse depends on the direction of changes in income or prices. For example, a high income elasticity of consumption is beneficial to the individual when the household is enjoying robust income growth and a burden during less favorable times. Unless models control somehow for this directional distinction, income and price elasticities alone may be inadequate for making any definitive intrahousehold welfare statements.

This paper examines whether there are intrahousehold nutritional disparities among demographic groups in pastoralist households in northern Kenya and southern Ethiopia. It also explores whether there are substantive disparities in how household demographic groups respond nutritionally to changes in household income and food commodity prices. Section III describes the data and setting of this study. In Section IV we build an empirical model of nutrition that estimates income elasticities separately for when income is above and below the household's intertemporal mean income. This model accounts for the directional movements of income and thus makes elasticities more appropriate for welfare comparisons. In Section V we plot nonparametric regressions comparing the dietary diversity of household heads in our data sample to that of wives, adult sons and adult daughters. Section VI discusses our estimation and results. In section VII we conduct distributional tests among simulated nutritional cohort-specific distributions in order to infer demographic welfare orderings. Finally, Section VIII concludes.

III. Data and Setting

The data come from a comprehensive set of panel data collected by the USAID Global Collaborative Research Support Program (GL CRSP) project "Improving Pastoral Risk Management on East African Rangelands" (PARIMA). Households were surveyed in three locations in southern Ethiopia and six in northern Kenya,[2] all in one livestock production and marketing region (Barrett et al., 2008). While some households may be involved in activities such as trade, wage labor, or, to a very limited extent, crop cultivation, the primary economic activities for most households in the area are centered around livestock.

Pastoralism allows households to be opportunistic in these arid and semi-arid lands where uncertainties in rainfall make primary production risky (Coppock 1994). Very few households do not own any livestock. In fact, only 2 out of 212 households in the sample did not own any livestock over the entire study period. Average herd size in the sample is approximately 17.87 Tropical Livestock Units (TLU).[3] Livestock products make up roughly 48% of total income in the sample population and livestock trade makes up another 17%. Descriptive statistics on households in the sample population can be found in Table 1.

Polygamy is widely practiced in the study area. Household heads in these communities are generally male. Female household heads are usually widows. Girls typically marry young and then go to live either in their husband's household or that of his parents. This explains the relatively small number of adult co-resident daughters in the sample population. While numerous household members may participate in livestock care, herding is primarily the responsibility of sons.

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[2] The six study locations in Kenya were Dirib Gumbo, Kargi, Logologo, Ng'ambo, North Horr, and Sugata Marmar. In Ethiopia the study sites were Dida Hara, Finchawa, and Qorate.

[3] TLU is a standard measure for aggregating livestock herds across various species based on equivalent average bodyweight; 1 TLU = 1 cattle = 0.7 camel = 0.1 sheep or goat.

In each study location 30 households were randomly sampled, resulting in a total of 337 households surveyed[4]. From each household, the household head was surveyed along with up to two non-head, adult household members. The non-head adults include one wife,[5] if there is a co-resident spouse, along with another co-resident adult member such as a parent, sibling, or adult child of the household head. Because the focus of this paper is on intrahousehold distribution, households in which only the head was surveyed were excluded. Additionally, households were excluded in which the only non-head member surveyed was not a wife, son or daughter. There were not enough observations on individuals in other, smaller demographic cohorts to generate meaningful estimations. For the same reason, observations on non-head individuals other than wives or adult children of the head were also excluded even if other members of their household were included.

Surveys were conducted in March 2000 to gather baseline information and then quarterly from June 2000 to June 2002, resulting in 10 quarterly observations.[6] Survey intervals were chosen to correspond to the bimodal rainfall patterns of the study region. Further details on these data are provided in Barrett *et al.* (2008).

The baseline survey provides information on individual and household characteristics such as age, sex, household size, education of head, and to which household demographic group the individual belongs. The repeated quarterly surveys give information on household income earned over the past quarter, community level food prices and average rainfall. The repeated quarterly surveys also ask surveyed individuals to recall their own food and beverage consumption over the past 24 hours.

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[4] Due to attrition, interruption and period-specific missing observations of particular variables for certain individuals or communities, the number of observations per survey period ranges from 231 to 412. Also, due to some known measurement error, the top and bottom five percent of observations over the observed income distribution were dropped.

[5] Wives surveyed may be a first, second, third or fourth wife.

[6] The March 2000 survey was used only for baseline information on households and individuals.

This information was used to calculate the dietary diversity of each individual in each period. Dietary diversity is defined here as the number of unique food and drink items consumed over the recall period. For example, if an individual consumed three helpings of maize, one helping of beans, and two servings of tea with milk, his dietary diversity count would be four.

Descriptive statistics on dietary diversity by household cohort and income tercile[7] can be found in Table 2. Looking at the descriptive statistics alone, household heads do not appear favored over other household members in terms of dietary diversity. In the full sample, as well as in the lower and upper income terciles, daughters have the highest mean dietary diversity, sons have the lowest, and there do not seem to be any statistically or substantively significant differences between the mean dietary diversity of heads and wives. In the middle tercile sons still have the lowest mean dietary diversity but daughters have a lower mean dietary diversity than that of their parents. One possible explanation for daughters enjoying a higher average dietary diversity than other household members is that a daughter's health represents an investment for the household. Pastoralist families in this region typically receive a bride price of several TLU for their daughters when they are married. Therefore, a healthy daughter could be valuable to the household above her inherent value as a family member.

Sons, on the other hand, have a markedly lower mean dietary diversity than other household members. Sons are typically the household members most active in herding. Thus much of their day is spent away from the home in grazing areas where the supply of a variety of foods throughout the day is quite limited. This might lower their dietary diversity relative to other household members who spend more time at the home or close to towns.

[7] Income terciles are based on households' intertemporal mean income.

IV. Model and Econometric Specification

The main objective of this paper is to explore the possibility of disparities in nutritional welfare among demographic groups within the household. We estimate a reduced form individual-level function in which nutrition depends on household income and food prices, as well as other individual- and household-specific characteristics. Dietary diversity is used as the dependent variable measure of nutritional status. Previous studies have often used nutrient intake or food expenditures as a measure of nutritional status. However, both of these measures suffer from a number of qualitative and quantitative problems.[8] In reaction to these issues, dietary diversity has been proposed as an alternative indicator of dietary quality and food security (Arimond and Ruel 2004, Hatloy et al. 1998, Hoddinott and Yohannes 2002, Ogle et al. 2001, Onyango et al. 1998, Ruel 2002, Ruel 2003, Torheim et al. 2004). While the PARIMA surveys do not have good nutrient intake or availability information, they do provide good data on dietary diversity.

Dietary diversity is here defined as the number of unique food and drink items consumed over a 24-hour recall period. Lack of dietary diversity is especially problematic in poor communities in developing countries. A diverse diet has long been associated with good nutritional status. Indeed, a number of studies have shown dietary diversity to be highly correlated with dietary quality and nutrient adequacy (Arimond and Ruel 2004, Hatloy et al. 1998, Hoddinott and Yohannes 2002, Ogle et al. 2001, Onyango et al. 1998, Torheim et al. 2004). Studies have also found a consistent and positive association between child growth and dietary diversity (Arimond and Ruel 2004, Onyango et al. 1998). Dietary diversity is also unlikely to suffer from the same measurement errors and bias problems[9] that have been problematic in many of the more conventional measures of nutritional status (Hoddinott and Yohannes 2002, Strauss and

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[8] See Strauss and Thomas (1995) and Hoddinott and Yohannes (2002) for a discussion of these problems.
[9] See footnote # 41.

Thomas 1995). Consequently dietary diversity shows much promise as an indicator of dietary quality and is used here as the dependent variable.

Because we are interested in intrahousehold differences, we employ dummy variables indicating membership in specific household demographic cohorts. These dummy variables are included as intercept shifters as well as interacted with income and price variables to allow nutritional responses to changes in these variables to vary among different cohorts. The log-linear approximation of nutrition at time *t* for individual *i*, living in household *h*, located in village *v*, and belonging to household cohort *c* is:

$$(1)\ \ln N_{ihvt}^{c} = \sum_{c=1}^{C} H_{ihvt}^{c} \left[\alpha^{c} + \beta^{c} \ln Y_{ihvt}^{c} + \sum_{g=1}^{G} \omega^{cg} \ln P_{vt}^{cg} \right] + \sum_{j=1}^{J} \theta^{j} X_{ihv}^{j} + \sum_{l=1}^{L} \gamma^{l} Z_{hvt}^{l} + \sum_{k=1}^{K} \delta^{k} V_{vt}^{k} + \mu_{i} + \varepsilon_{ihvt}^{c}$$

where

i indexes the individual,

h indexes the household,

v indexes the location or village,

t indexes the time period,

N indicates level of nutrition as proxied by dietary diversity,

Y is household income,

P is the price of commodity *g*,

X is individual-specific characteristic *j*,

Z is household-specific characteristic *l*,

V is village- or location-specific characteristic *k*,

H is a dummy variable indicating membership in household cohort *c*,

μ is an unobserved individual-specific time-invariant effect and

ε is the iid normally distributed disturbance term with mean zero and variance one.

Because the model is in partial log-log form, the parameters β^c and ω^c capture cohort-specific income and price elasticities of nutrition, respectively.

In our econometric specification, income is aggregated from six different sources: income earned from non-farm and non-livestock trade and business such as crafts, firewood and water; income earned from wages and salary; income earned from livestock trade; the value of livestock products produced (e.g. meat, milk and hides and skin); the value of crops harvested; and net remittances, which includes the value of cash and in kind gifts as well as food aid.[10] Village level maize and tea prices are included in the estimation. Maize and tea are by far the most important purchased food staples in the study region.[11] Individual-specific characteristics included are baseline age and demographic cohort indicator variables. The household member cohorts are male head, wife, adult co-resident son and adult co-resident daughter (hereafter simply "son" and "daughter"). The cohort variables necessarily control for an individual's gender. The male head of the household is the baseline cohort in our analyses.

Other time-invariant individual-specific characteristics are captured in μ, the individual-level fixed-effect parameter. Dummy variables indicating whether the household head has completed primary school, secondary school, or an adult education or literacy program are included as household-specific variables. Average rainfall over the past quarter is included as a time-varying village characteristic. To control for time-invariant, location-specific characteristics, we include geographic dummy variables, with Sugata Marmar excluded as the baseline.

This model allows for mean nutrition levels as well as income and price elasticities of nutrition to differ by cohort, as has been found previously. However, it does not make any distinctions for when having a relatively higher elasticity is beneficial

[10] For details on how each income sources was constructed see Barrett *et al.* (2008).
[11] Milk is another important food staple in the study area. However, since almost all households own livestock it is predominately self-provided rather than purchased.

or burdensome. As noted above, a higher income elasticity has positive welfare implications when household income is rising, but negative welfare implications when it is falling. In other words, an individual in the household with a relatively higher income elasticity when household income is growing implies more rapid nutritional gains for that individual. On the other hand, having a higher income elasticity than other household members when income is contracting, implies that that individual suffers to a greater degree than others.

In order to address this shortcoming, we modify equation (1) to allow cohort-specific income elasticities to differ depending on whether household income is above or below its intertemporal mean. [12] If current household income is above the household's intertemporal mean, then it is logical to think that current income changes are directionally positive and thus having a higher income elasticity is individually beneficial. If household income falls below its mean then it is likewise logical to think that current income changes are directionally negative and thus a higher income elasticity is burdensome. This results in the following model.

$$\text{(2)}\quad \begin{aligned} \ln N_{ihvt}^{c} = {} & \beta_1 \ln Y_{hvt} + \sum_{c=1}^{C} H_{ihvt}^{c}\left[\alpha^{c} + \beta_2^{c}\left(\ln Y_{hvt} - \ln \overline{Y}_{hv}\right) I_{hvt} + \beta_3^{c}\left(\ln Y_{ihvt} - \ln \overline{Y}_{hv}\right)\left(1 - I_{hvt}\right) + \sum_{g=1}^{G} \omega^{cg} \ln P_{vt}^{cg}\right] \\ & + \sum_{j=1}^{J} \theta^{j} X_{ihv}^{j} + \sum_{l=1}^{L} \gamma^{l} Z_{hvt}^{l} + \sum_{k=1}^{K} \delta^{k} V_{vt}^{k} + \mu_i + \varepsilon_{ihvt}^{c} \end{aligned}$$

where $\overline{Y}_{hv}$ is the intertemporal mean of household income in household *h* in location *v*

and I_{hvt} is and indicator variable such that $I_{hvt} = \begin{cases} 1 & if\ Y_{hvt} \geq \overline{Y}_{hv} \\ 0 & if\ Y_{hvt} < \overline{Y}_{hv} \end{cases}$.

[12] The model can be similarly be modified to allow for differing price elasticities when food prices are above and below their intertemporal mean. In this particular study however, there was not enough intertemporal variation in village-level food prices to make this modification meaningful. Most variation in food prices was experienced spatially over the two and one half years of data.

Thus the income elasticity of nutrition for cohort *d* when household income is above its intertemporal mean will be:

(3) $$\eta_A^d = {d \ln N_{ihvt}^d}\Big/{d \ln Y_{hvt}} = \beta_1 + \beta_2^d$$

and the below mean income elasticity of cohort *d* will be:

(4) $$\eta_B^d = {d \ln N_{ihvt}^d}\Big/{d \ln Y_{hvt}} = \beta_1 + \beta_3^d$$

where $1 \leq d \leq C$.

This approach allows for the possibility of making nutritional welfare comparisons within the household based on state-dependent as well as cohort-specific income elasticity estimates. A finding that members of household cohort A have a higher income elasticity than members of cohort B when household income is above its mean and a lower one when household income is below its mean would indicate favorable intrahousehold welfare implications for individuals in cohort A relative to those in cohort B. However, if members of cohort A have a higher income elasticity than those in cohort B when income is both above and below its mean, then no definitive welfare comparisons can be made.

Intrahousehold differences in nutritional response to income shocks can be tested with the following hypothesis:

(5) H_O: $\beta_2^i = \beta_2^j$ and $\beta_3^i = \beta_3^j$ for all $i \neq j$

H_A: $\beta_2^i \neq \beta_2^j$ and $\beta_3^i \neq \beta_3^j$ for all $i \neq j$

We can test whether household cohorts exhibit symmetrical nutritional responses to income changes occurring above and below household mean income with the following hypothesis:

(6) H_O: $\beta_2^i = \beta_3^i$
H_A: $\beta_2^i \neq \beta_3^i$

A rejection of the null hypothesis in (6) would indicate that individuals' nutritional status responds asymmetrically to changes in income occurring above mean income versus those occurring below. In this case the nested model in equation (1) would be inappropriate. A failure to reject the null, on the other hand, indicates that individuals exhibit symmetrical nutritional responses and that equation (1) would suffice.

Finally, we can determine whether any particular household member cohort is better off than another by using Monte Carlo simulation methods on cohort-specific nutritional values predicted by (2) to generate cohort-specific nutritional distributions which can then be analyzed using stochastic dominance methods.

V. Dietary Diversity of Non-Head Household Members Relative to Heads

When thinking about the intrahousehold allocation of nutrition, interest often focuses on how non-head household members fare relative to the household head. We use nonparametric regressions to generate an initial picture of the relationship between the dietary diversity of non-heads and heads in these pastoralist households. The intertemporal mean dietary diversity was calculated for each individual in the sample. That mean was then subtracted from each individual's observed dietary diversity in each period. This gave a measure of period-specific deviations from individual-specific mean dietary diversity. The de-meaned household-specific dietary diversity of each non-head cohort (wives, sons and daughters) was then regressed on the de-meaned household-specific dietary diversity of heads using a kernel-weighted local polynomial regression with a 95% confidence band. As a reference, a 45-degree line depicting perfectly equitable intra-household dietary adjustments was overlaid on these non-parametric plots.

The nonparametric regressions give some idea of how the dietary diversity of non-head cohorts changes with the dietary diversity of the head cohort. If changes in the dietary diversity of non-head cohorts are perfectly correlated with changes in the head cohort's dietary diversity, then the non-parametric regression should track the 45-degree line. On the other hand, a perfectly horizontal (at zero) nonparametric regression line would indicate that the dietary diversity of non-head cohorts is perfectly unrelated to changes in the head cohort's dietary diversity. This would mean that increases or decreases in the head's dietary diversity, or whatever factors cause the head's dietary diversity to change, do not affect the dietary diversity of non-heads in these households.

These nonparametric regressions appear in Figures 1, 2 and 3, for wives, sons and daughters, respectively. What is immediately striking in these plots is how little correlation exists between changes in the dietary diversity of non-heads as compared to the heads.

Wives' and adult sons' dietary diversity appears statistically invariant for a loss of up to approximately 2 items in the household head's dietary diversity —about 60% of mean dietary diversity. In Figure 3, daughters' dietary diversity appears statistically inelastic to negative changes in heads' dietary diversity. When heads consume above mean dietary diversity, all three non-head cohorts' dietary diversity is significantly positively correlated to that of the head. Thus, male household heads appear, at least unconditionally, to buffer their household members' dietary diversity against negative deviations but share in dietary improvements. If these results hold in multivariate regression analysis when controlling for potentially confounding factors, this indicates that during difficult times, non-head adult household members smooth consumption (dietary diversity) to a greater degree than do male household heads.

There are (at least) two candidate explanations for this pattern. One is that during difficult times, male household heads, as the most experienced herders, spend more time herding at more remote locations, where food variety is especially limited. A second potential explanation is that during times of stress, the head consciously acts as a buffer for the rest of the family, reducing his own consumption to protect that of other family members. Either or both of these explanations could account for why the pattern of intrahousehold allocation of dietary diversity differs depending on whether the household is consuming above or below their intertemporal mean. Unfortunately, our data do not allow for explicit testing of either hypothesis.

VI. Estimation and Results

Turning now to the multivariate regression analysis, equation (2) is estimated using a random effects generalized least squares estimator. Since the discrete nature of dietary diversity may cause heteroskedasticity, we employ White's correction for heteroskedasticity. We test for symmetric nutritional responses to income changes above or below mean household income (hypothesis (6)) using a Wald test, both in the full sample and separately by wealth terciles.

Results

Full regression results appear in Table 3. Overall, the estimation results make sense with the expected sign on most statistically significant coefficient estimates, the only exception being the coefficients on maize prices, which are discussed below. Outside of income and food prices, one the largest determinants of individual dietary diversity is the education of the household head. The marginal effects of the head having some adult, primary or secondary education on the natural log of dietary diversity are all statistically significant in the full sample regression with estimated values of 0.13, 0.07and 0.17, respectively. In the lower tercile, the estimated effect of the head participating in an adult education or literacy program is statistically significant with an estimated magnitude of 0.19. The effects of primary education are statistically insignificant in the lower wealth tercile and there are no households in this sub-sample where the head has received any secondary education. In the middle tercile, the effect of the household head having received some secondary education is statistically significant and substantial with an estimated value of 0.54. These results point to the importance of promoting continued education beyond primary school. Receiving primary school education alone appears to have a limited effect on the households' dietary diversity. In the upper tercile, the head's education effects on dietary diversity are statistically insignificant in all three education categories. Thus there appears to be decreasing marginal returns of having an educated household head to individuals' dietary diversity.

Estimated intercepts for each household cohort in each regression sample are reported in Table 4. As can be seen in Table 3, with one exception, none of the coefficients estimated for the cohort dummy variables (wife, son and daughter) are statistically different from zero in any of the samples. Holding all else equal, the mean dietary diversity of a wife, adult son or adult daughter is not statistically different from that of the male household head. The only exception is in the upper income tercile where the daughter's mean dietary diversity is significantly greater than that of the head. Among the wealthiest pastoralists, co-resident adult daughters appear relatively well fed.

Intrahousehold Price Effects

Estimated price elasticities are reported in Table 4. Estimated tea price elasticities using the full sample have the expected negative sign and are statistically significant for all four demographic cohorts with values ranging from –0.16 to -0.37. Estimated maize price elasticities on the other hand are positive. Given the prominence of maize as a dietary staple in all of the study locations, the positive estimated elasticities likely reflect a substitution effect wherein rising maize prices cause individuals to decrease their consumption of this staple food and substitute for it with other foods. Unless individuals completely eliminate maize from their diet, this substitution effect would cause dietary diversity to increase. Interacting either maize or tea prices with the cohort-specific dummy variables produces no statistically significant effect on individual dietary diversity. Therefore none of the price elasticities estimated for the non-head cohorts are statistically different from those estimated for heads. These general patterns remain unchanged when estimating equation (2) in the income tercile sub-samples.

Intrahousehold Income Effects

Estimated income elasticities for the full sample and for each of the income tercile sub-samples are also reported in Table 4. What is immediately striking about these estimates is that the above mean income elasticity of dietary diversity for heads is not statistically different from zero in either the full sample or any of the three sub-samples, while heads' below mean income elasticity is statistically significant in all of the sub-samples as well as in the full sample. Conversely, the below mean income elasticity is not statistically different from zero for wives or sons in any of the samples. The above mean income elasticity is statistically significant in the full sample and middle and upper tercile for sons and in the full sample and lower tercile for wives. Daughters' above mean income elasticity is not statistically significant in any of the samples and their below mean income elasticity is only statistically significant in the upper tercile.

Using the full sample, the above mean income elasticity is not statistically significantly different from zero for household heads or daughters, while it is for wives and sons with values of 0.13 and 0.21, respectively. On the other hand, the below mean income elasticity is not statistically significant for wives, sons or daughters, while it is for heads with a value of 0.08. Thus there appears to be significant differences in the cohort-specific income elasticity estimates depending on whether income changes occur when household income is above or below the household's intertemporal mean. A Wald test rejects the null hypothesis of symmetric responses to changes in income above and below the household mean with a test statistic of $\chi^2(4) = 10.93$ and a p-value of 0.027. This means that individuals' dietary diversity responds differently to income changes occurring above and below the household's intertemporal mean.

These results imply that wives and adult sons enjoy some nutritional rewards when household income is high relative to the household's intertemporal mean, but during more difficult times, male household heads' dietary diversity falls, allowing wives, sons and daughters to maintain their dietary patterns. Co-resident adult daughters appear to have the most stable diets, with their dietary diversity effectively invariant to fluctuations in household income. However, the relatively small number of daughters in the data sample may lead to insufficiently precise parameter estimates to clearly identify the income effects on their dietary diversity.

Estimating equation (2) within household income terciles does not meaningfully change any of these results. Household heads generally appear to bear the dietary diversity brunt of below mean income, buffering their wives and adult children, who appear to enjoy the dietary diversity gains associated with above mean income. However, in higher income terciles the differences across cohorts in dietary diversity response to above mean income changes appear to decrease. The only exception to this general pattern is daughters in the upper tercile. In addition to heads, daughters in the upper tercile also have statistically significant estimated below mean income elasticities. Daughters in the upper tercile are also substantially more price and below mean income elastic than any of the other cohorts.

The results of the parametric estimation thus corroborate the nonparametric regressions in Figures 1-3. When household income falls below its intertemporal mean, the household head adjusts his dietary diversity more than do other household members.

However, unlike the nonparametric regressions, multivariate analysis indicates that when the household experiences more favorable income draws, wives' and sons' dietary diversity increases more with changes in income than does heads'. These effects are most pronounced among the poorest households and diminish in higher income households.

Returning to the potential explanations posited earlier, if the results were driven by male household heads' undertaking long treks to remote areas with low dietary diversity supply during tough times, then we would also expect to see estimated below mean income elasticities for adult sons following a similar pattern, since herding is primarily the responsibility of adult (or teenage) sons. It is unlikely that sons would remain behind with the family's women and children while the father takes the herds to distant grazing areas. The fact that sons do not exhibit similar responses to changes in below mean income to those of heads favors the head-as-buffer explanation of these results. But we again emphasize that we cannot directly test this hypothesis in these data.

VII. Intrahousehold Welfare Orderings

The possibility that household heads buffer their family members against negative fluctuations in consumption naturally raises questions about the stochastic distribution of dietary diversity across demographic cohorts. Although there are, for the most part, no statistically significant differences in mean dietary diversity among demographic cohorts (see the cohort-intercept interaction estimates in Table 3), the cross-cohort differences in dietary response to income shocks raises the possibility of discernible welfare orderings among risk averse agents.

Toward that end, we now investigate such welfare orderings. First, we simulate cohort-specific dietary diversity distributions. We then conduct tests for stochastic dominance among demographic cohorts. We also use the Wilcoxon-Mann-Whitney (WMW) rank-sum test for equality among the simulated cohort-specific dietary diversity distributions to estimate the probability that a random draw from one cohort-specific distribution is greater than that from another (Mann and Whitney 1947, Wilcoxon 1945)[13].

From each of the four different estimations of (2)—the full sample and three income tercile sub-samples—we captured cohort-specific vectors of residuals and predicted dietary diversity values. We then drew 10,000 randomly sampled observations from each of these vectors to create simulated cohort-specific residual (ε_{ihvt}^{c}) and predicted dietary diversity ($\ln \hat{N}_{ihvt}^{c}$) vectors, which we then summed to generate cohort-specific dietary diversity pseudo-distributions. We then computed the resulting cohort-specific cumulative distributions and tested for first-, second-, and third-degree stochastic dominance among the cohort-specific dietary diversity pseudo-distributions to establish whether any welfare orderings could be made under reasonable assumptions about individual preferences over dietary diversity.

The results of the WMW test and corresponding estimated probabilities are reported in Table 5. The WMW test rejects the equality of cohort-specific dietary diversity distributions among all cohorts in all four samples. The equality of cohort-specific distributions is rejected at the five percent level for heads and wives in the lower tercile and at the one percent level for all other cohort pairs in all four samples. While all the cohort-specific distributions are statistically significantly different from each other, some of them are not substantively different. For example, although the cohort-specific distributions of wives and heads are statistically different from each other in all four samples, the probability that a random draw from the heads' distributions is greater than that from the wives distributions ranges from 0.473-0.517 (if the distributions were equal we would expect these probabilities to be 0.50). So although the WMW test shows wives

[13] The WMW rank-sum test tests the hypothesis that two independent samples (e.g. the heads' and wives' dietary diversity pseudo-distributions) come from populations with the same distribution. The rank-sum procedure can then be used to calculate the probability that a random draw from the first sample is greater than that from the second sample by taking all possible pairs between the two samples and asking in what percent of those pairs is the draw from the first sample greater than that from the second.

to be statistically significantly better off than heads in the full sample and lower and middle tercile, the calculated probabilities show the welfare of the two cohorts to be broadly equal.

Since the differences between cohort-specific dietary diversity distributions are statistically significant, we then explore whether welfare orderings can be established among them. For this, we use stochastic dominance methods (Whitmore and Findlay 1978). Stochastic dominance test results are reported in Table 6; the cumulative distributions are plotted in Figures 4-7. No stochastic dominance orderings exist between heads and wives in either the full sample or the lower tercile. In the middle tercile wives stochastically dominate heads in the second-degree whereas in the upper tercile heads stochastically dominate wives in the second degree. Looking at the cumulative distributions, however, the welfare of heads and wives seem broadly similar as reflected in dietary diversity measures. Thus while distributional dominance exists in all four samples between heads and wives, there appears to be little substantive difference between the two cohorts' welfare. This is consistent with the observation in Table 5 that the probability a random draw from the heads' pseudo-distribution will be greater than that from the wives' is always around 50 percent despite the statistically significant difference between the two cohorts' distributions.

Daughters enjoy either first- or second-degree stochastic dominance over heads, wives and sons in the full sample and in all sub- samples except the middle tercile. In the middle tercile daughters stochastically dominate sons in the first-degree but no stochastic dominance orderings exist between daughters and heads or wives. The probability that a random draw from the heads' and wives' distributions will be greater that than from the daughters' ranges from 0.378-0.485 and 0.387-0.466, respectively, across the full sample and the lower and upper terciles. In the middle tercile these probabilities are 0.527 and 0.553, respectively.

In contrast, heads, wives and daughters all enjoy either first- or second-degree stochastic dominance over sons in all four samples. The probability that a random draw from the heads' and wives' distributions will be greater than the sons' ranges from 0.559-0.626 and 0.566-0.623, respectively. Even more striking, the probability that a random draw from any of the four daughter-specific distributions will be greater than that from the corresponding son-specific distribution ranges from 0.564-0.677.[14]

Sons' lower dietary diversity than heads, wives and daughters likely results, in part, from their herding responsibilities. While herding, sons have less access to a diverse diet than do those who remain at home. Note that this does not necessarily mean that sons consume less food than do other household members, only that they enjoy less diversity in what they eat. Nonetheless, if people value dietary diversity, then adult sons are systematically worse off than their fathers, mothers or adult sisters in the east African pastoralist households we study.

Conversely, daughters appear to enjoy some measure of favoritism. This may be due to the practice of bride payments in these communities. Adult daughters still living in their parents' home are unlikely to be married. When they do marry their families normally receive a bride price. Healthier and more educated daughters often fetch higher payments. Thus daughters' health may have added value above and beyond that which is due to their inherent value as a family member. This may explain why daughters appear to enjoy somewhat greater dietary diversity than do other household members.

VIII. Conclusion

The mixed evidence pertaining to intrahousehold inequality points to an inherent danger in assuming *a priori* the existence, or lack thereof, of behavioral or welfare

[14] Table 5 reports probabilities that a random draw from the sons' distribution is greater than that from the daughters' distribution. The complement, that a random draw from the daughters' distribution is greater than that from the sons' is calculated by subtracting the reported probabilities from one.

disparities within the household. Misunderstanding this essential component of resource allocation can have potentially serious implications for the welfare impacts of development programs and policies. If nutritional inequality is assumed to exist where it does not, or assumed not to exist where it does, development policies and programs may have unintended effects. Understanding how different groups respond to changes in household income is essential to well-targeted programs concerned with nutritional outcomes, particularly among the poorest households.

Some studies have previously studied intrahousehold resource allocation by comparing the estimated price and income elasticities of different demographic groups within the household. Certainly, knowing how individuals' resource consumption responds to changes in prices and income provides important information on the potential welfare impacts of development policies. However, comparing individual elasticities does not necessarily provide a better understanding of possible welfare disparities within the household. A relatively high income (price) elasticity has positive welfare implications when income (prices) is increasing (decreasing) and negative welfare implications when income (prices) is decreasing (increasing). Therefore knowing individual elasticities without knowledge of the direction of price or income changes does not allow for any definitive welfare comparisons.

We therefore estimated cohort-specific income elasticities of nutritional welfare separately for income changes above and below the households' intertemporal mean income. If household income is above its mean, having a higher estimated income elasticity is beneficial. Conversely, if household income is below its mean, a higher estimated elasticity is undesirable.

Among the east African pastoralist households we study, the dietary diversity of household heads exhibits statistically significant responses to below mean income changes and appears unresponsive to above-mean changes in income. In contrast, wives' and sons' dietary diversity is unresponsive to changes in below-mean income but sometimes statistically significantly responsive to changes in above-mean income. Daughters' dietary diversity is relatively stable in the face of fluctuations in household income. Thus, for the most part, negative dietary diversity responses to changes in income are experienced disproportionately by household heads while positive changes are experienced disproportionately by other household members.

Investigating further using cohort-specific stochastic dominance tests, we find that that sons are systematically worse off than other household members in terms of dietary diversity while daughters are systematically better off. This difference seems to reflect sons' primary occupation in herding away from towns, thereby limiting their access to diverse diets, and daughters' value given bride sale customs among these peoples. Within these pastoralist communities, although dietary diversity is uniformly low, female household members appear to fare no worse than males.

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Figure 1: Wife's Dietary Diversity Against Head's Dietary Diversity

Figure 2: Son's Dietary Diversity Against Head's Dietary Diversity

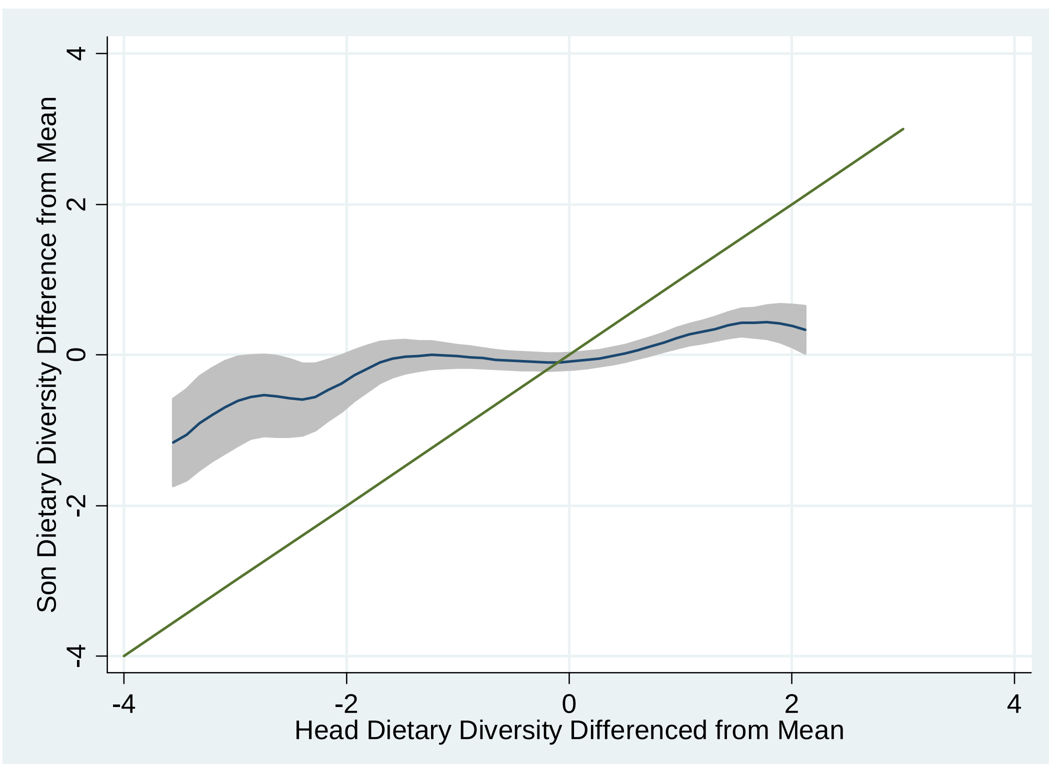

Figure 3: Daughter's Dietary Diversity Against Head's Dietary Diversity

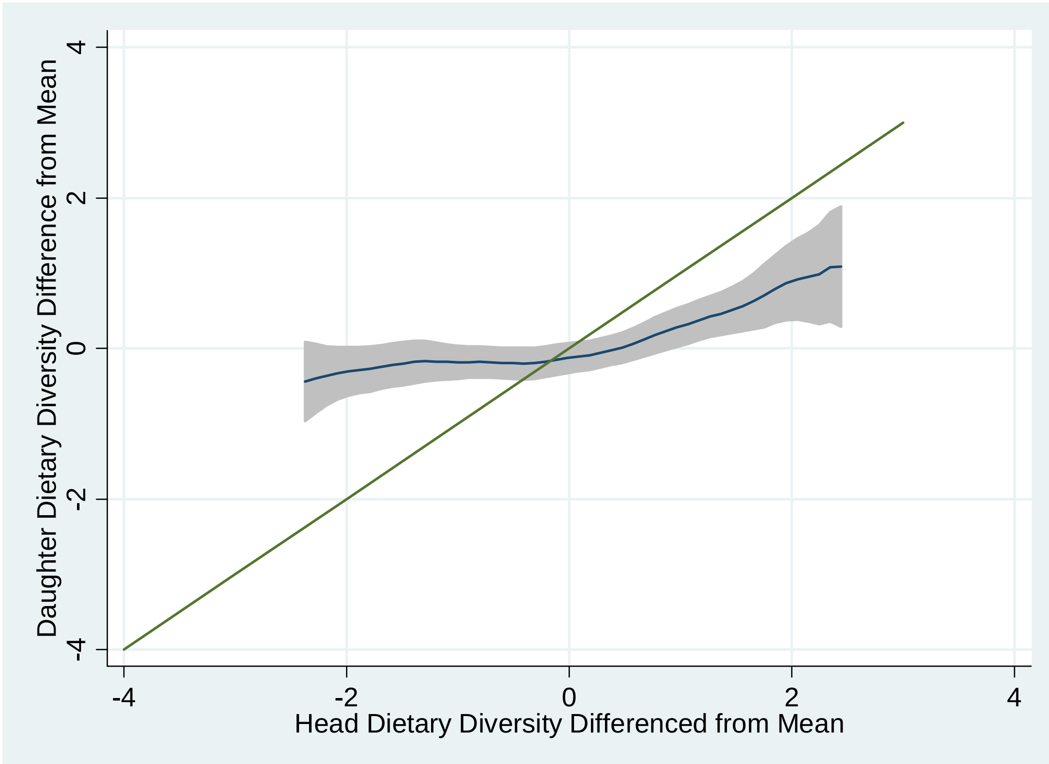

Figure 4: Cumulative Distribution of Four Cohorts in Full Sample

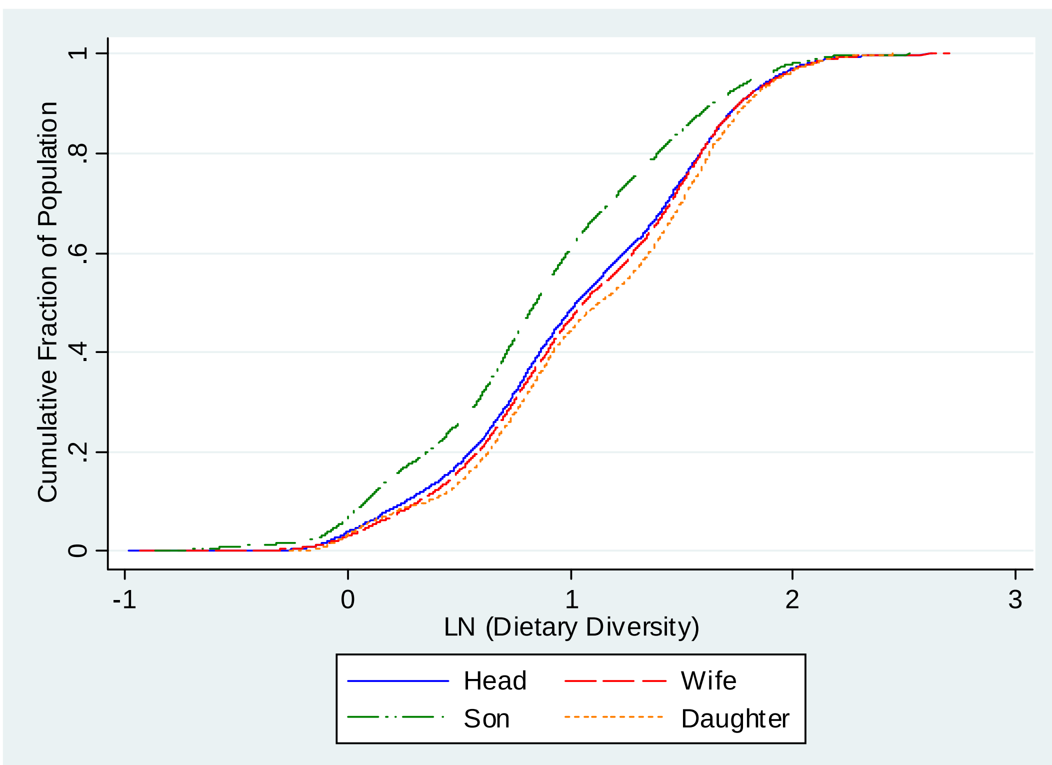

Figure 5: Cumulative Distribution of Four Cohorts in Lower Tercile

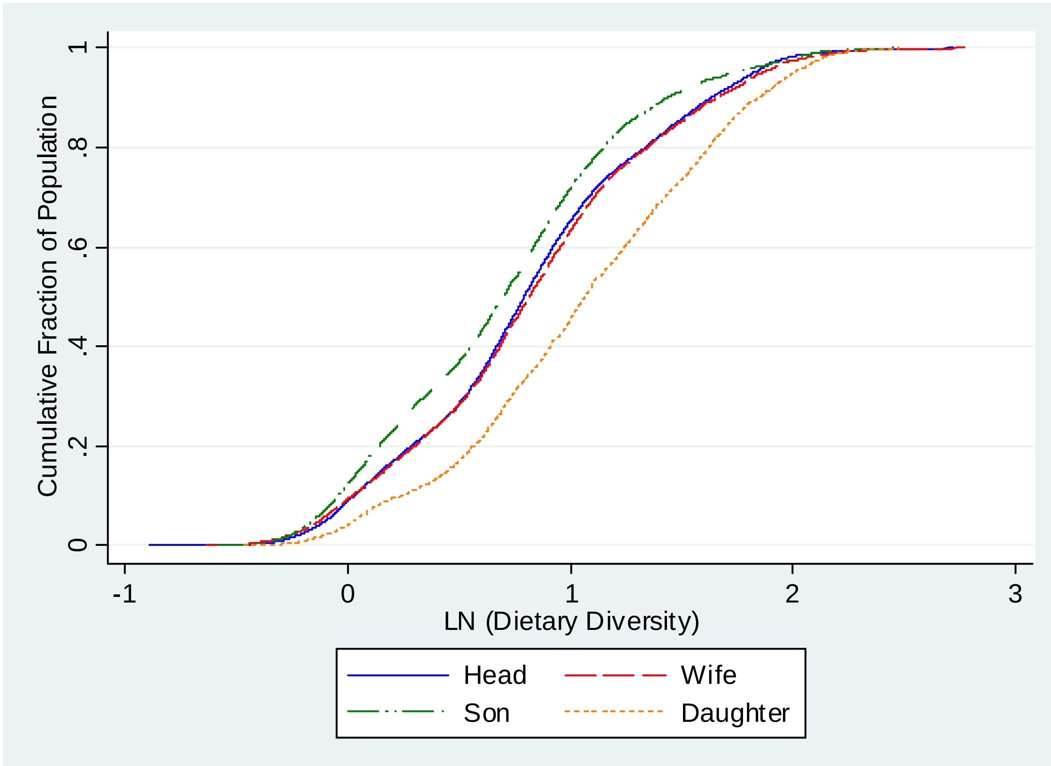

Figure 6: Cumulative Distribution of Four Cohorts in Middle Tercile

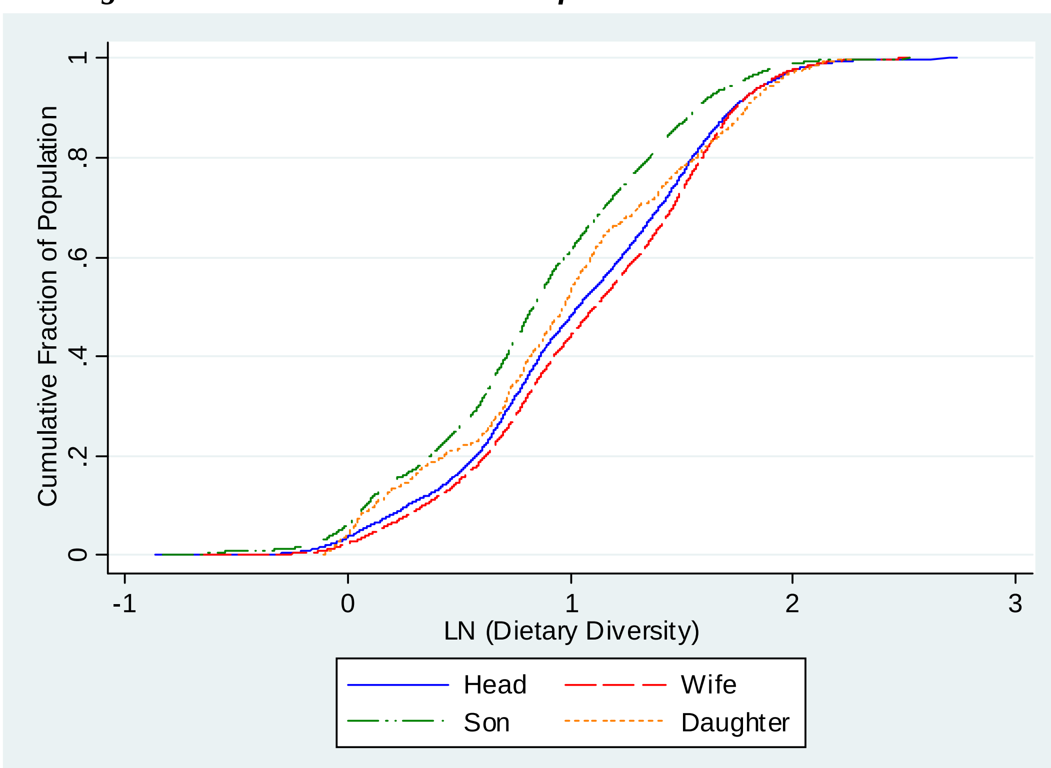

Figure 7: Cumulative Distribution of Four Cohorts in Upper Tercile

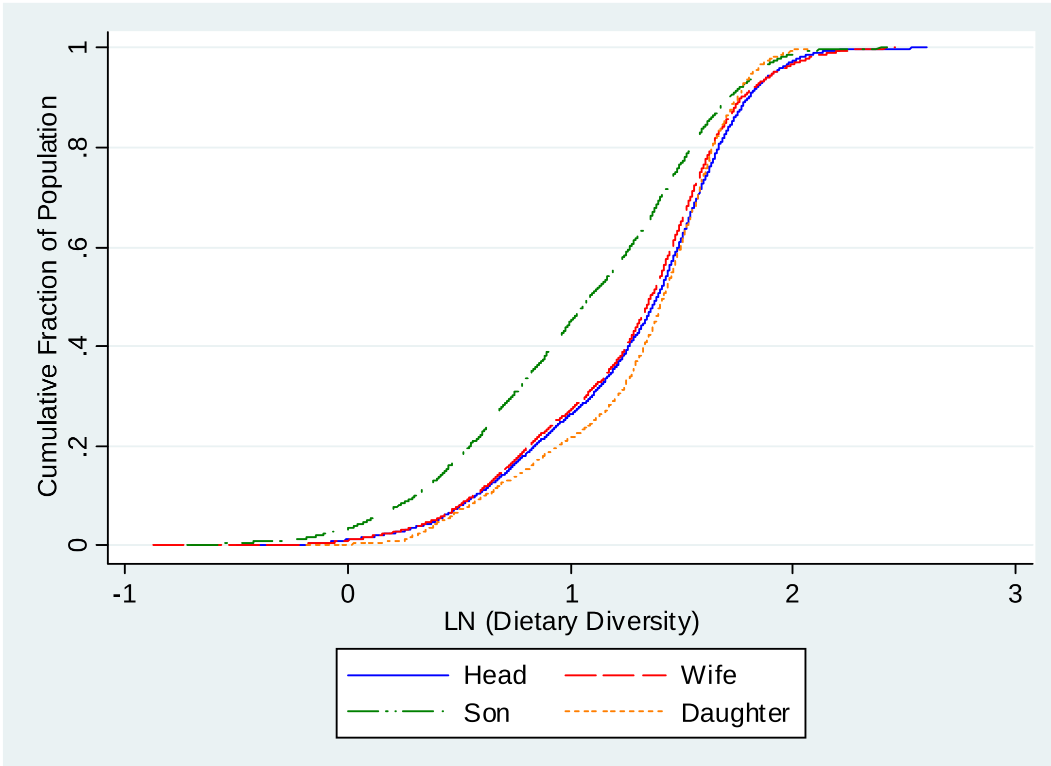

Table 1: Household Descriptive Statistics

	Mean	*Standard Deviation*	*Minimum*	*Maximum*
Full Sample (212)				
Income	10221.63	6530.37	829.31	34598.63
Herd Size (TLU)	17.87	35.59	0	385.94
Household Size	7.43	3.34	1	23
Adult/literacy school	0.05	0.21	0	1
Primary School	0.11	0.31	0	1
Secondary School	0.01	0.11	0	1
Lower Tercile (71)				
Income	4646.30	1571.69	829.31	9436.65
Herd Size (TLU)	11.57	45.35	0	385.94
Household Size	6.88	2.64	1.57	15.65
Adult/literacy school	0.06	0.24	0	1
Primary School	0.13	0.34	0	1
Secondary School	0.00	0.00	0	0
Middle Tercile (71)				
Income	8439.44	1970.91	4521.08	12256.91
Herd Size (TLU)	16.41	28.51	.34	233.57
Household Size	7.35	3.73	2	20.96
Adult/literacy school	0.04	0.20	0	1
Primary School	0.07	0.26	0	1
Secondary School	0.01	0.12	0	1
Upper Tercile (70)				
Income	17684.24	5675.50	9422.38	34598.63
Herd Size (TLU)	25.74	29.25	2.2	215.76
Household Size	7.74	3.18	2	16
Adult/literacy school	0.04	0.20	0	1
Primary School	0.13	0.34	0	1
Secondary School	0.03	0.17	0	1

Table 2: Dietary Diversity Descriptive Statistics

	Number of Groups	*N*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Full Sample						
Head	212	1449	3.28	1.57	1	8
Wife	178	1106	3.36	1.64	1	9
Son	71	371	2.82	1.65	1	8
Daughter	31	124	3.49	1.66	1	8
Lower Income Tercile						
Head	71	509	2.73	1.45	1	8
Wife	54	325	2.71	1.55	1	8
Son	24	130	2.42	1.54	1	8
Daughter	12	54	3.31	1.60	1	7
Middle Income Tercile						
Head	71	512	3.24	1.53	1	8
Wife	63	416	3.39	1.59	1	7
Son	20	120	2.71	1.41	1	8
Daughter	7	32	3.19	1.89	1	7
Upper Income Tercile						
Head	70	428	3.99	1.47	1	8
Wife	61	365	3.91	1.56	1	9
Son	27	121	3.37	1.83	1	8
Daughter	12	38	4.00	1.45	1	8

Table 3 Full Regression Results

	Full Sample	*Lower Tercile*	*Middle Tercile*	*Upper Tercile*
Head	1.035***	1.316**	0.206	0.073
(p-value)	(0.00)	(0.02)	(0.75)	(0.91)
Wife	-0.245	-0.422	-0.173	0.044
	(0.30)	(0.24)	(0.63)	(0.93)
Son	0.161	-0.207	0.307	0.745
	(0.65)	(0.68)	(0.60)	(0.38)
Daughter	0.533	0.144	-0.370	2.416***
	(0.45)	(0.90)	(0.84)	(0.01)
ln(Income)	0.076***	0.168***	0.131**	0.137***
	(0.00)	(0.00)	(0.02)	(0.01)
Cohort-Specific Income Effects				
Head Above Mean	-0.104***	-0.146*	-0.204**	-0.130
	(0.01)	(0.06)	(0.02)	(0.15)
Head Below Mean	0.008	-0.097**	-0.032	-0.076
	(0.75)	(0.05)	(0.63)	(0.20)
Wife Above Mean	0.156***	0.175*	0.150*	0.075
	(0.00)	(0.08)	(0.09)	(0.51)
Wife Below Mean	-0.062**	-0.027	-0.069*	-0.017
	(0.02)	(0.67)	(0.10)	(0.72)
Son Above Mean	0.241***	0.109	0.403***	0.235
	(0.00)	(0.45)	(0.01)	(0.16)
Son Below Mean	-0.047	0.020	-0.062	-0.059
	(0.37)	(0.85)	(0.44)	(0.51)
Daughter Above Mean	-0.008	-0.121	0.528*	-0.027
	(0.94)	(0.45)	(0.09)	(0.87)
Daughter Below Mean	-0.061	-0.143	-0.267**	0.066
	(0.36)	(0.46)	(0.02)	((0.23)
Cohort Specific Price Effects				
Head Maize Price	0.130***	0.157***	0.075	0.136**
	(0.00)	(0.00)	(0.11)	(0.02)
Wife Maize Price	-0.002	0.051	0.030	-0.042
	(0.94)	(0.35)	(0.55)	(0.54)
Son Maize Price	-0.035	0.026	-0.073	-0.018
	(0.46)	(0.76)	(0.39)	(0.85)
Daughter Maize Price	-0.013	-0.040	-0.011	0.291**
	(0.87)	(0.72)	(0.94)	(0.03)
Head Tea Price	-0.227***	-0.553***	-0.123	-0.057
	(0.00)	(0.00)	(0.23)	(0.63)
Wife Tea Price	0.065	0.080	0.030	0.003
	(0.34)	(0.41)	(0.78)	(0.98)
Son Tea Price	-0.053	0.032	-0.059	-0.269
	(0.60)	(0.80)	(0.75)	(0.27)
Daughter Tea Price	-0.140	-0.010	0.085	-0.983***
	(0.52)	(0.98)	(0.88)	(0.00)
Age	0.0008	-0.0007	0.003*	-0.001
	(0.28)	(0.56)	(0.06)	(0.50)
Rainfall	-0.0007**	-0.001	0.00001	-0.002***
	(0.04)	(0.11)	(0.98)	(0.00)

***, ** and * significant at the one, five and ten percent level, respectively
(###) p-value

Table 3 (continued)

		Full Sample	*Lower Tercile*	*Middle Tercile*	*Upper Tercile*
Adult Ed.		0.133***	0.187***	0.067	-0.057
		(0.00)	(0.00)	(0.47)	(0.60)
Prim Ed		0.066***	0.040	-0.020	0.066
		(0.01)	(0.32)	(0.76)	(0.12)
Sec. Ed		0.173*	no observations	0.536***	0.032
		(0.07)		(0.00)	(0.83)
R^2	**within**	0.034 3	0.0454	0.0359	0.0487
	between	0.8182	0.8646	0.8394	0.7291
	overall	0.5511	0.4765	0.5554	0.5584

***, ** and * significant at the one, five and ten percent level, respectively

(###) p-value

Table 4: Cohort-Specific Estimated Intercepts and Income and Price Elasticities

	Head	*Wife*	*Son*	*Daughter*
Full Sample				
N	1449	1106	371	124
Income Above Mean	-0.028	0.128***	0.214***	-0.036
(p-value)	(0.49)	(0.00)	(0.01)	(0.73)
Income Below Mean	0.084***	0.022	0.037	0.023
	(0.00)	(0.29)	(0.46)	(0.72)
Maize Price	0.130***	0.128***	0.096**	0.117
	(0.00)	(0.00)	(0.03)	(0.15)
Tea Price	-0.227***	-0.163**	-0.280***	-0.367**
	(0.00)	(0.02)	(0.01)	(0.09)
Intercept	1.035***	0.791***	1.197***	1.568**
	(0.00)	(0.00)	(0.00)	(0.03)
Lower Tercile				
N	509	325	130	54
Income Above Mean	0.022	0.197***	0.132	-0.098
	(0.11)	(0.01)	(0.30)	(0.50)
Income Below Mean	0.071**	0.044	0.090	-0.072
	(0.05)	(0.41)	(0.37)	(0.71)
Maize Price	0.157***	0.207***	0.182**	0.116
	(0.00)	(0.00)	(0.02)	(0.31)
Tea Price	-0.553***	-0.473***	-0.521***	-0.563*
	(0.00)	(0.00)	(0.00)	(0.08)
Intercept	1.316**	0.894	1.109	1.461
	(0.02)	(0.12)	(0.12)	(0.23)
Middle Tercile				
N	512	416	120	32
Income Above Mean	-0.073	0.077	0.330***	0.455
	(0.27)	(0.20)	(0.01)	(0.13)
Income Below Mean	0.099***	0.031	0.037	-0.167
	(0.00)	(0.31)	(0.63)	(0.12)
Maize Price	0.075	0.105**	0.002	0.064
	(0.11)	(0.03)	(0.99)	(0.68)
Tea Price	-0.123	-0.093	-0.182	-0.039
	(0.23)	(0.35)	(0.34)	(0.94)
Intercept	0.205	0.032	0.513	-0.165
	(0.75)	(0.96)	(0.55)	(0.963)
Upper Tercile				
N	428	365	121	38
Income Above Mean	0.008	0.083	0.243*	-0.019
	(0.92)	(0.32)	(0.10)	(0.89)
Income Below Mean	0.061**	0.045	0.003	0.128***
	(0.04)	(0.22)	(0.98)	(0.01)
Maize Price	0.136**	0.094	0.118	0.428***
	(0.02)	(0.13)	(0.20)	(0.00)
Tea Price	-0.057	-0.053	-0.326	-1.040***
	(0.63)	(0.67)	(0.17)	(0.00)
Intercept	0.073	0.118	0.818	2.489***
	(0.91)	(0.85)	(0.40)	(0.01)

***, ** and * significant at the one, five and ten percent level, respectively
(###) p-value

Table 5: Wilcoxon-Mann-Whitney Test Results (Probability that a random draw from row distribution is greater than that from column distribution)

	Wife	*Son*	*Daughter*
Full Sample			
Head	0.488***	0.588***	0.466***
Wife		0.600***	0.477***
Son			0.379***
Lower Tercile			
Head	0.492**	0.559***	0.378***
Wife		0.566***	0.387***
Son			0.323***
Middle Tercile			
Head	0.473***	0.596***	0.527***
Wife		0.623***	0.553***
Son			0.436***
Upper Tercile			
Head	0.517***	0.626***	0.485***
Wife		0.614***	0.466***
Son			0.354***

*** and ** indicate that the row distribution is significantly different from the column distribution at the one and five percent-level, respectively

Table 6: Stochastic Dominance Between Intrahousehold Dietary Diversity Distributions (Dominance of Row Distribution over Column Distribution)

	Head	*Wife*	*Son*	*Daughter*
Full Sample				
Head	**X**	No	FSD	No
Wife	No	**X**	FSD	No
Son	No	No	**X**	No
Daughter	SSD	SSD	SSD	**X**
Lower Tercile				
Head	**X**	No	SSD	No
Wife	No	**X**	FSD	No
Son	No	No	**X**	No
Daughter	SSD	SSD	FSD	**X**
Middle Tercile				
Head	**X**	No	FSD	No
Wife	SSD	**X**	FSD	No
Son	No	No	**X**	No
Daughter	No	No	FSD	**X**
Upper Tercile				
Head	**X**	SSD	FSD	No
Wife	No	**X**	FSD	No
Son	No	No	**X**	No
Daughter	SSD	SSD	SSD	**X**

FSD: First Degree Stochastic Dominance of column distribution by row distribution
SSD: Second Degree Stochastic Dominance of column distribution by row distribution