NUTRITION AND DIETARY DIVERSITY IN EAST AFRICAN PASTORALIST HOUSEHOLDS: MENTAL ACCOUNTING, MARKET FAILURES AND INTRAHOUSEHOLD ALLOCATION

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Kira Marie Villa

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ABSTRACT

In this thesis I explore the determinants and intrahousehold allocation of nutrition in pastoralist households in northern Kenya and southern Ethiopia. Little economic research has been done on pastoralist households, especially on these topics. This work helps to fill that void, while also testing some of the common assumptions made in modeling the relationship between nutrition and income more generally. In Chapter 1 I review some of the literature that provides background or motivation to the questions of this thesis.

In Chapter 2, I explore the nutrition-income relationship for pastoralist households in East Africa. Previous estimates of income elasticities of nutritional demand have ranged from zero to close to unity. However, these estimates are always based on nutrition's relationship with total income. One possible explanation for this wide range is that nutrition may respond differently to different sources of income if, for example, agents engage in "mental accounting", the practice of treating distinct income sources as not fully fungible. Estimating income-nutrition elasticities with total income may mask these differential responses and result in very different income elasticity estimates depending on which income source changes. I find that differential nutritional responses across income sources do exist among the pastoralist households studied. Possible explanations for this result are market failures for certain commodities, intrahousehold bargaining and mental accounting. Tests show that neither markets failures nor intrahousehold bargaining fully account for the differential responses observed. Thus it appears that mental accounting indeed plays some part in explaining the nutritional patterns evident in this sample.

In Chapter 3, I explore intrahousehold nutritional allocation in the pastoralist households studied. A number of previous studies have compared income or price elasticities of resource allocation across demographic cohorts as a way of inferring intrahousehold welfare disparities (or the lack thereof). However, 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 I 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 asymmetric responses to changes in above- and below-mean income. Furthermore, I 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 of than other household members, sons are systematically worse off, and there seems to be little difference between male household heads and their wives.

BIOGRAPHICAL SKETCH

Kira was born in Austin, Texas in 1979 but grew up in the Chicagoland area. She graduated from Wheaton Warrenville High School in 1997 and University of Wisconsin—Madison in 2002 where she majored in International Relations with an area emphasis on Africa. Kira's parents, John and Carol Johnstone, are both high-energy physicists and work at Fermi International Laboratory in Batavia, IL. She also has two little brothers, David and Ian, who are 19 and 15 years old, respectively. Kira is often affectionately referred to as the "accident in grad school" while her brothers are the "permanent position kids." She also has a foster brother Skylar, who is 20, and an adopted older brother Jim, who is 32. Jim was a childhood friend who was officially and legally adopted into the Johnstone clan when he and Kira were both in high school. In 2004 Kira married Gary Villa and in 2005 they had their first son, Aidan. From ages 7 to 27 Kira had a cat, Fraidy. This cat was Kira's companion from before her first boyfriend to after her first child was born.

For more than ten years Kira played clarinet and piano. In her youth she often dreamed of one day being in the New York Philharmonic. However as she grew older, the voice of her social conscience grew louder and her love of music began to take a back seat to her love for the poor and hungry in the world. Thus upon entering university Kira joined Wisconsin Public Research Interest Group (WISPIRG) where she worked on issues on hunger and homelessness and the environment. During the first few years of university Kira worked as a volunteer, intern, field manager and canvass director for WISPIRG.

In her junior year at UW-Madison, Kira participated in a year-long study abroad program to Kenya known as Minnesota Studies in International Development (MSID).

In this program, instead of attending a Kenyan University, Kira lived with a Maasai community, participated in their daily life and wrote an independent study. Kira loved Kenya and the people she knew there. She will thus always have a heart for that country and pastoralist communities.

Kira returned from Kenya with a new passion for development issues, especially poverty and hunger. While she learned much during her years in activism, she was now interested in a more substantive and less ideological methodology to battling the world's ills. Kira found the study of development economics to be both challenging and enjoyable. More importantly, she also found that economics offered a practical and systematic approach to understanding the problems she cared about most.

For a few years after graduating from University of Wisconsin—Madison, Kira worked at a bookstore where she met her husband, Gary. In the time between undergraduate and graduate school Kira and Gary had a son, Aidan. Gary also completed his graduate studies at Wheaton College where he received a Masters degree in church history and spiritual formation. Finally, in 2006 Kira began her graduate study of development economics at Cornell University in the Department of Applied Economics and Management.

There is much that fills Kira with joy. Topping the list are God, her family, her friends, her work and once upon a time her cat. She also loves the Bronte sisters, Alan Paton, C.S. Lewis, Thomas Hardy, Leo Tolstoy, J.R. R. Tolkien, Ivan Turgenev… and anyone else who can tell a really good story. Finally, the Beatles and the Chicago Cubs are not half bad either!

This thesis is dedicated to my mom, Carol Johnstone. She is my biggest fan and advocate. If it was not for her and her tireless efforts to help me find and develop what talents were in me there is no possible way I would have made it to this place. Thanks Mom, I love you.

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I have also had an amazing network of support and love in my family and friends. My husband Gary is so much more than I will ever deserve. He has held me up when I was at my weariest and has carried more responsibility than is fair in any partnership. He has done this without complaint. He has also loved me throughout, even when I was cranky, tired and stressed. My son Aidan has kept me grounded. He continuously reminds me of what is truly important and that a whole world exists outside the halls of Warren Hall to explore. I am so thankful to my family for giving me joy, love and a home. I love them more than my own breath. I am also thankful to New Life Presbyterian Church, Margaret Ang, Pimbucha Rusmevichientong, and LeslieVerteramo. New Life turned Ithaca into a true home for my family. Margaret, Pim and Leslie have been my very best friends here. I am so glad that we went through all this together. Together we have both celebrated and commiserated. So often things would have been miserable without their support and camaraderie.

Finally, above all else, I would like to thank Him from whom all good things come and in whom all my hope lies. May my life and work always be in his service.

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CHAPTER 1

LITERATURE REVIEW

The field of development economics is largely devoted to exploring ways of combating poverty, along with its many adverse effects. In countries at all levels of development, the food insecurity and low nutrient-intake of the poor have occupied a central place in the study of poverty. Income generation programs and food pricing policies have been some of the primary tools used by policymakers and development practitioners to combat hunger and malnutrition in poor households. However, these efforts have met with mixed and often disappointing results. Some argue that the failings of these programs and policies are because of mistargeting due to a need to better understand the relationship between nutrition and income (Behrman and Deolalikar, 1987, Bouis and Haddad, 1992, Strauss and Thomas, 1990) as well as the dynamics that govern the intrahousehold allocation of food resources (Behrman and Deolalikar, 1990, Deaton, 1997, Strauss and Thomas, 1995).

Until recent decades, it was generally thought that the most effective way to combat hunger and malnutrition was through economic growth and, more specifically, raising the incomes of the poor. Conventional wisdom has held that while nutrient intakes may not rise one for one with income, the elasticity of nutrient demand with respect to income is still substantially greater than zero. In the last few decades, however, some studies have emerged arguing that the income elasticity of nutrient demand is instead close to zero, meaning that increases in income will not produce substantial improvements in nutritional well-being (Behrman and Deolalikar, 1990, Behrman and Deolalikar, 1987, Behrman et al., 1988, Bouis, 1994, Bouis and Haddad, 1992). If this claim holds true then it has significant implications about how economist and policymakers think about food, poverty and development.

The debate over the nutrition-income relationship, however, is far from over. It is still widely believed that among the very poor, there are substantial food intake responses to changes in income and wealth.[1] Within the framework of this debate, though, there are some important considerations to be noted. Many studies focus intensely on changes in caloric intake (as a measure of nutritional well-being) in response to changes in determining factors such as prices or income. This characterization has gotten to the point that now debates are framed as over the calorie-income relationship rather than the nutrition-income relationship. Measuring calorie consumption began as a way of inferring nutritional status and food intake, whereas now it has virtually become the definition of nutritional status and food intake. Thus, the concern over undernutrition has been replaced by a concern over the intake of specific nutrients, most commonly, calories. While meeting energy requirements is certainly an essential element of a nutritious diet, it does not capture the whole picture. The debate must be re-oriented back to how determining factors impact individual and household nutritional well-being, of which caloric intake is but one part.

Additionally, practitioners working to better understand nutritional determinants must also reconsider how they think about household and individual food expenditure. Classical economic theory states that an income increase of any kind would elicit the same response in expenditure behavior, meaning that income elasticities on various expenditure activities are assumed to be identical across income sources. This implies that spending on food, electricity, clothing, entertainment, etc…would respond similarly to an increase in income, whether that income increase was due to extra hours worked or whether it came as a Christmas gift from Grandma. However, there is a large body of literature supporting the idea of mental accounting,

[1] For a good discussion of this debate and literature see Strauss and Thomas (1995).

of which one component proposes that where income comes from affects how it is spent.[2] In other words, changes in different sources of income may impact expenditure shares and activities differently. So in the context of the nutrition-income debate, instead of simply looking at nutritional responses to changes in total income, it might be more appropriate to ask from where does income allocated to households' food expenditures come and what are their nutritional responses to changes in different income components.

For those concerned with malnutrition and hunger, it is not only important to understand how various factors affect household nutritional well-being, but also how resource allocation behaviors within the household affect individual nutritional well-being. Nutritional well-being is an individual, not household, characteristic. While household members might (or might not) suffer and prosper together, hunger and malnutrition is an individual experience. The household, though, is probably the most prominent institution determining the welfare of its individual members. Development practitioners and policymakers, therefore, cannot be indifferent to intrahousehold processes of resource allocation.

There has been much discussion and debate concerning what are the primary determinants of nutritional well-being and whether intrahousehold processes of resource allocation favor certain demographic groups over others. Section II of this chapter reviews the literature on the relationship between nutrition and income. Section III looks at dietary diversity as a potential indicator of dietary quality and food security. Section IV reviews the evidence and literature on mental accounting and the possible role it plays in food consumption behavior. Section V examines evidence on intrahousehold processes of resource allocation. Finally, Section VI reviews the

[2] For a good discussion of mental accounting and a review of the literature on it see Thaler (1999).

literature on the nutritional dynamics of pastoralist households in Africa. Section VII concludes.

I. The Relationship between Nutrition and Income

Conventional wisdom holds that the low nutrient intake of the poor is, in a large part, due to low income. Substantial resources therefore have been devoted to income growth programs aimed at improving nutrition in poor communities. However, despite many studies on the subject, there is little agreement over the extent to which the nutritional status of the poor responds to changes in their income. Studies examining this matter often look at intake changes of specific nutrients, particularly calories, in relation to changes in some measure of income. The debate over this relationship ranges from studies arguing that the calorie-income curve is essentially flat (Behrman and Deolalikar, 1990, Behrman and Deolalikar, 1987, Bouis 1994, Bouis and Haddad, 1992, Wolfe and Behrman, 1983) to the other extreme where studies have estimated the income elasticity of demand for calories to be close to one (Pitt, 1983, Strauss, 1984). Other studies find a concave or elbow-shaped calorie-income curve (Ravallion, 1990, Strauss and Thomas, 1995, Strauss and Thomas, 1990, Subramanian and Deaton, 1996). These latter findings indicate that among the very poor, nutrient intakes would increase with income up to a certain level, after which the nutrient-income elasticity would decline, possible to zero.

Behrman and Deolalikar (1987) contend that even among the very poor, the income elasticity of caloric demand is not significantly different from zero. Consequently, substantial nutrient improvements would not automatically follow income increases in the process of development. They argue that previous studies reporting high nutrient elasticities may have overestimated those parameters due to confusion between income elasticities of food expenditure and income elasticities of nutrient intake. Behrman and Deolalikar (1987) claim that most of these studies estimated nutrient elasticities using food expenditure systems for a small number of food aggregates. Assuming that nutrient and food elasticities are equal at the level of aggregation, constant nutrient-to-food conversions were used to transform food elasticities to nutrient elasticities. This method assumes that within each food group, there is no substitution away from cheaper calories to more expensive ones. Thus, Behrman and Deolalikar argue the nutrient elasticities measured by the expenditure system at the level of aggregation are upwardly biased estimates.

To demonstrate this, they show the elasticity of nutrient intake with respect to expenditure as

$$\eta_{nE} = \sum \theta_i \eta_{EiE} - \sum \theta_i \eta_{qiE}$$

where η_{XY} is the elasticity of X with respect to Y, n is the quantity of a particular nutrient consumed (such as calories), θ_i is the share of total nutrients consumed from a particular food *i*, E is the total food expenditure, E_i is expenditure on food *i*, and q_i is the average cost of the nutrient obtained from food *i*. Behrman and Deolalikar note that indirect expenditure system estimates often assume that $\sum \theta_i \eta_{qiE}$ equals zero. However, this may not be the case. The authors contend that even at low incomes, households give considerable weight to food attributes other than nutrient content when making their food consumption decisions. These attributes include characteristics such as quality, aroma, variety and taste. They point out that if $\sum \theta_i \eta_{qiE}$ is indeed positive, then the weighted sum of *food expenditure* elasticities with respect to total expenditure would overstate the *nutrient* elasticity with respect to food expenditure. Thus, Behrman and Deolalikar believe that high food expenditure elasticities may still be consistent with low nutrient elasticities. They propose that direct estimates of nutrient consumption based on more detailed food data would avoid this aggregation bias and garner elasticity estimates closer to their true value. Consistent with that belief, in a study of rural households in Southern India, they found a high food expenditure elasticity of 1.18 along with a nutrient elasticity of 0.37 that was not significantly different from zero.

In another study, Behrman and Deolalikar (1990) explore whether nutrient elasticities would be higher with respect to permanent rather than current income. They postulate that households would likely want to protect their nutrient intake from short-term income fluctuations to a greater extent than they would from fluctuations in their long-term income. Using the same data they used for their 1989 study, they estimated the effects of both current and permanent income on caloric intake. They found both of these effects to be not significantly different from zero. Instead, they found relatively strong nutrient consumption responses to changes in food prices—many of which were positive. They claim that the high price elasticities of nutrient demand support their theory that households do not consume at a minimum cost diet. Rather, as household income increases, they substitute away from cheaper nutrients to more expensive one. Behrman and Deolalikar (1990) also find that what they call village-level characteristics—village population, average female wage and average male wage—are strong determinants of nutrient intake. They suggest that this could be indicative of the availability and quality of infrastructure and public services. These, the authors argue, may be more important in raising individual nutrient intakes than income-generating programs.

Bouis and Haddad (1992) also examine the relationship between the magnitude of the calorie-income/expenditure elasticity and the method of estimation and data collection. The authors highlight the importance of wastages and leakages[3] that are often unobserved by common data collection methods and that can potentially cause substantial upward bias in estimates. They also point out that if expenditure data is used to both estimate total expenditure (as an inference for income on the right-hand side of the equation) and food expenditure (as an inference of caloric availability on the left-hand side of the equation), there will likely be correlated measurement errors for the nutrition dependent variable and the expenditure explanatory variable. In other words, if an individual overestimates (underestimates) total expenditure then food expenditure will also likely be overestimated (underestimated). Since it is often the case that poor households will overestimate expenditure and rich households will underestimate expenditure, nutrient-income elasticities using those data will be upwardly biased.

Bouis and Haddad (1992) investigate different ways of measuring and estimating the calorie-income relationship and how each method might bias the estimated elasticity. They propose that biases resulting from estimation techniques and correlated measurement errors from common data collection methods may be of more importance than the aggregation bias discussed by Behrman and Deolalikar (1987). To explore they this estimate elasticities for four different combinations of nutrient intake and income measurements: caloric availability[4] (minus leakages) with total expenditures, caloric intake with total expenditures, caloric availability (minus leakages) with income, and caloric intake with income. The OLS estimates of the four elasticities range from as low as 0.03 to as high as 0.43. Bouis and Haddad reason that the caloric intake with total expenditure pair to be the most appropriate and least

[3] Wastages and leakages in this case is the difference between a household's food purchases and its food intake. This difference may come from things such as feeding guests and plate waste.
[4] Caloric availability is measured from food expenditures, this indicating the amount of calories available to be consumed based on food purchases.

biased variable pair to use when exploring the relationship between income and calorie consumption. The authors also report elasticity estimates for the four variable pairs using four different estimators: OLS, instrumental variables, fixed effects, and Hausman-Taylor random effects. From the four different estimation techniques used by the authors, the estimated elasticities using their preferred variable pair ranged from 0.08 to 0.14. The authors argue that these are their best estimates.

Bouis and Haddad further contend that elasticities based on caloric intake, garnered from a 24-hour food intake recall, tend to be considerably lower than those based on caloric availability. According to them, this is because the availability data fail to account for food transfers into and out of the household. Yet, not only do guests and workers in their data consume just a small percentage of the food, the authors also accounted for food transfers in their calculation of net caloric availability. Consequently, the bias resulting from food transfers should, for the most part, be taken care of. The estimates using net caloric availability range from 0.28 to 0.59. The authors claim that these estimates nonetheless remain upwardly biased because other leakages continue to be important. While this might be true, they provide no statistical basis for this assertion (Strauss and Thomas, 1995).

Bouis and Haddad (1992) explain that their preferred elasticity estimate is so low because many of the properties that might have caused their other estimates to be upwardly biased are taken care of. While that may be true, there may be another reason for the low magnitude of their preferred elasticity. A number of studies have found a concave relationship between nutrient intake and income/expenditure (Ravallion, 1990, Strauss and Thomas, 1995, Strauss and Thomas, 1990, Subramanian and Deaton, 1996). These studies have presented empirical evidence showing that caloric responses to income are considerable stronger at low levels of income than they are at high ones.

Intuitively, this makes sense. If incomes are rising with calories, as an individual gets closer to meeting his caloric needs, his demand for calories will become less elastic because non-nutritive attributes to food and non-food demands will gain more prominence in his consumption decisions. In the data used by Bouis and Haddad, the mean caloric intake of individuals in the lowest income groups is 2,226[5], which is close to the standard recommendations for the daily calorie requirement of adults[6] (USDA, 2008). In fact, in a non-parametric analysis of the same data set used by Bouis and Haddad (1992), Strauss and Thomas (1995) find clear non-linearities in the relationship between caloric consumption and expenditure. In this analysis, caloric intake and expenditure are positively correlated at low levels of income and calorie consumption. However, when per capita caloric consumption reaches around 2,000 calories per day, the curve flattens out. Thus, it is possible that the low calorie-expenditure elasticity observed by Bouis and Haddad arises because individuals in the study are for the most part on the flatter portion of the calorie-expenditure curve. At this point, individuals may be responding more to other nutrient needs, non-nutritive food attributes, and are buying more expensive calories. It is important to note that while individuals in this sample might have adequate or at least close to adequate caloric intake, this does not mean that their diets are sufficiently nutritious. Additionally, because the calorie-expenditure elasticity estimated is low does not mean that increases in income will not enhance the nutritional quality of their diet. This only means that individuals will not necessarily consume substantially more calories with increases in income. Their diets could still benefit as they diversify their

[5] The average caloric availability for adults in the lowest income groups of the data was 2,170.
[6] According to the USDA Food and Nutrition Information Center, the daily caloric requirement for a male adult with BMI of 18.5 kg/m^2 ranges from 1.848 (with activity level of sedentary) to 2,554 (for very active) an adult female of the same BMI ranges from 1,625 to 2,291. For a BMI of 24.99 kg/m^2 the range is from 2,080 to 2,898 for males and 1,762 to 2,489 for females.

diets and improve micronutrient consumption with increased incomes. Energy intake is but one aspect, albeit an essential one, of an adequate diet.

In a later study, Bouis and Haddad (1994) further investigate potential biases resulting from data collection methods and use bodyweight as a tool to evaluate the accuracy of food expenditure and 24-hour recall data. In this study, they argue that caloric intakes and bodyweights across income groups ought to increase or decrease proportionately. The authors further argue that calorie-income/expenditure elasticities even as low as 0.2 would lead to exceedingly unrealistic weight increases with increases in income. However, this conclusion not only ignores the existence of the non-linear concave relationship between calories and income shown empirically in other studies, it also makes rather strong assumptions about the relationship between energy intake and bodyweight. The role played by individual differences such as gender, age, weight, activity level and metabolism, in the energy requirement for maintaining bodyweight is ignored in this analysis. Furthermore, Ravallion (1990) argued that there also exist multiple intake-expenditure equilibria where bodyweight is maintained. According to this argument, income gains will not only affect energy intake, but energy requirements as well.

Subramanian and Deaton (1996) also investigate the relationship between nutrition and expenditure/income in the Maharashtra state of India. Because Maharashtra includes one of the villages in the data used by Behrman and Deolalikar, Subramanian and Deaton believe that comparisons between their results and those of Behrman and Deolalikar can be informative. Although their data set is not a panel, Subramanian and Deaton have observations on 5,630 households. Thus, they note, it is possible to estimate the calorie-expenditure elasticity with more precision with their data than with that used by Behrman and Deolalikar. This is an important consideration because, they point out, although it is statistically insignificant, Behrman and Deolalikar's preferred point estimate for the calorie-expenditure elasticity is 0.37, which is within range of what conventional wisdom asserts (Greer and Thorbecke, 1986, Pinstrup-Andersen and Caicedo, 1978, Reutlinger and Selowsky, 1976, Sahn, 1988, Strauss and Thomas, 1995, Strauss and Thomas, 1990).

Subramanian and Deaton (1996) explore the calorie-expenditure elasticity first with non-parametric estimation and then with multivariate regression. They show that even if their estimated elasticity was upwardly biased due to common measurement errors, this bias could not explain their results if the true elasticity was in fact close to zero. They also account for some of the potential bias brought to light by Bouis and Haddad (1992) by correcting for wastages and leakages.

In their analysis, Subramanian and Deaton (1996) find that the expenditure elasticity of caloric demand is around 0.55 for the poorest households and decreases slowly to 0.40 for the better-off households. Like Behrman and Deolalikar, the authors find that richer households tend to buy more expensive calories than do poorer ones. In fact, those at the top of the income distribution paid almost twice as much for calories as those at the bottom. They find, though, that this is mostly due to substitution between food groups rather than within them. Except for the very poorest households, where there was some evidence of quality upgrading in cereals (even within course grains), increases in the price per calorie happened much more between broad food groups than within them. The authors note, therefore, that if conversion factors were applied to appropriately defined broad food groups, calorie-income/expenditure elasticities should not be substantially overestimated due to an aggregation bias. Their results show the total expenditure elasticity of food to be around 0.75. They find this figure is, for the most part, equally divided between the expenditure elasticity of calories and the expenditure elasticity of the price of calories.

Strauss and Thomas (1990) use parametric and non-parametric techniques to investigate the shape of calorie-expenditure curve as well as the functional form representing it. They use a large data set from Brazil, with 53,000 households surveyed, which they split up into sub-samples.[7] They used one sub-sample for exploratory analysis and non-parametric estimation. They then used these results to guide their selection of the functional form for the model. In another sub-sample they used parametric estimation to estimate nutrient-expenditure elasticities and test a number of different functional forms for appropriateness. With the non-parametric methods used on the first sub-sample Strauss and Thomas find that the calorie-expenditure curve is positively sloped for households in the lower three quartiles of the per capita expenditure distribution. The curve is then kinked where per capita calorie intake is between 2,500 and 3,000 per day and is flat at higher expenditure levels. Using parametric forms suggested by the non-parametric curves, the authors estimate the calorie-expenditure elasticity as 0.26 for the bottom decile of expenditure groups and 0.03 for the top decile. In this analysis, it is apparent that appropriately defining the functional form used for estimation is important. When the form is specified as log-linear, the instrumented calorie-expenditure elasticity is 0.12. However when taking into account the non-linearities that exist in this relationship, the instrumented calorie-expenditure elasticity is between 0.25 and 0.30.

In a later work, Strauss and Thomas (1995) again use nonparametric regression in order to better understand the nutrient-income relationship and how it changes as income/expenditure changes. Using the same data from Brazil, the ICRISAT data used by Behrman and Deolalikar (1987, 1990) from India, and the Bukidnon data used by Bouis and Haddad (1992), they present non-parametric estimates of the estimated relationships between caloric intake and expenditure. What is striking in their analysis

[7] They use the Estudo Nacional da Despesa Familiar (ENDEF) data set.

is the similarity of each of the curves. For each data set, Strauss and Thomas find that caloric intake is indeed positively correlated with expenditure at lower levels of expenditure. However when per capita calorie consumption reaches approximately 2,000 calories per day, the curves flatten out. Thus, the calorie-expenditure elasticity decreases as expenditure increases. Furthermore, Strauss and Thomas found that for households below median per capita expenditure, the calorie-expenditure elasticity is 0.29 in the Brazil data, 0.30 (with a standard error of 0.04) in the ICRISAT data, and 0.33 in the Bukidon data. These results suggest that there is in fact a positive correlation between caloric intake and expenditure among poor households. It further indicates that this correlation declines to close to zero once some threshold of caloric intake has been crossed.

To further our understanding of food consumption patterns and how they are impacted by income and price changes, Sahn (1988) explored the importance of disaggregating data by region and income class. His study found that increases in total expenditure accompanied increases in the budget shares of high-quality, protein-rich foods. Over the range of income groups (from lowest to highest) the budget share of meat increased by a multiple of four, with the actual quantity of meat consumed increasing by almost 17 times. Additionally, the budget share of milk products increased 2.5 times across income groups. Another finding worth noting was that nearly all commodity groups, including staples, were consumed in higher quantities in households with higher income. This is despite the fact that the budget shares for these commodities were lower. Sahn found calorie-expenditure elasticities of 0.76 for low-expenditure groups, 0.62 for middle-expenditure groups, and 0.28 for high-expenditure groups. These results support the view that the income elasticity of calorie demand declines as income increases. Consequently, Sahn points out that in order to increase the nutritional well-being of the poor, income growth policies must focus on the distribution of income growth more than simply its aggregate magnitude.

Ravallion (1990) points out the distinction between 'nutrient intake' and 'under-nutrition'. He explains that under-nutrition is what we are primarily concerned with and that it depends on a number of other factors including but not limited to nutrient intake. One of these factors is nutrient requirements, which can vary widely among different individuals. Thus, he notes, a seemingly small difference in nutrient intake by two otherwise identical persons can result in substantial differences in the severity of the under-nutrition. Ravallion argues that when assessing the income and price effects on nutrient intake and under-nutrition, it is important to define and control for nutritional needs in a meaningful way. While requirement levels have been estimated for a few stylized types of individuals, most households will be different from those references. There are many characteristics that are relevant to nutrient requirements such as household demographics, type of work performed, and personal constitution. Ravallion contends that although there are certain expenditure-energy intake equilibria that are accepted as being able to sustain life, they nonetheless might be too low by the normative standards of a particular society. These accepted equilibria might be too low to allow certain basic capabilities and activity levels that are necessary for proper participation in society. Therefore, it is important to gauge the adequacy of a diet against the nutritional norm in a particular area or society. Then, when thinking about the income effects on under-nutrition, one must look at the distribution of nutrient intakes around that norm. Additionally, there are likely to be larger nutritional responses to income shifts for those whose under-nutrition is more severe. Moreover, these responses may be masked if one is only assessing nutritional responses at the mean. Ravallion thus recognizes the non-linearities between nutrition and income discussed by Strauss and Thomas (1990, 1995).

These points are well illustrated in the Indonesian data set used by Ravallion (1990). The nutrient-expenditure elasticity was estimated as 0.15 at the mean. However, the calorie distribution function in this data is rather steep and thus, he notes, the income slope of the calorie demand function rises sharply as income falls. While the 0.15 elasticity at the mean indicates that a 10% increase in income would result in only a 1.5% increase in energy intake at the mean, Ravallion found that households consuming less than 1,900 calories per person per day exhibit an calorie-expenditure elasticity close to unity. In fact, Ravallion further found that at only one half a standard deviation below the mean, the calorie-expenditure elasticity rose to 0.33. Thus the apparent concavity is marked.

There are a few lessons to be learned from the debate over the relationship between income and nutrition. First, one must consider possible biases that might arise due to data collection methods, estimation techniques, and how variables are being defined. Second, it clear and reasonable that non-linearities exist in this relationship and that they must be accounted for. Thus an appropriate functional form must be used in order to capture these non-linearities. A simple log-linear functional form may not be flexible enough for this task. Also, if one is concerned with the nutrient intakes of those who are undernourished, then one must assess the nutritional responses of those below the mean. Otherwise, evaluations run the risk of making assumptions based on information from the behavior of households that are possibly adequately nourished instead of those who are undernourished. Finally, if the nutritional well-being of the poor is our primary concern, then assessments cannot be made based solely on calorie consumption. While many studies would evaluate the intake of nutrients other than calories, these intakes were still evaluated separately. If one is to know whether or not there are dietary improvements in response to some determining factor, the diet must be considered as a whole. Individual movements of separate nutrient intakes will not capture the movement of the whole diet.

II. Dietary Diversity as an Alternative Indicator of Dietary Quality

While the wide range of estimated nutrient-income/expenditure elasticities can, in part, be explained by methodological differences in estimation techniques, many comment that the nature and importance of bias in estimation is likely related to the way nutrient consumption data are collected and nutrient intake is inferred (Behrman and Deolalikar, 1987, Bouis, 1994, Bouis and Haddad, 1992, Strauss and Thomas, 1995). One method of inferring nutrient intake is to estimate a measure of nutrient availability by looking at food purchases and imputed values based on the portion of own production or in-kind wages that is consumed. However, this may lead to the aggregation bias described by Behrman and Deolalikar (1987) and the 'leakages' bias described by Bouis and Haddad (1992). Another method is to obtain direct quantitative information on nutrient intakes rather than availability. This is done by directly measuring the amount of food consumed and the amount wasted. While more accurate than the nutrient availability measurement, this method is often unrealistic as it is rather intensive, requires a higher level of expertise in enumerators, and is very expensive. Another way to collect information on nutrient intakes is through recall surveys asking respondents about their meals consumed and the ingredients that went into them. These surveys are often based on a 24-hour recall but have also used longer periods such as 3, 7 or 14 days. Data using 24-hour recalls can pose problems in that they can be very noisy due to daily variation in eating habits. However, longer recalls tend to be more inaccurate and have more trouble capturing wastages and leakages (Strauss and Thomas, 1995).

Beyond measurement concerns, one must also ask whether or not the variables being measured are good indicators of the nutritional quality of diets. The studies discussed in the previous section focus on calorie consumption as an indicator of dietary quality. While adequate caloric intake is certainly essential to a healthy diet, it is far from a complete picture. In their defense, many of these studies also estimated elasticities for nutrients other than calories, such as protein. However, relationships were estimated for each of these nutrients separately.

So, ultimately, there was still not a clear picture of how explanatory variables of interest were affecting overall dietary quality. Low calorie-income elasticities have been used to defend the position that substantial nutritional improvements may not necessarily follow increases in income (Behrman and Deolalikar, 1987). Yet, this may not be true if individuals are substituting towards foods that although are more expensive per calorie, may provide other nutrients that are at that point marginally more valuable to the diet and the consumer's health. However, this is hard to assess if each nutrient is examined separately. If the nutritional quality of diets is to be assessed, diets must be examined as a whole.

Nutritionists have long recognized this issue and often use more encompassing measures of dietary quality. Methods that have been widely applied include the *nutrient adequacy ratio* (NAR) and the *mean adequacy ratio* (MAR) to gauge nutrient adequacy. The NAR is the ratio of an individual's nutrient intake to the recommended daily allowance (RDA) for that individual. The MAR gives a measure of overall nutrient adequacy by summing the NAR for each nutrient and then dividing that sum by the total number of nutrients. Each NAR calculated is usually truncated at 100% of the RDA in order to avoid excess consumption of certain nutrients compensating for low consumption of other nutrients in the resultant MAR (Ruel, 2002, Ruel, 2003). Measurements such as this give a fuller picture of dietary quality than does investigating the intake of various nutrients separately. However, this method still requires that the researcher find an adequate way of measuring the intake of nutrients and is thus susceptible to all of the same technical problems mentioned above.

In addition to the issues that have been discussed thus far concerning inferences of nutrient intakes, one must also consider the variation in nutritional quality and composition that exists even within like foods. For example, two individuals that consume equal amounts of maize do not necessarily consume the same quantity and quality of nutrients. The nutrient content of food varies depending on its variety, how it is grown/raised (i.e. soil nutrient content), how it is prepared, the length of time between harvest and consumption, how it is stored after harvest, and a host of other conditions.

In reaction to the time consuming, expensive nature of conventional methods, as well as their large room for measurement error, dietary diversity has been examined as a potential alternative indicator of food security and dietary quality (Hatloy, et al., 1998, Hoddinott and Yohannes, 2002, Ogle, et al., 2001, Ruel, 2002, Ruel, 2003, Torheim, et al., 2004). Dietary diversity is usually defined as either the number of food groups or the number of unique food and drink items consumed over a given period of time. Lack of dietary diversity is especially problematic in poor communities in developing countries. In these communities diets rely heavily on starchy staples and often include little to no animal products and limited fresh fruits and vegetables. Through improved micronutrient intake, a diverse diet has long been associated with enhanced nutritional status. Indeed, a number of studies have come out recently showing 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 unlikely to suffer from the same measurement errors and thus bias problems that have been problematic in many of the more conventional measures of nutritional status. Moreover, respondents find questions on dietary diversity relatively simple and undemanding on time or memory to answer (Hoddinott and Yohannes, 2002). Consequently, dietary diversity has been proposed as a promising alternative indicator of food security and nutrient adequacy.

In a study conducted in Mali, Hatloy *et al*. (1998) examined the predictive ability of dietary diversity for the nutritional adequacy of diets. The authors compiled two dietary diversity scores—a *food variety score* (FVS), which was based on a simple count of unique foods consumed, and a *dietary diversity score* (DDS), which was a food group count based on 8 different food groups. These measures were then validated against NAR and MAR measures for 10 different nutrients.[8] Hatloy *et al.* found that MAR is significantly correlated with both measures of dietary diversity. They report Pearson's correlation coefficients between MAR and FVS and DDS of 0.33 and 0.39, respectively. They further found that both dietary diversity indicators were especially associated with greater intakes of fat energy and higher densities of vitamin A and vitamin C in the diet. The authors conclude that dietary diversity scores are fairly good predictors of nutrient adequacy, especially when both dietary diversity scores are assessed together.

Ogle *et al.* (2001) note that conventional measures of nutritional well-being have difficulty capturing the contributions of local wild foods to diets, which are consumed in many rural areas of developing countries. These foods are often site specific, vary with ethnicity, and data on their composition is generally missing or

[8] The nutrients included in the measures for NAR and MAR were energy (calories), fat energy percentage, protein, iron, riboflavin, niacin, vitamin C, calcium, folic acid, and vitamin A.

outdated (Ogle, et al., 2001). Because of these problems the authors recognize that dietary diversity analysis presents a potentially useful tool in assessing diets, in which local foods are commonplace. Using a 7-day recall, Ogle *et al.* measured both FVS and DDS against the nutrient intakes of 11 major nutrients for women in Vietnam. Their findings confirmed a positive association between both measures of dietary diversity and nutrient intake. More specifically, they found that women in the highest FVS and DDS tercile had significantly higher intakes of most of the nutrients studied than did those in the lowest tercile.[9] They further found that women, who consumed 8 or more different food groups over the recall period, had significantly higher *nutrient adequacy ratios* for protein, energy, zinc, niacin, and vitamin C. Additionally, women in the highest tercile consumed a greater percentage of their energy from fat and protein and a smaller portion of their energy in the form of carbohydrates. Similar to Hatloy *et al.*, they also found that in one of the regions studied, micronutrient density was significantly higher, especially for vitamin C and vitamin A, in the highest dietary diversity tercile than in the lowest. Ogle *et al.* also noted that the dietary diversity scores were able to capture the role of wild foods in the diets of these women.

Torheim *et al.* (2004) also examined the association between dietary diversity and nutrient adequacy in Mali. Like Hatloy *et al.* (1998) the study validated measures of DDS and FVS against *mean adequacy ratio.*[10] The authors also assessed possible determinants for the three dietary indexes—MAR, FVS, and DDS. The determinants they investigated were individual characteristics such as age sex, education, and illness, as well as household and demographic factors. Their analysis showed that MAR was significantly associated with both FVS and DDS with Pearson's correlation

[9] Women in the highest tercile consumed 21 or more different foods on average over a 7-day recall period and women in the lowest tercile consumed 15 or less different foods on average over the 7-day recall period.
[10] MAR was calculated in this study from the NAR of energy intake and nine different nutrients.

coefficients of 0.34 and 0.30, respectively. FVS and DDS were also positively correlated with energy intake with Pearson's correlation coefficients of 0.38 and 0.29, respectively. In a linear regression, both FVS and DDS were significant explanatory variables for MAR. The authors conclude that the results from this study confirm that dietary diversity can be used as valid indicators of nutrient adequacy.

In a study of rural Kenyan toddlers, Onyango *et al.* (1998) examine the relationship between anthropometric measures with prolonged breastfeeding, the diversity of foods used during weaning, and the timing of the introduction of complementary foods during breastfeeding. The anthropometric measures assessed were a *weight for age* (WA) Z-score, a *height for age* (HA) Z-score, a *weight for height* (WH) Z-score, triceps skinfold and mid-upper arm circumference. Results from regression analysis showed that dietary diversity was consistently and positively associated with each of the anthropometric measures. Dietary diversity also played a significant role in the adequacy of mean nutrient intakes for children. In fact, the authors found that among partially breast-fed children, nutrient intakes were 20% to more than 50% higher for children with high dietary diversity than with low dietary diversity. This study highlights the importance of dietary diversity in the nutritional status of weaning-age children.

Through multivariate analysis, Arimond and Ruel (2004) explored whether dietary diversity was significantly associated with nutritional status independent of socioeconomic status. They study 11 different countries[11] with widely varying dietary practices and focus on infants and young children aged 6 to 23 months. The authors found that in bivariate analysis there were significant associations between dietary diversity terciles and HA Z-score for 9 of the 11 countries studied.[12] The multivariate

[11] The countries analysis in this study were Benin, Ethiopia, Malawi, Mali, Rwanda, Zimbabwe, Cambodia, Nepal, Colombia, Haiti, and Peru.
[12] The two countries where the bivariate relationship was not significant were Benin and Cambodia.

analysis controlled for child, maternal, and household factors when examining the relationship between dietary diversity and HA Z-score. The results from this analysis showed dietary diversity as statistically significant. Indeed, dietary diversity was the main determinant for HA Z-score in 7 of the countries studied.[13] Dietary diversity also significantly interacted with selected characteristics, such as child age and breast-feeding status, in a number of countries, including 3 of the 4 countries where dietary diversity was not significant as a determinant by itself. Dietary diversity was a stronger determinant of HA Z-score among children who were no longer breast-fed. Differences in the magnitudes of the effects of dietary diversity on HA Z-score may be due to variation in local diet patterns. In some areas there may be less nutritionally important variation in foods. There also may be cases where many food groups are given but in small quantities making the dietary diversity scores less meaningful (Arimond and Ruel, 2004). Their analysis confirmed a general association between dietary diversity and child nutritional status even when controlling for household wealth and other welfare factors.

Hoddinott and Yohannes (2002) rigorously examined dietary diversity as an indicator of food security. They drew data from 10 different countries[14] encompassing poor and middle-income countries, rural and urban sectors, as well as data collected in different seasons. The authors investigate the association of dietary diversity and traditional measures of food security by looking at contingency tables, receiver-operator curves, correlation coefficients, and linear regressions with the traditional measure as the dependent variable and dietary diversity as one of the explanatory variables. The traditional measures they validated dietary diversity against were per capita consumption of food and non-food goods, per capita caloric

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[13] Those countries were Ethiopia, Mali, Rwanda, Zimbabwe, Cambodia, Nepal, and Cambodia.
[14] The countries included were Bangladesh, Egypt, Ghana, India, Kenya, Mali, Malawi, Mexico, Mozambique, and the Philippines.

availability, per capita caloric availability from *staple* foods, and per capita caloric availability from *nonstaple* foods. Per capita consumption and per capita caloric availability are indicators of a household's or individual's *access* to food. Per capita caloric availability from *nonstaple* foods gives more of an indication of dietary quality. The food categories were divided into country-specific basic staples; country-specific "luxury staples"; vitamin A-rich roots, tubers, vegetables, and fruits; beans, soya, and other pulses; dairy; fats; sugars; meat, fish, and eggs; other roots and tubers; other fruits; other vegetables; and beverages, spices, and other products.

Through all of the methods utilized, Hoddinott and Yohannes find a consistently strong and positive association between dietary diversity and conventional methods of measuring household food security. More specifically, they find that a 1 percent increase in dietary diversity is associated with a 1 percent increase in per capita consumption, a 0.7 percent increase in household per capita daily caloric availability, a 0.5 percent increase in per capita caloric availability from staples, and a 1.4 percent increase in per capita daily caloric availability from non-staples. These results were consistent throughout the different analysis methods utilized. They held for both rural and urban areas as well as across seasons. The authors conclude, therefore, that dietary diversity can be used as a way to identify food-insecure households, track changes in their circumstances, and assess the impact of interventions (Hoddinott and Yohannes, 2002). Furthermore, the very high association of dietary diversity with caloric availability from non-staples (elasticity of 1.4) indicates that dietary diversity is an appropriate measure of dietary quality, capturing effects beyond simply energy intake.

Nutritionists have long recognized dietary diversity as an essential part of a quality diet. Lack of dietary diversity can be particularly acute among the poor in developing countries where their diets are heavily dependent on starchy staples. Thus, through improved macro- and micro-nutrient access, a more varied diet is associated with better nutrition. Studies in developing countries have consistently found a positive association between dietary diversity and nutritional status. A more varied diet has been associated with increased intakes of energy, fat, protein, carbohydrates, and a number of vitamins and minerals. Previous methods of measuring nutritional well-being have been either too prone to measurement error and bias, or are too time consuming and expensive to be feasible and cost-effective for most field studies. Dietary diversity has shown promise as a simple, low-cost alternative to these measures. For these reasons, dietary diversity is used as the measure of dietary quality for households studied in the following two chapters.

III. Mental Accounting in a Development Context

The existence of mental accounting is well documented in consumer behavior in developed countries (Thaler, 1999). Mental accounting provides an explanation for the many ways in which people's consumption behavior runs counter to standard economic theory. One component of mental accounting is that income is not perfectly fungible, as standard economic theory assumes. Instead, people may assign certain expenditure activities, implicitly or explicitly, to specific 'mental' accounts funded by different sources of income. Thus, mental accounting violates the economic notion of perfect fungibility. In other words, changes in income and wealth in one mental account, such as a windfall, are not perfect substitutes for income changes in another account, such as regular wages (Thaler, 1999). For example, if someone were to receive money as a birthday gift, he may be more likely to spend it on a luxury good such as a music player or a nice bottle of scotch, items he would otherwise not buy. However, if that same income increase were to be distributed over his regular wages, it may be much more likely to be spent on something like paying rent. In both cases the increase in total income is the same, but the effects on expenditure activities are very different, depending on the source of the extra increments of income.

One study found that people tend to match the perceived seriousness of an expense with the perceived seriousness of the income source. Funds received from more “frivolous” sources, such as office pools, will be spent on more “frivolous” expenses, such as eating out. On the other hand, funds received from more “serious” sources would be spent on more “serious” expenses such as paying the bills (O’Curry, 1997).

Thus, an increase in total income may not affect expenditure activities identically irrespective of the source of the increase, as standard economic theory suggests. Instead, an increase in income, depending on the ‘mental account’ it funds, may affect expenditure in one activity more than others. In fact, if an increase in one source of income causes a decrease in another source because of a change in earning activities, that may cause a *decrease* in a particular expenditure activity, even if the net effect on total income is positive.

Kooreman (2000) found expenditure on children’s clothing was much more responsive to changes in child allowance funds from the Dutch government than it was to changes in other sources of income. Thus, a particular source of income was earmarked for a certain type of spending activity. Standard theory would predict that a change in child allowances would cause households to reallocate income such that expenditure activities would respond identically to how they would have responded to changes in any other source of income. However, because of non-fungibility, changes in government child allowances had a very different impact on child expenditures than did changes in other sources of income. In other words, child allowances from the government did not cause families to reallocate their income previously spent on child expenses towards other activities. It instead increased child expenditures.

Using an additively decomposable measure, which allows for poverty to be distributed among population subgroups, Greer and Thorbecke (1986) estimate the magnitude, distribution, and factors associated with food poverty for Kenyan smallholders. They start with a multivariate analysis of variables associated with food consumption and then turn to a poverty profile which decomposes food poverty into six sets of variables: region of residence, household size and composition, household landholding size, cropping pattern and market involvement, type of employment, and individual characteristics of the household head. In the multivariate analysis, Greer and Thorbecke find that both the percent of income from own farm production and from farm operating surplus are positively and significantly related to calorie consumption. On the other hand, off-farm income earned by the household head was found to be significantly *negatively* associated with calorie consumption. The authors propose that an explanation for this result is that when the household head works off his own farm, all else being equal, he allocates more of his off-farm income to nonfood items than he would of on-farm income. In the food poverty profiles, they found the important positive determinants of food consumption were land holdings, rural employment (as opposed to urban employment), crop and livestock sales, and farm equipment value.

While Greer and Thorbecke (1986) do not explicitly test for mental accounting, there do appear to be differential responses of food consumption to changes in various income sources. Mental accounting could be a possible explanation for this. This leads to an important question of whether total income itself is a strong determining factor of nutrient consumption in poor households or if truer relationships are found in decomposing income and wealth based on income sources that are prevalent in the region and communities being examined.

Studies explicitly testing for mental accounting in a development context are scarce. Hoffmann (2007) investigates whether there is a mental accounting effect influencing the allocation of insecticide-treated mosquito nets to those who are more vulnerable to malaria within households in Uganda. Households were separated into a buying condition and a free nets condition. In both scenarios, participants were read a statement regarding malaria and were told of the particular danger it poses to young children and to pregnant women. Those in the buying condition were given enough cash to purchase enough mosquito nets to cover their entire household and then given the opportunity to purchase nets. Those in the free nets condition were simply given enough nets to cover their household and then were given the opportunity to exchange their nets for cash. Night home visits were then made to participant households to check the usage of each net. Some striking differences emerged between households in a buying condition and those in a free nets condition. An individual who earns all of the household's income is no more likely to be using the mosquito nets than members earning no income in the free nets condition. However, in the buying condition, the income earner is 50% more likely to be using the nets than those who earn no income. Also if the nets were purchased, the household member randomly selected to do so was 16% more likely to be using the net, whereas if the net were received freely, that individual was no more likely to be using the net than anyone else in the household. Even if the net was received by the same individual, how it was received changed who had access to it.

Duflo and Udry (2004) examined consumption choices among households in Cote d'Ivoire. They investigated how the demand for different types of goods is affected by different income sources. Some income is earned through *appreciated products*, which are defined as those that are controlled by the household head *"for redistribution to the entire household in the form of food"*. Descriptions from anthropologists of how different sources of income are spent seem to resemble the consumption behavior described by mental accounting theories. They suggest non-fungible income and wealth resources generated from different economic activities, even when those activities are performed by the same individual and regardless of whether those resources are cash or in kind. In other words, different categories of expenditure are decided by different sources of income—"mental accounts"—and transfers between those accounts are not freely made. Duflo and Udry investigate the empirical validity of these descriptions by testing if and how shocks to different income sources impact expenditure shares above and beyond their impact on overall expenditure.

Duflo and Udry (2004) find that changes in male and female income yield different effects on expenditure. They further find that although men typically cultivate yams, they are considered an appreciated crop, and thus, the effects on expenditure from changes in yam income are drastically different from those of other male-cultivated crops. More specifically, they find that the consumption of adult and prestige goods (tobacco, alcohol, jewelry, and adult clothing) is strongly associated with variations in income from male non-yam crops and female cultivated crops. Variations in yam income, on the other hand, are strongly associated with spending on household public goods and basic necessities, such as education, food staples, and overall food consumption. For example, education expenditures are positively related to yam income, but are inversely related to income from male- and female-controlled non-yam crops. Increases in yam income are associated with decreases in spending on adult and prestige goods, whereas increases in income from male non-yam crops results in a decrease in spending on food. Consequently, income shifts from yam output to either male- or female-controlled non-yam crops would be associated with substantial declines in education and food staple expenditures and a substantial rise in expenditure on adult and prestige goods. The authors further explain that while the male household head formally controls yam income, as an appreciated good, there are strong social sanctions against misusing this income. Thus would lend itself to the non-fungibility of spending from this account and is consistent with the authors' findings.

The findings of Duflo and Udry (2004) and Hoffmann (2007) highlight the importance of understanding "mental accounting" behavior in poor communities. Nutrient intake elasticities with respect to particular sources of income may in fact be zero, or even negative, while elasticities with respect to other sources of income may be substantially higher. Consequently, income-generating programs concerned with the food intake of poor households may be ineffective, or even counter-productive, if they are not targeting appropriate income sources. Recognizing and understanding mental accounting behavior in poor communities in developing countries can have a substantial positive impact on development efforts and appropriately targeting policies. However, as mental accounting behavior may not be homogenous across different communities, this also challenges researchers and policy-makers to better understand the economic and social structure of the communities with which they are concerned.

If mental accounting plays a prominent role in the consumption behavior of poor households in developing countries, then this has important implications for how the relationship between income and nutrition is assessed. Household food expenditures may respond very differently to fluctuations in total income depending on which income source is changing. If a household experiences an increase in income only from a source not typically used for food expenditures, then household food intake may be little affected by even dramatic changes in total income. This would result in a low estimate of the household's income elasticity of nutrient demand. The low elasticity could then indicate to policymakers and researchers that income does not matter to the nutritional status of individuals in poor households, when in fact, it is not that income does not matter, but that where income comes from does matter. Acquiring a better understanding of mental accounting and the consumption behavior of poor households will better equip policymakers to more appropriately and effectively target income generating programs.

IV. Intrahousehold Resource Allocation and Individual Welfare

While the average well-being of the household might be one of the largest determinants of the well-being of its members, nutritional well-being is a feature of the individual not the household. The household, though, may be the most important institution influencing the welfare of the individual. Consequently, development practitioners and policymakers cannot be indifferent to processes of intrahousehold resource allocation. Understanding not only how households allocate income to expenditure activities, but also how households allocate resources to its 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 order of ranking 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 resources differ according to demographic groups, such as gender and age. This examination proposes many challenges because in order for one to make any definitive welfare statements concerning a particular group within the household, he must not only consider the relative level of household resources allocated to that group, but also the relative volatility of those allocations along with that group's marginal utility from resource allocations as well as their need according to activities and endowments. Thus disparities in nutrient intake alone among different demographic groups do not necessarily signify disparities in nutritional welfare.

A number of studies have endeavored to examine the existence and magnitude of intrahousehold inequality by comparing income and price elasticities of household resource allocation for different demographic groups. Awareness of elasticity differences would allow for better and more informed evaluations of the welfare impacts of income growth and pricing policies. A number of studies have found consumption and human capital investment to be less price and income elastic for more "favored" demographic groups then for less favored ones (e.g., Behrman, 1988, Alderman and Gertler, 1997). This result implies that favored groups are more able to smooth their consumption over fluctuations in income and food prices. Higher income and price elasticities also imply that the nutrient intake of less favored groups is more volatile than that of more favored groups.

In a study of households in rural South India, Behrman and Deolalikar (1990) find that the nutrient intake of females is more price elastic than that of males. The authors conclude that these higher elasticities could leave women and girls vulnerable during lean seasons and times of food shortages. This implies that females suffer a greater risk of hunger and malnutrition. In a study of the same households, Behrman (1988), finds that households exhibit a pro-male bias in the allocation of nutrients to children during the lean season.

Alderman and Gertler (1997) demonstrate theoretically that demand for human capital of less favored demographic groups will be more income and price elastic than that of a more favored group. This occurs under the same conditions that lead to higher levels of investment in the favored group.[15] They further show that the price elasticity of human capital demand falls as income rises and does so at a faster rate for the less favored group than the more favored group. This implies that the disparity in gender price elasticities will diminish as income level rises. Alderman and Gertler (1997) then show empirically that demand for healthcare services is more price and income elastic for girls than it is for boys in a study of households in Pakistan. They further find that this difference disappears at higher levels of income.

Mangyo (2008) claims that higher income and price elasticities of human capital investment do not necessarily indicate weaker household status. He contends that previous studies on this matter are highly stylized and largely influenced by the notion that human capital investments in boys are more necessary than they are in girls. Models in these studies often assume that there is no difference in the rate at which marginal utility of human capital investment changes with changes in the level of human capital investment. He also claims that previous studies have not adequately controlled for potential confounding factors correlated with human capital investment. Mangyo (2008) then demonstrates theoretically that it is inconclusive whether human capital investment in a favored household member is more or less elastic than it is for other household members. He explains that as household income increases, the rate at which resource allocation to individuals increases depends on the rate at which the marginal utility and productivity of one household member fall relative to others.

Using a large data set from China, Mangyo (2008) estimates nutrient intake elasticities for six demographic groups: prime age men, prime age women, elderly men, elderly women, boys and girls. After controlling for potential confounding factors correlated with human capital investment, he finds that prime age men have the

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[15] Higher levels of investment in a favored group might be due to higher levels of productivity in that group, higher rates of return from resources invested in that group, or household preferences or favoritism.

highest nutrient intake elasticity with respect to income, females have lower elasticities than males, and that elderly household members generally have lower elasticities than other groups.

Other than comparing income and price elasticities among various demographic groups, studies have attempted to understand potential individual welfare disparities within the household by investigating how risk is shared among household members. Dercon and Krishnan (2000) investigate whether rural Ethiopian households engage in complete risk sharing. They test whether intrahousehold resource allocations are unaffected by individual-specific shocks. In most households they found that there is full risk sharing of unpredicted illness. However in poor households in southern Ethiopia they found that risk was not fully shared. In these households, the women were not fully insured against unpredicted illness whereas men were.

Pitt *et al.* (1990) develop a model of intrahousehold allocation that incorporates the interactions among nutrition, labor market productivity, health endowments, as well as the intrahousehold distribution of food and work activities. They examine whether households *reinforce* the higher endowment of more productive individuals by allocating them more food (meaning that the household is *income* maximizing) or if instead, lower-endowed individuals are *compensated* with higher food and lower labor allocations (meaning the household is *inequality averse*). In a study of households in Bangladesh, they find that men have both a higher level and higher variance in calories consumed than women. They also observe that men exhibit higher rates of participation in energy-intensive activities in which productivity is influenced by health status. The authors find that although there appears to be a larger rate of calorie reinforcement for adult males than adult females, these individuals are also much more likely to be involved in energy-intensive activities.

This results in a "tax" on adult male endowments that exceeds that of adult females. Thus households in this study ultimately appeared to be more inequality averse than income maximizing.

Food allocation within the household has been a widely studied facet of intrahousehold distribution.[16] While a number of studies have found a pro-male bias in intrahousehold nutrient distribution, this result has been predominantly found in Northern India and Bangladesh. Outside of these regions, evidence for male bias is scarce (Haddad, et al., 1996). The mixed evidence pertaining to intrahousehold inequality discussed above points to the inherent danger in assuming *a priori* the existence of intrahousehold equality or inequality. Misunderstanding this essential component of resource allocation can have potentially serious implications for the welfare impacts of development programs and policies. Therefore intrahousehold dynamics must be considered for effective and appropriate policy design.

V. Nutrition, Income and Wealth in African Pastoralist Communities

The 2006 UNDP Human Development Report put Kenya among the "low human development" countries of the world, ranking it 152nd out of 177 countries. Endemic poverty, low economic growth, drought prone arid and semi-arid lands, and high population growth contributed to increased hunger in the country. Poverty and vulnerability can be particularly acute among pastoralists in remote areas. Many households in these areas are chronically poor and there are persistently high malnutrition rates among children under five (World Food Program, 2008).

Ethiopia is one of the poorest countries in the world ranking 170th of the 177 countries on the Human Development Index. Poverty and food insecurity are widespread. Of the country's population of 77.5 million, 31 million people live below

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

the poverty line and 6 to 13 million are at risk of starvation. Transitory and chronic food insecurity are major challenges facing the rural population (World Food Program, 2006). Of Ethiopia's population, 44 percent are undernourished and 38 percent of its children are underweight for their age. Recurrent drought, disruptions from strife, soil exhaustion and erosion, as well as overcrowding of human and animal populations contribute to food insecurity, particularly in pastoralist areas (World Food Program, 2008). Under these circumstances, effectively targeting development and aid policies is vital. Developing well designed and appropriately targeted policies based on sound empirical evidence is essential to enhancing pastoral livelihoods and nutritional well-being. Unfortunately there is a paucity of empirical studies on nutritional determinants for African pastoralist households.

The primary economic activities of pastoralist communities all heavily rely on livestock. For this reason, many of the studies relating wealth and income to nutrition in pastoralist households have examined degree of livestock wealth as a potential nutritional determinant. Many of these studies have observed little to no association. McCabe *et al.* (1997) found that children had low weight-for-height measures in both wealthier and less prosperous households in Tanzania. In a study of Maasai households in Kenya, Grandin (1988) found little association between levels of milk consumption and livestock wealth. In a study of Datoga households in Tanzania, Sellen (2003) found that the number of cows milked per adult women did not increase with domestic herd size. He also found that households with middle-sized domestic herds (relative to the herd size of other households in the study) had a higher percentage of household caloric requirements satisfied by maize, meat and milk. The lack of association between livestock wealth and levels of milk consumption or number of cows milked found by Grandin (1988) and Sellen (2003), respectively, may be due to the abundance of overall milk supply in these communities. Most households in these communities tend to own livestock. This means that most households are able to some extent home produce milk and that there is not likely a large local milk market in these communities. Therefore once a certain threshold of milk production is satisfied, it is not inconceivable that increases in livestock wealth would not strongly coincide with increases in milk production or consumption. Many postulate that the lack of association between herd wealth and nutritional status is due to 'egalitarian' systems of wealth redistribution present in pastoralist societies (Sellen, 2003). Sellen (2003) also points out there may be an emphasis on using livestock to enhance livestock productivity and herd size rather than increase human consumption. Certainly there is evidence on the importance of herd accumulation to household survival and welfare in pastoral areas (Lybbert, et al., 2004, McPeak, 2005).

A number of studies have found that herd accumulation is the best means available to pastoralists to self-insure against risk (Lybbert, et al., 2004, McPeak, 2005). Lybbert *et al*. (2004) note that shocks such as prolonged droughts can cause pastoralist households to lose 50% or more of their herds. Moreover, if households do not escape the shock with a herd size above a certain threshold, they might be forced into a sedentarized production system, which usually means chronic, dire poverty.

It has also been found that holding assets in the form of livestock has a substantially higher rate of return than alternative savings methods available to pastoralists (Barrett, et al., 2006, McPeak, 2005). Thus pastoralist households appear to prefer using their herds as a "walking bank," drawing on livestock to meet immediate consumption needs only when cash is otherwise not available (Bellemare and Barrett, 2006). Consequently, livestock wealth and income may not be the most relevant form of wealth or income to examine when exploring the consumption behaviors of pastoralist households.

If drawing down on livestock assets is thought of as a last resort for most pastoralist households then it might no be appropriate to examine herd size changes when attempting to understand how pastoralists meet their consumption needs and what determines their nutritional status. Unfortunately, to my knowledge, there has yet to be a study of this kind using other income sources.

VI. Conclusion

Food is the most essential consumption good for survival. In fact, of the eight UN Millennium Development Goals, the first one listed is to "*eradicate extreme poverty and hunger*" (UN, 2008). In order to design well-targeted and appropriate policies combating malnutrition and hunger, it is first essential to understand what determines and influences household food expenditures and, once acquired, how food resources are distributed to individual members within the household.

The following chapters of this thesis seek to address those two questions in a pastoral context. Chapter 2 investigates the relationship between nutrition and household income. In order to address some of the qualitative and quantitative complaints about traditional methods of measuring nutrient intake, dietary diversity is used as the dependent variable. The chapter investigates whether food consumption behavior has differential responses to changes in various income sources and considers mental accounting, as well as other candidate explanations, as potential factors shaping food consumption decisions in pastoralist households.

Chapter 3 explores the intrahousehold dynamics of food consumption. In this chapter individual-level income and price elasticities of dietary diversity are measured to indicate nutritional volatility. These elasticities are then compared among different demographic groups within the household in order to draw out welfare implications. Demographic group elasticities are then tested to see if they differ depending on whether current household income is above or below its intertemporal mean. Then the welfare of different demographic groups are compared to see if certain groups are systematically better off than others given the level and volatility of their food consumption.

Development programs targeting pastoralist communities in East Africa have often proved disappointing. Better understanding how individual nutrition responds to various income growth programs and pricing policies as well as how those responses vary (or do not vary) within the pastoralist household may better equip policy makers to design well-targeted programs. The papers of this thesis aim to contribute to that understanding.

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CHAPTER 2

DIFFERENTIAL NUTRITIONAL RESPONSES ACROSS VARIOUS INCOME SOURCES AMONG EAST AFRICAN PASTORALISTS: INTRAHOUSEHOLD EFFECTS, MISSING MARKETS AND MENTAL ACCOUNTING

The field of development economics is largely devoted to exploring ways of combating poverty, along with its many adverse effects. In countries at all levels of development, the food insecurity and low nutrient intake of the poor have occupied a central place in the study of poverty. Until recent decades, it was generally thought that the most effective way to combat hunger and malnutrition was through economic growth and, more specifically, raising the incomes of the poor. Conventional wisdom has held that while nutrient intake may not rise one for one with income, the income elasticity of nutrient demand is still substantially greater than zero.

In the last few decades however, some studies have challenged this idea arguing that increases in income will not produce substantial improvements in nutritional well-being (Behrman and Deolalikar 1990, Behrman and Deolalikar 1989, Behrman and Deolalikar 1987, Behrman et al. 1988, Bouis 1994, Bouis and Haddad 1992). If this claim holds true, then it has significant implications for how economists and policymakers think about the effects of economic growth and development on hunger, malnutrition and household food security.

Traditionally it has been thought that the low nutrient intake of the poor is largely due to low income. Substantial resources have therefore been devoted to income growth programs aimed at improving nutrition in poor communities. However, despite many studies on the subject, there is still little agreement over the extent to which the nutritional status of the poor responds to changes in their income.

Studies examining this matter often look at the intake changes of specific nutrients, particularly calories, in relation to changes in some measure of income. The scope of the debate on this relationship ranges from studies arguing that the calorie-income curve is essentially flat (Behrman and Deolalikar 1990, Behrman and Deolalikar 1987, Bouis 1994, Bouis and Haddad 1992, Wolfe and Behrman 1983) to the other extreme where studies have estimated income elasticities of caloric demand close to one (Pitt 1983, Strauss 1984). Other studies find a concave or elbow-shaped calorie-income curve (Ravallion 1990, Strauss and Thomas 1995, Strauss and Thomas 1990, Subramanian and Deaton 1996). These latter findings indicate that among the very poor, nutritional intakes would increase with income up to a certain level, after which the nutrient-income elasticity would decline, possibly to zero.

A number of reasons have been proposed for the wide range of estimates of the nutrient-income elasticity for poor households.[17] However, the vast majority of studies on this matter have not considered the possibility that nutrition may respond differently to different sources of income. To my knowledge, studies have thus far only explored the nutrition-income relationship using total income. Yet, there are reasons to believe that where income comes from may change how it is used in the household. These reasons include intrahousehold dynamics, market imperfections or missing markets for certain goods, and mental accounting. Thus nutritional status may have differential responses to changes in different income sources. Therefore the

[17] Behrman and Deolalikar (1987) argue that an aggregation bias resulting from common methods of inferring nutrient intake cause and upward bias in nutrient-income elasticity estimates. Bouis and Haddad (1992) claim that estimates are often overestimated due to 'wastages and leakages' often unobserved by common data collection methods as well as because of correlated measurement errors between explanatory and dependent variables. A number of other studies also point to non-linearities in the relationship between nutrient intake and income that are often unaccounted for in functional forms modeling this relationship (Ravallion 1990, Strauss and Thomas 1995, Strauss and Thomas 1990, Subramanian and Deaton 1996).

impact of income on nutrition might be more appropriately evaluated with income disaggregated into different sources.

The rest of this paper explores the possibility of differential nutritional responses to changes in various income sources. Section II briefly reviews evidence thus far for the existence of differential responses and reasons why they might occur, such as intrahousehold dynamics, market imperfections and mental accounting. Section III develops an empirical model of nutrition allowing for differential responses of nutrition across various income sources. Section IV describes the data set used for this paper and the setting from which it comes. Section V describes the econometric specifications used for estimation. Section VI discusses the estimation results and tests for differential responses of dietary diversity to different income sources. Possible explanations for differential responses are tested for in Section VII. Finally Section VIII concludes.

I. Differential Nutritional Responses across Income Sources

There is evidence that changes in certain sources of income may impact food intake differently than changes in other sources A number of studies have found intrahousehold dynamics of resource control and allocation cause different sources of income to impact expenditure patterns and activities differently (Breunig and Dasgupta 2005, Haddad et al. 1996). Other studies have found differential expenditure responses to changes in various income sources that were seemingly due to mental accounting (Duflo and Udry 2004, Hoffmann 2007, Kooreman 2000, O'Curry 1997).[18] Differential nutritional responses to income sources may also result due to the failure or absence of markets for certain home-produced goods (de Janvry et al. 1991).

[18] For a good discussion of mental accounting of some of the literature on it see Thaler (1999).

Intrahousehold Distributional Effects

Intrahousehold dynamics might cause household consumption to respond differently to changes in different sources of income due to differences in preferences and resource control across various household members. Income sources typically controlled by household members more concerned with diet and nutrition may have a very different impact on household food intake than other income sources controlled by members less interested in nutrition. A number of studies have found that household resources and extra income controlled by women are typically more likely to be allocated towards the production of nutrition than those of men.[19]

Empirical studies have found that households in the United States exhibit a higher marginal propensity to consume food out of food stamps than out of cash income, even when households are unconstrained,[20] implying that food stamp income has a different impact on household consumption than cash income (Breunig and Dasgupta, 2005). Breunig and Dasgupta (2005) conjecture that this discrepancy is driven primarily by intrahousehold distribution effects. If so, then one would expect multiple-adult households to exhibit this behavior but not single-adult households. Studying households in San Diego, Breunig and Dasgupta (2005) find that single-adult households show no difference in their marginal propensity to consume food out food stamp or cash income, while multiple-adult households have an approximately six to eight times higher marginal propensity to consume food out of food stamp income than cash income. The authors interpret this economically and statistically significant difference as supporting their intrahousehold hypothesis.

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[19] For a review of this literature see Haddad et al. (1996).
[20] A household is unconstrained if it receives food stamps and but also spends a positive amount of cash income on food.

Market Failures and Missing Markets

Household specific market failures, or missing markets in an extreme case, for particular commodities may also cause varying expenditure responses to different income sources. Selective market failures for certain home-produced goods may result when household transaction costs associated with market participation for those goods increase to the point where those goods are rendered non-tradable for the household in question. This then induces such households to be autarkic producers and consumers of those particular goods. Thus increases in household production of those goods would increase consumption of just those goods, but have little to no impact on other household consumption goods. For example, if market failures cause a household to be an autarkic producer and consumer of maize, then marginal increases in maize production would increase household maize consumption but have no substantial impact on household education expenditures. Thus, household-specific missing markets or market failures may cause expenditure activities to respond differently to changes in different sources of income (de Janvry et al. 1991).

Mental Accounting

Finally, households may spend various income sources differently due to what behavioral economists refer to as mental accounting. One component of mental accounting is that income is not fungible across different sources as standard economic theory assumes. Instead, people may assign certain expenditure activities, implicitly or explicitly, to specific ‘mental’ accounts funded by different sources of income. Thus changes in income and wealth in one mental account, such as a windfall, are not perfect substitutes for income changes in another account, such as wages for labor.

Instances of mental accounting are fairly well documented in consumer behavior in developed countries and in experimental economics.[21] However, studies explicitly testing for mental accounting in developing countries are scarce. In a study conducted in Uganda, Hoffmann (2007) found that households who received insecticide-treated mosquito nets were more likely to use them for household members most vulnerable to the effects of malaria. Alternatively, if households received cash to purchase the nets on site, the nets were much more likely to be used by main income-earners in the household. Duflo and Udry (2004) found evidence of mental accounting in the expenditure patterns of households in Cote d'Ivoire. They found that yam cultivation, which is typically male-controlled, had a strong positive association with spending on household public goods and basic necessities, such as education, food staples, and overall food consumption. They also found that changes in income from male non-yam crops and female cultivated crops were strongly associated with the consumption of adult and prestige goods (tobacco, alcohol, jewelry, adult clothing and non-staple foods). Furthermore, increases in yam income were associated with decreases in spending on adult and prestige goods, whereas increases in income from male non-yam crops resulted in decreases in spending on food.

Factors associated with intrahousehold dynamics, missing markets and mental accounting could all cause differential nutritional responses across various income sources. With this in mind, it would be prudent to test the appropriateness of nutrition demand models using aggregated income as an explanatory variable rather than disaggregated income. Instead of looking at nutritional responses to changes in total income, it might by more appropriate to explore which income sources appear to be

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[21] For a review of the literature on mental accounting see Thaler (1999).

important to food expenditures and what are the nutritional responses to changes in different income components.

II. Model

The focus of this paper is to discover whether households exhibit differential nutritional responses to various sources of income. Previous studies in the development literature examining the nutrition-income relationship have assumed equivalent income elasticities of nutrition across various income sources. A common functional form in this literature follows the log-linear equation:

$$(1) \qquad \ln N_{ivt} = \alpha + \beta \ln Y_{ivt} + \sum_{j=1}^{J} \delta^{j} \ln P_{vt}^{j} + \sum_{f=1}^{F} \gamma^{f} H_{ivt}^{f} + \sum_{c=1}^{C} \theta^{c} V_{vt}^{c} + \mu_{iv} + \varepsilon_{ivt}$$

where

i is an index for the individual,

v indexes the village or location,

t indexes the time period,

N is some measure of level of nutrition,

Y is income,

P is the price of food commodity *j*,

H is household specific characteristic *k*,

V is village or location specific characteristic *c*,

μ is unobserved individual specific effects and

ε is the disturbance term.

This model has been modified to allow for variations in nutrition-income elasticities across levels of income (Strauss and Thomas 1990, Subramanian and Deaton 1996). However studies modifying this model to allow for nutrition-income elasticities to vary across income sources are scarce.[22] If households do in fact have different nutrition elasticities with respect to different income sources, then estimated nutrition elasticities with respect to total income may be misleading.

To illustrate, say a household earns income from two different sources, Y_1 and Y_2. Suppose the household uses income Y_2 primarily for food purchases and income Y_1 mostly for other expenditure activities and rarely for food expenditures. Suppose further that the nutrition elasticity with respect to Y_2 is positive while that with respect to Y_1 is zero. Say this household experiences a large increase in Y_1 and a very small increase in Y_2. Consequently the household experiences a large increase in total income but a very small increase in food expenditures, resulting in an estimated nutrition elasticity with respect to total income that is close to zero. This result masks the positive nutrition elasticity with respect to Y_1. On the other hand, if the large increase in total income was primarily due to an increase in Y_2, then a larger positive total income elasticity of nutrition would be estimated masking the zero nutrition elasticity with respect to Y_1. Either case could lead to mistargeted income growth programs concerned with nutrition.

The nutrition literature has estimated nutrition-income elasticities ranging from near zero (Behrman and Deolalikar 1990, Behrman and Deolalikar 1987, Bouis 1994, Bouis and Haddad 1992, Wolfe and Behrman 1983) to almost one (Pitt 1983, Strauss 1984). One possible explanation for this wide range of estimates is not accounting for the possibility of differential nutritional responses to changes in various income sources. The assumption that income elasticities of nutrition are equivalent across income sources has not been tested to date.

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[22] The only study I am aware of that allows nutritional responses to vary across income sources is Duflo and Udry (2004).

To explicitly test the assumption of equivalent nutrition elasticities we disaggregate income by source in (1) to get the following:

(2) $$\ln N_{ivt} = \alpha + \sum_{k=1}^{K} \beta^k \ln Y_{ivt}^k + \sum_{j=1}^{J} \delta^j \ln P_{vt}^j + \sum_{f=1}^{F} \gamma^f H_{ivt}^f + \sum_{c=1}^{C} \theta^c V_{vt}^c + \mu_{iv} + \varepsilon_{it}$$

where *k* indexes income sources and

(3) $$Y_{ivt} = Y_{ivt}^1 + Y_{ivt}^2 + Y_{ivt}^3 + ... + Y_{ivt}^k .$$

Using (2) we can test the null hypothesis

(4) $H_0: \beta^1 = \beta^2 = \beta^3 = ... = \beta^{\kappa}$

$H_A: \beta^m \neq \beta^n$ where $m \neq n$, $1 \leq m \leq k$ and $1 \leq n \leq k$

A rejection of the null hypothesis would indicate that there exist differential nutritional responses to different income sources and thus (1) is not an appropriate model for estimating nutrition elasticities with respect to income.

However this model is only adequate if the composition of income is similar among households at different levels of wealth. There is substantial evidence that nutrition income elasticities vary at different levels of wealth. Therefore if there are systematic differences in the income composition between poor and rich households, which are not controlled for explicitly, and these are related to patterns of income earning, then a rejection of the above null hypothesis may just be picking up differences in income-nutrition elasticities at various levels of wealth as opposed to differences due to income source. Therefore (2) must be further modified to allow for non-linearities in the relationship between the nutrition-income elasticity and income level.

To allow income elasticities to differ over different levels of income, dummy variables indicating the income quantile to which the household belongs are included in the model as both intercept shifters as well as interacted with income and price variables to allow for income and price elasticities to change with the level of income.[23] This gives us the following equation

(5) $$\ln N_{ivt} = \sum_{l=1}^{L} Q_l[\alpha_l + \sum_{k=1}^{K}\beta_l^k \ln Y_{ivtl}^k + \sum_{j=1}^{J}\delta_l^j \ln P_{vtl}^j] + \sum_{f=1}^{F}\gamma^f H_{ivt}^f + \sum_{c=1}^{C}\theta^c V_{vt}^c + \mu_{iv} + \varepsilon_{it}$$

where Q is an indicator variable equal to one if the individual *i* belongs to income quantile *l* and *l = 1, 2, 3,…L*. This gives *L* testable hypothesis.

(6) H_{10}: $\beta^{11} = \beta^{12} = \beta^{13} = ... = \beta^{1k}$

H_{1A}: $\beta^{1m} \neq \beta^{1n}$ where $m \neq n$, $1 \leq m \leq k$ and $1 \leq n \leq k$

H_{20}: $\beta^{21} = \beta^{22} = \beta^{23} = ... = \beta^{2k}$

H_{2A}: $\beta^{2m} \neq \beta^{2n}$ where $m \neq n$, $1 \leq m \leq k$ and $1 \leq n \leq k$

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H_{L0}: $\beta^{L1} = \beta^{L2} = \beta^{L3} = ... = \beta^{Lk}$

H_{LA}: $\beta^{Lm} \neq \beta^{Ln}$ where $m \neq n$, $1 \leq m \leq k$ and $1 \leq n \leq k$

Equation (5) allows for different income and price elasticities of nutrition at different levels of income and also controls for the possibility for differential nutritional responses due to wealth differentials as opposed to income source differentials. A rejection of the null hypotheses in hypothesis (6) indicates that nutritional status does not respond equivalently to changes in different sources of income for individuals in that income quantile. This would indicate that a model using

[23] As another way of capturing these effects, Strauss and Thomas (1990) proposed a few functional forms of log-inverse log models that seemed to work well. However these models are problematic if there are a number of observations where the log of income is between 0 and 1. Since in this paper, income is disaggregated there are many zero observations for each income source variable. This proved to be problematic when working with the log-inverse functional forms proposed by Strauss and Thomas (1990).

aggregated income as an explanatory variable is less appropriate than one in which income is disaggregated.

III. Data and Setting

The data for this paper come from a comprehensive set of panel data collected by the USAID Global Livestock Collaborative Research Support Program (GL CRSP) project “Improving Pastoral Risk Management on East African Rangelands” (PARIMA). Households were surveyed in five locations in southern Ethiopia and six in northern Kenya[24], all in one livestock production and marketing region (Barrett et al. 2008). In total, 337 households are included in the data.[25] In each household the household head was surveyed along with up to two adult, non-head household members. Only household heads are included in this particular study. Surveys were conducted in March 2000 for baseline information and then quarterly from June 2000 to June 2002, resulting in 10 quarterly observations for each household.[26] 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 gives information on individual and household characteristics such as household size, sex, age and education. The repeated surveys provide information on income earned from various sources such as trade, wages and salary, crop value, and remittances. They also report households’ livestock holdings, trade, and production.

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[24] 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, Dillo, Finchawa, Qorate, and Wachille.
[25] Due to some issues of attrition, interruption and missing observations of particular variables for certain individuals or communities the number of observations per survey period ranges from 186 to 303. Also, due to some known measurement error, the top and bottom 5% of observations over the observed income distribution were deleted from the study.
[26] The baseline survey in March 2000 did not provide dietary information or information on income over the quarter. Therefore this study included only 9 quarterly observations from June 2000 to June 2002 and information from the March 2000 survey was only used for baseline information on the household.

While a number of households are involved in activities such as trade, wage labor, or, to a very limited extend, crop cultivation, primary economic activities for most households in the area are centered on livestock. Pastoralism allows households to be opportunistic in the arid and semi-arid lands of the study region where uncertain rainfall makes primary production risky (Coppock, 1994). Only six households in the data do not own livestock over the study period. Mean annual rainfall in the study area is just around 400mm, making crop cultivation difficult. Therefore, pastoralist households rely chiefly on livestock for income. Average household herd size in the data is 12.10 tropical livestock units (TLU).[27] Production of livestock products makes up roughly 48% of all income earned in the study area over the survey period. Livestock trade is 17%, wages and salary is 11%, net remittances if 16%, non-farm non-livestock trade and business make up 5%, and crop value comprises only 2% of all income earned in the study area. Table 1 summarizes aggregated and disaggregated income in the study population.

In order to estimate equation (3) and control for the possibility of wealth differentials causing income elasticities to differ between income sources, the sample is broken up into three income terciles based on households' mean intertemporal income. Table 2 describes the income and its composition for the lower, middle, and upper terciles. The percentage shares of total income for trade and business, livestock trade, and crop value do not change substantially across income terciles. The income share of wages and salary increase somewhat from 5% and 4% in the lower and middle terciles, respectively, to 11% in the upper tercile. The value of livestock products produced increases from 35% in the lower tercile to 49% in the middle and upper terciles. The most drastic difference across income terciles is the in the share of

[27] TLU is a standard measure for aggregating herd size across various species. 1 cattle = 1 TLU, 1 camel = 0.7 TLU, and 1 sheep or goat = 0.1 TLU.

Table 2.1: Full Sample Summary Statistics

N=2089

Groups=318

	Proportion of Total Income	*Mean*	*Standard Deviation*	*Min*	*Max*
Total Income	1.00	7417.92	7433.77	380	34233.79
Trade and Business	0.06	409.94	1470.14	0	27000
Wages and Salary	0.06	826.19	3608.95	0	30000
Livestock Trade	0.13	1250.43	2745.27	0	30000
Livestock Products	0.44	3556.13	5237.63	0	32850
Crop Value	0.02	160.52	1194.36	0	25080
Remittances	0.29	1214.70	1779.28	0	28463.9
Herd Size (TLU)		12.16	18.01	0	269.93
Dietary Diversity		3.17	1.50	1	8

Table 2.2: Full Sample Summary Statistics by Income Tercile

	N	*% of Household Income*	*Mean*	*Standard Deviation*	*Min*	*Max*
Lower Tercile	698					
Total Income		1.00	3160.63	2637.04	400	19601.38
Trade and Business		0.06 (0.17)	189.45	635.82	0	5700
Wages and Salary		0.05 (0.16)	143.95	740.26	0	15000
Livestock Trade		0.11 (0.25)	572.34	1489.84	0	10407.52
Livestock Products		0.34 (0.38)	1105.66	1758.93	0	19601.38
Crop Value		0.02 (0.13)	86.43	454.04	0	6004
Remittances		0.41 (0.38)	1062.81	1364.58	0	13182.44
Middle Tercile	700					
Total Income		1.00	6195.45	5680.39	380	33705.5
Trade and Business		0.05 (0.14)	260.02	970.71	0	12690
Wages and Salary		0.03 (0.13)	215.31	1134.87	0	18000
Livestock Trade		0.15 (0.27)	1437.09	3140.20	0	30000
Livestock Products		0.48 (0.37)	3056.51	3961.43	0	25374.25
Crop Value		0.02 (0.11)	156.71	1045.73	0	18120
Remittances		0.27 (0.32)	1069.80	1853.37	0	28463.9
Upper Tercile	691					
Total Income		1.00	12956.72	8771.47	515	34233.79
Trade and Business		0.07 (0.17)	784.55	2228.20	0	27000
Wages and Salary		0.11 (0.25)	2134.16	5915.43	0	30000
Livestock Trade		0.14 (0.23)	1746.29	3134.93	0	17135.27
Livestock Products		0.49 (0.34)	6537.57	6982.94	0	32850
Crop Value		0.02 (0.09)	239.22	1728.83	0	25080
Remittances		0.17 (0.23)	1514.93	2021.01	0	15976.88

Table 2.3: Full Sample Summary Statistics on Positive Income Earners

	N	*% of Household Income*	*Mean*	*Standard Deviation*	*Min*	*Max*
Lower Tercile						
Total Income	698	1.00	3160.63	2637.04	400	19601.38
Trade and Business	137	0.29 (0.27)	965.24	1147.85	18.20	5700
Wages and Salary	91	0.37 (0.27)	1104.15	1780.98	30	15000
Livestock Trade	152	0.53 (0.28)	2628.23	2192.35	247	10407.52
Livestock Products	387	0.62 (0.29)	1994.18	1951.94	136.88	19601.38
Crop Value	37	0.47 (0.33)	1630.43	1184.93	29.42	6004
Remittances	550	0.52 (0.35)	1348.80	1406.28	10	13182.44
Middle Tercile						
Total Income	700	1.00	6195.45	5680.39	380	33705.5
Trade and Business	167	0.19 (0.23)	1089.89	1748.68	10	12690
Wages and Salary	88	0.27 (0.25)	1712.71	2784.56	50	18000
Livestock Trade	214	0.49 (0.26)	4700.76	4116.62	300	30000
Livestock Products	539	0.62 (0.30)	3969.49	4093.7	127.75	25374.25
Crop Value	47	0.35 (0.28)	2334.02	3380.07	29.42	18120
Remittances	499	0.38 (0.32)	1500.72	2042.88	1.49	28463.9
Upper Tercile						
Total Income	691	1.00	12956.72	8771.47	515	34233.79
Trade and Business	284	0.17 (0.23)	1908.88	3154.57	20	27000
Wages and Salary	156	0.48 (0.48)	9453.25	9280.99	36	30000
Livestock Trade	291	0.33 (0.33)	4146.68	3659.96	300	17135.27
Livestock Products	586	0.58 (0.58)	7708.98	6961.88	12.78	32850
Crop Value	36	0.31 (0.31)	4591.76	6194.06	160	25080
Remittances	554	0.22 (0.22)	1889.56	2094.56	11.86	15976.88

remittances in total household income. Net remittances make up, on average, 41% of total household income in the lower tercile but only 26% and 17% in the middle and upper terciles, respectively. Table 3 provides summary statistics only for period-specific observations in which the household reported strictly positive income earnings for the particular income being described.

The repeated surveys also ask individuals to recall their own food and beverage consumption over the past 24-hours. This information was used to calculated dietary diversity measures for 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 helpings of tea with milk, his dietary diversity count would be 4. Mean dietary diversity in the sample population is 3.14 and median dietary diversity is 3. Maize, tea and especially milk are by far the most consumed items in the study area.

IV. Econometric Specification

In order to test for differential nutritional responses to changes in different income sources, equation (5) is estimated using dietary diversity as a measure of nutritional status. Studies on the income-nutrition relationship have often used nutrient intake or nutrient availability[28] as a measure of nutritional status. However both of these measures are subject to a number of quantitative and qualitative problems.[29] In reaction to these problems, dietary diversity has been proposed as a

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[28] Nutrient availability is measured using food expenditures, indicating the amount of nutrients available to be consumed based on food purchases.
[29] See Strauss and Thomas (1995) and Hoddinott and Yohannes (2002) for a discussion of these problems.

potential 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 data do not have good nutrient intake or availability information, they do have 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.[30] Lack of dietary diversity is especially problematic in poor communities in developing countries. Through improved micronutrient acquirement, a diverse diet has long been associated with enhanced nutritional status. Indeed, a number of studies have come out recently showing 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 unlikely to suffer from the same measurement errors and bias problems that have been problematic in many of the more conventional measures of nutritional status (Hoddinott and Yohannes 2002, Strauss and Thomas 1995). Consequently dietary diversity shows much promise as an indicator of dietary quality and is used here as the dependent variable in equation (5).

On the right-hand side of the equation (5), income is disaggregated into six different sources: income earned from non-farm and non-livestock trade and business such as from crafts, firewood and water; income earned from wages and salary; income earned from livestock trade; income earned from the production of livestock products; the value of crops harvested; and net remittances, which includes the value

[30] Dietary diversity can also be defined as the number of unique food groups an individual consumes over the recall period. Recall periods can vary.

of cash and in-kind gifts as well as of food aid.[31] Village level food prices included in the model are those for maize and tea. Maize and tea are by far the most important food staples in the study region (other than milk which is mostly home produced since only a few households do not own livestock). Age, education, gender and household size are included as controls for individual- and household-level characteristics. To control for time-invariant village or location specific characteristics, regional dummy variables are included for 10 of the 11 locations.

V. Estimation Results

In this section equation (5) is estimated using a random effects generalized least squares estimator. Since the discrete nature of dietary diversity would cause heteroskedasticity, White's correction for heteroskedasticity was used. Hypothesis (6) is then tested using a Wald test. A rejection of the null hypotheses in (6) indicates that different income sources have differential effects on individual nutritional status. Once differential effects are established, possible explanations for this result are then tested.

Full Sample Tests for Differential Effects

Full regression results are reported in the Appendix as A1 and A2. Table 4 reports the income and price elasticities estimated from equation (5) with income disaggregated. It also includes estimated elasticities from equation (1) with aggregated income as the explanatory variable. What is immediately striking is that the estimated income elasticities on both aggregated and disaggregated income are small relative to the estimated price elasticities. The estimated total income elasticities

[31] For details on how each income source was constructed see Barrett *et al.* (2008)

Table 2.4: Full Sample Elasticity Estimates

N=2089

Groups=318

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

	Lower		*Middle*		*Upper*	
	Elasticity	*Standard Error*	*Elasticity*	*Standard Error*	*Elasticity*	*Standard Error*
Disaggregated Income Model						
Trade & Business	0.020***	0.006	0.004	0.006	0.011***	0.004
Wages & Salary	0.007	0.007	0.010	0.006	0.007**	0.003
Livestock Trade	0.010*	0.005	0.005	0.004	-0.003	0.003
Livestock Products	0.008*	0.005	0.007	0.005	0.003	0.004
Crop Value	-0.025**	0.013	0.020**	0.009	0.007	0.011
Remittances	0.011	0.007	0.025***	0.007	0.013**	0.006
Tea Price	-0.209***	0.067	-0.337***	0.085	-0.092	0.079
Maize Price	0.060	0.058	0.029	0.043	0.091*	0.047
Aggregated Income Model						
Aggregated Income	0.072***	0.021	0.063***	0.016	0.035**	0.017
Tea Price	-0.238***	0.062	-0.270***	0.084	-0.076	0.080
Maize Price	0.105**	0.054	0.076**	0.037	0.122**	0.043

of dietary diversity is 0.072 for the lower tercile, 0.063 for the middle tercile and 0.035 for the upper tercile, each significant at the one percent, one percent and five percent levels, respectively. Price elasticities, on the other hand, are much higher in magnitude. The relatively higher estimated price elasticities likely points to issues of market access. There is very little intertemporal variation in the prices measured. Most variation occurs cross-sectionally. It therefore appears that improving market access may have substantial nutritional benefits for individuals in the study locations.

Despite the small magnitude of estimated income elasticities, the estimated source-specific income elasticities appear, statistically, quite different from each other and from those estimated for total income. For the lower tercile, income elasticities for income from wages and salary and remittances are not statistically different from zero. Income elasticities for income from livestock trade and livestock products are both significant at the 10% level. The elasticity with respect to non-farm and non-livestock trade and business income is significant at the one percent level and that with respect to crop value is significant at the five percent level. The dietary diversity of individuals in the lower tercile appears to have the largest positive response to changes in income from trade and business and livestock trade with income elasticities of dietary diversity of 0.020 and 0.010, respectively. Lower tercile individuals' dietary diversity appears to have a negative response to changes in crop value with a statistically significant income elasticity of -0.025. As explained earlier, the arid and semi-arid lands of the study region are not well suited to crop production. It is likely that households in the lower tercile are cultivating crops out of necessity and desperation, hence the negative sign on this elasticity estimate. In the sample, crop value has a statistically significant negative correlation of –0.086 and –0.268 with trade and business income and remittances, respectively. Both of these income sources have higher estimated elasticities of dietary diversity than other sources of income. Although the estimated income elasticity for remittances in not significant at the 10% level, it is significant at the 15% level, albeit with a very low point estimate of 0.01. Therefore unless these households are cultivating a variety of crops it is unlikely that increases in crop value will increase their dietary diversity. In fact of the 38 observations that reported positive crop values in the lower tercile, 22 of those observations had a dietary diversity of only one.[32]

Income sources that appear to be the most important to the dietary diversity of individuals in the middle tercile are crop value and remittances. The estimated elasticity with respect to crop value is 0.020 and is significant at the five percent level and that with respect to remittances is 0.025 and is significant at the one percent level. Elasticities estimated with respect to other income sources were not statistically different from zero for individuals in the middle tercile. For individuals in the upper tercile, statistically significant income elasticities were those with respect to non-farm, non-livestock trade and business, wages and salary, and remittances with trade and business and remittances having a relatively larger influence over dietary diversity.

Estimated tea price elasticities were –0.209 in the lower tercile and –0.337 in the middle tercile, each significant at the one percent level. The estimated tea price elasticity for the upper tercile was -0.092, however it was not statistically significantly different from zero. As would be expected, the upper tercile is less price elastic than the other terciles. The middle tercile, however, is more price elastic than the lower.

Unlike the tea price elasticities, which had the expected negative sign, the estimated maize price elasticities were positive, although they were not significantly different from zero for the lower and middle terciles. Given the prominence of maize as a dietary staple in all of the study locations, the positive estimated elasticities are

[32] A dietary diversity of one means that the individual only consumed one type of food or drink item over the 24-hour recall period. However, they could have consumed that food or drink item multiple times during that period.

likely due to a substitution effect. Rising maize prices will cause individuals to decrease their consumption of the staple good, maize, and to substitute it with other foods. Unless individuals completely eliminate maize from their diet then this substitution effect would cause dietary diversity to increase.

There do seem to be differences in the relative magnitudes and significance of the estimated income elasticities for the various income sources. In addition, the impacts of individual income sources on dietary diversity appear different from the impact of aggregated income. However, we must test statistically for differences in dietary diversity responses to changes in various sources of income, particularly since the estimated income elasticities are very low.

A Wald test of hypothesis (6) rejects the equality of income source elasticities for each income tercile. Equivalent income source elasticities is rejected at the at the 5% level for the lower tercile and the 10% level for the middle and upper terciles with test statistics of $\chi^2(5) = 11.77$, 10.46, and 10.01, respectively. Differential responses of dietary diversity towards different income sources are thus confirmed statistically. The next step then is to explore possible explanations for this result.

VI. Possible Explanations for Differential Responses

As discussed earlier, three possible explanations for this result exist in the literature: missing markets for certain home produced commodities, intrahousehold dynamics of resource control and allocation, and mental accounting. There is no way to explicitly test for mental accounting as the cause of the differential responses. However, missing markets and intrahousehold effects can be tested directly as explanations. If both fail to account to account for the differential responses of dietary diversity to various income sources, then mental accounting is left as the residual explanation.

Missing Markets and Non-Tradable Goods

Almost all households in the study area own livestock and thus produce milk. However, income earned from livestock products, which includes milk production, appears to be less important to dietary diversity than other income sources. The estimated elasticity with respect to livestock production income is not statistically different from zero for the middle and upper terciles and is only 0.008 for the lower tercile. Given the prominence of livestock products as an income source in this population (livestock products make up 34%, 48% and 49% of income in the lower, middle and upper terciles, respectively) one would expect it to play a larger role in the provision of basic necessities such as food, outside of milk.

A possible reason behind this result is that many pastoralist households might not participate in markets for livestock products, rendering those goods non-tradable. If the transaction costs associated with market-based exchange induce the household to be an autarkic milk producer and consumer, any increased income from production of that non-tradable good necessarily expands only the quantity of milk that household consumes, not the variety of foods it consumes. Therefore production of milk and other livestock products may do little to enhance dietary diversity.

In order to test the possibility that household-specific non-tradable home-produced goods causes the deferential dietary diversity responses observed in the full sample, equation (5) was re-estimated using just the sub-sample of observations where households recorded positive milk sales, as opposed to just positive milk production. Those who sell milk necessarily treat milk as tradable. By focusing only on these observations, we excluded any household-period observations for which milk might have been non-tradable. In addition, positive milk sales indicate that households participated in a more formal market setting in settlements where they were not only able to participate in the market for milk but also would have the opportunity to participate in markets for other goods as well.

Restricting the sample resulted in a much smaller data subset. The milk market sub-sample has only 327 of the full sample's 2,089 observations covering only 127 households as opposed to 318 households in the full sample. The small sample size was too restrictive to estimate equation (5) controlling for the different income quantiles. Therefore, in order to conserve degrees of freedom, equations (1) and (2) were estimated, with dummy variables for the middle and upper tercile left in as intercept shifters only. There are no systematic differences in the income composition between the three income terciles in this sub-sample.

Descriptive statistics on the milk market sample can be found in Tables (5) and (6), where Table (6) provides descriptive statistics only on households in the sample that earned positive amounts of the particular source of income being described. In addition to pooling the income terciles, the seasonal dummy variables were dropped to conserve degrees of freedom. The seasonal variables were not statistically significant and are adequately represented by the average rainfall variable. Dropping the seasonal dummy variables did not substantially change the estimated parameters but it did increase the precision of the estimates.

Table (7) reports parameter estimates for the milk market sub-sample. In the aggregated income model, equation (1), the total income elasticity of dietary diversity is 0.042 and is not statistically significant at standard levels ($p = 0.110$). When income is disaggregated and equation (2) is estimated with the milk market sub-sample, the estimated income elasticities again differ by source as well as from the total income elasticity. Income from remittances and livestock trade appear to be most important to dietary diversity in this sample. The dietary diversity elasticity with respect to remittances is statistically significant at the five percent level with a value of

Table 2.5: Milk Market Sub-Sample Summary Statistics

	N	*% of Household Income*	*Mean*	*Standard Deviation*	*Min*	*Max*
Lower Tercile	74					
Total Income		1.00	3839.32	2376.25	475.45	12141.47
Trade and Business		0.02 (0.08)	90.55	323.50	0	1799
Wages and Salary		0.00 (0.01)	6.76	46.14	0	380
Livestock Trade		0.10 (0.20)	515.35	1111.26	0	4500
Livestock Products		0.64 (0.30)	2416.99	1754.88	0	7278.93
Crop Value		0.01 (0.03)	22.68	137.64	0	918.33
Remittances		0.24 (0.25)	786.99	870.53	0	3596.24
Middle Tercile	82					
Total Income		1.00	8208.03	5930.26	805.94	33705.5
Trade and Business		0.05 (0.10)	408.69	767.77	0	3599
Wages and Salary		0.01 (0.06)	168.93	792.42	0	5661.9
Livestock Trade		0.16 (0.25)	1821.00	3341.54	0	16100
Livestock Products		0.57 (0.29)	4541.06	3724.89	0	18250
Crop Value		0.03 (0.14)	178.35	799.54	0	4845
Remittances		0.17 (0.21)	1090.00	1535.22	0	8348.16
Upper Tercile	155					
Total Income		1.00	14592.85	7957.63	1115.82	34224
Trade and Business		0.09 (0.15)	1168.16	2073.92	0	13398.3
Wages and Salary		0.03 (0.12)	552.36	2780.00	0	24000
Livestock Trade		0.11 (0.18)	1565.38	2608.95	0	12500
Livestock Products		0.63 (0.29)	9676.16	7408.42	0	32850
Crop Value		0.02 (0.09)	333.80	1746.81	0	17864.4
Remittances		0.12 (0.16)	1296.99	1623.12	0	9487.73

Table 2.6: Milk Market Sub-Sample Summary Statistics on Positive Income Earners

	N	*% of Household Income*	*Mean*	*Standard Deviation*	*Min*	*Max*
Lower Tercile						
Total Income	74	1.00	3839.32	2376.25	475.45	12141.47
Trade and Business	10	0.15 (0.18)	670.03	646.09	35.80	1799
Wages and Salary	2	0.07 (0.05)	250	183.85	120	380
Livestock Trade	19	0.38 (0.23)	2007.17	1359.25	358.02	4500
Livestock Products	67	0.70 (0.23)	2669.51	1649.83	475.45	7278.93
Crop Value	2	0.23 (0.02)	839.17	111.96	760.00	918.33
Remittances	59	0.30 (0.25)	987.07	867.71	44.66	3596.24
Middle Tercile						
Total Income	82	1.00	8208.03	5930.26	805.94	33705.5
Trade and Business	37	0.11 (0.13)	905.75	929.30	39	3599
Wages and Salary	5	0.23 (0.14)	2770.38	1925.27	260	5661.9
Livestock Trade	32	0.42 (0.24)	4666.32	3933.18	400	16100
Livestock Products	80	0.59 (0.28)	4654.58	3700.13	380	18250
Crop Value	7	0.33 (0.39)	2089.24	1993.07	75	4845
Remittances	66	0.21 (0.21)	1354.25	1604.28	1.49	8348.16
Upper Tercile						
Total Income	155	1.00	14592.85	7957.63	1115.82	34224
Trade and Business	107	0.13 (0.16)	1692.19	2313.80	39	13398.3
Wages and Salary	15	0.28 (0.27)	5707.69	7313.39	100	24000
Livestock Trade	75	0.23 (0.20)	3235.11	2947.95	350	12500
Livestock Products	147	0.67 (0.26)	10202.76	7244.48	302.94	32850
Crop Value	12	0.24 (0.21)	4311.58	4899.91	459.17	17864.4
Remittances	122	0.15 (0.16)	1647.82	1664.38	18.87	9487.73

Table 2.7: Milk Market Sub-Sample Elasticity Estimates

N=311

Groups=127

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

	Elasticity	*Standard Error*	*P-value*
Disaggregated Income Model			
Trade & Business	0.011	0.019	0.545
Wages & Salary	-0.010	0.009	0.255
Livestock Trade	0.009*	0.005	0.100
Livestock Products	-0.006	0.007	0.371
Crop Value	0.006	0.018	0.765
Remittances	0.021**	0.010	0.040
Tea Price	-0.077	0.098	0.431
Maize Price	-0.094	0.100	0.344
Aggregated Income Model			
Aggregated Income	0.042	0.027	0.110
Tea Price	0.018	0.027	0.848
Maize Price	-0.084	0.093	0.411

0.021. The elasticity with respect to livestock trade is only just significant at the 10% level with a magnitude of 0.009. Other income source elasticities are not statistically significantly different from zero. However, this might be due to the small sub-sample size. As can be seen in Table (6), of the 311 observations in this sub-sample only livestock products and remittances have more than 200 observations of positive reported earnings. Only 154 observations reported positive earnings in trade and business and 126 in livestock trade. There were very few income earners in wages and salary and crops with only 22 and 21 observations reporting positive earnings in those income sources, respectively.

Although livestock products make up a large portion of the income earned in the sub-sample, its estimated elasticity is not only not statistically significant, it is also negative. Livestock product income is negatively correlated with remittances in this sample. Thus even though the sample has been restricted such that milk is necessarily treated as tradable, livestock product income still has little, and possibly negative, effect on dietary diversity. The large standard errors of some of the elasticity estimates are likely due to the small size of the milk market sub-sample.

A Wald Test testing the equivalence of income source elasticities only weakly fails to reject the null hypothesis in hypothesis (1) with a test statistic of $\chi^2(5) = 8.99$ and a p-value of 0.1097. Based on the value of their estimated elasticities, income sources that appear important to dietary diversity in the full sample, namely remittances and trade and business, also appear to be important in the milk market sub-sample. Additionally, the relative differences between the estimated elasticities in the milk market sub-sample are as large as those in the full sample. However the standard errors are also relatively larger in the milk market sample than in the full sample. This combined with the loss of degrees of freedom may contribute to the Wald Test's failure to reject the null hypothesis of equality of income source elasticities. Therefore, although the Wald Test fails to reject the null hypothesis of equivalent income elasticities across income sources, it does so very weakly and there still seems to be evidence that dietary diversity does respond differently to changes in different income sources. However, missing markets may at least partly explain the differential dietary diversity responses observed in the full sample.

Intrahousehold Bargaining and Resource Allocation

Many pastoralist households in the study region practice polygamy. In addition, households also often include extended family members such as parents, siblings of the household head or his spouse(s), and adult children. Therefore intrahousehold processes of bargaining and resource allocation could provide a reasonable explanation for the differential responses of dietary diversity to different income sources. In such households, preferences surely vary among members. So if different income sources are associated with different household members, it would result in the differential dietary responses across income sources that we find.

In order to test for intrahousehold effects as the cause for differential responses, a method similar to that performed by Breunig and Dasgupta (2005) was adopted. Breunig and Dasgupta (2005) restricted their analysis to single-adult households in order to test whether intrahousehold effects cause cash income to impact household consumption differently than food stamp income. We likewise restrict the data to households where the household head was unmarried. Since many households also house extended family members the sample was further restricted to households in which the household head was single and the oldest non-head household member was no older than 10 years less than the age of the head. By restricting the sub-sample to only households with one adult, this necessarily excludes any households that are affected by processes of intrahousehold bargaining, since only one member in the household has any significant bargaining power.[33]

Due to the culture of the area the vast majority of the households in the single-adult sub-sample are female-headed households. In fact, there are just 13 observations on only two male-headed households included in the single adult sub-sample. The

[33] This of course assumes that children have no substantial or systematic bargaining power over resource allocation within the household. While we cannot test this assumption, we feel safe in making it.

female household heads in the sub-sample are often widowed or divorced and almost half of the observations in this sub-sample are in the lower income tercile.

Summary statistics on this sub-sample are provided in Tables 8 and 9. Table 9 provides descriptive statistics on households in this sub-sample that reported positive earnings of the particular income described. As with the milk market sub-sample, limiting the data to only single adult households resulted in a much smaller sub-sample and was too restrictive on degrees of freedom to control for income terciles. The single adult sub-sample has only 508 of the 2089 observations in the full sample and only 75 of the 318 households in the full sample. Therefore, again to preserve degrees of freedom, equations (2) and (1) were estimated in which the income terciles are pooled.

Table 10 reports parameter estimates for equations (2) and (1) using the single adult sub-sample. In the aggregated income model, the total income elasticity of dietary diversity is 0.054 and is statistically significant at the one percent level. But as with the milk market sub-sample and full sample, certain income sources appear to be more important to dietary diversity than others when income is disaggregated and equation (2) is estimated with the single adult sub-sample. The most influential income sources on dietary diversity are trade and business and wages and salary, with statistically significant estimated elasticities of 0.014 and 0.017, respectively. Other income source elasticities are not statistically different from zero. A Wald Test again rejects the null hypothesis of equal income elasticities of dietary diversity across income sources at the 10% level with a test statistic of $\chi^2(5)=9.68$ ($p = 0.0847$). Thus, even after controlling for intrahousehold effects, there still exist differential responses of dietary diversity to changes in various sources of income.

Table 2.8: Single Adult Sub-Sample Summary Statistics

	N	*% of Household Income*	*Mean*	*Standard Deviation*	*Min*	*Max*
Lower Tercile	245					
Total Income		1.00	3167.48	2982.16	450	17721.67
Trade and Business		0.06 (0.17)	213.06	702.31	0	5700
Wages and Salary		0.06 (0.18)	196.68	1058.26	0	15000
Livestock Trade		0.11 (0.26)	593.14	1648.16	0	10010.66
Livestock Products		0.31 (0.38)	976.57	1651.05	0	10149.7
Crop Value		0.03 (0.14)	112.54	571.46	0	6004
Remittances		0.44 (0.39)	1075.48	1533.44	0	13182.44
Middle Tercile	189					
Total Income		1.00	5902.04	6313.76	425	33705.5
Trade and Business		0.06 (0.15)	196.24	494.50	0	4500
Wages and Salary		0.03 (0.13)	240.88	1429.58	0	18000
Livestock Trade		0.14 (0.26)	1501.77	3749.33	0	30000
Livestock Products		0.46 (0.37)	2902.36	4217.33	0	24405.83
Crop Value		0.02 (0.12)	182.20	1443.41	0	18120
Remittances		0.29 (0.34)	878.59	943.82	0	6095.55
Upper Tercile	74					
Total Income		1.00	15309.77	9510.25	1486	34224
Trade and Business		0.14 (0.28)	1766.96	4691.95	0	27000
Wages and Salary		0.28 (0.34)	5670.15	8158.42	0	25500
Livestock Trade		0.06 (0.11)	784.05	1541.92	0	8800
Livestock Products		0.32 (0.31)	4388.59	6288.19	0	32850
Crop Value		0.02 (0.13)	445	3021.87	0	25080
Remittances		0.19 (0.20)	2255.01	2857.64	0	15976.88

Table 2.9: Single Adult Sub-Sample Summary Statistics on Positive Income Earners

	N	*% of Household Income*	*Mean*	*Standard Deviation*	*Min*	*Max*
Lower Tercile						
Total Income	245	1.00	3167.48	2982.16	450	17721.67
Trade and Business	44	0.31 (0.28)	1186.37	1271.72	46.92	5700
Wages and Salary	33	0.43 (0.27)	1460.22	2576.16	100	15000
Livestock Trade	45	0.59 (0.30)	3229.33	2521.36	400	10010.66
Livestock Products	127	0.60 (0.32)	1883.93	1885.71	182.5	10149.7
Crop Value	17	0.39 (0.36)	1621.92	1542.42	29.42	6004
Remittances	196	0.55 (0.36)	1344.35	1605.93	36	13182.44
Middle Tercile						
Total Income	189	1.00	5902.04	6313.76	425	33705.5
Trade and Business	56	0.19 (0.22)	662.30	722.19	30	4500
Wages and Salary	31	0.21 (0.25)	1468.61	3308.16	50	18000
Livestock Trade	54	0.48 (0.26)	5256.20	5455.08	300	30000
Livestock Products	139	0.62 (0.30)	3946.37	4481.08	334.52	24405.83
Crop Value	8	0.48 (0.34)	4304.54	5972.88	125	18120
Remittances	147	0.38 (0.34)	1129.61	928.19	48	6095.55
Upper Tercile						
Total Income	74	1.00	15309.77	9510.25	1486	34224
Trade and Business	46	0.22 (0.33)	2842.5	5708.51	30	27000
Wages and Salary	34	0.60 (0.25)	12340.91	7900.66	1000	25500
Livestock Trade	24	0.18 (0.12)	2417.5	1850.79	700	8800
Livestock Products	62	0.38 (0.30)	5238.00	6542.00	255.5	32850
Crop Value	3	0.53 (0.44)	10976.67	12645.3	650	25080
Remittances	72	0.20 (0.20)	2317.65	2872.09	175	15976.88

Table 2.10: Single Adult Sub-Sample Elasticity Estimates

N=508

Groups=75

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

	Elasticity	*Standard Error*	*P-value*
Disaggregated Income Model			
Trade & Business	0.014**	0.006	0.019
Wages & Salary	0.017***	0.005	0.001
Livestock Trade	-0.005	0.006	0.388
Livestock Products	0.006	0.006	0.273
Crop Value	-0.005	0.013	0.670
Remittances	0.005	0.008	0.524
Tea Price	-0.247**	0.122	0.042
Maize Price	0.081	0.068	0.234
Aggregated Income Model			
Aggregated Income	0.054***	0.021	0.009
Tea Price	-0.254**	0.121	0.035
Maize Price	0.083	0.064	0.198

VII. Conclusion

We find evidence of differential dietary diversity responses to changes in various income sources. The differential impacts of various income sources on dietary diversity persist after controlling for intrahousehold effects as a possible explanation. Thus intrahousehold processes of resource control and allocation fail to fully account for this result. Statistical tests failed to fully reject household-specific missing markets as an explanation for the differential effects. However, the failure to reject was weak and there still appears to be evidence of differential effects after controlling for missing markets. Thus both intrahousehold effects and market failures appear unable to fully account for the differential responses of dietary diversity across income sources. This leaves mental accounting as the residual explanation.

For the most part, research on the nutrition-income relationship in developing countries has investigated the nutritional impacts of changes in total household income. However, where income comes from may change how it is used in the household. Therefore, it may be more accurate to examine the impact of different sources of income on nutritional status rather than merely aggregate income. If income source matters to how households respond nutritionally to changes in income, then this has important implications for how the relationship between income and nutrition is assessed. Income generating programs concerned with the food intake of poor households may be ineffective, or even counter productive, if they are not targeting appropriate income sources. Recognizing and better understanding the consumption behavior of poor households as it relates to various sources of income could substantially improve policy targeting and development efforts on the whole. Treating all income equally may lead to inadequate assessments of income-consumption relationships.

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CHAPTER 3

INTRAHOUSEHOLD ALLOCATION OF DIETARY DIVERSITY IN EAST AFRICAN PASTORALIST HOUSEHOLDS

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.

I. Intrahousehold Allocation of Nutrition

Food allocation within the household has been a widely studied facet of intrahousehold distribution.[34] 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.

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

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 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 VII concludes.

II. 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,[35] 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

[35] 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.

size in the sample is approximately 17.87 Tropical Livestock Units (TLU).[36] 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.

In each study location 30 households were randomly sampled, resulting in a total of 337 households surveyed[37]. 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,[38] 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.

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[36] 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.

[37] 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.

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

Table 3.1: 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

Surveys were conducted in March 2000 to gather baseline information and then quarterly from June 2000 to June 2002, resulting in 10 quarterly observations.[39] 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).

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

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.

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[40] 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.

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

Table 3.2: 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

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.

III. 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.[41] 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[42] that have been problematic in many of the more conventional measures of nutritional status (Hoddinott and Yohannes 2002, Strauss and Thomas 1995). Consequently dietary diversity shows much promise as an indicator of dietary quality and is used here as the dependent variable.

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

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.[43] 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.[44] 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

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[43] For details on how each income sources was constructed see Barrett *et al.* (2008).

[44] 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.

does not make any distinctions for when having a relatively higher elasticity is beneficial 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. [45] 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.

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

[45] 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.

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 $I_{hvt} = \begin{cases} 1 & if\ Y_{hvt} \geq \overline{Y}_{hv} \\ 0 & if\ Y_{hvt} < \overline{Y}_{hv} \end{cases}$.

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.

IV. 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.

Figure 3.1: Wife's Dietary Diversity Against Head's Dietary Diversity

Figure 3.2: Son's Dietary Diversity Against Head's Dietary Diversity

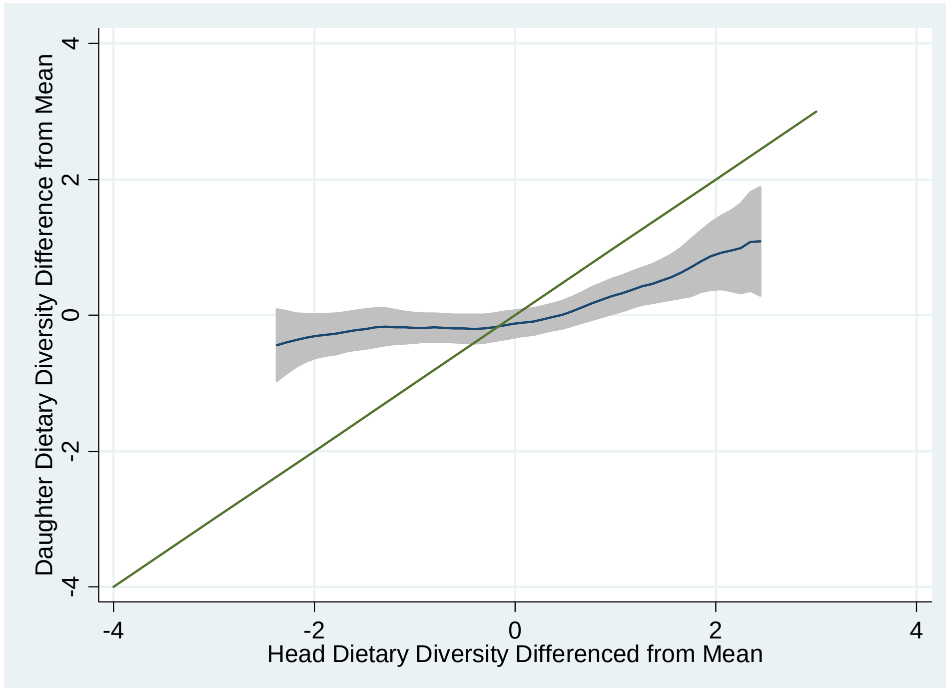

Figure 3.3: Daughter's Dietary Diversity Against Head's Dietary Diversity

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.

V. 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

Table 3.3 Full Regression Results

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

(###) p-value

	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)

Table 3.3 (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

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-

Table 3.4: Cohort-Specific Estimated Intercepts and Income and Price Elasticities

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

(###) p-value

	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)

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 appears 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.

VI. 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)[46].

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[46] 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.

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^{c}_{ihvt}) and predicted dietary diversity ($\ln \hat{N}^{c}_{ihvt}$) 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 the 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 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.

Table 3.5: Wilcoxon-Mann-Whitney Test Results (Probability that a random draw from row distribution is greater than that from column distribution)

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

	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***

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

Table 3.6: Stochastic Dominance Between Intrahousehold Dietary Diversity Distributions (Dominance of Row Distribution over Column Distribution)

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

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

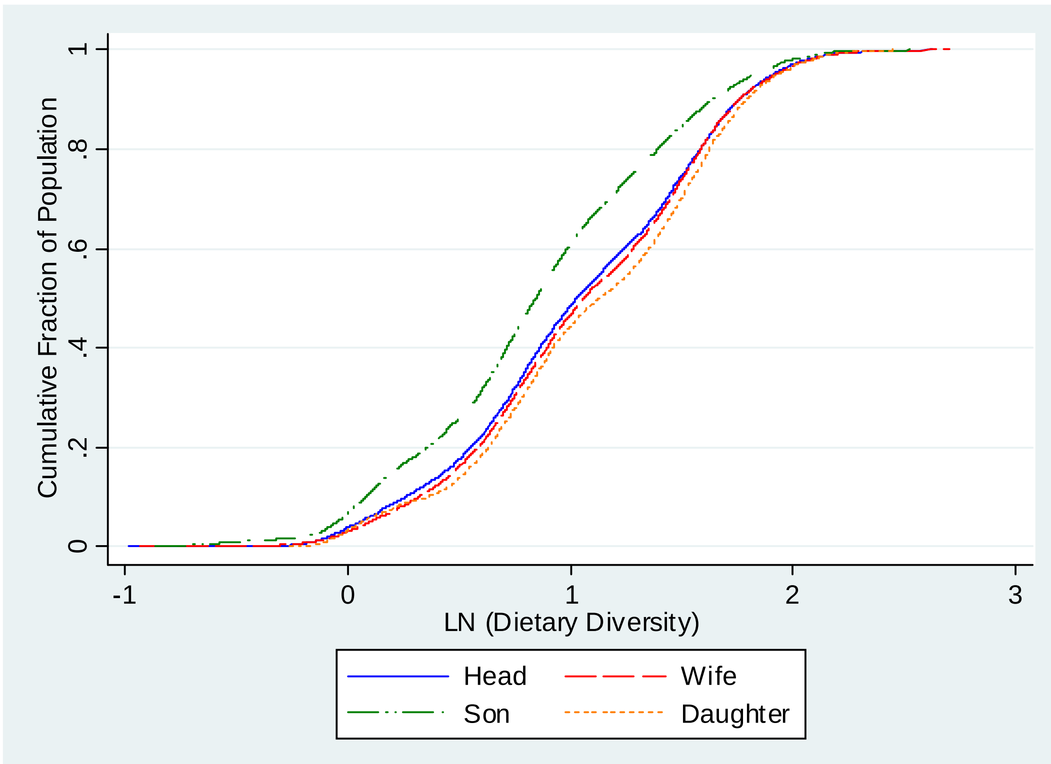

Figure 3.4: Cumulative Distribution of Four Cohorts in Full Sample

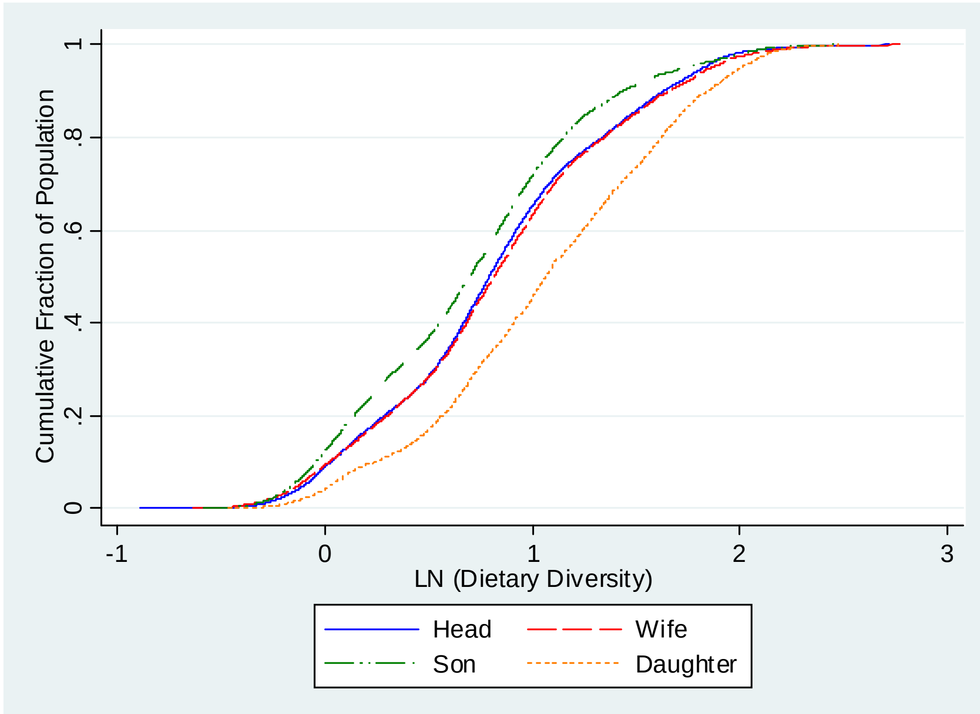

Figure 3.5: Cumulative Distribution of Four Cohorts in Lower Tercile

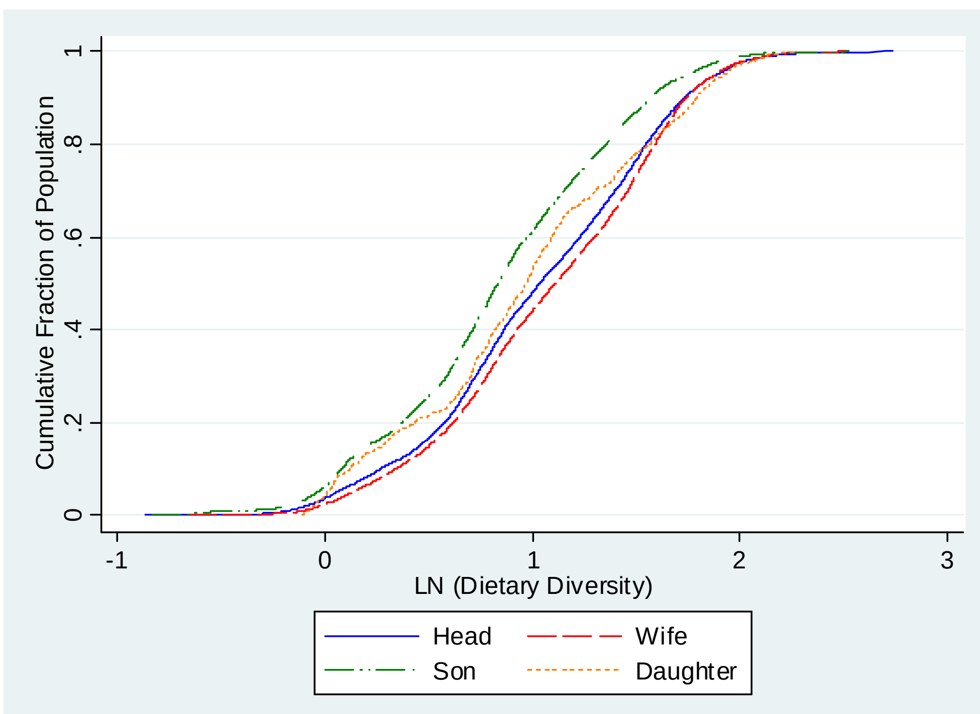

Figure 3.6: Cumulative Distribution of Four Cohorts in Middle Tercile

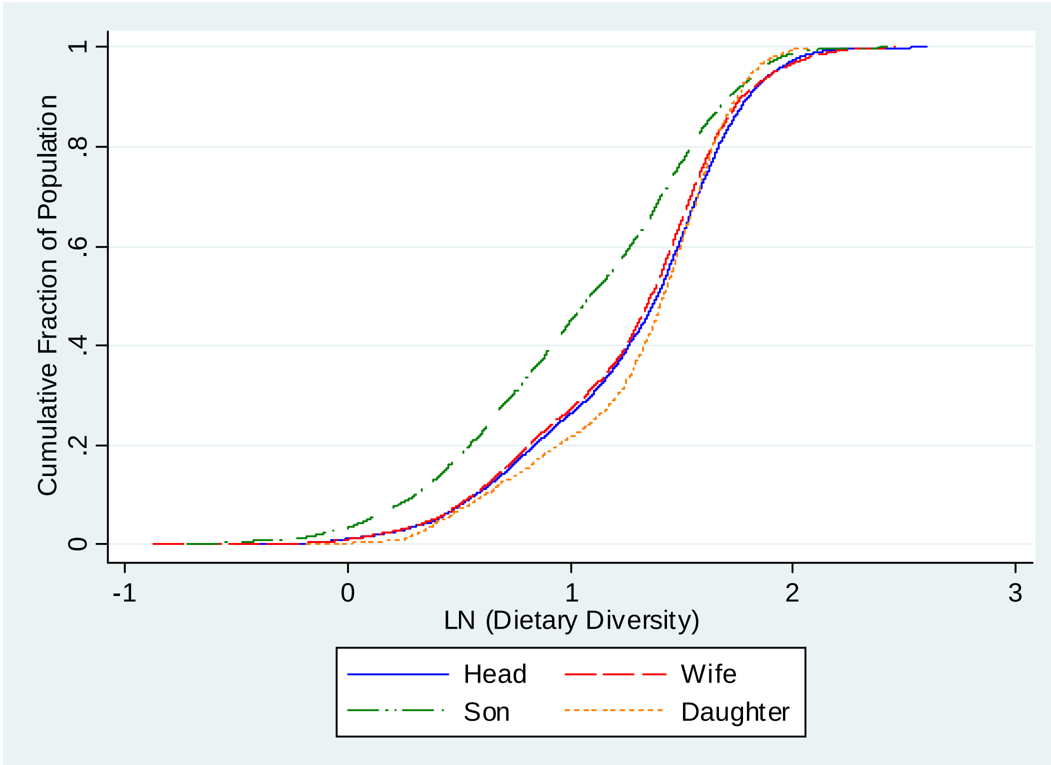

Figure 3.7: Cumulative Distribution of Four Cohorts in Upper Tercile

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.[47]

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.

[47] 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.

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.

VII. 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 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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APPENDIX

Table A1: Full Regression Results from Disaggregated Income Model

	Full Sample	*Milk Sale Sub-Sample*	*Single Adult Sub-Sample*
N	2089	311	508
Number of Groups	318	127	75
Trade & Business	0.020***	0.011	0.014**
	(0.006)	(0.019)	(0.006)
Trade & Business, Middle Tercile	-0.016*		
	(0.008)		
Trade & Business, Upper Tercile	-0.008		
	(0.007)		
Wages & Salary	0.007	-0.010	0.017***
	(0.007)	(0.009)	(0.005)
Wages & Salary, Middle Tercile	0.002		
	(0.009)		
Wages & Salary, Upper Tercile	-0.0001		
	(0.008)		
Livestock Trade	0.010*	0.009*	-0.005
	(0.005)	(0.005)	(0.006)
Livestock Trade, Middle Tercile	-0.005		
	(0.007)		
Livestock Trade, Upper Tercile	-0.013**		
	(0.006)		
Livestock Products	0.008*	-0.006	0.006
	(0.005)	(0.007)	(0.006)
Livestock Products, Middle Tercile	-0.002		
	(0.007)		
Livestock Products, Upper Tercile	-0.006		
	(0.007)		
Crop Value	-0.025**	0.006	-0.005
	(0.013)	(0.019)	(0.013)
Crop Value, Middle Tercile	0.045***		
	(0.015)		
Crop Value, Upper Tercile	0.032**		
	(0.016)		
Remittances	0.011	0.021**	0.005
	(0.007)	(0.010)	(0.008)
Remittances, Middle Tercile	0.014		
	(0.010)		
Remittances, Upper Tercile	0.002		
	(0.009)		
Tea Price	-0.209***	-0.077	-0.247**
	(0.067)	(0.098)	(0.122)
Tea Price, Middle Tercile	-0.128		
	(0.087)		

	Full Sample	*Milk Sale Sub-Sample*	*Single Adult Sub-Sample*
Tea Price, Upper Tercile	0.117		
	(0.091)		
Maize Price	0.060	-0.094	0.081
	(0.058)	(0.100)	(0.068)
Maize Price, Middle Tercile	-0.031		
	(0.066)		
Maize Price, Upper Tercile	0.031		
	(0.067)		
March	0.033		0.143***
	(0.027)		(0.054)
June	0.021		0.133***
	(0.024)		(0.049)
September	-0.013		0.090*
	(0.025)		(0.051)
Household Size	0.0009	-0.004	0.007
	(0.004)	(0.008)	(0.009)
Male	-0.020	-0.004	0.168*
	(0.023)	(0.047)	(0.104)
Age	0.0002	0.002	-0.002
	(0.0008)	(0.002)	(0.002)
Average Rainfall	-0.0006	-0.002*	-0.0004
	(0.0004)	(0.001)	(0.0008)
Adult Education	0.084*	0.119	0.335***
	(0.049)	(0.085)	(0.058)
Primary School	0.081**	0.106	0.181**
	(0.035)	(0.092)	(0.092)
Secondary School	0.216**	no observations	no observations
	(0.089)		
Middle Tercile	0.403	-0.116*	-0.074
	(0.310)	(0.069)	(0.053)
Upper Tercile	-0.415	0.019	-0.068
	(0.324)	(0.092)	(0.076)
Constant	1.235***	1.144***	1.406***
	(0.252)	(0.431)	(0.477)
R^2 within	0.0381	0.0646	0.0521
between	0.8081	0.6382	0.8484
overall	0.5100	0.5295	0.5419

***, ** and * significant at the one, five and ten percent level, respectively
(###) standard error

Table A2: Full Regression Results from Aggregated Income Model

	Full Sample	*Milk Sales Sub-Sample*	*Single Adult Sub-Sample*
N	2089	311	508
Number of Groups	318	127	75
Total Income	0.072***	0.043	0.054***
	(0.021)	(0.027)	(0.021)
Total Income, Middle Tercile	-0.009		
	(0.026)		
Total Income, Upper Tercile	-0.037		
	(0.026)		
Tea Price	-0.238***	0.018	-0.254**
	(0.062)	(0.093)	(0.121)
Tea Price, Middle Tercile	-0.032		
	(0.081)		
Tea Price, Upper Tercile	0.163*		
	(0.088)		
Maize Price	0.105*	-0.084	0.083
	(0.054)	(0.102)	(0.064)
Maize Price, Middle Tercile	-0.029		
	(0.056)		
Maize Price, Upper Tercile	0.017		
	(0.059)		
March	0.035		0.154***
	(0.026)		(0.052)
June	0.021		0.133***
	(0.024)		(0.048)
September	0.001		0.103**
	(0.025)		(0.050)
Household Size	-0.0006	-0.004	0.011
	(0.004)	(0.007)	(0.009)
Male	-0.027	-0.011	0.207*
	(0.023)	(0.047)	(0.108)
Age	0.0002	0.002	-0.002
	(0.0008)	(0.002)	(0.002)
Average Rainfall	-0.0004	-0.002*	-0.0004
	(0.0004)	(0.001)	(0.0008)
Adult Education	0.084*	0.122	0.354***
	(0.050)	(0.084)	(0.061)
Primary School	0.097***	0.091	0.179*
	(0.034)	(0.098)	(0.094)
Secondary School	0.212**	no observations	no observations
	(0.091)		
Middle Tercile	0.204	-0.130*	-0.108**
	(0.350)	(0.069)	(0.051)
Upper Tercile	-0.289	-0.008	-0.097
	(0.373)	(0.095)	(0.080)

		Full Sample	*Milk Sales Sub-Sample*	*Single Adult Sub-Sample*
	Constant	0.771***	0.483	1.002**
		(0.263)	(0.444)	(0.494)
R^2	within	0.0286	0.0402	0.0524
	between	0.8007	0.6276	0.8354
	overall	0.5029	0.5146	0.5376

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

(###) standard error