Does Increase in Women's Income Relative to Men's Income Increase Food Calorie Intake in Poor Households? Evidence from Nigeria

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ABSTRACT

This paper addresses an important but not widely investigated question of how calorie consumption in African low income households would respond to intra-household redistribution of income from men to women. Specifically, I use survey data on a sample of 480 households from semi-rural areas of south-western Nigeria to analyze the response of per capita calorie intake to changes in women's share of household income, after controlling for per capita income and demographic characteristics at individual, household and community levels. I also examine the effect of marginal increases in household income on per-capita calorie intake conditional on the income distribution factor, women's share of income. My results suggest that redistributing household income from men to women would not raise per capita food energy intake in rural south-western Nigeria. I also find that calorie-income elasticity is close to zero and conclude that neither gender neutral household income increases nor redistribution of household income in favor of women would substantially motivate increased food energy intake within households in the population under study. These results do not differ significantly when per-income is replaced with per-capita expenditure in the estimated model.

Key words: Nigeria, Intra-Household Redistribution of Income, Women's Income Share Elasticity, Calorie Consumption.

JEL Classifications: D13, I12, O15, Q18

1.0 INTRODUCTION

While a relatively large amount of attention has been devoted by development economists to the provision of empirical evidence in support or opposition of a hypothesized strong positive relationship between household income and calorie intake in low income societies, (Alderman, 1986; Behrman and Deolalikar,1987; Bouis and Haddad, 1992; Boius *et al*, 1992; Wolfe and Behrman , 1983; Subramanian and Deaton, 1996; Behrman and Deolalikar, 1987; Grimard, 1996;) not much work has been reported on the effect of redistributing household income from men to women on the calorie demand behavior of low income households.

Studies that investigate the effect of variation in household resource control pattern on food demand and consumption patterns in developing countries are not common, due to the dearth of gender disaggregated household level information on income and consumption. No such study is available for Nigeria. Hopkins et al (1994) found that in Niger, changes in female annual income, while controlling for male income impacted positively on household food expenditures. These results, they claim, hold for both earned and non-labor income. Hoddinott and Haddad (1995), using data from Cote De 'Ivoire found a positive but small marginal effect of women's income share on household food budget share. A doubling of the proportion of household cash income received by wives would lead to a meager 1.9 % rise in budget share of food eaten within the household. Thomas (1997) on the other hand found in his analysis of Brazilian data that the marginal effect of increasing women's income on food expenditure share is negative and higher than the marginal effect of husband's income. He also found that household food calorie intake and protein intake of children responds more positively to increases in women's income than to increases in husband's income. He concludes that the identity of the household member controlling income (non-labor or total) affects calorie intake and protein intake of children.

This paper hopes to contribute to the growing literature on determinants of calorie intake at the household level by investigating the response of calorie intake of individuals in the household to increases in both per capita income and the share of household income under the control of women. Specifically, I investigate the potential effects of redistributing household incomes from men to women in low income households using data from semi-rural areas of south-western Nigeria. The study poses a major question: "after controlling for household per capita income, would an increase in women's share of household income raise calorie intake levels by household members?"

The major hypotheses to be tested by the study are that:

- Gender neutral increases in household income would increase per-capita calorie intake in low income rural households in south western Nigeria.
- Increases in women's income share conditional on total household income would increase per-capita calorie intake in rural south western Nigeria.

2.0 THEORETICAL FRAMEWORK

The framework of analysis adopted for this study is the household bargaining model. The model is a form of collective household model which does not assume income pooling but allows for the explicit effect of income distribution on household demand or expenditure share.

Assume that a household in this study is made up of a husband (m), a woman (w), and others members who are non-income earners (c); individuals in the household have differentiated preferences; and household income is not pooled. Suppose that the each individual in the household derive utility from two composite good: calorie/energy producing good C, and non-calorie producing goods, Q. Calorie itself cannot be purchased but its intake depends on the amount of food item F_j consumed. The amount of food item, F_j, consumed in turn depends on its price, P_j, and a number of tastes factors such as characteristics of the individual (γ^i) and household level characteristics (γ^h) and community characteristics (γ^v). We assume that the pareto/welfare weights of the man, Ψ^m, and the woman, Ψ^w, sum to unity, implying that other members of the household, (c), who have no bargaining power have pareto weights $\Psi^c = 0$. Also the household income, I^h, is the sum of the individual incomes of the man, I^m, and the woman, I^w. Given a particular level of household income, higher levels of I^f would imply higher bargaining power for the woman or higher Ψ^w. Thus Ψ^w is a function of the distributional /power sharing factor I^w/I^h.

The household solves the maximization problem stated in expressions 1to 6:

Maximize $U^h = \Psi^m U^m(C, Q) + \Psi^w U^w(C, Q)$ (1)

Subject to:

$I^h = pF_j + Q$ (2)

$I^h = I^m + I^w$ (3)

$C = C(F_j, \gamma^i, \gamma^h, \gamma^v)$ (4)

$\Psi^i \neq K$; where K is a constant and i = (m, f) (5)

$\Psi^w = \Psi^w(I^w/I^h)$, and $\Psi^m = (1 - \Psi^w)$ (6).

From this constrained maximization problem, we derive an optimal demand function for calorie intake as a function of prices, household income, a power sharing or distributional factor, individual and household level characteristics. Formally,

$$C = C\ (F_j(p),\ I^h,\ \Psi^w\ (I^w/I^h),\ \gamma^i,\ \gamma^h,\ \gamma^v) \qquad (7)$$

The model specifically assumes that $\Psi^i \neq [1, 0]$ as in unitary model and that $\Psi^i \neq \theta$, where θ is a constant, as in collective models with pareto weights of man and woman fixed at a level determined at marriage. Thus this model allows changes in power sharing or distributional factors to lead to changes in Ψ^i and the changes in Ψ^i to in turn lead to changes in demand pattern or expenditure shares.

3.0 DATA

3.1 Data Collection Procedure

Three states were selected out of the six states in South-western Nigeria namely: Ogun, Ondo and Oyo states. Four rural/semi-urban Local Government Areas were selected from each state, given a total of twelve LGAs. A combination *of cluster and systematic random sampling* was used to select 40 households from each of the selected 12 rural/semi-urban communities. Thus, a total of 160 households per state and 480 households in all were selected. The needed information was collected through the use of interview schedules/questionnaires that were personally administered by field assistants. Food price data were obtained through community market surveys. [1]

Food consumption information was collected on individual basis from the households. Quantities of daily food intake were collected for each member of the household, using a 48-hour recall method.[2] Each household was visited at least once in two weeks. Data were collected over a period of 6 months (October 1999 – March 2000).

Thus daily food intake quantities for each individual in the household were collected two times every month for a total of twelve times in 6 months. The analysis reported here was based on per capita daily food consumption averaged over the 6 months of data collection. This is designed to reduce measurement error in food consumption by smoothening day-to-day fluctuations in food intake. These quantities were then converted into kilogram units. Income and expenditure information was obtained on a fortnightly basis for a period of six months.

4.0 EMPIRICAL MODEL

The structural form equation derived from the individual preference model adopted as framework for this study is represented as

$$C = \beta_0 + \beta_1 Y + \beta_2 W + \beta_3 I + \beta_4 H + \beta_5 P + \beta_6 L + \upsilon \quad (8)$$

Where:

C is natural log of individual or per capita daily calorie intake (Kilocalories).

Y is log of per-capita Income.

W is women share of household gross income (range 0-1)

I is the vector of individual level variables (age, sex etc)

H is the vector of household level variables (household composition variables, household's major income source)

P is the vector of food prices in Naira/kilogram.

L is the vector of local government area dummies.

υ is the disturbance or error term .

5.0 ECONOMETRIC ESTIMATION ISSUES

Even though the structural equation presented in expression 8 is theoretically valid, estimating the model by a single equation ordinary least square (OLS) regression procedure would likely result in biased estimates of elasticity coefficients for income and women's share of income. Theoretically both income and women's income share are considered endogenous to the calorie intake model for two reasons. First, since the income variable used in this model is basically labor-income, its value is largely an outcome of labor supply choices. Second, reverse causality is a potential source of bias in the OLS estimate of the coefficients of income and women's income. Furthermore, given the difficulty in getting accurate information on income of individuals and household in developing countries, classical measurement error bias (or attenuation bias) may also be a very important source of bias in this study.

A number of steps were taken to address the potential biases of the OLS estimates of per capita income and women's income share elasticity as discussed earlier. In order to reduce classical measurement error bias, we take averages of food intake and income data through multiple visits over a period of six months. Calorie intake quantity data was obtained directly from food quantity data and not indirectly from food expenditure data in other to reduce non-classical measurement error and aggregation bias. Furthermore, the instrumental variable two stage least square (2SLS) estimation procedure is used to address the problems of bias due to measurement error, omitted variable and reverse causality which is likely to occur if the OLS procedure is used to estimate women's income share and per capita income elasticities.

6.0 RESULTS AND DISCUSSION

Results presented in the first row of the first panel of Table 2 shows a significant ordinary least square (OLS) estimate of per-capita income elasticity of calorie intake between 0.3 and 1.5 percent.[3] That is, after controlling for distribution power factor between men and women, a doubling of household income would raise per-capita calorie intake by less than 2 percent. This estimate supports the empirical school which argues that the response of calorie intake to marginal changes in income is close to zero (Wolfe and Behrman, 1983, Behrman and Deolalikar, 1987).

The OLS results presented in Table 2 show that the linear and quadratic terms of the income coefficient in the calorie intake equation are jointly significant with a p-value of 0.00, suggesting that calorie intake is likely to respond more to marginal income changes in households located at the lower percentile of income distribution compared with households located at the higher percentile. This result is fairly common in empirical literature (Behrman and Wolfe, 1984; Strauss, 1986) although some studies have also found that the log-linear model fits the calorie intake-expenditure data more satisfactorily (Ward and Sanders 1980, Wolfe and Behrman, 1983).

We observe from the first panel and first row of Table 3 that a 10 percent increase in women's share of household income would lower per-capita daily calorie intake by 0.17 percent.[4] Even though this negative effect is small, it is a rejection of the hypothesis that redistribution of household income from husband to wife would motivate increases in the consumption of food calories by low income rural households in south western Nigeria.

In addition, we observe an insignificant difference between the women's income share elasticity estimate from the log-linear and the non-linear income-calorie intake models. This is an evidence of the robustness of the women share of income estimate.

As discussed earlier, ordinary least squares estimates of calorie-income and calorie-women's income share elasticity are likely to be biased if per-capita income and women's income share are endogenous to the calorie intake model. If this assumption of endogeneity of income is true, then we would expect that the true elasticity estimates should be significantly smaller or larger than what the OLS estimate suggests. On the other hand, if measurement error is considered as a likely dominant source of bias, then the resulting attenuation bias would imply that the true elasticity estimates should be higher than what the OLS estimates suggest.

The proposed way of addressing these problems is to use an instrumental variable (IV) estimator to estimate the coefficients of per-capita income and women's income share through a 2SLS procedure.. .

The first row of the second panel on Table 3 presents the income and women's income share elasticity estimates derived from the 2SLS estimation results reported in the second and fourth columns of Table 2. Generally, we find consistency in the sign attached to the estimated coefficient of per- capita income and women's income share variables irrespective of the type of estimator (i.e. OLS or 2SLS) or the assumptions about the behavior of income elasticity vis-à-vis household income level.

According to the estimates in the first row of the second panel in table 3, per capita income elasticity of calorie intake is curiously negative but not statistically different from zero under both linear and non-linear specification.[5] Theoretically, it is expected that income increases would enable individuals in low income households to increase their food calorie intake. This in turn is expected to improve nutrition status, health and productivity of household members. The observed low calorie intake elasticity suggests that calorie intake does not get a substantial share of marginal increases in household income. This result is in line with the conclusion of Bouis and Haddad (1992) that most recent studies have reported calorie-income elasticity which are less than 0.2 in contrast to conventional wisdom that calorie-income elasticity for low income populations in the developing world ranges between 0.4 and 0.8. Thus, increasing household income may not be a very effective strategy for bringing about increased food energy intake among low income households in south western Nigeria.[6]

Women's share of income elasticity estimate is negative and between 6.04 and 6.45 percent, depending on the assumption about the behaviour of per capita income elasticity as income level increases. Contrary to what we find in the case of per capita income, these estimates are higher in absolute terms than the corresponding OLS estimates reported earlier. This may be an indication that classical measurement error bias is an important source of bias in this investigation since we were unable to empirically confirm the endogeneity of women's share of income in this study.[7] Both estimates of women's share of income elasticity are statistically significant at 5 percent α-level. Thus, a doubling of the share of household income controlled by women from the current average of 0.31 to 0.62 will result in a 6 percent decline in per capita calorie intake of the household from the current average of 2204 kilocalories.

As implied by the OLS estimates, the 2SLS estimates clearly reject the hypothesis that per capita calorie intake responds positively to increasing women's share of household income, and suggests that income redistribution from men to women would not increase per capita food energy intake in this population.

However, it can be argued that the observed non-positive response of per capita calorie intake to changes in women's share of household income may be evidence of female preference for more expensive foods with less energy content. To check this, I estimate the effect of women's share of income on food calorie price.[8] The elasticity estimates as presented in the second row of the first and second panels of Table 3, show that the unit cost of calorie consumed does not vary positively with changes in women's share of income, suggesting that women do not seem to reallocate expenditures towards more expensive calorie sources as their income share increase. Furthermore the significant negative response of log per capita food expenditure to women's share of income in Table 3 confirms the plausibility of the observed negative response of calorie intake by showing that the household actually spends less on food when the share of income in the hands of women increases, and suggests that households reallocate income away from food consumption as women's share of income increases.

Thus, the negative sign on the women's share of income coefficient is more likely to be an indication that food calorie intake would respond negatively to a reallocation of household income from men to women, rather than a consequence of a reallocation of income towards more expensive and lower calorie foods. Thus, more income in the hands of women relative to men would not increase calorie intake of household members in the study area.

7.0 CONCLUSION

This study investigates how per capita calorie intake in low income households of rural south western Nigeria responds to changes in total household income and women's share of household income. I utilize data collected with multiple visits over a period of six months from 2573 individuals in 480 randomly selected households. The study addresses two major questions. First, is calorie-income elasticity large enough to justify the placement of nutrition policy emphasis on increasing household income? Second, holding household income constant, in what way and to what extent is intra-household redistribution of income from men to women likely to increase per capita calorie intake of household members?

The results of the study show that per capita income elasticity of calorie intake is positive and less than 0.02, while the elasticity of calorie intake with respect to changes in women's share of household income is negative and lies between 0.017- 0.065. I show that the estimated negative effect of increasing women's share of income on calorie intake is not the consequence of reallocation of women's income from low quality/high calorie foods to high quality/low calorie foods, but rather the result of reallocation of household income away from food purchase as women get larger shares of a fixed amount of household income. These results do not differ significantly when per-capita income is replaced with per-capita expenditure is the estimated equations.

The findings of the study support the following major conclusions.

First, the response of calorie intake to increases in household income, after controlling for income distribution factor, between husband and wife is small and close to zero, implying that income policies may not be the most effective way to achieve substantial improvements in calorie intake levels in the study area.

Second, increases in women's share of household income are likely to result in marginal declines in food calorie intake by individual household members. This result does not support the general thinking that intra-household resource reallocation from men to women would increase food energy intake. Rather it would imply that food calorie intake by household members is enhanced with more income in the hands of men relative to women.

I conclude that neither gender neutral household income increases nor redistribution of income in favor or women would substantially motivate increased food energy intake within households in the study area.

Table 1: Description of Model Variables

Variable	Mean	Std Deviation
LEFT HAND SIDE ENDOGENOUS VARIABLES		
Natural log of Individual daily calorie intake	7.591	0.486
Natural log of Individual daily food expenditure	3.998	0.509
Natural log calorie price	1.012	0.279
Cash purchase share in total food expenditure (ratio)	0.574	0.327
RIGHT HAND SIDE ENDOGENOUS VARIABLES		
Natural log of per capita income	7.548	1.089
Natural log of per capita consumption expenditure	7.291	0.901
Women's share of household income (ratio)	0.305	0.272
RIGHT HAND SIDE CONTROLS		
Individual sex (male = 1, female = 0)	0.488	0.500
Age	26.7	19.4
Number of wives	1.30	0.810
Number of female aged in household (60+)	0.170	0.450
Number of male aged in household	0.350	0.550
Number of female adults in household (19-59)	1.59	1.000
Number of male adults in households (19-59)	1.26	1.23
Number of female adolescents in household (11-18 years)	0.690	1.000
Number of male adolescents in household (11-18 years)	0.810	0.920
Major occupation of household head (Non-Farming =1, Farming =0)	0.587	0.492
Major occupation of senior wife (Non-Farming =1, Farming =0)	0.703	0.457
EXCLUSION RESTRICTIONS USED TO IDENTIFY 2SLS		
Total Years of schooling of husband and wife	9.40	9.60
Ratio of senior wife's to husband's education	0.420	0.580
Value of total assets of households in Naira value ($1= 80 Naira)	810506.0	1941756.0
Women's share of total business asset (ratio)	0.304	0.341
OTHER INTERESTING VARIABLES NOT IN FINAL MODEL		
Individual daily calorie intake	2204.0	969.0
Unit cost of calorie intake (Naira/100 kilocalories)	2.857	0.769
Per capita gross income (N/month)	3018.1	3725.8
Per capita consumption expenditure (N/month)	2135.0	1894.0
Household size (no of persons)	7.11	3.26
Value of farm assets of households (Naira)	124533.0	269392.0
Women's share of farm size (ratio)	0.144	0.294
Years of education of household head	5.08	5.43
Years of education of senior wife	4.31	5.02
Women's share of household farmland value (ratio)	0.0703	0.180
Women's share of food expenditure (ratio)	0.321	0.301
Women's food share in total women expenditure (ratio)	0.320	0.246
Women's share of home consumed farm produce. (ratio)	17.0	30.5
Women's share of value of crops on farm. (ratio)	11.1	26.8

Source: field survey, August 1999-April 2000

Table 2: Results of Regression of Log Per Capita Daily Calorie Intake on Per Capita Income and Women's Income Share.

	Model with linear per-capita income		Model with quadratic per-capita income	
Estimation Method	OLS	IV- 2SLS	OLS	IV- 2SLS
Log Per Capita income	0.0153	-0.0448	0.362	0.817
	(0.00927)	(0.0654)	(0.0592)	(0.720)
Quadratic of Log Per income			-0.0238	-0.0584
			(0.00394)	(0.0499)
Women Share of Household Income	-0.0538	-0.192	-0.0559	-0.208
(Ratio)	(0.0258)	(0.0689)	(0.0257)	(0.0729)
Age of Individual	0.0262	0.0279	0.0262	0.0278
	(0.00157)	(.00147)	(0.00157)	(0.00147)
Quadratics of Individual's Age	-0.000229	-0.000255	-0.000229	-0.000253
	(0.0000235)	(.0000205)	(0.0000235)	(0.0000206)
Sex of Individual	0.0274	0.0249	0.0272	0.0229
	(0.0123)	(0.0127)	(0.0122)	(0.128)
No of Aged Females in Household	-0.0289	-0.0182	-0.0331	-0.0266
(60+)	(0.0129)	(0.0140)	(0.0130)	(0.0162)
Number of Aged Males in	-0.0891	-0.0904	-0.0866	-0.0861
Household	(0.0129)	(0.0143)	(0.0129)	(0.148)
Number of Adult Females in	-0.0527	-0.0605	-0.0535	-0.0606
Household (19-59)	(0.00702)	(0.00900)	(0.00698)	(0.00901)
Number of Adult Males in	-0.0170	-0.0205	-0.0159	-0.0180
Households (19-59)	(.00574)	(0.00619)	(0.00568)	(0.00617)
Number of Adolescent Females in	0.00520	0.00548	0.00840	0.00133
Household (11-18 Years)	(0.00645)	(0.00696)	(0.00636)	(0.00945)
Number of Adolescent Males in	0.0186	0.0146	0.0176	0.0124
Household (11-18 Years)	(0.00714)	(0.00815)	(0.00707)	(0.00837)
Household Head Major Occupation	0.0134	0.00659	0.0144	0.00985
(Non-Farming =1, Farming =0)	(0.0158)	(0.0170)	(0.0156)	(0.0171)
Senior Wife Major Occupation	0.0458	0.0351	0.0442	(0.0331)
(Non-Farming =1, Farming =0)	(0.0153)	(0.0204)	(0.0152)	(0.0207)
Control for 11 local government areas with Ayetoro as the base LGA	Included	Included	Included	included
Constant	6.822	7.281	5.572	4.145
	(0.0806)	(0.623)	(0.228)	(2.578)
R^2	0.631		0.635	
Joint significance F-test for the linear and quadratic terms of the income variable (P-value)			0.000	0.474

* Number of observations is 2555

* Figures in parenthesis are standard errors

*Since the left hand side variables are individual observations, while a number of the right-hand side variables are observed at household level, we are faced with the problem of understating the standard error of the estimated coefficients due to cluster effects. We correct for this in all equations estimated in this paper by using robust standard error estimates (The Stata software package used for this analysis has a robust cluster command that adjusts for cluster effects).

TABLE 3: Income Elasticity Estimates for Calorie Intake Quantity, Calorie Price, and Food Expenditure.

A.	Ordinary Least Squares (OLS)			
Dependent Variable	Linear Income Model		Non-Linear Income Model	
	Log Per- Capita income	Women's Share of Income	Log Per-Capita Income	Women's Share of Income
Log per capita calorie intake	0.015 (0.00927)	-0.0167 (0.00799)	0.003 (0.0138)	-0.0173 (0.00796)
Log calorie price	0.0630 (0.00628)	-0.00263 (0.527)	0.067 (0.0118)	-0.00242 (0.00523)
Log per capita food expenditure	0.0783 (0.0105)	-0.0193 (0.00865)	0.071 (0.01147)	-0.0197 (0.00865)

B.	Instrumental Variable Two Stage least Squares (2SLS)			
Dependent Variable	Log-Linear Income Model		Non-Linear Income Model	
	Log Per-Capita Income	Women's Share of Income	Log Per-Capita Income	Women's Share of Income
Log per capita calorie intake	-0.0448 (0.0654)	-0.0604 (0.00145)	-0.065 (0.0726)	-0.0645 (0.0257)
Log calorie price	0.206 (0.0322)	-0.00326 (0.0137)	0.170 (0.0441)	-0.0125 (0.0163)
Log per capita food expenditure	0.162 (0.0726)	-0.0626 (0.0217)	0.095 (0.0828)	-0.0778 (0.0258)

*The complete set of controls in Table 5 is included in each equation.
*Figures in parenthesis are standard errors.
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END NOTES

[1] Consequently, food prices only vary across the 12 local government areas. As a result food prices and local government dummies were highly correlated and could not be used in the same empirical equation. In this paper the local government area dummies were used to control for both community characteristics and food prices.

[2] Individuals were asked about the amount of food they consumed in the last 24 hours, and then in the preceding 24 hours. There was no direct weighing of food quantities. The method used to obtain the measure of food quantities was indirect. A standard size of each major food item was prepared and weighed at the research office. These physical measures were taken as the unit of measurement on the field. Each survey personnel carried the physical measures with them and used them to assist the individuals in assessing the quantities of food items taken in the past 48 hours. For example, if one respondent says he consumed twice the field unit for a particular food item, then his intake of that item in kilograms will be the weight of the standardized field unit multiplied by 2.

[3] The standard errors of the estimated coefficients were corrected for clustering within households by using the robust cluster command in STATA software package. The reason is that the simple estimates of standard errors become incorrect when we have multiple observations, which are not independent within a data. In the data set used for this analysis most of the income and expenditure variables, as well as household head and senior wife characteristics fall into this category of variables. All individuals that belong to the same household have the same values for these variables. This is referred to as clustering within households

[4] Elasticity for women's share of income in the calorie intake, calorie price and food expenditure equations are calculated as the product of the estimated coefficient and the mean value of women's share of income in the sample (0.31). Income Elasticity for the share of food purchased from market is calculated as the ratio of the estimated coefficient to the mean value of log per capita income, the women's share of income elasticity is computed as the product of the estimated coefficient and the mean value of women's share of income, divided by the mean value of market purchased share of food expenditure

[5] Since the income elasticity coefficients in of the non-linear income specifications in Table 7 (say $\hat{E} = f(\mathbf{\hat{a}_n})$) are estimated at the mean value of per capita income, Y*, the applicable standard error estimate needed to evaluate statistical significance must be derived from the joint distribution of estimated linear (say $\hat{a}_0$) and quadratic terms (say $\hat{a}_1$) in the non-linear expenditure equations. To compute these joint standard errors, I adopt the statistical concept called "Delta Method", which is a lemma that allows us to test non-linear hypothesis given the asymptotic distribution of the estimator (see Hayashi (2000) for detailed description of the lemma). Deriving from the lemma, if we assume that we have a set of 2-dimensional random vector $\mathbf{\hat{a}_n} = [\hat{a}_0 \ \hat{a}_1]$ that converges in probability to $\mathbf{\Phi}$ and converges in distribution to $\mathbf{Z}$; and suppose that $f(\mathbf{\hat{a}_n})$ is a function which has continuous first derivatives with $\mathbf{g(\hat{a}_n)}$ denoting the matrix of first derivatives, ie. $[\delta f/\delta \hat{a}_0 \ \delta f/\delta \hat{a}_1]$; then $f(\mathbf{\hat{a}_n})$ will converge in distribution to $\mathbf{g(\hat{a}_n)Z}$ **.** Thus, for the calorie intake non-linear expenditure elasticity coefficient, if $\mathbf{\hat{a}_n} = [\hat{a}_0 \ \hat{a}_1]$ converges in distribution to $N(\mathbf{0}, \sum)$, then it must be the case that $f(\mathbf{\hat{a}_n}) = \hat{a}_0 + 2\hat{a}_1 X^*$ would converge in distribution to $N(\mathbf{0}, \mathbf{g(\hat{a}_n)} \sum \mathbf{g(\hat{a}_n)'})$. Where $\sum$ **is** the estimated variance-covariance matrix of $\mathbf{\hat{a}_n}$ and $\{\mathbf{g(\hat{a}_n)} \sum \mathbf{g(\hat{a}_n)'}\}$ is the variance of $f(\mathbf{\hat{a}_n})$ given the joint distribution of the $\hat{a}_0$ and $\hat{a}_1$. The standard error of $f(\mathbf{\hat{a}_n})$ is just the square root of the calculated variance. In this study, $f(\mathbf{\hat{a}_n})$ represents the various non-linear expenditure elasticities tabulated in Table 11. For the case of the double log functions, $\mathbf{g(\hat{a}_n)} = [1, 2Y^*]$ since $\delta f/\delta \hat{a}_0 = 1$ and $\delta f/\delta \hat{a}_1 = 2Y^*$. An adaptation of this procedure was used to calculate the all standard error estimates for women share income variable reported in Table 7.

[6] Ravallion (1990) argues that the low calorie income elasticity estimates in literature is counterintuitive and is likely to be the result of data imperfections. He further argues that if this low estimates were a true reflection of reality; it still does not support a conclusion that income increment is not a good policy strategy for reducing under-nutrition. According to him, if we think in terms of head count index of under nutrition, the marginal effect of a change in income of undernourished households on a headcount index of under-nutrition is determined by the product of the calorie income elasticity and the slope of the distribution function of intake. If the distribution function is very steep (ie a large proportion of the population are just above nutritional adequacy level), a small drop in intake resulting

from income changes may move a large proportion of the people below the minimum nutrient intake line. So to assess the impact of income on under-nutrition, we must know the distribution of nutrient intake of the population. That is, we need to know the proportion of households that are close to the minimum nutrient intake line. The more households that are near to this line the more important is income increments in achieving improvements in under-nutrition. He argues that there is a clear difference between the concepts of nutrient intake (which most empirical literature has measured income effect for) and under-nutrition (which involves other factors such as minimum requirement and household and personal characteristics.   His major goal in this study are to estimate calorie income elasticity and then use the elasticity estimates to simulate the effects of income changes on various measures of caloric under-nutrition such as head count nutrition index, nutrition deficiency depth index and nutrition deficiency severity index all based on FGT poverty index

[7] Thus even though the use of 2SLS may have resulted in the inability to reject the null hypothesis of zero effect of income on calorie intake due to larger standard error estimates compared with OLS, the higher estimates of elasticity coefficients for women's share of income would suggest that using the 2SLS approach could have at least achieved significant reductions in the effect of classical measurement error bias on elasticity estimates.

[8] Food calorie price here is a proxy for how expensive the calorie being taken is. A higher value of food calorie price/cost implies higher quality calorie source. It is computed as the ratio of per capita food expenditure to per capita food calorie intake. i.e. calorie price (Naira/kcals) = per capita food expenditure (Naira) / per capita calorie intake (kcals) A significant and positive coefficient of women share of income would imply that women actually reallocate towards more expensive calorie sources which may have less calorie content.