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# QUANTIFYING FOOD INSECURITY IN THE CONTEXT OF MEASUREMENT ERROR IN MADERA COUNTY, KENYA

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## ABSTRACT

The objective of this paper is to estimate food insecurity using household expenditure against the backdrop of measurement error for rural households in Mandera County in Kenya. The study uses ordinary least squares and instrumental variable in generalized method of moment (GMM) techniques to quantitatively analyze data on quadratic Engel curve. The study demonstrates that microeconomic data are contaminated by measurement errors which make it easy to overlook food insecure households that are untraceable statistically. Therefore superior statistical techniques that reduces the effect of measurement error should form the basis of quantifying food insecurity to facilitate decision making process and resources allocation.

**Keywords:** Expenditure, Measurement error, Households, GMM, Mandera

## 1.0. INTRODUCTION

Reducing food insecurity continues to be a socio-economic public policy illusion in many developing countries. This challenge is complicated by insufficient analytical approaches to provide accurate information on severity, magnitude and underlying causes of food insecurity. However, to address food insecurity accurate measurement is critical. For instance, United Nations development goal No.2, to end hunger, achieve food security and improved nutrition and promote sustainable agriculture is based on identifying the accurate proportion of people who are food insecure and developing strategies geared towards halving this population by 2030 (United Nations, 2015).

  

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At present, the methods of measuring food insecurity suffer from a number of limitations (Smith et al, 2006). The methods most widely employed for measuring food consumption is aggregate data on food availability based on the country's food supplies rather than the data representing people's access to food (Smith et al, 2006). The method has often been criticized on the basis of its reliability. Household expenditure and consumption have widely been used in economic and poverty analysis and as indicators of welfare of households as well as enlighten on food policies. Food consumption data is particularly important in developing countries where the budget allocation on food is comparatively larger to other household expenditures. While microeconomic data is important in assessing food security, they are often contaminated by measurement error that lead to biased and inconsistent parameter estimates resulting to erroneous conclusions in economic analysis (Cameron et al, 2005). Grooves (1989) highlights that, cross-sectional expenditure data collected from surveys usually suffers from survey errors such as interviewer's errors, errors due to respondents, and so on. This underlines the significance of correcting for measurement error for the development of appropriate policy instruments.

Surprisingly, the available literature presents inadequate empirical work to describe the nature and consequence of measurement error in measurement of food insecurity. The methods used frequently, fail to correct for measurement error which is inherent with microeconomic data and leads to biased conclusions. This paper points out the consequence of measurement error while estimating food insecurity for rural households in Mandera County, Kenya. The paper underlines the significance of correcting for measurement error while measuring food security for the development of appropriate policy instruments.

## 2.0. THEORETICAL FRAMEWORK

Engel curves describe how household expenditure of a good varies with household income. According to Engel (1857) "the poorer the family, the greater the proportion of its total expenditure that must be devoted to the provision of food" i.e. as income increases, the share of expenditure for food declines, demonstrating the shares of income spent on food are inversely related to income levels (Chen and Wallace, 2009). Informed by this theory, this study employed household expenditure data to put forward a case for Mandera County in Kenya in estimating the extent of food insecurity.

As suggested by Blundell et al (1997), quadratic terms in the Engel curve allows to account for goods being luxuries at some income levels and necessities at others. However, studies show that errors in variables induce non-zero correlation between the contaminated repressors and the equation disturbances, so that OLS estimates are biased and inconsistent (Fuller, 1987). This study employs the concepts of measurement error both in dependent and independent variables

  

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and uses instrumental variable approach as suggested by Lewbel et al (1996) and Battistin et al (2012).

**2.1. Model specification**

Application of the demand theory of the household was specified as follows;

$q_i = f_n(x, p)$.....1

I = 1, 2 ….n

Where $q_i$ is the quantity demanded, p is the price; x is total household expenditure. This employed a working-Lesser single demand model, where the share of the food item is linear function of the log of the total household expenditure.

$w_{ih} = a_i + b_i ln\, x_h + u_{ih}$ .....2

The framework used in the in the study is the Engel curve estimation expressed as follows:

$x_h = fn\,(y_h)$.....3

Where $X_h$ is expenditure of food by the household $h^{th}$, $y_h$ denotes monthly total household expenditure.

Let $y_h^*$ and $x_h^*$ represent the correct total consumption expenditure and correct expenditure on food items respectively for household h=1…, H.

Likewise, let $y_h$ and $x_h$ be the measured values of $y_h^*$ and $x_h^*$ respectively. Therefore the measurement error in $x_h$, denoted as $v_h$ can be given as;

$V_h = x_h / x_h^*$ .....4

In log terms yields to

$ln\, v_h = ln\, x_h - lnx_h^*$ .....5

The correct and measured food expenditure

$W_h^* = x_h^*/y_h^*$.....6

The observed food expenditure,

$W_h = x_h/y_h$.....7

  

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Consequently, the measurement error in the observed food expenditure is given by,

$\omega_h = w_h - w_h^* \ldots\ldots\ldots\ldots\ldots\ldots\ldots 8$

Applying budget shares that are higher than first degree polynomial, equation 2 is replaced by the following quadratic food share model

$W_h^* = \beta_0 + \beta_1 ln\, x_h^* + \beta_2 (ln\, x_h^*)^2 + \mu_h \ldots 9$

$\mu_h$ is a mean zero error,

This according to Hausman et al (1995), who proposes the use of quadratic equation (equation 9), as adequate specification than linear equation (equation 2).

Combining equation 9 with equations 5 and 8 leads to the estimating equation as follows

$W_h = \beta_0 + \beta_1\, lnx_h + \beta_2\, (ln\, xh)^2 + \varepsilon_h \ldots 10$

Where

$w_h$ - The food expenditure share of the household i

$x_h$ - Total household i expenditure per adult equivalent

$\varepsilon_h$ - Household i compound error term

**2.2. Sampling design and sample size determination**

Sampling was constructed based on the 2008 integrated households' budget survey report. The target population being all households in the Mandera County, estimated at 40,599. (GoK, 2008). Using the fisher's formula a sample of 323 household was estimated and the proportionate ratio of the households in each district to the total households in the county was used to define the sample sizes in all administrative districts as follows; Mandera west 73, Mandera Central 102 and Mandera east 148. The households in the sample were randomly selected in the districts.

**2.3. Data types and sources**

The study used both primary and secondary data collected in the moths of June to august 2012. The primary data was collected from household units as follows; household total expenditure i.e. food and non-food expenditure, and household income, farm production data, relief supplies both food and non-food items, income sources and amounts. The study employed questionnaires, key informant interviews and group discussions for data collection. Secondary data including

  

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background information on population and households' budget profiles. This was gathered from government and NGOs reports.

### 2.4. Data Analysis

Measurement error is a major drawback in the application of household consumption in economic analysis. The present study, sought to investigate the consequence of neglecting measurement error in measuring household food insecurity using household expenditure data. In the above equation (eq. 10), the dependent variable (household expenditure share) was estimated by dividing expenditure on food by total household expenditure. The independent variable (Total household expenditure) was estimated by summing all household expenditure both food and non-food items. I.e. food and non-food expenditure, farm production data, relief supplies and any other items received by the households during the study period. The equation was analyzed as follows:

To quantify the effect of measurement error the quadratic Engel curve was analyzed using Ordinary Least squares (OLS) and instrumental variable approach of general method of moments (GMM). Ordinary least squares was used to offer a basis for which to estimate the variance caused by measurement error. This was done to show that estimators that do not correct for measurement error are biased and inconsistent for estimating microeconomic data coefficients as pointed out by Cameron et al (2005). The inconsistency of OLS in this study is due to measurement error in household expenditure data. To overcome this challenge the study employed instrumental approach using general method of moments (GMM) as proposed by Lewbel (1996) and Battistin et al (2012). This involved two- step approach; first by transforming the structural model into a reduced form and secondly by developing a relationship between the structural and reduced model to obtain consistent estimators as explained by the Denadai (2005). Data analysis was done using STATA 12 software.

## 3.0. RESULTS AND DISCUSSION

### 3.1 Food expenditure for households in Mandera County

Table 3.0 provides statistical summary of the household variables that were used in the study. On average the study shows that food share accounts for approximately 88% of the total household expenditure.

  

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**Table 3.0. : Food Expenditure for households in Mandera County**

| Variable | mean | Std. dev. | Min. | Max. |
|---|---|---|---|---|
| Food Share | 0.881 | 0.074 | 0.72 | 0.99 |
| Total Expenditure (Kshs.) | 9439.6 | 4547.8 | 1933.3 | 26033.5 |
| Household size (No) | 8.9 | 2.7 | 4 | 16 |
| Sample size | | | | 323 |

*Source: Field Survey data 2012*

The household expenditure on food is observed at 88.1% this is parallel to GoK (2007) report that puts it at 80%. However, this level of food expenditure is high compared to the national average of 51.1%. In comparison to national statistics[1] Mandera County differs in a number of ways. This can be explained on a number of factors; high on the list is the high poverty levels. According to government reports, Mandera County is categorized as poor with a poverty index of 72% (GoK, 2007). This is consistent with the Engel's point of view that low income households' expenditure on food is proportionally higher in the total household expenditure (Thompson and Metz, 1998). Secondly, Mandera County relies heavily on markets and food aid as the major food source which stands at 54.8% and 36.2% respectively. At national level, 53.9% of food consumed in rural areas comes from purchases (GoK, 2007).

### 3.2. Food insecurity estimates with measurement error – Quadratic OLS regression results

The study employed OLS regression procedure to emphasize the significance of correcting for measurement error in the analysis of survey data. The OLS procedure is based on certain assumptions some which refer to the relationship between the variables. In the relationship between variables OLS assumes that the explanatory (independent) as well as dependent variables are measured without error (Wooldridge, 2006). However, as reviewed in the literature, microeconomic data is contaminated by measurement errors and therefore OLS estimators are both biased and inconsistent.

[1] Kenya National Bureau of Statistics: Kenya Integrated Household Budget Survey 2005/06 Basic report and Basic Report Well-Being in Kenya 2005/06.

  

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Table 3.1 presents the estimated ordinary least squares (OLS) regression parameters for the Food share and household expenditure relationship. The regression parameters are significant at 95 % level.

**Table 3.1. : Food expenditure estimates with measurement error - OLS regression results**

| (Dependent Variable = Household expenditure on food)[2] | |
|---|---|
| Log of total household Expenditure | 0.5260 (2.64)* |
| Square of log of the total household Expenditure | -0.1002 (-3.21)* |
| Log of household size | 37.3806 (2.054)* |
| Constant | -0.1616 (3.25)* |
| R-Squared | 0.9606 |
| [3]Turning point (95% confidence interval) | 8,513 |

*Source: Computed form Field Survey, August 2012; t-test in parenthesis*

[2] $W_h = \beta_0 + \beta_1 \ln x_h + \beta_2 (\ln x_h)^2 + \varepsilon_h$; $w_h$ is the household food expenditure; $x_h$ is the total household expenditure.
[3] The value of x that defines the extremum of the relationship between $w_h$ and $x_h$ was derived using $\theta = -\beta_1/2\beta_2$. Where, $\theta$ is the maximum value of x with measurement error.

The results display the quadratic relationship which justifies its application in this study. The turning point is estimated at Kshs. 8,513, which means that OLS regression food is considered a luxury beyond this level of expenditure. This means that any policy to address food insecurity in this County will focus at this being the minimum level of income per month.

### 3.3. Food insecurity estimates with corrected Measurement Error - GMM results

The measurement error corrected estimates are presented in table 3.2. From the table, the results are demonstrating presence of quadratic Engel curve relationship of the estimated model. The negative and significant coefficient of the square log of the household expenditure supports the use of quadratic relationship in this study. To test the validity of the instruments, the test of over-identifying restriction (p–values) was conducted and confirmed to be appropriately uncorrelated

  

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with the disturbance process. The calculated p-value of 0.1867 is larger than the preferred significant level of 0.05, thereby accepting the null hypothesis of the validity of the instruments.

**Table 3.2: Food expenditure estimates with corrected Measurement Error - GMM results**

| (Dependent Variable = Household expenditure on food) | |
|---|---|
| Log of total Household expenditure | 0.6302 (7.59)* |
| Square of the log of total household Expenditure | -0.0860 (-5.36)* |
| Log of household size | 0.0644 (2.04)* |
| Constant | -0.6526 (-1.80)* |
| [4]Turning point (95% confidence interval) | 13,020 |
| *P-value* of the Over-identifying restriction | 0.1867 |
| *P-value* of test for endogeneity | 0.0005 |

*Source: Field Survey, August 2012 (Standard errors in parenthesis)*

study also employed Durbin-Wu-Hausman test for endogeneity to expose any differences between the estimation methods i.e. Ordinary Least Squares (OLS) and the General method of moments (GMM). The comparison in this test was restricted to the point estimate and the standard error of the endogenous variable (Total household expenditure). The result of the Hausman test statistic shows the small *p*-value of (0.0005) which is less than the preferred at significant level of 0.05, indicates that OLS results are not consistent, and thereby rejects the exogeneity of the total household expenditure variable. In other words, the test shows that OLS method of estimation will result to biased and inconsistent parameters, and supports the use of instrumental variables in the estimation model.

In quadratic functions, the usual interpretation of coefficients that the effect of one a unit change in its associated variable holding all other variables constant is not applicable. This because it's not possible $X_h$ to change without changing $x^2_h$, one has to differentiate the equation with respect to $X_h$, one obtains the change in $W_h$ per unit change in $X_h$.

But looking at the coefficients of the two equations (OLS and GMM) there is noticeable difference in magnitude with the OLS coefficients being smaller. The marked difference can be

  

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traced to the effect of measurement error, which causes the coefficient of the $X_h$ (household expenditure) to be biased downwards, that is smaller in magnitude.

Turning the attention to the discussion of the measurement error corrected quadratic Engel curve model, real income was used to construct the instrumental variables. This is because income as an instrument is correlated with endogenous variable (i.e. Total household expenditure); it is uncorrelated with error term and is assumed not to enter the main equation (i.e., does not explain the dependent variable, the food share).

One may argue that income may as well be measured with error, but as pointed out by Lewbel (1996), there is no valid justification that reported income is correlated with measurement error in total household expenditure. He further argues that, under the standard assumptions, income should be independent of the demand model errors.

Quadratic expression is one way of capturing the diminishing effect of a good. The Engel curve of the corrected measurement error indicates that the food share increases with the total household expenditure up to the turning point at Kshs. 13,020. This corresponds to $85^{th}$ percentile of the raw data, indicating that for this proportion of households, their food requirements are classified as luxury. In contrast, the Ordinary Least Squares estimates the food share start displaying signs of necessity in terms of budget proportion of Kshs. 8513. This corresponds to $65^{th}$ percentile of the raw data the level beyond which food stops being a luxury in these households.

Accordingly, the Ordinary Least Squares estimate, understates the food insecurity situation of the households in Mandera County by about 20%. This means that any policy formulation that relies on approaches that do not account for measurement error will underestimate the problem of food insecurity and exclude many households in the pursuit of addressing this challenge.

Turning to the coefficients of the household size, the results show marked difference between the OLS and GMM estimates. Comparatively OLS estimates are larger than the ones presented through GMM analysis. This difference can be traced to the presence of measurement error in OLS as opposed to GMM estimates. According to Gibson (2006), measurement error in household expenditure is correlated with household size which inflates the OLS coefficients. He further argues that food expenditure data obtained through recall process shows reporting errors that are correlated with household size (Gibson, 2003).

## 4. CONCLUSIONS AND POLICY RECOMMENDATIONS

The study has found out that using the techniques that do not account for measurement error, would underestimate the scale of food insecurity and any intervention to reduce food poverty in

  

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Mandera County would ignore the welfare of about a fifth of the population. The study also shown that the depth of food insecurity is affected by the measurement error, and therefore limit the allocation of the resources that would be needed to lift the food poor out of deprivation through perfectly targeted assistance.

The study found that is it is easy to disregard food insecure households if they are statistically imperceptible and therefore suggests use of sound data-based analysis, to estimate the extent of food insecurity for definitive quantitative evidence that contributes to helpful policy discussions for the purpose of planning, developing and targeting food security interventions. Based on household expenditure, the study has established that measurement error leads to underestimation of the magnitude of food insecurity problem.

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## STATEMENT OF NO CONFLICT OF INTEREST

We the authors of this paper hereby declare that there are no competing interests in this publication.

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