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WHOSE EDUCATION MATTERS IN THE DETERMINATION OF HOUSEHOLD INCOME: EVIDENCE FROM A DEVELOPING COUNTRY

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ABSTRACT

This paper aims to answer how best to model education attainment, which is an individual-level variable, in household-level income functions. The accepted practice in the literature is to use the education level of the household head. This paper compares the head-of-household model to three competing models and concludes that the maximum or average level of education in the household is a better explanatory variable of household income. Least absolute deviations (LAD) estimators and censored least absolute deviations (CLAD) estimators are used to predict income. Standard errors, which are robust to violations of homoscedasticity and independence, are generated by a boot-strap method that replicates the two-stage sample design.

CONTENTS

Acknowledgments v

1. Introduction 1

2. Data and Descriptive Statistics 4

3. Empirical Specification 8

    Household School Attainment 8
        Weakest Link—Household Minimum 9
        Talented Tenth—Household Maximum 11
        Household Median and Household Average 11
    Household Income 14
        Farm Profits 14
        Off-Farm and Total Income 16
        Farm and Off-Farm Labor 18

4. Estimation 19

    Censored Dependent Variables 20
    Outliers and Other Violations of Normality 21
    Complex Sample Design 22
    Independent and Identically Distributed Residuals 24
    LAD and CLAD Estimators 27

5. Results 28

    Tests of Household School Attainment Models 29
        Weakest Link and Household Head Models 29
        Talented Tenth and Household Average Models 30
    Comparison of Head, Minimum, Average, and Maximum Estimates 34
    Gender and Household Schooling 37

6. Conclusion 38

Appendix 42

References 45

TABLES

1. Head of household's education attainment, intrahousehold comparisons by household size 6

2a. Tests of minimum, average, and maximum schooling: Household income and schooling (households with two or more adults) 31

2b. Tests of minimum, median, and maximum schooling: Household income and schooling (households with two or more adults) 32

3. Comparison parameter estimates: Household school attainment measures and household income 35

4. Comparison of parameter estimates: Sample design effects and standard errors, OLS versus LAD 36

5. Tests of joint significance for the gender model (p-values reported) 38

6. Descriptive statistics 42

7. Household income and household schooling estimates of (1) using all households with two or more adults 43

8. Total household income and household schooling: Comparison of household head's schooling, maximum, and average schooling 44

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1. INTRODUCTION

In developed countries, where the majority of workers are wage earners, the returns to human capital are typically measured by regressing an individual's wage on that individual's school attainment.[1] The human capital literature for developing countries is similarly focused on measuring the returns to education for wage earners, in spite of the fact that in most of these countries, wage earners are a relatively small fraction of the labor force.[2] A predominant feature of many developing countries is that the largest share of the labor force is engaged in self-employed activities that generate income for households—either as farm households or as small enterprises.[3] The different composition of the labor forces in developed and developing countries has important implications for the way income data are collected in both types of countries. Income generated from farming or other household enterprises is almost always measured at the household level, whereas wage income is uniformly available at the individual level.

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[1]The standard Mincer equation regresses wages on schooling and potential experience (the difference between age and schooling, plus six years).

[2]For a discussion of the relative focus of the human capital literature in developing countries, see Jolliffe (1996). Good examples of the vastness of the literature on the returns to human capital for wage earners in developing countries are Psacharopoulos (1981), (1985), and (1994).

[3]See World Bank (1995) for a detailed discussion of the typical composition of labor forces in developing countries. See Grigg (1991) for more discussion about the predominance of agricultural laborers in developing countries.

This difference in the way income data are collected makes it difficult to extend the wage regression model to the developing country context. The difficulty is that in developing countries, income data are largely measured at the household level, but the data on education attainment are available at the individual level. As survey data rarely allow for the decomposition of household income to the individual level, it is not possible to map an individual's education attainment to their contribution to household income. A seemingly natural extension of the wage regression model for this situation would be to regress the household's income on the household's education level. This extension, though, leads to the difficulty of how to model the household's education level. The extension begs the question: whose education matters?

The existing literature only indirectly addresses this issue and answers the question largely by assuming that only the head of household's education level matters for the determination of household income. Jamison and Lau's (1982) survey of the literature on schooling and household farm income discusses the results of over 35 studies from Asia, Africa, and Latin America. With limited exception these studies implicitly assume that it is only the education level of the head of household that affects farm income and that the education levels of all other household members have no effect.[4] Similarly studies by Fane (1975), Wu (1977), and Jamison and Moock (1984) also use the education level of the head of household to represent the school attainment for the household, whereas Huffman

[4]One exception is a study of 1,904 Korean farm households, in which the household average level of education is used as a measure of education attainment for the household. This study is discussed in Chapter 4 of Jamison and Lau (1982).

(1974) uses the education levels of the head of household and spouse and Lin (1991) uses both head of household and average household level of education.[5]

Another important component of household income in many developing countries is self-employed, off-farm income. This component of household income has been widely ignored in the human capital literature, even though self-employed, off-farm income is at least as significant as wage income in many developing countries.[6] Vijverberg's (1991a) study is one of few papers on returns to human capital that examines self-employed, off-farm work. He uses the education level of the operator of the household enterprise as the measure of education for the enterprise.

The practice of using the school attainment of only one household member implicitly assumes that the education level of all other household members is irrelevant. While this assumption is pervasive, it may not be reasonable. Consider two households, one in which no one has any schooling and the other in which the head has no schooling, but all other members have completed secondary schooling. The standard assumption implies that these two households possess the same amount of human capital.

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[5]Fane's and Huffman's studies used U.S. farm households. Jamison and Moock look at Nepalese farm households, and Wu examines Taiwanese farm households. Lin examines whether education affects the adoption of new technologies in the Hunan Province of China.

[6]In the case of Ghana, 47 percent of the households generate some self-employed, off-farm income, while 36 percent of the households have at least one wage-earning member. Similarly, the average value of self-employed, off-farm income is 225 percent greater than the average household income generated from wage employment. Vijverberg (1991a, 2) also notes that, "family enterprises with one to four workers accounted for about 70 percent of manufacturing in India and Indonesia, 60 percent in the Philippines, and 40 percent in Korea and Columbia."

The purpose of this paper is to empirically consider three models of household education, and determine whether the intrahousehold allocation of education matters in the determination of household income. The plan of this paper is as follows. Section 2 discusses the data used in this paper and presents a few descriptive statistics on headship in Ghana and labor activities of Ghanaian households. Section 3 presents three simple paradigms of whose education matters in regression models of household income. This section also describes the composition of household income, and proposes the appropriate explanatory variables for estimation. Section 4 describes the estimation methodology. Consistent estimates for the farm and off-farm income functions are obtained by using Powell's (1984) censored least absolute deviations (CLAD) estimators. Consistent standard errors are obtained by using a bootstrap methodology that mimics the two-stage sample design. Section 5 contains a summary of the estimation results. Most notably, the results suggest that using either the maximum or average level of schooling in the household (rather than the education level of the head of household) provides a more accurate measure of the return to education. Section 6 provides some concluding comments.

2. DATA AND DESCRIPTIVE STATISTICS

The data used in this paper are from the Ghana Living Standards Survey (GLSS), a nationwide household survey carried out by the Ghana Statistical Service with technical assistance from the World Bank. The survey, administered from October 1988 to

September 1989, covers 3,200 households and contains detailed information on formal and informal labor activities, household farm activities, expenditures, education status of household members, and many other determinants of household welfare. (See Glewwe and Twum-Baah [1991] for more information.) A supplemental education module was also administered to a nationally representative subsample of 1,585 households. This paper uses the data from the subsample of 1,585 households. Thirty-eight of these households are dropped due to missing data, resulting in a sample of 1,547 households.[7]

In the GLSS data, as with many household surveys, the head of household title is a self-ascribed characteristic. As the definition of head of household varies across cultures and across surveys, it is likely to be an unreliable characteristic for cross-survey comparisons. Similarly, if the concept of headship varies across households within Ghana or if headship is based not on education attainment or management skills but on age, for example, then the headship model is likely to mismeasure the returns to education for the household.

Using the education level of the head would be a more tenable assumption if headship were correlated with the education level in the household. In this case, it could be argued that headship is assigned to those with the most (or close to the most) education, because they will make the best decisions for the household. In the GLSS data, the head of household's education level is often the highest in the household, but it is also frequently the lowest. Table 1, below, presents the percentage of households in which the

[7]Five households are missing school data, and 33 households are missing agricultural price data.

head of household has the highest and lowest level of education in the household. Table 1 shows that as household size increases,[8] both the percentage of households where the head has the most education declines and the gap between the education level of the head and the most-educated household member increases.

Presumably the head of household model supposes that the head acts as a household manager, making all of the labor decisions that require education. (This

Table 1 Head of household s education attainment, intrahousehold comparisons by household size

Number of adults in household	Head is most educated adult	Head is least educated adult	Gap[a] maximum	Gap[b] minimum	Number of households
	(percent)		(years)		
1	100	100			488
2	73	60	1.6	2.4	543
3	59	55	2.8	3.2	265
4	50	63	3.8	2.7	121
5	39	61	4.6	3.4	72
> 5	29	66	6.2	2.3	58

Notes: Total sample size is 1,547 households. An adult is defined as 15 years of age or older. If the head of household is tied with another member for the most or least educated in the household, then the head is treated as most or least educated adult in this table.

[a] Gap maximum is the average difference in years between the head of household's education attainment and the maximum education attainment in the household.

[b] Gap minimum is the average difference in years between the head of household's education attainment and the minimum education attainment in the household.

[8]The table actually lists households by the number of household members over the age of 15. Throughout this paper, all education attainment variables are only for individuals over the age of 15. This is to ensure that the majority of continuing students are not included in the analysis.

assumes that it is only the decisions, and not the implementation, that require human capital.) This model is most credible in the context of a household in which all members are working on the same task, such as farming. The assumptions of the model seem less tenable as households engage in additional income-generating activities. This is because the monitoring demands on the manager are likely to dramatically increase when parts of the household are working on the farm, while other household members are working off of the farm.

In the case of Ghana, there is a great amount of diversity in labor activities. There are 3,698 laborers in this sample of 1,547 households. Of these individuals, 77 percent spend some time working on a farm and 56 percent spend some time engaged in some other form of labor. Thirty-four percent of the individuals are engaged in both some farming and nonfarming activities. The extent of the labor diversification increases when considering all labor within the household. In 55 percent of the households, at least one person has spent some time working on a farm and at least one person has spent some time in nonfarm labor. This level of labor diversity further suggests that the assumptions of the head of household model are difficult to support.

The human capital literature for developing countries estimates the returns to education by either estimating a Mincer-type wage equation or by estimating some form of a farm production or profit function. Without exception, the literature assumes that individuals or farm households are engaged in only one income-generating activity. Because so many households and individuals are engaged in more than one income-

generating activity, estimating the returns to education by focusing on either strictly farm income or wage income will provide an incomplete picture of the importance of education. For this reason, this paper examines total household income, farm household income, and off-farm household income.

3. EMPIRICAL SPECIFICATION

This section first lays out a general specification of the household's school attainment, which captures much of the information on the household's distribution of schooling. Following this is a description of three basic paradigms of how to model household school attainment. The testable implications of these models of household-level school attainment are also described. This section finishes with a brief explication of how total household income and its components are calculated.

HOUSEHOLD SCHOOL ATTAINMENT

In order to answer the question of whose education matters for the determination of household income, this paper first considers a basic specification that includes the minimum, average, and maximum value of school attainment from the distribution of schooling within each household. The three models tested alternatively assume that one of these terms is a determinant of household income, while the other two have no effect on household income. The model is then extended in two ways. First, the education level of the head of household is also included (along with minimum, average, and maximum

schooling in the household) in the set of school regressors. The assumption that only the head's education level matters is examined by testing both whether the head's education level is a significant explanatory variable of income and whether the other variables are jointly equal to zero. The second extension to the model considers whether the results differ when the median level of education is used in lieu of the household average level of school attainment.

The basic model of the log of total income for household j is[9]

$$Ln(Y_j) = \alpha_\eta + \alpha_\Theta \boldsymbol{X}_j + \sum_{i=\eta \epsilon K \pi \Theta \eta \eta} \beta_i S_{ij} + \epsilon_j, \qquad \textbf{(1)}$$

where S_0, S_{50}, and S_{100} are the minimum, average, and maximum level of schooling within household *j*; and $\boldsymbol{X}$ is a vector of the other explanatory variables.[10] The elements of $\boldsymbol{X}$ will be discussed in the section on household income (page 14).

Weakest Link Household Minimum

The fairly general specification of household schooling given in equation (1) nests a few simple paradigms of how school attainment within a household affects the determination of household income. The first considered here is the paradigm that only the household's minimum value of education attainment matters in the determination of

[9]The assumption that the school terms enter the income function linearly is tested by estimating income with the squares and interactions of the school terms. In all of the models estimated, the assumption that the squared and interaction terms are jointly zero can not be rejected.

[10]The model is also tested where S_{50} is the median instead of the average.

household income. This model is motivated by the popular management aphorism that a production process is only as good as its weakest link. The notion is that one bad input or one mistake will ruin the entire product. This model is most likely to be appropriate for production processes that are highly sensitive to mistakes.

Of the three paradigms considered in this paper, the weakest link most closely resembles the head of household model, at least in the case of Ghana, where in 70 percent of the households, the head has the lowest level of education.[11] In Ghana, the elderly have the least amount of education,[12] and it is quite common for the oldest person in the household to be designated the head by the household. In 91 percent of the GLSS households, headship is ascribed to the oldest member in the house.

If the weakest link paradigm is the correct model, then there are two testable implications from estimating equation (1). The first is that the parameter estimates on the average and maximum level of schooling, β_{50} and β_{100}, are jointly equal to zero. The second implication is that the parameter on the minimum level of schooling, β_0, is nonzero.

[11]When considering households with more than one member over the age of 15, the percentage of households where the head has the least amount of education drops to about 60 percent.

[12]For example, those individuals between the ages of 15 and 44 have, on average, 6.6 years of schooling, while those 45 years of age and older have, on average, 2.2 years of education. (The t-statistic for whether these averages are different is 26.4.) See Jolliffe (1996) for a breakdown of education attainment by age and sex.

Talented Tenth Household Maximum

Another paradigm considered in this paper is that only the household's maximum value of education attainment matters in the determination of household income. This model is motivated by the notion that one well-educated member of the family can make the business decisions requiring the skills acquired in schools and can partake in the most intellectually demanding activities.[13] In some ways, this may be the model many have in mind when using the education level of the head of household.

If the talented tenth paradigm is the correct model, there are two testable implications that are very similar to those for the weakest link model. The implications are that the parameter estimates from estimating equation (1) on the minimum and median level of schooling, β_0 and β_{50}, are jointly equal to zero, while the term for the maximum level of schooling, β_{100}, is nonzero.

Household Median and Household Average

The final paradigm of how household school attainment affects household income is that a midpoint value of the household's school attainment is the important determinant of household income. To test this, both the average and median values of schooling are used

[13]The *talented tenth* nomenclature is taken from a model of macroeconomic development proposed by W.E.B. Du Bois for the black community in America. Du Bois believed that the path to improved living standards for African-Americans would be best attained by educating a small elite group of African-Americans, who would then be able to lead the rest of their community into prosperity. The use of this name is only meant to evoke the idea of investing all of the education resources into a few individuals who would then help out the others. It is not intended to suggest that Du Bois proposed this idea as a theory of intrahousehold allocation of education.

for the S_{50} variable. The motivation for this model is that the skills of all workers are important for the creation of household income, and one good manager or one weak link is not the driving force. While the median and the average values of school attainment are very similar, the estimation results differ slightly and a summary of both are presented.

If the household average or median paradigm is the correct model, there are again two similar sets of testable implications. The first is that the parameter estimates on the minimum and maximum level of schooling, β_0 and β_{100}, are jointly equal to zero. The second implication is that the parameter on the average or median level of schooling, β_{50}, is nonzero.

One important assumption placed on the way schooling is specified in all three models is that households cannot hire-in educated laborers. In other words, the market for educated laborers is imperfect and households are unable to purchase the profit-maximizing level of schooling by hiring in educated managers. There is some evidence in the GLSS data that suggests that markets for educated laborers are not very active and that this assumption is reasonable. For example, the average Ghanaian farm household spends less than 5 percent of farm income on hiring in labor. Of the labor that is hired-in, 70 percent of the wages go for clearing land—presumably not an education-intensive job.

One problem in estimating the models of school attainment is that they require regressing household income on three measures of school attainment that are highly correlated. This is primarily the case because there are numerous households with only one or two adult members. In households with only one adult member, the minimum,

average, and maximum level of school attainment will all be the same value. In order to reduce the level of correlation across the variables, all models are estimated over three samples: (1) all households, (2) all households with two or more adult members, and (3) all households with three or more adult members.[14]

It is important to also note that human capital is a complex, multidimensional characteristic, and school levels will capture certain aspects of it, but are also likely to confound human capital with other characteristics such as wealth or innate ability. These issues are only dealt with in this paper to a limited extent. For example, to control for some forms of omitted variable bias, the regression models include household composition variables and some information on household assets. The household composition variables will control for differences in education levels that are correlated with income levels but are due to gender differences.[15] To control for the possibility that schooling may not measure human capital at all, this paper refers to Jolliffe (1996), which uses a different measure of human capital (cognitive skills) and finds that the returns to skills are positive and similar to the returns from schooling.[16]

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[14]Only the estimation results from using the sample of households with two or more households are presented in this paper. The results from using all households and households with three or more adults are qualitatively similar and are presented in full in Jolliffe (1996).

[15]Households with more female members have, on average, lower levels of schooling because females attain less education than males, on average. Households with more females are also likely to engage in different types of labor, which will affect farm and off-farm income differently. In particular, females are more likely to engage in work that does not generate income as measured by the GLSS survey, such as housework. These gender effects are likely to be both correlated with income levels and schooling, and unless controlled for, will bias the estimated effect of schooling on income.

[16]The similarity is that higher levels of cognitive skills and schooling both increase household off-farm income by much more than they increase farm income.

The difficulties associated with using school attainment to measure human capital are substantial, so it is worthwhile to note that the purpose of this paper is not to measure the returns to human capital. Rather this paper compares different measures of household school attainment to determine which measures best explain income, and also to determine if the standard practice of using the head of household's schooling as the measure of the household's total level of schooling is valid.

HOUSEHOLD INCOME

To test the three paradigms discussed above, this paper estimates three separate household income functions—total income, farm income, and off-farm income. This strategy explicitly acknowledges that many households are engaged in numerous income-generating activities, and while a household member's education level may not matter for the determination of income in one activity, it may matter for another. Below is a description of the components of total household income.

Farm Profits

Farm output is measured as the value of all crops and animal products marketed in the last 12 months plus the value of crops kept for seed and given away as gifts.[17]

[17]To correct for an inflation rate of 24 percent during the year of fieldwork (Ghana Statistical Service 1991a), all values are converted to constant cedis (₵), with the base month as October 1988. The average exchange rate during 1988 was ₵200 to US$1 (Ghana Statistical Service 1991b).

Because many farmers cover their subsistence needs from their own production, the estimated value of home consumption of food and animal products is also included in the measure of total farm output.[18] Subtracted from this measure of farm output are expenditures on seed, fertilizer, insecticide, pesticide, livestock, storage, transportation, rented-in land, and hired-in labor. Crops given as payments for other inputs are also subtracted from the value of farm output. The resulting figure is a measure of profit, conditional on the quantity of land and labor. (The value of one is added to farm profit to allow the log transformation of farm profit.) The log of farm profit is modeled as a Type 1 Tobit model:[19]

$$\begin{aligned} \ln (Y_f^* + 1) &= \ln Y_f^*(A_f, L_f, \boldsymbol{p_f}\ \boldsymbol{S}, \mu) \qquad (2) \\ \ln (Y_f + 1) &= \ln (Y_f^* + 1) \quad \text{if} \quad Y_f^* + 1 > 1 \\ &= 0 \qquad\qquad \text{if} \quad Y_f^* + 1 \leq 1 , \end{aligned}$$

[18]In Ghana, the GLSS data indicate that the value of home-consumed crops constitutes 62 percent of the total value of farm output. Crops sold on the market contribute to 35 percent of the total farm output, and the remaining 3 percent comes from the sale and home consumption of animal products.

[19]In the Type I Tobit model, the zeros are typically explained by an optimization problem which results in a negative value for the desired level of the dependent variable. This estimation problem perhaps more naturally falls into the Type II Tobit, or selection model framework. In the Type II framework, the zeros exist because some households choose not to be farmers. The Type I Tobit framework is chosen for this paper due to a lack of a credible model defining the selection process into (or out of) farming.

where the *f* subscript denotes a farm variable,[20] A_f is the log of acres of land cultivated and is treated as a fixed input,[21] L_f is the log of household farm labor hours, $\boldsymbol{p_f}$ is a vector of prices for farm products and farm inputs,[22] $\boldsymbol{S}$ is the vector of household school attainment variables discussed above, and μ is an error term. It is assumed that Y_f is observed for all households, but Y_f^* is only observed if $Y_f^* > 0$. About 70 percent of the households engage in some farming activities and the average restricted profit of those farming households is ₡144,604.

Off-Farm and Total Income

The measure of off-farm income, Y_o, aggregates wage income and self-employment income. The decision to aggregate these two loses some information but helps focus on the difference between farm and nonfarm income. The measure of wage income adjusts the wage rate by including all pecuniary remuneration for the labor supplied, including commissions, bonuses, tips, allowances, and gratuities. Wage income is also adjusted to

[20]Throughout this paper the subscript f will denote a farm variable and the subscript o will denote an off-farm variable. These subscripts will only be used on variables which could pertain to either farm or off-farm activities. The subscripts denoting household- and individual-level characteristics previously used are dropped here for clarity.

[21]Land is treated throughout this paper as a fixed input. In an economy where land markets function well, treating land as fixed would be inappropriate. The more appropriate strategy would be to treat land like any other input: subtract the rental value of land from total output and include the rental price of land in the set of regressors. In the case of Ghana, though, it is difficult to establish a reasonable rental value for the land. Only 17 percent of the farmers rent any land in or out and land is rarely sold, both of which mean that land rental prices are not well defined. The fact that land rental markets are not very active suggests, though, that treating land as a fixed input may not be a too egregious assumption.

[22]The p_f vector contains cluster average prices for maize, okra, cassava, and pepper crops as well as the cluster average input prices for fertilizer and insecticide.

reflect the value of all nonpecuniary payments, including remuneration in the form of food, crops, animals, housing, clothing, transportation, or any other form.

The measure of off-farm, self-employed income is recommended by Vijverberg (1991b) and is the reported amount of money left over from self-employed business activities after expenses have been incurred. This measure has the advantage of resulting in strictly nonnegative values.

The log of off-farm income is also modeled as a Type I Tobit:

$$\begin{aligned} \ln (Y_o^* + 1) &= \ln Y_o^*(A_o , L_o , \boldsymbol{S}, \varepsilon) \qquad (3) \\ \ln (Y_o + 1) &= \ln (Y_o^* + 1) \quad \text{if } Y_o^* + 1 > 1 \\ &= 0 \qquad\qquad \text{if } Y_o^* + 1 \leq 1 , \end{aligned}$$

where the *o* subscript denotes an off-farm variable, A_o is the log of business assets and years of work experience, L_o is the log of household off-farm labor hours, $\boldsymbol{S}$ is the vector of household school attainment variables discussed above, and ε is an error term. It is assumed that Y_o is observed for all households, but Y_o^* is only observed if $Y_o^* > 0$. (The value of one is also added to off-farm income to allow the log transformation of farm profit.) About 67 percent of the households have at least one household member who engages in some form of off-farm work, and the average off-farm income for these households is €373,143. Total household income is modeled simply as the sum of farm and off-farm income. The average value of total household income is €326,743.

Farm and Off-Farm Labor

Both the farm and off-farm income functions include hours of household labor, the levels of which are chosen by the household. To correct for the likely case that this endogenous variable will bias the estimated school effect, farm and off-farm labor are modeled as functions of household size, gender composition of the household, wages, and the relative productivity of labor in farm and off-farm activities.[23] Household size and gender composition enter the labor functions primarily because it is the total household level of labor supply, not individual-level labor supply, that is being modeled.[24] This model of labor supply assumes that labor markets are not perfect and that the principal of separation does not hold. As already noted, the average farm household spends less than 5 percent of the farm income on hiring in outside labor, which suggests that formal labor markets are not very active. This model of labor supply allows equations (2) and (3) to be rewritten as

[23]The relative productivity in the farm and off-farm activities is measured by wages in the two sectors. The measure of farm wages used is the wages for an adult male, day laborer. The measures of off-farm wages are representative of the wages faced by the sample, yet are drawn from an independent sample. The supplemental education module was included for only a randomly selected half of the total sample. From the half that did not receive the supplemental module, an hourly wage for all off-farm work was calculated and then grouped by occupation types. From these occupation groupings, which are representative of the off-farm work of the tested sample, mean wages by regions are calculated and then used as estimates of the off-farm wages faced by the sample.

[24]Gender composition is also included, as there are cultural norms that dictate that men, women, and children will typically perform different work activities; and, often times, the activities of the women and children will not be picked up in the measure of off-farm work. For example, the time spent collecting firewood or food preparation is not included in the measure of total hours worked.

Farm Income

$$\ln (Y_f^* + 1) = \ln Y_f(\boldsymbol{A_f}, L_f(Y_f^*, Y_o^*, X_h, \boldsymbol{T_f}, \boldsymbol{T_o}), \boldsymbol{p}, \boldsymbol{S}, \mu)$$

$$= \ln Y_f^*(\boldsymbol{A}, X_h, \boldsymbol{T}, \boldsymbol{p}, \boldsymbol{S}, \mu), \quad (4)$$

Off-farm Income

$$\ln (Y_o^* + 1) = \ln Y_o^*(A_o, L_o(Y_f^*, Y_o^*, X_h, \omega_o, \omega_f), S, \varepsilon)$$

$$= \ln Y_o^*(A, X_h, \omega, p, S, \varepsilon), \quad (5)$$

where $\boldsymbol{A}$ is the vector of fixed farm and off-farm inputs, X_h represents household characteristics, $\boldsymbol{T}$ is a vector of farm and off-farm wages, $\boldsymbol{p}$ is a vector of farm input and output prices, $\boldsymbol{S}$ is the vector of household school attainment variables discussed above, and μ, ε, and ν are error terms. It is again assumed that Y_f and Y_o are observed for all households, but Y_f^* and Y_o^* are only observed if positive.

4. ESTIMATION

Most household survey data is fraught with violations of the assumptions made for the classical linear regression model. The GLSS data is no exception. Three important sources of the violations are censored observations, outlier values, and two-stage sample design. The estimation methods used in this paper are sensitive to these three factors. The regression estimates presented in this paper are either least absolute deviations (LAD) estimators or censored least absolute deviations (CLAD) estimators. The standard errors

used for these estimators are bootstrap estimates, which are derived by replicating the two-stage sample design.

CENSORED DEPENDENT VARIABLES

Roughly 70 percent of all Ghanaian households are engaged in farming activities, and similarly about 67 percent of the households generate some of their household income from off-farm activities. The strategy used in this paper avoids modeling the selection rule determining who farms and who does not, and simply treats farm and off-farm income as data that are censored at zero.[25]

The problem introduced by censoring is that OLS results in biased estimators, and the standard Tobit or Heckman estimators for censored models rely heavily on the assumption of normality. Arabmazar and Schmidt (1981) show that the bias resulting from the Tobit estimator in the presence of heteroscedastic residuals can be quite large. Vijverberg (1987) presents similar results showing that the bias of the Tobit estimator is quite large when kurtosis and skewness are nonnormal. Powell's CLAD estimator results in consistent estimates for the limited dependent variable model in the presence of many violations of normality, including heteroscedasticity.

[25]This decision is made because it is difficult to find variables that explain why a household engages in farming, but that have no effect on the households farming abilities. This is particular true in a country like Ghana, where movement between farm and off-farm activities is fairly fluid, and so many households are engaged in both activities.

OUTLIERS AND OTHER VIOLATIONS OF NORMALITY

A standard feature of many household data sets is the presence of unusually large or small values. In addition to outliers, the skewness and kurtosis of the data will often exhibit nonnormal characteristics.[26] When the dependent variable in a model contains outlier values or is nonnormally distributed, it is likely that the resulting residuals will be nonnormally distributed. Consider, for example, the total income variable used in this paper. The mean value for total household income is ₡326,743, the standard error of total income is ten times this size, and the maximum value is ₡140,000,000. The residuals from estimating the log of total household income, exhibit large values of kurtosis and strongly violate the assumption of normality.[27]

It is these characteristics that frequently lead either the statistical agency that collected the data or the researcher using the data to arbitrarily dispense of observations that seem incredibly large or small. Often the rules used to include or exclude variables are based on some prior belief that the data *should* be normally distributed. The advantage of the LAD and CLAD estimators used in this paper is that they are less sensitive to outliers than OLS and are robust to violations of kurtosis. For this reason, no extreme data points are excluded from the sample and arbitrary selection rules are

[26]Often times, one or two large outliers are enough to significantly affect the skewness. The assumption that kurtosis is near 3, which is indicative of normality, is also typically violated, because the number of relatively extreme values is large. (In other words, the tails of the distribution are typically 'thicker' than those of the normal distribution.)

[27]The value of kurtosis is 10.4 for the residuals. The Shapiro-Francia (1972) test of normality for the residuals from predicting the log of total income results is a Z-statistic of 9.6, which has a p-value of approximately zero.

avoided. The LAD estimators are less sensitive to outliers than OLS because it is the distance from the median and not the square of the distance (from the average) that determines the parameter estimates. (This is analogous to the fact that medians are less sensitive to outliers than are means.)

COMPLEX SAMPLE DESIGN

As with essentially all nationwide household surveys, the design of the GLSS sample is not a simple random draw of households. The GLSS sample design is a two-stage, systematic design, which results in a clustered and stratified sample.[28] The two-stage aspect of the design entailed first dividing Ghana into numerous clusters or geographic regions and assigning to each cluster a weight that was proportional to the population residing within the cluster. Then using these weights, approximately 200 clusters were randomly chosen.[29] The second stage of the sample selection process randomly selects a fixed number of households within each cluster.[30]

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[28]The systematic aspect of the sample design results in a sample that is stratified on geographic (coastal, forest, and savannah) and urban/rural regions. The stratification ensures that the sample is in proportion to the population of the strata. Stratification will also reduce sampling error to the extent that the characteristics defining the strata are correlated with the variables of interest. (For more details on the sample design, see Scott and Amenuvegbe 1989.)

[29]Fewer than 200 unique clusters were selected because once a cluster was selected, it was returned to the pool of candidate clusters. Selection with replacement allows for the possibility that certain clusters will be selected more than once.

[30]In the case of Ghana, 16 households were selected from within each cluster. If the same cluster was chosen twice, for example, then 32 households were selected. Household selection, in contrast to cluster selection, was not done with replacement.

The advantages of a clustered, two-stage sample design are purely practical. By using a clustered design, the interview teams are required to cover less territory and the cost of the survey is dramatically reduced. A disadvantage of the clustered design is that clustering will typically result in higher estimated variances than the same number of observations from a purely random sample. Another more generic and important disadvantage of complex designs is that analytical standard errors can become difficult to calculate.[31]

The primary concern with data from a two-stage sample design is that it is likely to result in residuals that are neither homoscedastic nor independently distributed. This is because households within a specific cluster are likely to be more similar to each other than to households in other clusters. The result of this is that intracluster variation is likely to be significantly different from inter-cluster variation of the residuals. Numerous papers illustrate that these violations can have large effects on estimated parameters and standard errors, and it is now being somewhat more widely recognized in the economics literature that correcting for these violations are important for generating credible results.[32] This section proceeds by examining whether the residuals from estimating total household, farm, and off-farm income exhibit heteroscedasticity and dependence.

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[31]For a more detailed discussion about the advantages and disadvantages, as well as the estimation implications, of complex survey designs, see Howe and Lanjouw-Olson (1995).

[32]Scott and Holt (1982) for example, discuss the impact of sample design on the correction required for the OLS standard errors. Arabmazar and Schmidt (1981) show that when complex sample designs result in heteroscedasticity, that standard limited dependent variable estimators (including the Tobit and Heckman's two-step procedure) are significantly biased.

INDEPENDENT AND IDENTICALLY DISTRIBUTED RESIDUALS

The Breusch-Pagan (1979) test is used to check the assumption of homoscedastic residuals from the total income regression model. This test statistic strongly rejects the assumption of homoscedasticity.[33] The Breusch-Pagan test cannot be directly used to examine the assumption of homoscedasticity for the farm and off-farm income models because a necessary condition of the test is that the vector of errors have an expected value of zero. Since both farm and off-farm income are censored at zero, the residuals from OLS estimation will not have an expected value of zero in the presence of heteroscedasticity. Pagan and Vella (1989) propose a modified version of the Breusch-Pagan test that first constructs "generalized" residuals by using any consistent estimator and then employs the standard Breusch-Pagan test. The Pagan-Vella test statistics from the household farm and off-farm income regressions strongly reject the assumption of homoscedasticity in these models.[34]

The observed heteroscedasticity of the residuals most likely results from the cluster design of the sample. If observations are more similar within clusters than they are across clusters, this will likely affect the residuals in a similar fashion. Observing a pattern of intracluster correlation of the residuals suggests that the assumption of independently distributed errors is also untenable. The Kish design effect provides a measure of

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[33]The p-value of the statistic is essentially zero. The test statistic is equal to 560, which is distributed as a χ^2 with 60 degrees of freedom.

[34]The p-value of both of these test statistics are zero. The test statistics are 1,152.5 and 108.6 for the farm and off-farm functions, respectively. Both statistics are distributed as a χ^2 with 60 degrees of freedom.

intracluster correlation, and the square root of this statistic provides an estimate of the extent to which the dependence of the residuals affects the standard errors.[35]

The LAD residuals from estimating the log of total income have a Kish design effect equal to 2.18, suggesting that the standard errors will need to be increased by roughly 48 percent to correct for the sample design effects.[36] The magnitude of this adjustment is difficult to ignore, yet analytical solutions are complicated and difficult to implement. Rogers (1993) suggests the use of bootstrap standard errors to correct for heteroscedasticity, but this does not address the problem of correlated residuals. The standard bootstrap fails to correct for dependent residuals, because the bootstrap method typically redraws samples using purely random selection. Since the sample design is not a pure random sample, this bootstrap method will not accurately reflect the characteristics of the data.

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[35]The Kish design effect, which measures intracluster correlation, is given by

$$1 + \left(\frac{\Sigma n_{ci}^2}{n} - 1 \right) \left(\frac{\Sigma\Sigma\Sigma_{c \; i \; j \neq 1} (x_{ci} - \bar{x})(x_{cj} - \bar{x})}{\hat{\sigma}^2 \Sigma_c n_c (n_c - 1)} \right)$$

where n is the total number of households and n_{ci} is the number of households in cluster i.

[36]These adjustments assume that the only corrections required for the LAD standard errors are due to the sample design effects. This may not be the case, as Rogers (1993) shows that the LAD standard errors reported by *Stata* are not robust to violations of homoscedasticity of any sort.

In order to correct for both heteroscedasticity and the dependence of the residuals, this paper uses a bootstrap procedure that replicates the sample design. The bootstrap resamples the data using a two-stage procedure, which is also stratified on the three geographic regions of Ghana as well as the urban/rural split. In the first stage, clusters are randomly selected from each of the six strata. In the second stage, a fixed number of households are selected in each cluster.[37] Using this method, each household does not have an equal probability of being chosen; rather, there is a dependence created in the re-sampling such that if one household is selected in a cluster, then the probability of selection for the other households in that cluster increases. By following this method, the redrawn samples exhibit the same characteristics as the initial sample, and the estimated standard errors are robust to violations of both homoscedasticity and independence.

LAD AND CLAD ESTIMATORS

To estimate total household income, this paper uses the LAD estimator. The properties of this estimator are presented in Koenker and Bassett (1978).[38] The LAD estimator is found by minimizing

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[37]The number of selected households is equal to the total number of households that are in the cluster. Similarly, the number of clusters chosen from each strata is equal to the number of clusters that belong in each strata. The random selection is with replacement, so a given household or cluster may be represented more than once in any of the bootstrapped samples.

[38]The LAD estimates presented in this paper come from Stata's *qreg* command, which follows Koenker and Bassett in deriving its estimates. Rogers (1993) shows that the standard errors reported by Stata are not robust to violations of homoscedasticity or independence. The standard errors presented in this paper are derived from the stratified, two-step bootstrap procedure described above.

$$\sum | y_i - x_i' \beta | . \quad (6)$$

To estimate farm and off-farm income, both of which are censored at zero, this paper uses Powell's (1984) CLAD estimator. This estimator provides consistent estimates for the censored model when heteroscedasticity is present, as well as other violations of normality. The CLAD estimator is found by minimizing

$$\sum | y_i - \max(0, x_i' \beta) | . \quad (7)$$

The consistency of this estimator rests on the fact that medians are preserved by monotone transformations of the data, and equation (7) is a monotone transformation of equation (6), the standard median regression.

The estimation technique used in this paper for the CLAD estimator is Buchinsky's (1994) iterative linear programming algorithm (ILPA). The first step of the ILPA is to estimate a quantile regression for the full sample, then delete the observations for which the predicted value of the dependent variable is less than zero.[39] Another quantile regression is estimated on the new sample, and again negative predicted values are

[39]More generally, observations are dropped if the predicted value is less than the censoring value when the left tail of the distribution is censored. Similarly, observations are dropped if the predicted value is greater than the censoring value when the right tail of the distribution is censored.

dropped. Buchinsky (1991) shows that if the process converges,[40] then a local minimum is obtained.

5. RESULTS

This section first summarizes the results from testing the weakest link, talented tenth, household head, and household average models of school attainment. Each of the models is tested for the three measures of household income (total, farm, and off-farm).[41] This section then summarizes results from estimating household income separately, using the maximum, average, and household head's level of school attainment. In addition to comparing the differences in the estimated effects of school attainment from using different measures of school attainment, this section discusses the differences between OLS and LAD estimates as well as the effect on the standard errors from correcting for sample design effects. In conclusion, an extension to the model of schooling, which incorporates gender, is discussed.

[40]Converges occur when there are no negative predicted values in two consecutive iterations. All of the models estimated in this paper converged, and, typically, converged in fewer than 15 iterations.

[41]The models are tested over three samples—all households, households with two or more adults, and households with three or more adults. Only the results from using the sample with two or more adults are presented in this paper. The estimation results from the other two samples are qualitatively similar and are presented in Jolliffe (1996).

TESTS OF HOUSEHOLD SCHOOL ATTAINMENT MODELS

Weakest Link and Household Head Models

The two conditions tested for the weakest link model state that the minimum value of schooling is the only school variable that has a statistically significant effect on the determination of household income. The null hypothesis tested is actually that the minimum level of schooling has no effect. Rejection of this is taken as evidence supporting the weakest link model.[42] The other hypothesis is that the average and maximum level of schooling have no effect on income. Failing to reject this hypothesis is supportive of the weakest link model. In discussing the results, rejecting a model means that one of the two tests is not supportive of the model, strongly rejecting means both tests fail to support the model, and failing to reject means the results from testing both hypotheses support the model.

Appendix Table 7 presents the full results from estimating household income, using minimum, average, and maximum levels of household schooling. Table 2a summarizes this table by presenting the p-values from testing each of the school models. (This table also shows the estimated schooling parameters.) Table 2b presents the summary test statistics for each of the schooling models, using the minimum, median, and maximum level of schooling.[43]

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[42]Throughout this paper, a hypothesis is rejected if the p-value of the test statistic is less than (or equal to) 0.10.

[43]The full set of estimation results, when median schooling is used instead of average schooling, are not provided in this paper. They are essentially the same as the full estimation results provided in Appendix Table 7. (The primary differences are in the schooling estimates, which are listed.)

The test results presented in these tables present a strong argument against the weakest link and household head models.[44] In all cases of estimating total, farm, or off-farm income and over the three samples, both models are rejected.[45] As a large percentage of household heads are the least educated household member, it is perhaps not too surprising that the results from testing these two models are similar.

Talented Tenth and Household Average Models

The results from testing the maximum and average values of schooling are somewhat mixed. When the minimum, average, and maximum levels of schooling are used, the data reject the talented tenth model (see Table 2a). This contrasts with the results presented in Table 2b, which support the talented tenth model for predicting total household income. The only difference between these sets of tables is that the median

[44]The household head model is tested by reestimating (1) with the head's education level included with the minimum, average, and maximum schooling levels. For the sake of brevity, only the p-values from the relevant F-tests are reported in this paper; the regression results are omitted. The results are qualitatively similar to the regression results reported in Appendix Table 7.

[45]The weakest link model is strongly rejected in four of the nine cases where the minimum, average, and maximum levels of schooling are used.

Table 2a Tests of minimum, average, and maximum schooling: Household income and schooling (households with two or more adults)

	Total income		Farm income		Off-farm income	
	LAD[a] Estimate	Standard Error	CLAD[b] Estimate	Standard Error	CLAD Estimate	Standard Error
Household minimum level of schooling	0.016	(0.0340)	-0.071	(0.0852)	-0.042	(0.1323)
Household average: years of schooling	-0.016	(0.0608)	0.285	(0.1613)	0.434	(0.2457)
Household maximum level of schooling	0.036	(0.0306)	-0.084	(0.0798)	-0.158	(0.1340)
Weakest link	Reject[c]		Reject[d]		Reject	
H_0: Condition 1 (average and maximum = 0)	0.13		0.10		0.11	
Condition 2 (minimum = 0)	0.63		0.41		0.75	
Talented Tenth	Reject		Reject[*]		Reject[d]	
H_0: Condition 1 (minimum and average = 0)	0.83		0.10		0.00	
Condition 2 (maximum = 0)	0.24		0.29		0.24	
Average Member	Reject		Fail to Reject[e]		Fail to Reject	
H_0: Condition 1 (min & max = 0)	0.42		0.57		0.36	
Condition 2 (avg = 0)	0.79		0.08		0.08	
Head of Household	Reject		Reject		Reject[d]	
H_0: Condition 1 (minimum, average and maximum = 0)	0.73		0.54		0.07	
Condition 2 (head = 0)	0.39		0.47		0.64	

Notes: The parameter estimates are presented in full in Appendix Table 7. Evidence supporting a model appears as a large p-value for Condition 2 and a small p-value for Condition 1. The sample is all households with two or more members 15 years of age or older.

[a] Least absolute deviations estimators.

[b] Censored least absolute deviations estimators.

[c] One of these two conditions fails to support the model.

[d] Both conditions fail to support the model.

[e] Both conditions provide evidence that supports the model.

Table 2b Tests of minimum, median, and maximum schooling: Household income and schooling (households with two or more adults)

	Total income		Farm income		Off-farm income	
	LAD[a] Estimate	Standard Error	CLAD[b] Estimate	Standard Error	CLAD Estimate	Standard Error
Household minimum level of schooling	0.011	(0.0207)	0.010	(0.0506)	0.088	(0.0756)
Household median level of schooling	-0.007	(0.0276)	0.121	(0.0646)	0.173	(0.1116)
Household maximum level of schooling	0.032	(0.0175)	-0.005	(0.0412)	-0.028	(0.0764)
Weakest link	Reject[c]		Reject[d]		Reject	
H_0: Condition 1 (median and maximum = 0)	0.11		0.07		0.15	
Condition 2 (minimum = 0)	0.59		0.85		0.24	
Talented tenth	Fail to Reject		Reject[d]		Reject[d]	
H_0: Condition 1 (minimum and median = 0)	0.86		0.10		0.00	
Condition 2 (maximum = 0)	0.07		0.90		0.71	
Median member	Reject		Fail to Reject[e]		Reject	
H_0: Condition 1 (minimum and maximum = 0)	0.19		0.97		0.42	
Condition 2 (median = 0)	0.81		0.06		0.12	
Head of household	Reject		Reject		Reject	
H_0: Condition 1 (minimum, median, and maximum = 0)	0.72		0.37		0.12	
Condition 2 (head = 0)	0.42		0.42		0.60	

Notes: The full set of parameter estimates are not presented in this paper, though they are essentially the same as those reported in Appendix Table 7. The only difference between the model presented in Appendix Table 7 and this model is that the median level of schooling is used rather than the average level of schooling. Evidence supporting a model appears as a large p-value for Condition 2 and a small p-value for Condition 1. The sample is all households with two or more members 15 years of age or older.

[a] Least absolute deviations estimators.

[b] Censored least absolute deviations estimators.

[c] One of these two conditions fails to support the model.

[d] Both conditions fail to support the model.

[e] Both conditions provide evidence that supports the model.

level of schooling is used in Table 2b in place of the average level of schooling. The difference between these two sets of results comes from the difference in the standard errors of the parameter estimates.[46] When the median level of schooling is used instead of the average level of schooling, the estimated effect of the maximum level of schooling is much more precisely estimated. This difference may be partially due to the fact that even though the median and the average levels of schooling are very similar,[47] the median level of schooling is not as highly correlated (as the average level of schooling) with the maximum level of schooling.[48]

The summary results presented in Table 2a show some support for using the average level of schooling when predicting farm and off-farm income. Similarly, the results presented in Table 2b show some support for using the median level of schooling when estimating farm and off-farm income. The data fail to reject the household average model when estimating farm income using all households, and when using all households with two or more adult members. Similarly, the data fail to reject the household average model when estimating off-farm income using the sample of households with two or more adults, and when using households with three or more adults.

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[46]The point estimates for maximum schooling are almost identical, whether the median or average level of schooling is used.

[47]They have the same minimum, median, and maximum values, and the difference between their average values is statistically insignificant. However, the difference between their variances is statistically significant.

[48]The coefficient of correlation between maximum schooling and average schooling is 0.89, while the correlation between the median level of schooling and maximum is 0.85.

COMPARISON OF HEAD, MINIMUM, AVERAGE, AND MAXIMUM ESTIMATES

Table 3 presents a summary of results from estimating the log of household income (total, farm, and off-farm income) separately using the household minimum, average, maximum, and head of household's school level. For example, the parameter estimate for head's schooling in the total income column results from regressing total income on only the head's schooling and the other nonschool explanatory variables. The results from Tables 2a and 2b suggest that either the average or maximum values of schooling serves as better measures of household school levels (depending on whether total income or its components are being estimated), and that the school level of the head of household will likely mismeasure the effect that the household's schooling level has on income. Table 3 presents some evidence that using the head of household for the GLSS data will somewhat underestimate the return to schooling.

The estimated return to schooling from using the maximum level of schooling to predict total income is 27 percent higher than from using the head's schooling. The estimated return to schooling from using the average household level to predict farm and off-farm income is 22 and 29 percent higher than from using the head's schooling.[49] Table 3 also shows that the estimates for the head of household are very similar to the estimates from using the minimum value of schooling. While the differences across parameters are not statistically significant, they show further support for rejecting the

[49]Similarly, the estimated return to schooling from using the household median level to predict farm and off-farm income is 21 and 23 percent higher, respectively, than from using the head's schooling.

Table 3 Comparison parameter estimates: Household school attainment measures and household income

	Total household income		Farm Profit		Off-farm income	
	LAD[a] Estimate	Standard Error	CLAD[b] Estimate	Standard Error	CLAD Estimate	Standard Error
Household head: schooling	0.037	(0.0114)	0.097	(0.0330)	0.194	(0.0390)
Household minimum: schooling	0.038	(0.0121)	0.096	(0.0423)	0.215	(0.0442)
Household maximum: schooling	0.047	(0.0125)	0.069	(0.0316)	0.185	(0.0395)
Household average: schooling	0.052	(0.0140)	0.118	(0.0467)	0.250	(0.0465)

Notes: Each parameter in the table results from separately estimating the school effects. The full regression results for the average, maximum, and head of household models are presented in Appendix Table 8 for total income. The full set of results for farm and off-farm income are presented in Jolliffe (1996). The regression results from the minimum model are very similar to the results for the head of household model, and for the sake of brevity are not presented in full. Household total income is estimated in log form, using the least absolute deviations estimator. Farm and off-farm income are estimated in log form using the CLAD estimator. The standard errors are estimated with 500 replications of the bootstrap two-step, stratified procedure described in the paper. The sample includes all households with at least one member 15 years of age or older.

[a] Least absolute deviations estimators.

[b] Censored least absolute deviations estimators.

head of household model in favor of the household maximum or household average model.

This paper discusses in detail the problems of the data, both in terms of violations of nonnormality and in the complex nature of the sample design. The paper argues that the violations of normality that are observed in the data are likely to result in differences between the OLS and LAD estimators. The paper also argues that the complex sample design is likely to result in reported standard errors that dramatically underestimate the correct standard error. Table 4 presents some evidence to support these claims.

Table 4 presents a summary of two separate specifications of the log of total household income. The first specification uses the maximum level of schooling as the measure of household schooling and the second uses the average level of schooling in the household. Both specifications are estimated by OLS and LAD, and both show that the OLS estimates are significantly larger than the LAD estimates. (The OLS estimate for maximum schooling is 94 percent greater than the LAD estimate.) Similarly, the table shows the difference between standard errors that assume identical and independently distributed (iid) errors and standard errors that have been corrected for violations of the iid assumption. This correction results in standard errors that are substantially larger in size.

Table 4 Comparison of parameter estimates: Sample design effects and standard errors, OLS versus LAD

Dependent variable: Log of total household income	OLS Estimate	Standard Error[b]	LAD[a] Estimate	Standard Error[c]	LAD Estimate	Standard Error[d]
Household maximum: schooling	0.091	(0.0161)	0.047	(0.0074)	0.047	(0.0125)
Household average: schooling	0.107	(0.0218)	0.052	(0.0086)	0.052	(0.0140)

Notes: Household total income is estimated in log form. The sample includes all households with at least one member 15 years of age or older. The remaining regression results have been suppressed here and are presented in full in Jolliffe (1996).

[a] Least absolute deviations estimators.
[b] Standard errors are Huber-corrected for sample design effects.
[c] Standard errors are uncorrected for sample design effects.
[d] The standard errors are estimated with 500 replications of the bootstrap two-step, stratified procedure described in the paper.

GENDER AND HOUSEHOLD SCHOOLING

One important issue so far ignored in this paper is that gender may play an important role in whether income can be explained by a specific individual's school attainment. For example, one hypothesis could be that the maximum school level only matters if it is held by a male or a female. This paper will briefly explore this issue by considering a null hypothesis that the gender of the individual with the minimum or maximum level of schooling has no effect on the determination of household income.

To test this hypothesis, total income, farm profit, and off-farm income are estimated using four variables for school measures: years of schooling of the least educated male and female, and years of schooling of the most educated male and female.[50] Under the null hypothesis, the parameters on the minimum level of schooling will be equal for men and women, as will be the parameter estimates for the maximum level of schooling. In addition, the null hypothesis is only credible if the four school variables are jointly significant.

The results summarized in Table 5 are fairly ambiguous. For total income, farm profit, and off-farm income, the data fail to reject the hypothesis that the school affects are the same across genders.[51] This supports the null hypothesis that there are no gender effects of this type. The ambiguity results from noting that for the total income and farm

[50]The model is tested on the sample of all households with at least one male and female adult member.

[51]These tests are listed as Condition 1a and 1b separately, as well as the joint test of Condition 1a and 1b together.

Table 5 Tests of joint significance for the gender model (p-values reported)

Tested Hypotheses	Total income	Farm profit	Off-farm income
Condition 1a: The effect of the female's minimum schooling is the same as the male's	0.45	0.64	0.99
Condition 1b: The effect of the female's maximum schooling is the same as the male's	0.25	0.30	0.52
Condition 1a and 1b jointly true:	0.52	0.53	0.68
Condition 2: All four school terms (female minimum and maximum, male minimum and maximum) are jointly equal to zero	0.16	0.25	0.00

Notes: The statistics reported are the p-values from four separate joint conditions estimated over total income, farm profit, and off-farm income. The sample contains all households with one adult male and one adult female member. The p-values are based on the regression results reported in Jolliffe (1996, Table 17). Total income is estimated by LAD, while farm and off-farm income are estimated by CLAD. The p-values are based on a variance-covariance matrix that is the result of 500 replications of the two-step, stratified bootstrap procedure described in the paper.

functions, the school terms are not jointly significant. One interpretation of the results is that the data is not well-suited for exploring in greater detail how the allocation of schooling across gender affects income.

6. CONCLUSION

The focus of this paper is on finding an appropriate statistic or variable to measure a household's level of education attainment. The motivation comes from noting that in developing countries, income is primarily earned (or more importantly, measured) at the household level and not the individual level. The overwhelming majority of the literature

assumes that the education attainment of the head of household measures the entire household's level of education attainment. On the basis of only the basic descriptive statistics presented in this paper, this assumption appears dubious.

This paper presents further evidence against using the head of household by testing three competing models of school attainment against each other and against the head of household model. The most unambiguous result in this paper is the robust rejection of the weakest link and head of household model.[52] While the estimation results reject using either the minimum level or the head's level of education to measure household school attainment, they show support for using the maximum level of school attainment when estimating total household income. The data also show support for using the average level of schooling when estimating farm and off-farm income.[53]

This paper also asserts that it is important to examine estimates that are robust to violations of normality. Many data sets, particularly data resulting from household surveys in developing countries, are fraught with numerous outliers and other violations of normality. The GLSS data are shown to be no exception to this statement. Similarly, the

[52]The rejection of both of these models is robust to whether total income, farm profit, or off-farm income is estimated, using either the full sample of all households, or the sample of households with two or more adults, or the sample with three or more adults.

[53]No attempt is made in this paper to explain why the average level of schooling is important for farm and off-farm income, while the maximum level of schooling is important for total income. These results are certainly consistent with the hypothesis that the intrahousehold allocation of education affects household income in a complex way. Attempting to produce a richer explanation of how the intrahousehold allocation affects household income is an example of the type of future research this project points toward.

large majority of nationally representative household data sets is based on complex sample designs, which need to be incorporated into the estimation strategy.

The brief summary in Table 4 shows that the differences between OLS and LAD estimates are large. This supports the claim that nonnormalities in general, or outliers in particular, are important to the results and support using estimators like LAD that are robust to these types of violations of normality. Table 4 also shows that the effect of correcting estimated LAD standard errors for violations of the iid assumption is also large.

This paper attempts to explore a richer model of household school attainment that incorporates the possibility that how schooling is distributed across the male and female members may also be an important determinant of income. The GLSS data do not support the hypothesis that it is important to capture the gender differences in school attainment when estimating household income. This rejection, though, is weak, and primarily suggests that the hypothesis is not well tested with the GLSS data.

The attempt to test whether schooling affects household income differently if held by a male or female is a good example of the type of research this paper points toward. This paper focuses on finding a unidimensional statistic to measure household school attainment, which is a complex, multidimensional characteristic. While the paper shows that the maximum and the average level of schooling are both better measures of household school attainment than the minimum or household head's, these measures are still somewhat naive and restrictive. An area for future research, then, is to explore in more detail how the allocation of education across different household members of

different ages or genders and across individuals engaged in different activities, affects household income.

APPENDIX

Table 6 Descriptive statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Income					
Log: Total household income	1,547	11.02	3.137	0	18.76
Log: Restricted farm profit	1,547	8.04	5.160	0	14.15
Log: Off-farm income	1,547	7.29	5.379	0	18.76
Schooling[a]					
Household minimum level of schooling	1,547	3.80	4.711	0	20
Household median level of schooling	1,547	5.55	4.763	0	21.5
Household maximum level of schooling	1,547	7.40	5.247	0	23
Household head: Schooling	1,547	5.63	5.566	0	23
Household average: Years of schooling	1,547	5.58	4.516	0	21.5
Household minimum male schooling	921	6.16	5.357	0	23
Household minimum female schooling	921	3.39	4.528	0	20
Household maximum male schooling	921	7.62	5.381	0	23
Household maximum female schooling	921	4.94	4.958	0	20
Farm income					
Log (acres of land farmed)	1,547	1.90	1.906	0	6.55
Household average: Log of farm experience	1,547	1.70	1.231	0	4.19
Cluster/Zone average: Day farm wage	1,547	3.44	1.120	0	6
Region average: Ln(price fertilizer)	1,547	7.57	0.245	7.05	7.93
Region average: Ln(price insecticide)	1,547	7.11	0.508	6.19	7.85
Region average: Price of maize	1,547	51.56	24.264	20	157.5
Region average: Price of okra	1,547	6.75	3.490	2	32
Region average: Price of cassava	1,547	11.28	8.678	0.07	40
Region average: Price of pepper	1,547	29.45	9.754	6	58.88
Off-farm income					
Log: Business assets	1,547	3.72	4.384	0	19.60
Household maximum: ln(off-farm experience)	1,547	1.58	1.187	0	4.511
Area average: Off-farm wage, type 1	1,547	0.350	0.111	0.082	0.454
Area average: Off-farm wage, type 2	1,547	0.470	0.148	0.204	0.654
Area average: Off-farm wage, type 3	1,547	0.751	0.243	0.388	1.093
Area average: Off-farm wage, type 4	1,547	0.833	0.321	0.385	1.532
Area average: Off-farm wage, type 5	1,547	2.165	1.061	0.990	3.883
Household characteristics					
Number of males: 15-24 years old	1,547	0.387	0.692	0	5
Number of males: 25-34 years old	1,547	0.237	0.443	0	3
Number of males: 35-44 years old	1,547	0.173	0.379	0	1
Number of males: 45-55 years old	1,547	0.125	0.331	0	1
Number of females: 15-24 years old	1,547	0.388	0.642	0	5
Number of females: 25-34 years old	1,547	0.310	0.498	0	3
Number of females: 35-44 years old	1,547	0.176	0.396	0	2
Number of females: 45-55 years old	1,547	0.157	0.385	0	3

[a] The sample size for the most (and least) educated male and female in the household is 921. For the example on gender differences, only those households with at least one adult male and female are included.

Table 7 Household income and household schooling estimates of (1) using all households with two or more adults

	Total household income		Farm Profit		Off-farm income	
	LAD[a] Estimate	Standard Error	CLAD[b] Estimate	Standard Error	CLAD Estimate	Standard Error
Household minimum level of schooling	0.016	(0.0340)	-0.071	(0.0852)	-0.042	(0.1323)
Household average: Years of schooling	-0.016	(0.0608)	0.285	(0.1613)	0.434	(0.2457)
Household maximum level of schooling	0.036	(0.0306)	-0.084	(0.0798)	-0.158	(0.1340)
Log (acres of land farmed)	0.172	(0.0501)	0.818	(0.1445)	0.015	(0.1730)
Household average: Log of farm experience	-0.062	(0.0711)	2.720	(0.5371)	-1.246	(0.2937)
Cluster/Zone average: Day farm wage	-0.040	(0.0824)	-0.025	(0.1442)	0.083	(0.3249)
Region average: Ln(Price fertilizer)	-1.106	(0.4936)	0.084	(1.9166)	0.469	(2.2422)
Region average: Ln(Price insecticide)	-0.140	(0.3861)	-0.488	(1.4769)	0.138	(1.8850)
Region average: Price of maize	0.002	(0.0032)	0.017	(0.0093)	0.006	(0.0114)
Region average: Price of okra	-0.003	(0.0211)	0.019	(0.0565)	-0.038	(0.0968)
Region average: Price of cassava	0.013	(0.0097)	0.004	(0.0274)	0.039	(0.0471)
Region average: Price of pepper	0.008	(0.0066)	0.009	(0.0157)	0.000	(0.0312)
Log: Business assets	0.025	(0.0126)	0.056	(0.0282)	0.237	(0.0518)
Household maximum: ln(Off-farm experience)	0.062	(0.0581)	-0.247	(0.1184)	2.319	(0.3220)
Area average: Off-farm wage, type 1	4.189	(5.8086)	-9.827	(15.642)	-1.971	(22.944)
Area average: Off-farm wage, type 2	-1.043	(1.6276)	2.869	(4.2740)	2.312	(6.9801)
Area average: Off-farm wage, type 3	-1.439	(2.1959)	5.088	(5.5675)	2.044	(7.9940)
Area average: Off-farm wage, type 4	-1.007	(0.7465)	0.950	(2.3684)	0.059	(3.1652)
Area average: Off-farm wage, type 5	-0.083	(0.1567)	-0.953	(0.9674)	-0.436	(0.6817)
Number of males: 15-24 years old	0.064	(0.0742)	0.184	(0.1676)	-0.112	(0.2957)
Number of males: 25-34 years old	0.286	(0.1477)	0.342	(0.2727)	0.718	(0.5264)
Number of males: 35-44 years old	0.323	(0.1331)	0.127	(0.3007)	0.173	(0.5369)
Number of males: 45-55 years old	0.161	(0.1424)	0.239	(0.2853)	0.433	(0.6274)
Number of females: 15-24 years old	0.189	(0.0714)	0.362	(0.1807)	0.067	(0.3502)
Number of females: 25-34 years old	0.261	(0.1054)	0.412	(0.2692)	0.604	(0.4890)
Number of females: 35-44 years old	0.174	(0.1108)	0.456	(0.3046)	0.078	(0.5577)
Number of females: 45-55 years old	0.000	(0.1132)	-0.533	(0.2707)	-0.140	(0.5533)
Intercept	21.016	(5.0576)	1.491	(15.250)	-2.547	(23.344)
Pseudo R^2	0.105		0.333		0.224	
Number of observations	1,059		989		1,027	

Notes: Household total, farm, and off-farm income are all estimated in log form. The standard errors are estimated with 500 replications of the two-step, stratified bootstrap procedure described in the paper. The sample includes all households with at least two members 15 years of age or older. The total income is estimated by least absolute deviations, while farm and off-farm income are both estimated using Powell's censored least absolute deviations estimator.

[a] Least absolute deviations estimators.
[b] Censored least absolute deviations estimators.

Table 8 Total household income and household schooling: Comparison of household head s schooling, maximum, and average schooling

	LAD[a] Estimate	Standard Error	LAD Estimate	Standard Error	LAD Estimate	Standard Error
Household head: Schooling	0.037	(0.0114)				
Household maximum level of schooling			0.047	(0.0125)		
Household average level of schooling					0.052	(0.0140)
Log(acres of land farmed)	0.148	(0.0416)	0.132	(0.0416)	0.150	(0.0449)
Household average: log of farm experience	0.101	(0.0659)	0.080	(0.0646)	0.095	(0.0657)
Cluster/Zone average: Day farm wage	-0.032	(0.0778)	-0.078	(0.0896)	-0.040	(0.0818)
Region average: Ln(price fertilizer)	-1.219	(0.5598)	-1.257	(0.5159)	-1.135	(0.4972)
Region average: Ln(price insecticide)	-0.049	(0.3917)	-0.158	(0.3790)	-0.125	(0.3637)
Region average: Price of maize	0.004	(0.0031)	0.004	(0.0031)	0.004	(0.0030)
Region average: Price of okra	-0.002	(0.0237)	0.004	(0.0264)	0.002	(0.0246)
Region average: Price of cassava	0.017	(0.0102)	0.017	(0.0097)	0.017	(0.0094)
Region average: Price of pepper	0.006	(0.0067)	0.007	(0.0072)	0.007	(0.0076)
Log: Business assets	0.025	(0.0132)	0.023	(0.0136)	0.023	(0.0121)
Household maximum: ln(Off-farm experience)	0.166	(0.0539)	0.153	(0.0535)	0.163	(0.0515)
Area average: Off-farm wage, type 1	5.383	(6.4705)	7.175	(6.6618)	6.488	(6.1948)
Area average: Off-farm wage, type 2	-1.072	(1.7531)	-1.701	(1.8695)	-1.566	(1.7599)
Area average: Off-farm wage, type 3	-1.696	(2.4473)	-2.414	(2.5377)	-2.178	(2.3629)
Area average: Off-farm wage, type 4	-1.280	(0.8637)	-1.396	(0.8583)	-1.336	(0.7861)
Area average: Off-farm wage, type 5	-0.175	(0.1639)	-0.152	(0.1544)	-0.136	(0.1447)
Number of males: 15-24 years old	0.135	(0.0699)	0.076	(0.0661)	0.101	(0.0678)
Number of males: 25-34 years old	0.446	(0.1410)	0.442	(0.1315)	0.447	(0.1434)
Number of males: 35-44 years old	0.442	(0.1302)	0.465	(0.1284)	0.494	(0.1289)
Number of males: 45-55 years old	0.256	(0.1530)	0.303	(0.1494)	0.266	(0.1559)
Number of females: 15-24 years old	0.344	(0.0735)	0.263	(0.0727)	0.321	(0.0744)
Number of females: 25-34 years old	0.359	(0.1081)	0.307	(0.1149)	0.322	(0.1019)
Number of females: 35-44 years old	0.234	(0.1275)	0.207	(0.1284)	0.281	(0.1312)
Number of females: 45-55 years old	0.012	(0.1327)	-0.019	(0.1343)	0.003	(0.1294)
Intercept	20.604	(5.2683)	22.018	(5.1657)	20.606	(4.9686)
Pseudo R^2	0.118		0.117		0.119	
Number of observations	1,547		1,547		1,547	

Notes: Household total income is estimated in log form. The standard errors are estimated with 500 replications of the two-step, stratified bootstrap procedure described in the paper. The sample includes all households with at least one member 15 years of age or older.

[a] Least absolute deviations estimators.

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