Living Standards
Measurement Study
Working Paper No. 62

LSM - 62
JAN. 1990

Testing for Significance of Poverty Differences

With Application to Côte d'Ivoire

Nanak Kakwani

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The Living Standards Measurement Study

The Living Standards Measurement Study (LSMS) was established by the World Bank in 1980 to explore ways of improving the type and quality of household data collected by statistical offices in developing countries. Its goal is to foster increased use of household data as a basis for policy decisionmaking. Specifically, the LSMS is working to develop new methods to monitor progress in raising levels of living, to identify the consequences for households of past and proposed government policies, and to improve communications between survey statisticians, analysts, and policymakers.

The LSMS Working Paper series was started to disseminate intermediate products from the LSMS. Publications in the series include critical surveys covering different aspects of the LSMS data collection program and reports on improved methodologies for using Living Standards Survey (LSS) data. More recent publications recommend specific survey, questionnaire, and data processing designs, and demonstrate the breadth of policy analysis that can be carried out using LSS data.

LSMS Working Paper
Number 62

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The World Bank
Washington, D.C.

Manufactured in the United States of America
First printing January 1990

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Library of Congress Cataloging-in-Publication Data

Kakwani, Nanak.
Testing for significance of poverty differences with application to Côte d'Ivoire / Nanak Kakwani.
p. cm. — (LSMS working paper, ISSN 0253-4517 ; no. 62)
Includes bibliographical references (p.).
ISBN 0-8213-1426-2
1. Poor—Ivory Coast—Statistical methods. 2. Households—Ivory Coast--Statistical methods. I. Title. II. Series.
HC1025.Z9P615 1989
362.5'2'096668—dc20 89-70647
CIP

ABSTRACT

Several poverty indices have been suggested to measure the intensity of poverty suffered by those below the poverty line. Because the studies are estimated on the basis of sample observations, we need to test whether the observed differences in their values are statistically significant. This paper provides distribution free asymptotic confidence interval and statistical inference for several poverty indices. The methodology developed in the paper is applied to analyze poverty in Côte d'Ivoire from the data of the Living Standards Survey, 1985.

ACKNOWLEDGEMENT

The paper could not have been completed without the invaluable computational assistance of Kalpana Mehra. Thanks are also due to Maria Felix for typing and to Brenda Rosa for editing the manuscript.

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1. INTRODUCTION

To formulate an adequate program to combat poverty, it is essential to identify the poor and measure the intensity of their poverty. Thus, the measurement of poverty involves two distinct problems: (1) the specification of the poverty line - the threshold below which one is considered to be poor; and (2) once the poverty line is determined, construction of an index to measure the intensity of poverty suffered by those below that line.

Since the publication of Sen's (1976) article on the axiomatic approach to the measurement of poverty, several indices of poverty have been developed, which make use of three poverty indicators:

- the percentage of poor,
- the aggregate poverty gap and
- the distribution of income among the poor.[1/]

These measures differ on the assumptions made about the welfare function implied by them.

Because the poverty measures are estimated on the basis of sample observations, we need to test whether the observed differences in their values are statistically significant. No significant tests have been devised for poverty measures because of their complex nature. The paper considers the

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1/ See for instance Sen (1979), Takayama (1979), Kakwani (1980, 1980a), and Clark, Hemming and Ulph (1981), and Thon (1983). For a review of the literature on poverty indices, see Clark, Hemming and Ulph (1981) and Kakwani (1984).

problem of statistical inference with estimated poverty measures. The problem is of considerable importance because we are often interested in knowing if poverty has increased or decreased over time or in comparing poverty differences between countries or various socio-economic groups within the same country. The asymptotic distributions for poverty measures are derived. The results are used to provide distribution free asymptotic confidence interval and statistical inference for poverty measures.

The methodology developed in the paper is applied to analyze poverty in Côte d'Ivoire. The data for this purpose were obtained from the 1985 Living Standards Survey in the Côte d'Ivoire. A description of the survey and sampling methodology is given in Ainsworth and Muñoz (1986).

2. A BRIEF REVIEW OF POVERTY MEASURES

Suppose income x of an individual is a random variable with the distribution function F(x). Let z denote the poverty line - the threshold income, below which one is considered to be poor. Then F(z) is the proportion of individuals (or families) below the poverty line and has been widely used as a poverty measure. This measure is called the head-count ratio.

The head-count is a crude poverty index because it does not take account of the income-gap among the poor. If the degree of misery suffered by an individual is proportional to the income shortfall of that individual from the poverty line, then the sum total of these shortfalls may be considered an adequate measure of poverty. Such a measure is called the poverty gap ratio and can be written as:

$$G = \int_0^z g(x)f(x)dx = F(z)[\frac{z-\mu^*}{z}] \qquad (2.1)$$

where $g(x) = (z-x)/z$, $f(x)$ is the density function and μ^* the mean income of the poor.

The measure P will provide adequate information about the intensity of poverty if all the poor are assumed to have exactly the same income, which is less than the poverty level. In practice, the income among the poor is unequally distributed and, therefore, P cannot be an adequate measure of intensity of poverty. More inequality of income among the poor with the mean remaining unchanged should imply greater hardship to the extremely poor in a society, and therefore, the degree of the poverty should be higher.

To make G sensitive to the income inequality among the poor Sen (1976) proposed the following poverty measure:

$$S = F(z)\ [z-\mu^*(1-G^*)]/z$$

where μ^* is the mean income of the poor and G^* is the Gini index of the income distribution among the poor. He arrived at this measure on the basis of rank order weighting, which in some way captures the relative deprivation aspect of the poverty.

Suppose that the population is divided into m groups according to certain socio-economic and demographic characteristics of households to which individuals belong. Let $f_i(x)$ be the density function of the ith group. Further, suppose that due to certain government policies, the density function of the ith group changes from $f_i(x)$ to $f_i^*(x)$ and the distributions of the remaining (m-1) groups have not changed at all. As a consequence, the poverty measure P_i of the ith group has changed to P_i^* such that $P_i^* > P_i$. Intuitively then the poverty in the entire population must increase. This property requires that the subgroup and total poverty must move in the same direction. Unfortunately, Sen's poverty measure violates this simple requirement in certain cases. This violation occurs because Sen's measure is not additive separable.

A class of additively separable poverty measures is given by

$$P = \int_0^z \theta(z,x)\ f(x)dx \qquad (2.2)$$

where $\theta(z,x)$ is a function of the poverty line z and income x. P is equal to

the head-count measure of poverty when $\theta(z,x) = 1.0$. The poverty gap measure in (2.1) is obtained when $\theta(z,x) = \frac{(z-x)}{z}$.

The probability density function $f(x)$ of the entire population may be written as

$$f(x) = \sum_{i=1}^{m} \lambda_i \, f_i(x) \tag{2.3}$$

where $f_i(x)$ is the probability function of the ith subgroup which has the λ_i proportion of individuals such that $\sum_{i=1}^{m} \lambda_i = 1$ or in other words all the subgroups are mutually exclusive.

Multiplying both sides of (2.3) by $\Theta(z,x)$ and integrating we obtain

$$P = \sum_{i=1}^{m} \lambda_i \, P_i$$

where P_i is the poverty measure for the ith subgroup. It implies that total poverty is a weighted average of the subgroup poverty levels, the weights being proportional to the population shares. These poverty measures are called additively decomposable (Foster, Greer and Thorbecke, 1984). Thus, we have proved that all additively separable poverty measures are additively decomposable.

The additively decomposable poverty measures are useful because they allow assessment of the effects of changes in subgroup poverty to total poverty. If the population is disaggregated according to some socio-economic and demographic characteristics, it is of interest to know how the poverty in the population is related to each subgroup, that is, how much is the

contribution of each subgroup to total poverty. Sen's poverty measure is inadequate to analyze such issues because it is not additively decomposable. An important attribute of Sen's measure is that it captures the relative deprivation which Sen considers to be central to the notion of poverty. But, in the context of developing countries where the majority of people live below the subsistence level, the idea of relative positions of the poor is not very appealing. Our concern should be with the absolute deprivation rather than with the relative deprivation.

To make the poverty measures in (2.2) operational we need to specify $\theta(z,x)$. First, we consider some general restrictions which may be imposed on this function.

It can be easily seen that Sen's monotonicity axiom (which implies that, given other things, a reduction in the income of a poor individual must increase the poverty measure) will be satisfied by (2.2) if $\theta(z,x)$ is a decreasing function of x; that is, $\frac{\partial\theta}{\partial x} < 0$.

Second, we consider Sen's transfer axiom which states that "given other things, a pure transfer of income from a poor individual to any other richer individual must increase the poverty measure". This axiom will be satisfied if

$$\theta(z,y+\delta) - \theta(z,x-\delta) > 0$$

for $y > x$ or in other words $\frac{\partial^2\theta}{\partial x^2} > 0$.

Kakwani (1980) introduced the transfer sensitivity axiom which states "if a transfer of income takes place from a poor with income x to a poor with income (x+h) then for a given $h > 0$, the magnitude of increase in poverty measure decreases as x increases". This axiom gives more weight to transfers of income at the lower end of the distribution than at the higher end. If a society is particularly averse to inequality among the poor, the poverty measure must give maximum weight to a transfer from the poorest poor and the weight should decrease with the level of income. This axiom in the case of poverty measures in (2.2) implies that $\frac{\partial Q}{\partial x} < 0$, where

$$Q = \theta(z, x + h + \delta) - \theta(z, x - \delta).$$

for fixed $h > 0$ and $\delta > 0$ or in other words $\frac{\partial^3 \theta}{\partial x^3} < 0$.

Finally, we require that doubling all incomes and doubling the poverty line should leave the poverty measure unaltered. This requirement can be met by specifying $\theta(z,x)$ to be a homogeneous of degree zero in z and x or in other words

$$\theta(kz, kx) = \theta(z, x).$$

3. SPECIFIC POVERTY MEASURES

Foster, Greer and Thorbecke (1984) proposed a class of poverty measures which are additively decomposable. This class of measures is obtained if we substitute $\theta = \left(\frac{z-x}{x}\right)^{\alpha}$ in (2.2):

$$P_{\alpha} = \int_0^z \left(\frac{z-x}{x}\right)^{\alpha} f(x)dx \tag{3.1}$$

where α is a parameter to be specified. These measures satisfy Sen's monotonicity axiom for $\alpha > 0$ and transfer axiom for $\alpha > 1$. When $\alpha > 2$, P_{α} also satisfies Kakwani's transfer-sensitivity axiom.

In 1968, Watts proposed a poverty measure which can be obtained by substituting $\theta(z,x) = \log z - \log x$:

$$W = \int_0^z (\log z - \log x)\, f(x)dx \tag{3.2}$$

Although this is an extremely simple poverty measure, at the same time it has all the important attributes: it satisfies Sen's monotonicity and transfer axioms and also Kakwani's transfer-sensitivity axiom.

Finally, we consider the Clark, Hemming and Ulph (1981) poverty measure which can be obtained by substituting $\theta(z,x) = \frac{1}{\beta}\,[1 - (\frac{x}{z})^{\beta}]$:

$$C_{\beta} = \frac{1}{\beta} \int_0^z [1 - (\frac{x}{z})^{\beta}]\, f(x)dx \tag{3.3}$$

and clearly satisfies Sen's monotonicity axiom for all $\beta > 0$. Both transfer and transfer sensitivity axioms will be satisfied for all $\beta < 1$. Thus, β must lie in the range $0 < \beta < 1$.

4. CONFIDENCE INTERVAL AND HYPOTHESIS TESTING

Let $x_1, x_2, \ldots, x_n$ be a random sample of n observations drawn from a population with mean μ and variance σ^2. Suppose P given in (2.2) is a poverty measure defined in terms of the population distribution and $\hat{P}$ is its sample estimate based on n observations. It will be demonstrated below that $\sqrt{n}\,(\hat{P}-P)$ is asymptotically normally distributed with zero mean and variance $\sigma^2(\hat{P})$. If $\hat{\sigma}^2(\hat{P})$ is a consistent sample estimator of $\sigma^2(\hat{P})$, $\hat{\sigma}(\hat{P})/\sqrt{n}$ is called the standard error of $\hat{P}$, which we denote by $SE(\hat{P})$. Then

$$t = \frac{\hat{P}-P}{SE(\hat{P})} \tag{4.1}$$

is distributed asymptotically normal with zero mean and unit variance. Thus, t can be used to form a distribution free confidence interval for poverty measures.

Further, suppose $\hat{P}_1$ and $\hat{P}_2$ are estimates of a poverty measure P computed on the basis of two independently drawn random samples of sizes n_1 and n_2, respectively. Let $\hat{\sigma}_1^2$ and $\hat{\sigma}_2^2$ be the sample estimators of the variances of the asymptotic distributors of $\sqrt{n_1}\hat{P}_1$ and $\sqrt{n}\hat{P}_2$, respectively, then the standard error of $(\hat{P}_1 - \hat{P}_2)$ will be

$$SE(\hat{P}_1-\hat{P}_1) = \sqrt{\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_2}}$$

and the statistic

$$\eta = \frac{\hat{P}_1 - \hat{P}_2}{SE(\hat{P}_1-\hat{P}_1)} \tag{4.2}$$

follows asymptotic normal distribution with zero mean and unit variance. Thus, η can be used to test the null hypothesis that the observed poverty differences in any two samples are statistically insignificant. To calculate t and η, we need to derive the asymptotic distributions of various poverty measures which is attempted in the next section.

5. ASYMPTOTIC DISTRIBUTION OF POVERTY MEASURES

Suppose that q ($\leq$n) is the number of people who have income below the poverty line, then H = q/n is a natural estimator of the head-count ratio F(z). Let

$$I_i = 1, \; x_i < z \qquad (5.1)$$
$$= 0, \text{ otherwise.}$$

Obviously then

$$P_r[I_i = 1] = F(z) \text{ and } P_r[I_i = 0] = 1 - F(z)$$

and

$$H = \frac{1}{n} \sum_{i=1}^{n} I_i$$

P_r stands for probability. H is a binomial variate with parameters n and F(z). The central limit theorem implies that $\sqrt{n}\,(H - F(z))$ follows an asymptotic normal distribution with zero mean and variance F(z) [1 - F(z)] (Cramer, 1946). Thus, the standard error of H will be $\sqrt{\frac{H(1-H)}{n}}$ which, in conjunction with (4.1), provides a distribution free statistical inference for the head-count ratio.

A sample estimate of the class of additively separable poverty measures P in (2.2) is given by

$$\hat{P} = \frac{1}{n} \sum_{i=1}^{q} \theta(z, x_i) \qquad (5.2)$$

which when using (5.1) can also be written as

$$\hat{P} = \frac{1}{n} \sum_{i=1}^{n} M_i. \tag{5.3}$$

where

$$M_i = I_i \theta(z,x_i)$$

Note that

$$E(M_i) = \int_0^z \theta(z,x)\ f(x)dx = P$$

which implies that $\hat{P}$ is an unbiased estimator of P.

Because the sample observations x_i and x_j are independently distributed, it implies that M_i and M_j will also be independently distributed. Applying central limit theorem on (5.3) (Cramer 1946), leads to the result that $\sqrt{n}\ (\hat{P} - P)$ is asymptotically normally distributed with zero mean and variance

$$\sigma_M^{\ 2} = E[M_i - P]^2 = \int_0^z \theta^2(z,x)\ f(x)dx - P^2 \tag{5.4}$$

A sample estimate is

$$\hat{\sigma}_M^{\ 2} = \frac{1}{n} \sum_{i=1}^{q} \theta^2(z,x_i) - \hat{P}^2 \tag{5.5}$$

It can be seen, when $\theta(z,x) = 1.0$, that P is identical to the head-count ratio and, therefore, σ_M^2 becomes $F(z)\ [1 - F(z)]$ which is in fact the

variance of $\sqrt{n}$ H as derived above. Similarly, if we substitute $\theta(z,x) = \frac{z-x}{z}$, σ_M^2 in (5.4) it gives the variance of $\sqrt{n}\,\hat{G}$, $\hat{G}$ being the unbiased estimate of the poverty gap ratio given in (2.1).

The above formulation allows us to find the asymptotic distribution of all the specific poverty measures discussed in Section 3. Thus, the sample estimates of the variance of these measures are:

(1) $$\text{var}\,(\sqrt{n}\,\hat{P}_\alpha) = \hat{P}_{2\alpha} - \hat{P}_\alpha^2$$

where $$\hat{P}_\alpha = \frac{1}{n} \sum_{i=1}^{q} \left(\frac{z-x_i}{z}\right)^\alpha$$

(2) $$\text{var}\,(\sqrt{n}\,\hat{W}) = \frac{1}{n} \sum_{i=1}^{q} (\log z - \log x_i)^2 - \hat{W}^2$$

where $$\hat{W} = \frac{1}{n} \sum_{i=1}^{q} (\log z - \log x_i)$$

(3) $$\text{var}\,(\sqrt{n}\,\hat{C}_\beta) = \frac{1}{\beta^2 n} \sum_{i=1}^{q} \left[1 - \left(\frac{x_i}{z}\right)^\beta\right]^2 - \hat{C}_\beta^2$$

where $$\hat{C}_\beta = \frac{1}{\beta}\left[H - \frac{1}{n} \sum_{i=1}^{q} \left(\frac{x_i}{z}\right)^\beta\right]$$

6. APPLICATION TO COTE D'IVOIRE

The methodology developed in this paper is applied to the data obtained from the Côte d'Ivoire Living Standards Survey, conducted by the World Bank's Living Standards Unit and the Direction de la Statistique, Ministère de l'Economie et des Finances of the Republic of Côte d'Ivoire in 1985.

To analyze poverty, we need to measure the economic welfare of each individual in the society. Although income is widely used to measure economic welfare, it has many serious drawbacks.[2/]

In this paper we have used per capita adjusted consumption as a measure of household economic welfare. This measure, constructed by Glewwe (1987), takes account of the imputed value of owner-occupied dwelling, regional price variation and depreciated value of consumer durables. To take account of the differing needs of various household members, Glewwe divided the total household consumption by the number of equivalent adults. In his formulation of equivalent adults, children were given smaller weight than adults: children less than seven years old were given a weight of 0.2; between the ages of seven and thirteen a weight of 0.3, and between the ages of thirteen and seventeen a weight of 0.5.

When the index of household welfare is constructed, the next step involves the determination of the welfare of the individuals in the household. In this paper individual welfare was derived by assigning every individual in a household a welfare value equal to the consumption per

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[2/] For a detailed discussion of this issue see Kakwani (1986).

equivalent adult for that household. The validity of this approach is discussed in Kakwani (1986).

Once we have decided upon a suitable index of economic welfare for individuals, the next step is to find a threshold welfare level below which an individual is poor. In this paper we have considered two poverty lines: one with adjusted per capita consumption of 91394 CFAF and another of 162613, CFAF per year. The two poverty lines identify approximately the poorest 10 percent and the poorest 30 percent of the total Ivorian population. As measured in adjusted per capita terms, consumption for the poorest 10 percent of Ivorians is less than 20 percent consumption for the average Ivorian; the poorest 30 percent consume about one third of the national average. The poverty line of 91394 CFAF per year, in our opinion, measures the ultra-poverty situation, below which physical personal maintenance is unstable (Lipton 1988).

The numerical values of various poverty measures and their standard errors are presented in Table 1. The t-value in the table is equal to the value of poverty measure divided by its standard error (see equation 4.1). This statistic follows an asymptotic normal distribution with zero mean and unit variance. If t exceeds 1.96, it means that the hypothesis of zero poverty is rejected at 5 level of significance. This method is valid subject to the condition that our sample is large. In practice, it is often difficult to know whether our samples are so large that these large sample approximations are valid. However, the approximation is usually good for samples larger than 30 (Cramer 1946). Because our analysis of poverty is based on sample sizes larger than 250, the statistical inference based on asymptotic distributions is appropriate.

TABLE 1: Poverty Measures and their Standard Errors: Côte d'Ivoire, 1985

Poverty Measures	Poverty line = 162.61			Poverty line = 91.39		
	Value %	Standard error	t-value	Value %	Standard error	t-value
Head-count Ratio	27.76	1.13	24.57	9.36	0.73	12.82
Poverty gap Ratio	9.34	0.48	19.46	2.42	0.24	10.08
Watts Measure	13.22	0.75	17.63	3.22	0.35	9.20
Foster et Measures						
α = 2.00	4.42	0.28	15.78	0.98	0.13	7.54
= 3.00	2.43	0.19	12.79	0.49	0.08	6.12
Clark et Measures						
c = 0.25	12.01	0.66	18.20	2.98	0.32	9.31
0.50	10.98	0.58	18.93	2.77	0.29	9.55
0.75	10.10	0.52	19.42	2.58	0.26	9.92
0.95	9.48	0.48	19.75	2.45	0.25	9.94

The table shows that the values of t are considerably larger than 1.96 (varying from 12.79 to 24.57 for the poverty line 162613 CFAF) which leads to the conclusion that a large degree of poverty exists in Côte d'Ivoire. However, an important observation to be made is that the numerical values of t differ considerably for different poverty measures. The size of t indicates how large the standard error of a poverty measure is relative to its value. Thus, the larger the value of t the greater is the precision with which the poverty measure can be estimated from a given sample. Among all the poverty measures presented in the table, the head-count ratio gives the

smallest confidence interval relative to its value. But the head-count ratio is a crude measure of poverty because it does not take account of the depth of poverty.

The precise estimation of a poverty measure depends on how sensitive the measure is to income transfers among the very poor. For instance, in the case of Foster, Greer and Thorbecke's poverty measures, α is a measure of degree of inequality aversion - the larger the value of α, the greater weight is attached to the poorest poor. The numerical results suggest that the precision of this class of poverty measures is a monotonically decreasing function of α. If our value judgement suggests that the greater weight be attached to income transfers among the most poor, we must select a poverty measure with high value of α. But if we cannot obtain a precise estimate of such a poverty measure from a given sample, its usefulness is limited even if it may have all the desirable properties from the welfare point of view. Should we reject a desirable poverty measure because of its undesirable statistical properties? This is a difficult question to answer particularly when the sample size is small.

7. BREAKDOWN OF AGGREGATE POVERTY BY SOCIO-ECONOMIC AND DEMOGRAPHIC HOUSEHOLD CHARACTERISTICS

This section focuses on testing for significance of poverty differences between various socio-economic and demographic groups. Table 2 presents poverty comparisons by sex of household head. It is of interest that the mean consumption (adjusted) of female-headed households is about 20 percent higher than those of male-headed households. The difference between the mean consumption of the two household groups is statistically significant at 5 percent level (see Table 2, last row). With the exception of P_α for $\alpha = 3.0$, all the remaining poverty measures show that poverty is significantly higher among male-headed households. This is a surprising result because in many developing and also developed countries, female-headed households are often poorer than those headed by males. Some explanation of the situation has been provided by Glewwe (1987) who observed that female-headed households are disproportionately located in Abidjan and other urban areas which are considerably richer than the rural areas.

Several nationalities live in Côte d'Ivoire but Ivorians are the most dominant comprising 85.7 percent of the surveyed population. For our poverty comparisons we have placed all other nationalities into one group. The comparisons are provided in Table 3. It is interesting to note that the adjusted per capita consumption is almost identical in the two groups. The difference is insignificant at the 5 percent level as is shown by a value of -0.11 for η given in the last column of the table. Therefore, any significant difference in poverty levels will be due to a difference in within group consumption inequalities.

TABLE 2: Poverty Comparison by Sex of Household Head: Côte d'Ivoire, 1985
Poverty Line = CFAF 162.61

Poverty Measures	Female-Headed Households			Male-Headed Households			
	Value of Poverty Measure	Standard error	t-value	Value of Poverty Measure	Standard error	t-value	η
Head-count Ratio	16.96	3.37	5.03	28.46	1.19	23.92	-3.22*
Poverty gap Ratio	5.73	1.38	4.15	9.57	0.50	19.14	-2.62*
Watts Measure	8.10	2.16	3.75	13.55	0.79	17.15	-2.37*
Foster et Measures							
α = 2.00	2.70	0.81	3.33	4.53	0.30	15.10	-2.12*
= 3.00	1.49	0.54	2.76	2.49	0.20	12.45	-1.74*
Clark et Measures							
c = 0.25	7.36	1.90	3.87	12.31	0.69	17.84	-2.45*
= 0.50	6.74	1.69	3.40	11.25	0.61	18.44	-2.51*
= 0.75	6.20	1.52	4.08	10.35	0.55	18.82	-2.57*
Mean consumption per person CFAF	406.96	34.21	11.90	337.64	9.47	35.63	1.95

* Poverty differences are significant at 5% level.

Table 3 shows that among Ivorians, 28.38 percent of the population is poor as against 24.04 percent among other nationalities. But these differences are statistically insignificant at the 5 percent level. Thus, the hypothesis that the two groups have the same proportion of poor cannot be rejected. The other poverty measures, however, show that poverty among Ivorians is significantly higher than that among other nationalities. These

TABLE 3: Poverty Comparison by Nationality of Household Head: Côte d'Ivoire, 1985
Poverty Line = CFAF 162.61

Poverty Measures	Ivorian			Others			
	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	η
Head-count Ratio	28.38	1.25	22.70	24.04	2.60	9.25	1.50
Poverty gap Ratio	9.77	0.54	18.09	6.78	0.92	7.37	2.80*
Watts Measure	13.94	0.85	16.40	8.89	1.29	6.89	3.27*
Foster et Measures							
α = 2.00	4.70	0.32	14.69	2.75	0.46	5.98	3.48*
= 3.00	2.62	0.22	11.91	1.29	0.26	4.96	3.91*
Clark et Measures							
c = 0.25	12.63	0.75	16.84	8.26	1.17	7.06	3.14*
= 0.50	11.52	0.66	17.45	7.71	1.08	7.14	3.01*
= 0.75	10.58	0.59	17.93	7.22	0.99	7.27	2.92*
Mean consumption per person	341.52	10.22	33.42	343.87	19.43	17.70	-0.11

* Poverty differences are significant at 5% level.

conflicting conclusions emerge because the head-count ratio is insensitive to the poverty gap as well as the distribution of income among the poor. From these observations, we conclude that the depth of poverty among Ivorians is significantly higher than that among other nationalities. Thus, the poverty analysis based on head-count ratio can lead to the misleading conclusion that the two groups have the same poverty level.

TABLE 4: Poverty Comparison by Size of Household: Côte d'Ivoire, 1985

Poverty Line = CFAF 162.61

Poverty Measures	Small Households			Medium Size Households			Large Households		
	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value
Head-count Ratio	15.20	1.88	8.09	23.40	2.36	9.92	29.75	1.54	19.32
Poverty gap Ratio	5.28	0.81	6.52	7.73	0.96	8.05	10.02	0.65	15.42
Watts Measure	7.93	1.41	5.62	10.69	1.44	7.42	14.17	1.02	13.89
Foster et Measures									
α = 2.00	2.66	0.52	5.12	3.55	0.54	6.57	4.75	0.39	12.18
= 3.00	1.58	0.39	4.05	1.87	0.34	5.50	2.61	0.26	10.04
Clark et Measures									
β = 0.25	7.05	1.19	5.92	9.79	1.28	7.65	12.88	0.90	14.31
= 0.50	6.34	1.03	6.16	9.01	1.15	7.83	11.78	0.89	14.72
= 0.75	5.76	0.90	6.40	8.33	1.05	7.93	10.83	0.72	15.04
Mean consumption per person	529.69	31.05	17.06	422.62	28.0	15.09	309.43	9.68	31.97

TABLE 5: Statistics for Testing Significance of Poverty Differences Among Households of Different Size: Côte d'Ivoire, 1985

Poverty Measures	Small Households Medium Households	Small Households Large Households	Medium Households Large Households
Head-count Ratio	-2.72*	-5.99*	-2.25*
Poverty gap Ratio	-1.95*	-4.56*	-1.98*
Watts Measure	-1.37	-3.59*	-1.97*
Foster et Measures			
α = 2.00	-1.19	-3.22*	-1.80
= 3.00	-0.56	-2.20*	-1.73
Clark et Measures			
β = 0.25	-1.57	-3.91*	-1.97*
= 0.50	-1.73	-4.17*	-1.98*
= 0.75	-1.86	-4.40*	-1.96*
Mean consumption per person	2.56*	6.77*	3.82*

* Poverty differences are significant at 5% level.

The household size is an important demographic variable that has an impact on poverty. A large household has greater needs than a small household. In several studies it has been observed that larger households also tend to have higher income because such households probably have on average a greater number of persons in the work force (Kakwani 1986). The question whether the larger households are better or worse off has important implications because of the closer association between the government poverty reduction programs and the number of dependent persons in the household.

Table 4 presents the numerical estimates of various poverty measures and their standard errors when the households are classified according to size. The three classifications used are: small households (1 to 4 members); medium size households (5 to 6 members), and large households (7 and more members). All the poverty measures show that small households have the least poverty and large households the highest poverty. In all cases the t values are considerably larger than 1.96 showing that high and significant poverty levels exist in each of the three household size classifications. To test if the poverty differences between households of different sizes are statistically significant we computed the values of η for all possible pairs of households classified according to their size. The numerical results are presented in Table 5.

All poverty measures presented in Table 5 show that the large households have significantly higher poverty than the small and medium households. The poverty differences between small and medium households are statistically significant only for the head-count ratio and the poverty gap ratio. For the remaining poverty measures, the hypothesis of equal poverty levels in the two groups cannot be rejected at 5 percent significance level. This analysis indicates that the large households are almost certainly more susceptible to poverty than the small and medium sized households.

The Côte d'Ivoire may be divided into five regions: Abidjan, Other Urban, West Forest, East Forest and Savannah. The first two regions are the urban areas and the remaining three are the rural areas. About 60 percent of Ivorians live in rural areas. Table 6 presents the poverty estimates and their standard errors according to the geographical location of the

TABLE 6: Poverty Comparison by Regions: Côte d'Ivoire 1985

Poverty Line = CFAF 162.61

Poverty Measures	Abidjan			Other Urban			West Forest			East Forest			Savannah		
	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value
Head-count Ratio	5.25	1.22	4.30	11.94	1.78	6.71	18.40	2.51	7.33	39.13	2.57	15.23	61.62	2.79	22.09
Poverty gap Ratio	1.26	0.36	3.50	2.68	0.52	5.15	5.30	0.93	5.70	12.52	1.05	11.92	24.38	1.49	16.36
Watts Measure	1.58	0.47	3.36	3.41	0.72	4.74	7.21	1.36	5.30	17.25	1.64	10.52	36.01	2.52	14.29
Foster et Measures															
α = 2.00	0.44	0.16	2.75	0.96	0.25	3.84	2.34	0.51	4.59	5.56	0.62	8.97	12.68	1.00	12.68
= 3.00	0.19	0.08	2.38	0.42	0.15	2.80	1.21	0.31	3.90	2.91	0.42	6.93	7.41	0.72	10.29
Clark et Measures															
c = 0.25	1.49	0.44	3.39	3.19	0.65	4.91	6.63	1.23	5.39	15.79	1.44	10.97	32.32	2.17	14.89
= 0.50	1.41	0.41	3.44	3.00	0.60	5.00	6.13	1.11	5.52	14.54	1.28	11.36	29.23	1.89	15.47
= 0.75	1.33	0.38	3.50	2.83	0.56	5.05	5.68	1.01	5.62	13.46	1.16	11.60	26.62	1.67	15.95
Mean consumption per person	614.39	32.11	19.13	392.23	17.25	22.74	295.96	13.00	22.77	244.63	11.49	21.29	175.40	8.19	21.42

TABLE 7: Statistics for Testing Significance of Poverty Differences Among Regions: Côte d'Ivoire, 1985

Poverty Line = CFAF 162.61

Poverty Measures	Abidjan Other Urban	Abidjan West Forest	Abidjan East Forest	Abidjan Savannah	Other Urban West Forest	Other Urban East Forest	Other Urban Savannah	West Forest East Forest	West Forest Savannah	East Forest Savannah
Head-count Ratio	-3.10*	-4.71*	-11.91*	-18.51*	-2.10*	-8.70*	-15.01*	-5.77*	-11.52*	-5.93*
Poverty gap Ratio	-2.25*	-4.05*	-10.14*	-15.08*	-2.46*	-8.40*	-13.75*	-5.15*	-10.86*	-6.51*
Watts Measure	-2.13*	-3.91*	-9.19*	-13.43*	-2.47*	-7.73*	-12.44*	-4.71*	-10.06*	-6.24*
Foster et Measures										
α = 2.00	-1.75	-3.55*	-8.00*	-12.09*	-2.43*	-6.88*	-11.37*	-4.01*	-9.21*	-6.05*
= 3.00	-1.35	-3.19*	-6.36*	-9.97*	-2.29*	-5.58*	-9.50*	-3.26*	-7.91*	-5.40*
Clark et Measures										
c = 0.25	-2.17*	-3.93*	-9.50*	-13.92*	-2.47*	-7.98*	-12.86*	-4.84*	-10.30*	-6.35*
= 0.50	-2.19*	-3.99*	-9.77*	-14.38*	-2.48*	-8.16*	-13.23*	-4.96*	-10.54*	-6.44*
= 0.75	-2.22*	-4.03*	-9.94*	-14.77*	-2.47*	-8.25*	-13.51*	-5.06*	-10.73*	-6.47*
Mean consumption per person	6.09*	9.19*	10.84*	13.25*	4.46*	7.12*	11.36	2.96*	7.85*	4.91*

* Poverty differences are significant at 5% level.

household. The empirical results in the table show that poverty varies widely among the regions. For instance, only 5.25 percent of the population is poor in Abidjan whereas in Savannah it is as high as 61.62 percent. All the poverty measures tell the same story: poverty in Savannah is distressingly high whereas in Abidjan it is extremely low. The values of t are considerably larger than 1.96 in all the regions which implies that every region in Côte d'Ivoire has significant poverty.

To test whether poverty differences between regions are statistically significant, we computed the value of η given in (4.2) for all possible pairs of regions. The numerical values are presented in Table 7. The last column in the table provides the values of statistics for testing the significance of differences of mean consumption per person (adjusted for size and composition of the household). All the mean consumption differences are significant at the 5 percent level. Thus, the observed differences in mean consumption among the regions are not due to sampling errors. There are some other facts which must be analyzed to explain such wide differences.

Almost all poverty measures show significant poverty differences among the regions. One exception is when we compare Abidjan with Other Urban Cities, for which Foster et measures show insignificant differences. The results clearly indicate that poverty in rural areas is significantly higher than that in urban areas. Poverty differences between regions are statistically significant even within rural and urban regions. Thus, the geographical location of a household has a sizeable effect on the poverty level.

The economic welfare of a household is closely associated with the age of the head. In many countries it has been observed that income per household shows a marked rise, from a low for the under 26 age of head class, to a peak for the 45 to 54 age class, and then a sharp decline to a trough in the 65 and over class (Kuznets 1974). This phenomenon may be explained by skills and experience acquired before a person settles down to a particular field of work. At the age of 65, a sharp decline in income is faced, at retirement from the work force.

The age of the head may also have a close relationship to the household size. The size of a household increases with the age of the head as children are born and added to the family.

Poverty comparisons by age of household head are presented in Table 8. The last column in the table presents the mean consumption per person. The incidence of poverty is highest among households where the head is over 65 years. This group has the lowest per capita consumption. The age group 46 to 65 also has a fairly high incidence of poverty. The absolute magnitude of t exceeds 1.96 in most cases implying that significant poverty exists in all age groups.

Table 9 presents values of η for testing significance of poverty differences among households with different age of household head. The results indicate that poverty differences are insignificant when we make pair comparisons of the age groups (< 26), (26 to 35) and (36 to 45). Poverty in the age group (46 to 65) is significantly higher than that in the three lower age groups. The age group 65 and over has significantly higher poverty than any other age group. Thus, the age of head, when it exceeds 45 years becomes an important determinant of poverty.

TABLE 8: Poverty Comparison by Age of Household Head: Côte d'Ivoire, 1985

Poverty Line = CFAF 162.61

Poverty Measures	< 26			26 to 35			36 to 45			46 to 65			> 65		
	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value
Head-count Ratio	22.13	5.27	4.20	18.59	2.19	8.49	19.22	2.13	9.02	31.50	1.77	17.80	42.40	3.86	11.11
Poverty gap Ratio	5.40	1.67	3.23	5.24	0.76	6.89	4.72	0.68	6.94	10.85	0.77	14.09	18.82	1.98	9.51
Watts Measure	6.99	2.40	2.91	6.88	1.07	6.43	6.09	0.94	6.48	15.51	1.23	12.61	28.04	3.30	8.50
Foster et Measures															
α = 2.00	2.03	0.88	2.31	2.12	0.39	5.44	1.80	0.33	5.45	5.24	0.47	11.15	9.98	1.29	7.74
= 3.00	0.96	0.53	1.81	1.00	0.22	4.55	0.82	0.19	4.32	2.93	0.32	9.16	5.87	0.92	6.38
Clark et Measures															
c = 0.25	6.52	2.17	3.00	6.40	0.98	6.53	5.69	0.86	6.62	14.05	1.08	13.01	25.11	2.85	8.81
= 0.50	6.10	1.98	3.08	5.97	0.90	6.63	5.33	0.79	6.75	12.81	0.95	13.48	22.66	2.49	9.10
= 0.75	5.73	1.82	3.15	5.58	0.83	6.72	5.01	0.73	6.86	11.76	0.85	13.84	20.59	2.21	9.32
Mean consumption per person	357.94	36.06	9.93	487.91	27.55	17.71	392.26	23.07	17.00	298.38	10.99	27.15	220.91	15.14	14.59

TABLE 9: Statistics for Testing Significance of Poverty Differences Among Households With Different Age of Household Head: Côte d'Ivoire, 1985

Poverty Measures	< 26 26 to 35	< 26 36 to 45	< 26 46 to 65	< 26 > 65	26 to 35 36 to 45	26 to 35 46 to 65	26 to 35 > 65	36 to 45 46 to 65	36 to 45 > 65	46 to 65 > 65
Head-count Ratio	0.62	0.51	-1.69	-3.18*	-0.21	-4.58*	-5.48*	-4.43*	-5.37*	-2.68*
Poverty gap Ratio	0.09	0.38	-2.96*	-5.18*	-0.51	-5.19*	-6.40*	-5.97*	-6.74*	-3.75*
Watts Measure	0.04	0.35	-3.16*	-5.16*	0.55	-5.29	-6.10	-6.09	-6.40	-3.56
Foster et Measures										
α = 2.00	-0.09	0.24	-3.22*	-5.09*	0.63	-5.11*	-5.83*	-5.99*	-6.14*	-3.45*
= 3.00	-0.07	0.25	-3.18*	-4.62*	0.62	-4.97*	-5.15*	-5.67*	5.38*	-3.02*
Clark et Measures										
β = 0.25	0.05	0.36	-3.11*	-5.19*	0.54	-5.25*	-6.21*	-6.-06*	-6.52*	-3.63*
= 0.50	0.06	0.36	-3.06*	-5.21*	0.53	-5.23*	-6.30*	-6.05*	-6.63*	-3.70*
= 0.75	0.07	0.37	-3.00	-5.19	0.52	-5.20*	-6.36*	-6.02*	-6.69*	-3.73*
Mean consumption per person	-2.68*	-0.80	1.58	3.50*	2.66*	6.39*	8.49*	3.67*	6.21*	4.14*

* Poverty differences are significant at 5% level.

Tables 10 and 11 present numerical results for poverty comparisons of households classified according to the employer of the household head. Poverty is zero among households whose head is employed by parastatal firms (government-owned corporations). The households whose head is self-employed are most susceptible to poverty. It is interesting to observe that households whose head was not working have lower poverty than those whose head is self-employed. This second group of households has a much lower poverty level than the national average. Unemployment is more common among the non-poor households. Glewwe (1987) points out that some of these households may be entirely composed of retired persons living on pensions or other sources of transfer income.

The numerical results in Table 11 show that most of the poverty differences are significant at the 5 percent significance level, suggesting that the employer of the household head is an important factor affecting poverty. Although households whose head is unemployed have significantly higher per capita consumption levels than those whose head is self-employed. All poverty measures do not indicate a significant difference in their poverty levels. Foster et measures show that poverty differences between the two groups are insignificant. Similarly, per capita consumption differences between households whose head is employed by government and parastatal firms are not significant. However, the government employed households have significantly higher levels of poverty than those employed by parastatal firms. This is indicated by all poverty measures presented except the Foster et measures when $\alpha = 3.0$.

TABLE 10: Poverty Comparison of Households According to Employer of Household Head: Côte d'Ivoire, 1985

Poverty Measures	None			Government			Parastatal			Private			Self-employed		
	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value
Head-count Ratio	21.95	3.49	6.29	3.31	1.34	2.47	0.00	0.00	-	7.07	1.79	3.95	36.54	1.51	24.20
Poverty gap Ratio	8.73	1.57	5.56	0.45	0.20	2.25	0.00	0.00	-	1.59	0.48	3.31	12.35	0.65	19.00
Watts Measure	12.25	2.33	5.26	0.49	0.22	2.23	0.00	0.00	-	1.94	0.61	3.18	17.56	1.04	16.88
Foster et measures															
$\alpha = 2.00$	4.24	0.89	4.76	0.07	0.03	2.33	0.00	0.00	-	0.51	0.19	2.68	5.90	0.40	14.75
$= 3.00$	2.27	0.54	4.20	0.01	0.06	0.17	0.00	0.00	-	0.19	0.08	2.38	3.27	0.27	12.11
Clark et measures															
$\beta = 0.25$	11.18	2.09	5.35	0.48	0.21	2.29	0.00	0.00	-	1.84	0.58	3.17	15.93	0.91	17.51
$= 0.50$	10.25	1.89	5.42	0.47	0.21	2.24	0.00	0.00	-	1.75	0.54	3.24	14.55	0.81	17.96
$= 0.75$	9.44	1.72	5.49	0.46	0.20	2.30	0.00	0.00	-	1.67	0.51	3.27	13.37	0.72	18.57
Adjusted mean consumption per per capita	331.93	21.01	15.80	648.33	45.07	14.38	516.05	60.50	8.53	487.37	30.65	15.90	265.85	8.27	32.15

TABLE 11: Statistics for Testing Significance of Poverty Differences According to Employer of Household Head: Côte d'Ivoire, 1985

Poverty Measures	Non-Government	Non-Parastatal	Non-Private	Non-Self-employed	Government Parastatal	Government Private	Government Self-employed	PARASTATAL PRIVATE	PARASTATAL SELF-EMPLOYED	PRIVATE SELF-EMPLOYED
Head-count Ratio	4.99*	6.29*	3.79*	-3.84*	2.47*	-1.68*	-16.46*	-3.95*	-24.20*	-12.58*
Poverty gap Ratio	5.23*	5.56*	4.35*	-2.13*	2.25*	-2.19*	-17.50*	-3.31*	-19.00*	-13.32*
Watts Measure	5.02*	5.26*	4.28*	-2.08*	2.23*	-2.24*	-16.06*	-3.18*	-16.88*	-12.96*
Foster et measures										
$\alpha = 2.00$	4.68*	4.76*	4.10*	-1.70	2.33*	-2.29*	-14.53*	-2.68*	-14.75*	-12.17*
$= 3.00$	4.16*	4.20*	3.81*	-1.66	-0.17	-1.80	-11.79	-2.37*	-12.11*	-10.94*
Clark et measures										
$\beta = 0.25$	5.09*	5.35*	4.31*	-2.08*	2.29*	-2.20*	-16.54*	-3.17*	-17.51*	-13.06*
$= 0.50$	5.14*	5.42*	4.32*	-2.09*	2.24*	-2.21*	-16.83*	-3.24*	-17.96*	-13.15*
$= 0.75$	5.19*	5.49*	4.33*	-2.11*	2.30*	-2.21*	-17.28*	-3.27*	-18.57*	-13.26*
Adjusted consumption per capita	-6.36*	-2.87*	-4.18*	2.93*	1.75*	2.95*	8.35*	0.42*	4.10*	6.98*

* Poverty differences are significant at 5% level.

In Côte d'Ivoire there were 65 percent of households whose head had no education. This figure varied considerably between regions. For instance, Abidjan had about 36 percent of such households whereas in Savannah the figure was as high as 93 percent. It is possible that significant poverty differences observed earlier between regions are attributed to educational levels of the household head.

Tables 12 and 13 present the poverty comparisons of households classified by the education of the household head. As expected, poverty is highest among households whose head had no education. Poverty decreases monotonically with the education level of the household head. Households whose head attended senior high school have zero poverty. But those households whose head had a university education have statistically insignificant poverty level. Poverty differences between these two groups are not significant at the 5 percent level. The numerical results show that education (up to senior high school) of the household head has an important bearing on poverty. Education even up to elementary school can significantly and substantially reduce poverty.

TABLE 12: Poverty Comparison by Education of Household Head: Côte d'Ivoire, 1985

Poverty Line = CFAF 162.61

Poverty Measures	None			Elementary School			Junior High School			Senior High School			University		
	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value	Value of Poverty Measure	Standard error	t Value
Head-count Ratio	35.62	1.48	24.1	20.09	2.52	8.00	3.62	1.55	2.30	0.00	0.00	—	1.25	1.51	0.83
Poverty gap Ratio	12.43	0.65	19.10	5.30	0.87	6.10	0.75	0.34	2.20	0.00	0.00	—	0.52	0.63	0.82
Watts Measure	17.75	1.04	17.10	7.01	1.23	5.70	0.85	0.39	2.20	0.00	0.00	—	0.68	0.82	0.83
Foster et Measures															
α = 2.00	6.00	0.40	15.00	2.19	0.45	4.90	0.17	0.09	1.90	0.00	0.00	—	0.22	0.27	0.81
= 3.00	3.34	0.28	11.90	1.06	0.25	4.20	0.04	0.02	2.00	0.00	0.00	—	0.09	0.11	0.82
Clark et Measures															
β = 0.25	16.08	0.91	17.70	6.50	1.12	5.80	0.82	0.38	2.20	0.00	0.00	—	0.64	0.77	0.83
= 0.50	14.67	0.81	18.10	6.06	1.02	5.90	0.80	0.36	2.20	0.00	0.00	—	0.60	0.72	0.83
= 0.75	13.46	0.72	18.70	5.66	0.94	6.00	0.77	0.35	2.20	0.00	0.00	—	0.56	0.68	0.82
Mean consumption per person	254.18	6.15	41.31	323.70	13.68	23.70	578.86	40.02	14.50	790.00	68.69	11.50	1285.95	128.86	10.00

TABLE 13: Statistics for Testing Significance of Poverty Differences Among Households With Different Educational Levels of Household Head: Côte d'Ivoire, 1985

	None Elementary School *	None Junior High School	None Senior High School	None University	Elementary School Junior High School	Elementary School Senior High School	Elementary School University	Junior High School Senior High School	Junior High School University	Senior High School University
Head-count Ratio	5.32*	14.95*	24.10*	16.29*	7.19*	8.00*	6.41*	2.30*	1.10	-0.83
Poverty gap Ratio	6.54*	16.00*	19.10*	13.09*	4.84*	6.10*	4.43*	2.20*	0.32	-0.82
Watts Measure	6.67*	15.22*	17.10*	12.93*	4.77*	5.70*	4.28*	2.20*	0.19	-0.82
Foster et measures										
α= 2.00	6.35*	14.22*	15.00*	12.04*	8.42*	4.90*	3.79*	1.90*	-0.18	-0.81
= 3.00	6.16*	11.78*	11.90*	10.83*	4.25*	4.20*	3.73*	2.00*	-0.50	-0.82
Clark et measures										
β= 0.25	6.65*	15.57*	17.70*	12.97*	4.81*	5.80*	4.31*	2.20*	0.21	-0.83
= 0.50	6.62*	15.58*	18.10*	12.91*	4.87*	5.90*	4.37*	2.20*	0.25	-0.83
= 0.75	6.61*	15.86*	18.70*	13.03*	4.89*	6.00*	4.40*	2.20*	0.28	-0.82
Mean consumption per person	-4.63*	-8.02*	-7.80*	-8.00*	-6.03*	-6.66*	-7.43*	-2.66*	-5.24*	-3.40*

* Poverty differences are significant at 5 percent level.

8. CONCLUSIONS

The main contribution of this paper has been to provide distribution free asymptotic confidence interval and statistical inference for poverty measures. The methodology developed is applied to analyze poverty in Côte d'Ivoire.

The empirical results suggest that observed differences in values of poverty measures may lead to misleading conclusions without the statistical tests. Some poverty measures may show significant differences in poverty while others may show insignificant differences. This is an important finding which suggests an appropriate measure should be selected before embarking on the analysis of poverty differences between populations. The results also suggest that poverty measures which give greater weight to income transfers among the most poor may have larger confidence intervals. This raises a difficult question: should a desirable poverty measure be rejected because of undesirable statistical properties? This issue is of crucial importance when the sample size is small.

The paper demonstrates how to use statistical inference to analyze poverty. The importance of these statistical tests cannot be overemphasized because the poverty measures are estimated on the basis of sample observations. However, these tests are based on the assumption that samples used are representative of the population they are drawn from. In practice this assumption may be violated due to non-response errors.[3/] Moreover, non-

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3/ The Living Standards Survey data for Côte d'Ivoire, 1985, used in the present paper had a 92 percent response rate, therefore, the possibility of large non-sampling errors is very small.

sampling errors may be so large that it makes little sense to worry about sampling errors. Greater attention should be paid to the non-sampling errors in future work.

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