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Are Poor, Remote Areas Left Behind in Agricultural Development: The Case of Tanzania

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ABSTRACT

In Tanzania, as in many other developing countries, the conventional wisdom is that economic reforms may have stimulated economic growth, but that the benefits of this growth have been uneven, favoring urban households and farmers with good market access. This idea, although quite plausible, has rarely been tested empirically. In this paper, we develop a new approach to measuring trends in poverty and apply it to Tanzania in order to explore the distributional aspects of economic growth and the relationship between rural poverty and market access. We find that, between 1991 and 2003, a period of extensive economic reforms, the overall rate of poverty fell about 9 percentage points. The degree of poverty reduction was similar between rural and urban areas, though poverty appears not to have declined in Dar es Salaam. The poverty rate fell more among households with a less educated head of household than among those with a more educated head. The gains were greater among male-headed households than female-headed households. We find that rural poverty is associated with remoteness, but the relationship is surprisingly weak and it varies depending on the definition used. Rural poverty is more closely related to access to regional urban centers than distance to roads or to Dar es Salaam. We find little evidence that remote rural areas are being "left behind" in terms of the absolute decline in the poverty rate.

Key words: Tanzania, poverty, market access
JEL classification: I32, O18, O55, Q13, R11

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ARE POOR, REMOTE AREAS LEFT BEHIND IN AGRICULTURAL DEVELOPMENT: THE CASE OF TANZANIA

Nicholas Minot[1]

1. INTRODUCTION

In the late 1980s, Tanzania embarked on a series of wide-ranging reforms to allow markets to play a larger role in the economy. The government removed extensive controls on prices, liberalized agricultural markets, devalued the exchange rate and eventually allowed it to float, removed import controls and lowered tariffs, and closed or privatized a large majority of the state enterprises, which had been established in almost every sector of the economy.

In macroeconomic terms, the reforms have been relatively successful. After stagnation in the 1980s, the Tanzanian economy grew at 4-5 percent per year in the second half of the 1990s and 5-6 percent over the past few years (see Figure 1). Budget deficits have been brought under control, and inflation has been reduced to less than 5 percent. The impact of the economic reforms on rural areas, however, has been widely debated. Some argue that market liberalization has created new opportunities for farmers, particularly in high-value agriculture for sale to the cities or for export. Others claim that the reforms have increased unemployment, widened the gap between the poor and the rich, and disadvantaged farmers by removing input subsidies. An intermediate position is that the reforms have benefited well-endowed households, but left behind

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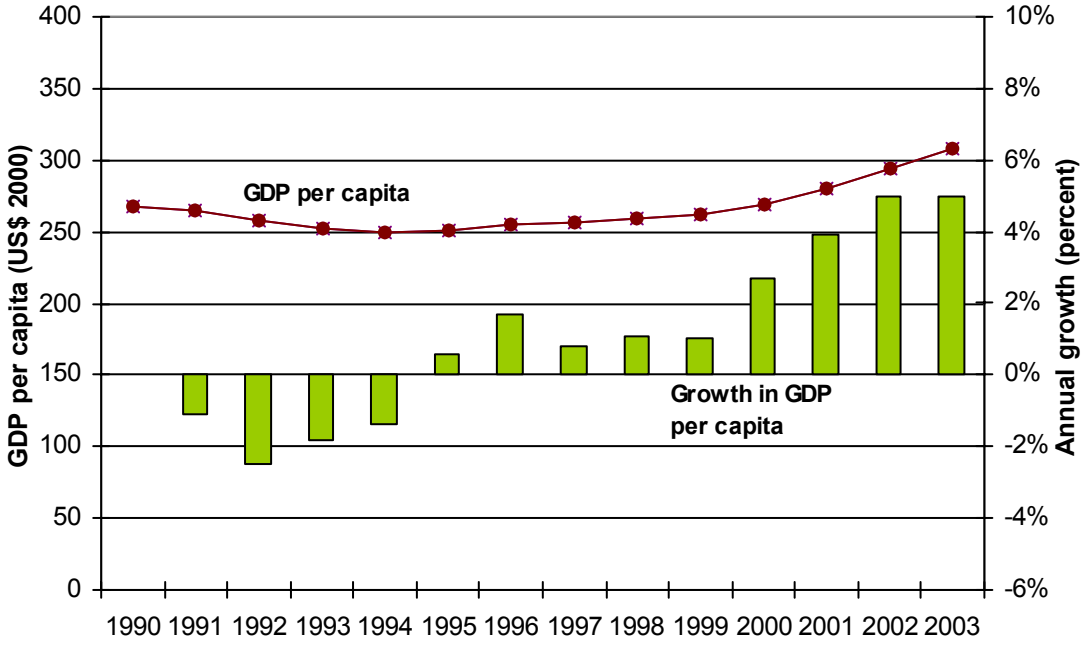
others, particularly those in remote areas (see Eele et al., 2000 and Rutasitara, 2005). These issues are important because they affect the design and implementation of the Poverty Reduction Strategy Programme (PRSP), as well as the rural development strategy more generally.

Figure 1—Trends in real per capita gross domestic product in Tanzania



Source: World Bank (2005)

This debate has suffered from a lack of comparable information regarding the trends and spatial patterns in poverty. Better information on trends in poverty and inequality would help government agencies and international organizations understand and guide the impact of policy reforms. More accurate data on the spatial patterns in poverty would help efforts to target assistance to the poorest areas.

The objective of this study is to examine the trends in poverty in Tanzania since the early 1990s. In particular, we address the following questions:

- Has poverty increased or decreased during the 1990s, a period of extensive market liberalization?
- What types of households have gained or lost as a result of these changes?
- Have households in poor, remote areas been "left behind" other rural areas in terms of poverty reduction?

This study develops a new approach for measuring medium-term trends in poverty and inequality, drawing from both the small-area estimation method (Hentschel et al, 2000 and Elbers et al, 2003) and the asset index method (Filmer and Pritchet, 1998). We use the 1991-92 Tanzanian Household Budget Survey (HBS) to estimate the relationship between per capita expenditure and various household characteristics. This relationship is then applied to the same household characteristics in the Tanzanian Demographic and Health Surveys, carried out in 1991-92, 1996, 1999, and 2003 to estimate the incidence of poverty in each of those years[2]. We then use GIS analysis to compare levels and trends in poverty between urban areas, rural areas with good market access, and remote rural areas.

The results of the analysis indicate that the incidence of poverty has declined about 9 percentage points between 1991-92 and 2003. The decline in poverty was roughly equal in urban and rural areas, but contrary to conventional wisdom, the poverty rate declined more in rural areas than in Dar es Salaam. Less-educated household seem to have benefited than more-educated households from economic growth over this period.

[2] The 1999 survey was called the Reproductive and Child Health Survey and the 2003 survey was called the HIV/AIDS Indicator Survey, but all four were carried out by Macro International and use very similar questionnaires and sample designs. For convenience, we refer to all four as DHS surveys.

Using six definitions of market access, we find that the relationship between rural poverty and lack of market access is weaker than generally supposed, though this relationship varies widely depending on the definition of market access used. In terms of poverty, the distance from a rural household to a regional urban center matters more than the distance to a road or to Dar es Salaam. Furthermore, we find little evidence that remote, rural areas have lost more or gained less from economic growth than other areas.

2. BACKGROUND

At least four approaches have been used for measuring trends in poverty in developing countries. One approach is to combine information on per capita gross domestic product, a measure of inequality (usually the Gini coefficient), and an assumed functional form for the distribution of income (usually log normal). This method is not very precise, but, being the least data-intensive, it has been used for large-scale cross-country analyses (see Chotikanapich et al., 1997). This relationship is often described in terms of the elasticity of poverty with respect to income or per capita gross domestic product (Kakwani, 1993).

Another approach is to compare the results of household budget surveys carried out in different years. Typically, this involves a comparison of some welfare measure, such as income or expenditure, adjusted for household size and changes in the cost of living between the two surveys. But survey results are often difficult to compare in developing countries due to changes in the questionnaire and sampling method, as well as problems adjusting for inflation. Eele et al (2000) reports that seven household surveys

were carried out in Tanzania between 1983 and 1999. They note that "comparison between surveys, however, is complicated by differing methodologies, definitions, and populations covered" (p 69). Among the problems mentioned are the valuation of non-marketed food production, small sample sizes, the lack of an official poverty line, and inflation, which resulted 40-fold increase in poverty lines from 1983 to 1998. Using data from two surveys in Tanzania, Sarris and Tinios (1994) show that such comparisons are very sensitive to seemingly-arbitrary decisions regarding how to adjust for inflation. A recent study compared the results of the 1991-92 Tanzania Household Budget Survey (HBS) and the 2000-01 HBS, concluding that the poverty rate had declined 2.9 percentage points over the nine-year period (NBS, 2002). However, the extensive adjustments that were required in the analysis of the 1991-92 HBS reconfirm the difficulties in making such comparisons[3].

A third approach is to construct an asset index based on household surveys that do not collect income or expenditure data. The asset index combines information about housing characteristics, source of water, sanitation, and ownership of consumer durables into an index using weights that are generated from principal component analysis (Filmer and Pritchit, 1998) or cluster analysis (Stifel et al, 2003).

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[3] In one report on the results of the 1991-92 HBS, the basic needs headcount poverty rate was estimated at 48.4 percent for mainland Tanzania and 5.6 percent for Dar es Salaam (NBS and OPM, 2000). A later report made numerous adjustments to make the results comparable to the 2000-01 HBS, yielding poverty estimates of 38.6 percent for mainland Tanzania and 28.1 percent for Dar es Salaam (NBS, 2002). The adjustments included recalculation of the poverty line, use of a different price index, exclusion of some consumption categories to match the 2000-01 HBS, and adjustment of sampling weights. The consumer price index indicated that prices increased by a factor of 4.4 between 1991-92 and 2000-01, while the Fisher price index estimated that prices had increased by a factor of just 2.5 (see Appendix 1 of NBS, 2000). Although the adjustments appear to be justified, the substantial change in the poverty estimates reveal the difficulties in measuring poverty trends by comparing household budget surveys.

The asset index approach is typically based on data from the Demographic and Health Surveys (DHS), which have been carried out 2-3 times in many developing countries. Comparing the asset index in the 1991-92 DHS and the 1996 DHS in Tanzania and defining poverty to be 40 percent in 1991-92, Stifel et al (2003) estimates that poverty declined 7 percentage points to 33 percent in 1999.

A fourth approach is to develop an index based on available measures of health, education, and nutrition. Sometimes called basic needs indicators, these measures often give equal weight to each indicator or attach subjective weights based on the perceived importance of each indicator. The Human Development Indicator (HDI), developed and monitored by the United Nations Development Programme, falls into this category. For Tanzania, the HDI index declines over the 1990s, implying worsening conditions, but increases slightly between 2000 and 2003 (UNDP, 2005: 226).

3. METHODS

In the last five years, a new approach has been developed to estimate poverty for small areas (such as districts) by combining data from a household expenditure survey and a census (Hentschel et al, 2000; Elbers et al, 2003). The idea is to use the household survey to estimate the relationship between poverty and a set of household characteristics, and then apply this relationship to the same household characteristics in the census data. This method has been applied in a growing number of countries (Henninger and Snel, 2003). However, census data are typically available only every ten years, making it difficult to use this approach to describe medium-term trends. Although

often called "poverty mapping", this approach can be used to generate small-area estimates for any variable that can be predicted using household characteristics.

This study uses a new method for estimating trends in poverty in the medium term that draws from both the asset index approach and small-area estimation methods. To implement this method, we select household characteristics that are available in both a household budget survey and the Demographic and Health Surveys for that country. Typically, these variables include the size and age-sex composition of the household, the education of household members, the sex and ethnicity of the head of household, housing characteristics (type of roof, floor, and walls), source of water, type of toilet, whether or not the house has electricity, and ownership of consumer durables such as radios, bicycles, and motor vehicles.

The next step (called "Stage 1" in the small-area estimation literature) is to use the household budget survey (HBS) to estimate per capita expenditure (y_i) as a function of these household characteristics (X_i^{HBS}). In order to reduce heteroskedasticity and ensure that the residuals in the regression approximate a normal distribution, we follow the convention of using a semi-log functional form:

$$\ln(y_i) = X_i^{HBS}\beta + e_i \qquad (1)$$

In Stage 2 of the standard small-area estimation method, the regression coefficients from Stage 1 would be applied to the same household characteristics from census data to generate spatially disaggregated estimates of poverty. In this study, we apply the regression coefficients to the same household characteristics from Demographic

and Health Surveys (DHS). Hentschel et al. (2000) show that the expected value of the probability that household i is poor (P_i) can be described as follows:

$$E\left(P_i \mid X_i^{DHS}, \beta, \sigma\right) = \Phi\left[\frac{\ln(z) - X_i^{DHS}\beta}{\sigma}\right] \quad (2)$$

and that a consistent estimate of the incidence of poverty for a set of households is simply the average of these household probabilities[4]. Although we lose the spatial resolution available from the census data, we gain a temporal dimensions from the fact that DHS surveys have been carried out two or three times in many developing countries. The similarity of the questionnaires and sampling method, as well as the generally high quality of the data generated, make the DHS surveys a useful tool in measuring trends over time.

An important assumption of this approach is that the model for predicting income based on household characteristics is valid over the range of years covered by the DHS surveys. In other words, we assume that the regression coefficients (β) are constant over the 1990s and that any changes in poverty are reflected in changes in the household characteristics (X_i). Although this assumption is standard in the asset index literature, we report on the results of sensitivity analysis to test this assumption.

We apply this method in Tanzania by using the 1991-92 Household Budget Survey (HBS) for the regression analysis in Stage 1. The HBS covered 4750 households

[4] Typically, the poverty rate is calculated as a weighted average, taking into account the sampling weights of the census (if any) and the size of the households. This results in an estimate of the proportion of people below the poverty line rather than the percentage of households below the line.

in mainland Tanzania, using a stratified random cluster sample[5]. The survey collected data on income, expenditure, the characteristics of household members, ownership of assets, and housing characteristics. Stage 2 of the analysis uses three Demographic and Health Surveys carried out in Tanzania in 1991-92, 1996, 1999, and 2003. The DHS surveys collect information on characteristics of household members, ownership of a few assets, and housing characteristics, as well as a wide range of health and nutrition variables (see Appendix A for more information on the HBS and the four DHSs).

In what could be called Stage 3 of the analysis, the results from Stage 2 are then combined with geographic information system (GIS) data to explore the relationship between rural poverty and market access in Tanzania and whether this relationship changed over the 1990s. We use six definitions of market access: straight-line distance to the nearest road, straight-line distance to the nearest regional center[6], and travel time to cities and towns in four size-categories. To link the DHS poverty data and the GIS market access data, we first identified the geographic coordinates of the DHS clusters. This was possible for 329 of the 357 clusters in the first two DHS surveys[7]. Second, the straight-line distance from these clusters to the nearest roads and regional centers was calculated using GIS software. The four travel-time measures were generated with a raster analysis that measured the distance along the road network, with weights for each type of road to convert distance into travel time. This analysis created a country-wide

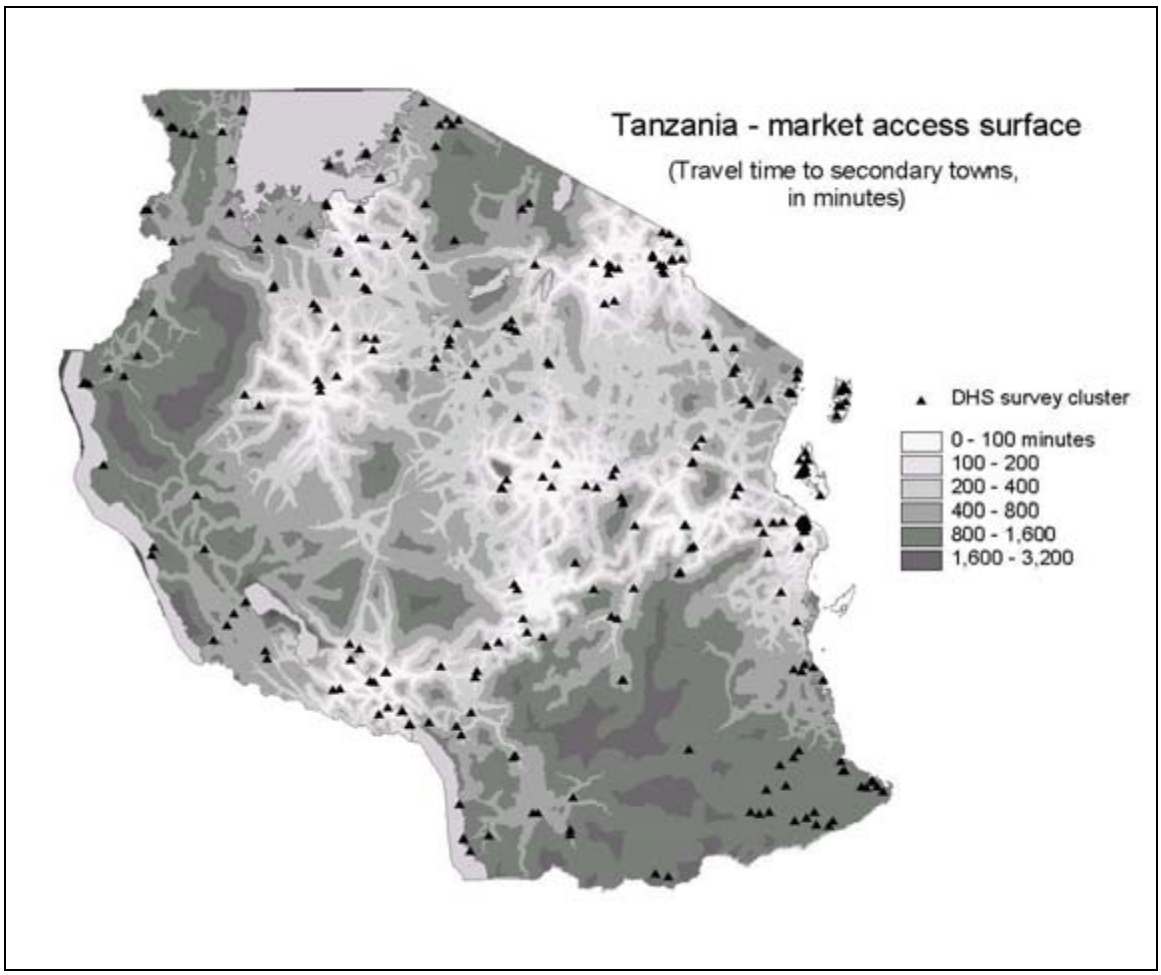
[5] Asset data are missing for 14 households in the HBS, so the sample that we used for the regression analysis included 4736 households.
[6] During the 1990s, mainland Tanzania wasis divided into twenty administrative regions, each with an administrative center. Recently an additional region was created.
[7] Twenty-eight clusters in the 1996 and 1998 DHS surveys could not be found in GIS databases of places in Tanzania, nor on paper maps of the country.

"surface" for each of the four travel-time market access variables, from which the values corresponding to each DHS cluster were selected (Figure 2 shows the values of travel time to a secondary town on a map of Tanzania). The final result is a database with poverty estimates at the household level and GIS variables at the cluster level[8]. Appendix B describes the calculation of the market access variables in more detail.

The use of cluster-level GIS variables will introduce some error to the extent that the cluster-level values differ from household-level values. In Tanzania, the clusters are based on census enumeration areas, which are designed to include about 100 households. Given the average population density in rural Tanzania (32 inhabitants per km^2) and the average household size (5 persons), this implies that the average EA covers an area equivalent to a circle with radius of 2.2 kilometers. This suggests that the errors associated with using cluster-level GIS values will be negligible for all the market access variables, with the possible exception of distance to road, for which the mean value in rural areas is 20 kilometers.

[8] Macro International, the research firm that conducts the Demographic and Health Surveys, kindly provided the geo-coordinates for the 176 clusters in the 1999 survey. Todd Benson geo-coded another 156 clusters, compiled GIS variables, and calculated some of the market access indicators. Jordan Chamberlin calculated the travel-time measures of market access.

Figure 2—Map of Tanzania with travel time to secondary towns



4. RESULTS

The results of the analysis are divided into four sections. First, we describe the regression analysis used to predict per capita expenditure as a function of household characteristics, using household survey data from Tanzania. Then, we present estimates of Tanzanian poverty over the 1990s derived from applying the regression models to the household characteristics in three Demographic and Health Surveys. Third, we present the results of a sensitivity analysis to test a key assumption in the method. Finally, these poverty estimates are used to analyze econometrically the relationship between poverty, on the one hand, and various definitions of market access. .

PREDICTORS OF HOUSEHOLD WELFARE

In this section, data from the 1991-92 Household Budget Survey (HBS) are used to estimate the logarithm of per capita expenditure as a function of household characteristics, as shown in equation (1). Although the HBS collected information on many more variables that could be used to "predict" per capita expenditure, we are limited to those that are also available in the four Demographic and Health Surveys (DHS) carried out in Tanzania in 1991-92, 1996, 1999 and 2003. In many cases, categorical variables such as water source had to be grouped into a small number of categories to ensure compatibility between the HBS and the three DHS surveys.

The sample of the 1991-92 HBS is divided into four strata: Dar es Salaam, large towns, small towns, and rural areas. A Chow test indicates that the coefficients in the four strata are significantly different from each other, so separate regressions were run for

each stratum. Ordinary least squares (OLS) models were used to carry out some diagnostic tests. The Breusch-Pagan test indicates the presence of multiplicative heteroskedasticity in two of the four models (Dar es Salaam and large towns). We address this problem by using the Huber/White/sandwich estimator of the standard errors, which is consistent under heteroskedasticity. The Ramsey RESET test, using powers of the predicted values, suggests the omission of variables in the same two models. In spite of adding squared terms and additional variables, we were not able to address this problem. The variance inflation factors (VIF) were calculated to test for multicollinearity. Two variables in the Dar es Salaam model had VIF values over 20, the conventional limit, were removed.

Next, the four models were run using the *svyregress* command in Stata which takes into account the stratification and clustering of the HBS sample and, as mentioned above, calculates Huber/White/ sandwich standard errors. Individual variables and sets of dummy variables were removed if they were not statistically significant at the p=0.20 level. Note that we are not concerned about likely endogeneity of some of the explanatory variables (e.g. ownership of consumer goods) in the models because we are only interested in generating a model to predict per capita expenditure.

Table 1 gives the results of the final models. Some coefficients were statistically significant in all four models: household size, household size squared, and ownership of a radio, refrigerator, and car. The sets of dummy variables representing the age-sex composition of the household, the education of the head of household, and the region are each jointly significant, based on the F-test. Somewhat surprisingly, the poverty rate

does not vary significantly between male- and female-headed households. The coefficients representing the education of the spouse were jointly significant only in the rural model. The signs of the coefficients are broadly consistent with expectations: the coefficients on ownership of consumer goods and electricity are uniformly positive, while the coefficient on earth floors is negative.

The overall fit of the four models is relatively good, with the value of R^2 ranging from 0.42 to 0.53. This is toward the upper range of similar prediction models carried out as part of poverty mapping analyses in other countries (see Henninger and Snel, 2003).

Table 1—Regression models of per capita expenditure

	Dar es Salaam		Large towns		Small towns		Rural areas	
	N = 1107		N = 794		N = 664		N = 2171	
	R^2 = 0.5034		R^2 = 0.4279		R^2 = 0.5268		R^2 = 0.4178	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Household size	-0.25492	-8.91***	-0.224030	-2.79***	-0.252674	-5.74***	-0.159395	-10.27***
Households size squared	0.00972	4.54***	0.011910	2.20**	0.011629	4.38***	0.004886	6.59***
% males under 5 yrs share of total	0.00539	3.30***	0.001294	0.32	0.002042	0.64	0.003574	1.91*
% females under 5 yrs as % share of	0.00555	3.02***	0.000240	0.07	0.001382	0.33	0.001045	0.75
% males 5-15 yrs	-0.00012	-0.09	-0.012338	-1.73*	-0.002905	-0.93	-0.001735	-1.23
% females 5-15 yrs	0.00028	0.25	-0.003835	-1.1	-0.005580	-2.38**	-0.001598	-1.03
% males 16-30 yrs	-0.00059	-0.66	-0.002234	-1.18	-0.000363	-0.17	0.000734	0.71
% females 16-30 yrs	0.00092	1.26	-0.003077	-1.54	-0.002251	-1.14	0.000172	0.12
% females 31-55 yrs	-0.00030	-0.22	-0.002818	-2.67***	-0.002908	-1.23	-0.000399	-0.25
% males over 55 yrs	0.00243	1.15	-0.001686	-0.44	-0.005041	-2.15**	0.003162	2.48**
% females over 55 yrs	0.00233	1.24	-0.001034	-0.42	-0.001228	-0.36	0.000748	0.54
Female head								
Age of head	-0.00357	-2.61**	-0.001256	-0.53				
Head has some primary schooling	0.01550	0.24	0.279551	2.34**	0.243244	2.69***	0.086257	2.39**
Head finished primary school	-0.10593	-1.32	0.527486	3.57***	0.391461	3.04***	-0.012855	-0.18
Head has some second. schooling	0.04493	0.57	0.237551	1.48	0.386034	3.87***	0.230773	1.93*
Head finished upper sec school	0.19154	2.51**	0.321873	2.24**	0.401873	3.32***	0.042039	0.65
Spouse has some primary schooling							0.052134	1.52
Spouse finished primary school							0.358541	2.64***
Spouse has some second. schooling							0.177469	1.11
Spouse finished upper sec school							-0.019249	-0.33
Floor of house made of earth	-0.17159	-3.99***	-0.288577	-2.67***			-0.205615	-3.76***
Water from indoor pipe	0.28188	4.82***			0.193219	1.05		
Water from outdoor pipe					0.148876	1.44		
Water from well					-0.154783	-1.19		
Flush toilet					0.246282	1.44		
Latrine					0.240432	2.24**		
House has electricity							0.121323	1.51
Radio ownership	0.08130	1.87	0.127064	1.49	0.304930	2.90**	0.293940	7.62***
Television ownership	0.23464	2.02**	0.345648	1.22				
Refrigerator ownership	0.30908	5.88***	0.191551	1.80*	0.368204	2.57**	0.426404	1.48
Motorbike ownership							0.149271	1.50
Car ownership	0.33038	2.75***	0.434943	2.45**	0.263515	1.66	0.240083	1.97**
Constant	10.99431	85.61***	10.56714	38.72***	9.823588	29.81***	-0.34683	-1.81*

Source: 1991-92 Tanzanian Household Budget Survey

* = significant at the 10 percent level, ** = significant at the 5 percent level, *** = significant at the 1 percent level

Note: Dependent variable is log of per capita expenditure. Coefficients of regional dummy variables omitted to save space.

ESTIMATED POVERTY TRENDS

The regression equations described in the previous section are then applied to the same household characteristics in the Tanzanian Demographic and Health Surveys (DHS) of 1991-92, 1996, 1999 and 2003. The result is an estimate of the per capita expenditure for each household in the four DHS surveys. This estimate is transformed into the probability that the household is poor using equation (2) and averaged over groups of households to obtain estimates of the incidence of poverty. Table 2 presents the poverty estimates for each year of the DHS and for different household groups. Appendix C gives the standard errors of these estimates. According to our analysis, the overall poverty rate for mainland Tanzania is estimated to be 46.8 percent in 1991-92. This is very close to the poverty rate of 47.1 estimated directly from the expenditure data in the 1991-92 Household Budget Survey. The 1991-92 poverty rate for Dar es Salaam is 3.6 percent, close to the HBS estimate of 3.1 percent, while the 1991-92 rural poverty rate is 52.9 percent, somewhat lower than the HBS estimate of 56.3 percent. In general, these results provide some confidence that the poverty estimates derived from the household characteristics in the DHS are reasonable close to the poverty estimates from the original budget survey.

Table 2—Incidence of poverty by year and by household category

	Year				Change from
	1991-92	1996	1999	2003	1991-92 to 2003
Tanzania mainland	0.468	0.429	0.424	0.380	-0.088
Urban-rural residence					
Urban	0.247	0.199	0.188	0.175	-0.072
Rural	0.529	0.484	0.492	0.450	-0.079
Stratum					
Dar es Salaam	0.036	0.041	0.033	0.045	0.009
Large towns	0.184	0.165	0.118	0.173	-0.011
Small towns	0.345	0.305	0.296	0.302	-0.043
Rural areas	0.529	0.484	0.492	0.450	-0.079
Zone					
Coast	0.385	0.346	0.371	0.265	-0.120
Northern Highlands	0.284	0.304	0.261	0.219	-0.065
Lake Zone	0.498	0.440	0.477	0.411	-0.087
Central Zone	0.520	0.550	0.526	0.517	-0.003
Southern Highlands	0.590	0.528	0.508	0.471	-0.119
Southern Zone	0.513	0.460	0.438	0.400	-0.113
Sex of head of household					
Male	0.469	0.422	0.416	0.367	-0.102
Female	0.465	0.460	0.461	0.430	-0.035
Education of household head					
No schooling	0.576	0.547	0.555	0.536	-0.040
Some primary school	0.490	0.459	0.410	0.397	-0.093
Completed primary school	0.343	0.345	0.354	0.336	-0.007
Some secondary school	0.137	0.128	0.121	0.131	-0.006

Source: Based on analysis of the 1991-92 Household Budget Survey and the Demographic and Health Surveys of 1991-92, 1996, 1999, and 2003.

Note: Incidence of poverty refers to the proportion of the population living in households with per capita consumption expenditure below the poverty line.

Looking at the trends over time, the figures in table 2 suggest that the poverty rate has fallen about 9 percentage points between 1991-92 and 2003, with most of the decline occurring between 1999 and 2003. This rate of poverty reduction is greater than 2.9 percentage point reduction estimated from a comparison of the 1991-92 and 2000-01 Household Budget Surveys (NBS, 2002). This discrepancy raises several questions regarding the credibility of our results. First, is the change in poverty statistically significant? Using formulas developed by Hentschel et al (2000) and adapted to include

Stage 2 sampling error, we calculate that the standard errors of the poverty estimates (see Appendix C). Based on these standard errors, the change in overall poverty in mainland Tanzania between 1991-92 and 2003 is statistically significant at the 1% confidence level.

Second, is the decline in poverty derived from improvements in a small number of household indicators or a broad set of indicators? The latter would be a more credible sign of improved living conditions. Of the 20 indicators with an unambiguous relationship with poverty, only one suggests deteriorating living conditions, three show no change, and 16 suggest improved living conditions. Thus, our estimate of poverty reduction in Tanzania is based on improvement in a broad range of household indicators.

Third, are these results consistent with the trends in GDP per capita over the same period? Per capita GDP growth between 1991-92 and 2003 was 1.47 percent, with much of the growth occurring since 2000 (see Figure 1). Two recent studies have estimated the elasticity of poverty with respect to per capita GDP growth to be about -1.7 (Chen and Ravallion, 2001; AFD et al., 2005). This would imply a 12-percentage-point decline in Tanzanian poverty over this period. Our estimate of a 9-percentage-point decline in poverty is certainly not exaggerated given GDP growth in Tanzania. Our results are also consistent with GDP trends in that both show the greatest improvement over the 1999-2003 period.

Table 2 also indicates that poverty declined 7.2 percentage points in urban areas and 7.9 percentage points in rural areas. This contradicts the widespread view that the benefits of growth have been concentrated in urban areas. The overall decline in poverty

(9.9 percentage points) was greater than the decline in either urban or rural areas. The explanation for this apparent paradox is that the share of the population living in urban areas, where poverty is lower, increased from 18 percent in 1991-92 to 24 percent in 2003. Thus, the change in the composition of the population contributed to poverty reduction, in addition to changes within urban and rural areas[9].

Interestingly, the poverty reduction in urban areas does not come from gains in Dar es Salaam, where poverty was essentially unchanged over the period under consideration. Rather the urban poverty reduction is due to declines in poverty in small towns and, to a lesser degree, large towns, along with migration toward larger centers (see Table 2). One hypothesis is that during the 1990s, economic reforms resulted in a more geographically decentralized pattern of growth, now that the public sector and state enterprises (most of which were based in Dar es Salaam) play a smaller role in economic decisions.

The poverty ranking of zones appears to be fairly stable over the decade (see table 2). The lowest poverty rates are in the Northern Highlands which benefits from horticultural production, tourism, and trade with Kenya. The Central Zone is among the poorest two zones in all four periods, probably reflecting the low and unreliable rainfall that affects this region.

[9] As shown in Appendix B, the standard errors for these poverty estimates is generally between 0.02 and 0.04. This implies a 95% confidence interval of ±4-8 percentage points. The change in rural poverty between 1991-92 and 2003 is statistically significant at the 5% confidence level.

The Coast, Southern Highlands, and Southern zones saw poverty decline by more than 10 percentage points between 1991-92 and 2003. The Coast probably benefited from population growth in Dar es Salaam[10], while the South has gained from the dramatic growth in cashew nut production and exports. In 1998, Mtwara and Lindi accounted for 80 percent of Tanzanian cashew nut production (URT, 2000). The strong poverty reduction in the Southern Highlands is somewhat surprising because this zone (the main maize-surplus zone in Tanzania) is said to have been hurt more than other regions by market reforms that eliminated fertilizer subsidies and removed maize price supports. On the other hand, it is a region with good agricultural potential, so perhaps it has gained from market reforms and, in particular, from the gradual opening of cross-border trade with Zambia. The Northern Highlands and the Lake zones had significant but not dramatic reductions in poverty, but the Central Zone shows no poverty reduction over this period. As mentioned above, the Central Zone is the driest and most drought-prone zone.

The poverty rate among female-headed households was roughly equal to that of male-headed households in 1991-92. Over the next 12-13 years, however, poverty among male-headed household appears to have declined substantially (about 10 percentage points), while that of female-headed households has declined much less (about 3.5 percentage points) (see Table 2). This pattern is particularly strong in urban areas, where the poverty rate among female-headed household did not change over the

[10] Although our results indicate that the poverty rate in Dar es Salaam did not decline over the 1990s, the share of the population living in Dar es Salaam has increased. An increase in the share of the population living in Dar es Salaam (located in the Coast Zone) would reduce the poverty rate of the zone.

decade. One hypothesis is that female-headed households have been less able to take advantage of new market opportunities provided by the economic reforms due to cultural norms, the demands of child care, or other factors. Alternatively, the growing problem of HIV/AIDS may mean that many of these female-headed households are AIDS widows, who would have faced costs associated with the illness and incapacity of their husbands. The DHS data indicate that the proportion of female-headed households has increased from 19 percent in 1991-92 to 23 percent in 2003.

Table 2 shows the poverty trends by the educational level of the head of household. The results confirm the strong negative relationship between education and poverty. The incidence of poverty is more than four times greater among households in which the head has no education compared to those in which the head has at least some secondary education. The results also suggest that the gains in poverty reduction have been greater among less educated households. The poverty reduction among households with a head with no education or some primary was 4 and 9 percentage points, respectively. However, households in which the head had completed primary school had virtually unchanged poverty rates. This suggests that less educated households (typically poor households in rural areas) have gained at least as much as more educated households, suggesting that the benefits of economic growth have not been limited to a small elite.

SENSITIVITY ANALYSIS

The analysis presented above relies on the assumption that the relationship between per capita expenditure and household characteristics (the βs in equation (1)) remains constant over time. In other words, we assume that the regression model estimated using data from the 1991-92 Household Budget Survey (HBS) applies to all the DHS surveys up to the year 2003. In order to test this assumption, the analysis was repeated using the 2001-01 HBS instead of the 1991-92 HBS. If the relationship between per capita expenditure and household characteristics had changed over the 1990s, this would result in different results when the 2000-01 HBS is used in Stage 1.

Using the 2000-01 HBS, the predictive power of the Stage 1 regression models fall somewhat and the estimated poverty rates for each year are about 2-6 percentage points lower. However, many of the basic patterns and trends are similar. Specifically, the results indicate that:

- The overall basic needs poverty rate in mainland Tanzania declines steadily across the four periods, though the overall poverty reduction is smaller (5.3 percentage points instead of 8.8 percentage points).
- Poverty declines more in the rural areas and other urban areas than in Dar es Salaam.
- Poverty declines more among male-headed households than female-headed households.
- Poverty rates are lowest in the Northern Highlands and Coast zones and highest in the Central Zone.

- Poverty reduction is greatest in the Coast and Southern Highlands and below average in the Central Zone.
- Poverty is essentially unchanged among households whose head has completed primary school; almost all the gains in poverty reduction are among households whose head did not complete primary school.

Thus, we conclude that the findings presented earlier are not very sensitive to the year of the household budget survey used in the Stage 1 regression analysis (for more information, see Makbel, 2005).

RELATIONSHIP BETWEEN MARKET ACCESS AND POVERTY

As described earlier, the poverty estimates from the DHS data were combined with cluster-level GIS variables to explore the relationship between rural poverty and market access over time. The focus is on *rural* poverty because urban areas have, almost by definition, good market access, and we do not want the large urban-rural income differences to affect our results. In this analysis, we use six measures of market access:

- Straight-line distance to a primary or secondary road
- Straight-line distance to a regional center
- Travel time to Dar es Salaam
- Travel time to the closest of eight primary towns[11] or Dar es Salaam,

[11] Large towns are those given the status of "municipality" in Tanzania and comprise Arusha, Dodoma, Iringa, Mbeya, Morogoro, Moshi, Mwanza, and Tabora.

- Travel time to the closest of 11 secondary towns[12], primary towns, or Dar es Salaam,
- Travel time to the closest of 22 tertiary towns[13], secondary towns, primary towns, or Dar es Salaam.

Somewhat surprisingly, the different measures of market access are not very closely correlated with each other. Of the 15 combinations of market access indicators, most pairs have correlation coefficients (r) between 0.4 and 0.6, and only one is above 0.65.

Table 3 presents the estimates of rural poverty by year and by degree of market access using the six definitions given above. The average poverty rate for rural areas, in the first row, is almost identical to the rural poverty rates reported in Table 2, the slight differences being due to the omission of clusters that could not be geo-coded. The relationship between poverty and market access varies across different measures of market access. Rural poverty is most closely related to distance to a regional center and, to a lesser degree, travel time to primary, secondary, and tertiary towns. On the other hand, distance to a road and travel time to Dar es Salaam do not seem to be related to the incidence of poverty at all. The latter result is partly explained by the fact that the coastal area near Dar es Salaam is dry and has a low agricultural potential.

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[12] Bagamoyo, Bukoba, Chake Chake, Kigoma, Lindi, Mtwara, Musoma, Shinyanga, Singida, and Songea.
[13] Babati, Ifakara, Kahama, Kibaha, Kilosa,, Kondoa, Korogwe, Makambako, Manyoni, Masasi, Mpanda, Mpwapwa, Newala, Njombe, Nzga, Same, Sengerama, Sumbawanga, Tukuyu, Tunduru, Urambo, and Wete.

Table 3—Incidence of rural poverty by year and by measures of market access[1]

	Year			Change from
	1991-92	1996	1999	1991-92 to 1999
Tanzania rural areas	0.531	0.484	0.491	-0.040
Distance to road				
On road	0.595	0.536	0.565	-0.030
Less than 2 km	0.468	0.467	0.461	-0.007
2-5 km	0.503	0.439	0.49	-0.013
More than 5 km	0.546	0.487	0.482	-0.064
Distance to regional center				
Less than 10 km	0.335	0.292	0.364	0.029
10-50 km	0.515	0.485	0.457	-0.058
50-100 km	0.54	0.481	0.503	-0.037
More than 100 km	0.561	0.517	0.523	-0.038
Quartile of travel time to Dar es Salaam				
Closest	0.534	0.499	0.534	0.000
2	0.499	0.457	0.419	-0.080
3	0.544	0.478	0.488	-0.056
Farthest	0.543	0.500	0.519	-0.024
Quartile of travel time to a primary town				
Closest	0.480	0.448	0.448	-0.032
2	0.550	0.484	0.505	-0.045
3	0.570	0.504	0.545	-0.025
Farthest	0.515	0.498	0.469	-0.046
Quartile of travel time to a secondary town				
Closest	0.486	0.456	0.450	-0.036
2	0.540	0.472	0.504	-0.036
3	0.531	0.494	0.490	-0.041
Farthest	0.565	0.509	0.522	-0.043
Quartile of travel time to a tertiary town				
Closest	0.515	0.469	0.495	-0.020
2	0.536	0.507	0.482	-0.054
3	0.552	0.478	0.472	-0.080
Farthest	0.523	0.482	0.517	-0.006

Source: Based on analysis of the 1991 Household Budget Survey, the Demographic and Health Surveys of 1991-92, 1996 and 1999, and GIS analysis.
(1) Incidence of poverty refers to the proportion of the population living in households with per capita consumption expenditure below the poverty line.

In order to get a more detailed picture of the bivariate relationship between poverty and market access, we use non-parametric regression analysis[14]. Figures 3-8 give the results of regressing rural poverty (or more precisely, the household-level probability of poverty) as a function of each of the six measures of market access at the cluster level. In each case, the first panel (a) gives the result for 1991-92 and the second (b) for 1999. Figure 3 shows an unexpected, possibly U-shaped, relationship between rural poverty and distance from a road, particularly beyond 75 kilometers. It should be noted that fewer than 10 percent of the households live this far from the road[15], so the result is being driven by a relatively small number of observations. Figure 4 shows a positive relationship between rural poverty and distance to a regional center in 1991-92, but the relationship appears weaker in 1999. A similar pattern occurs in Figure 5 with travel time to Dar es Salaam. In Figures 6-8, the shapes are similar in 1991-92 and 1999. All six graphs reveal a downward shift in the graph, reflecting the overall reduction in rural poverty, but none of the graphs show an increase in the slope, which would indicate that remote rural areas have lost more (or gained less) than rural areas with better market access.

[14] To implement the non-parametric regression analysis, we use the *kernreg* command in Stata and adopt a half-bandwidth of 40 percent of the range of the independent variable, an Epanechnikov kernel, and 30 points where the regression analysis is carried out. The confidence intervals are estimating by bootstrapping with 100 replications.

[15] In 1991-92, 424 households in 17 clusters lived more than 75 km from a road, while in 1999, 153 households in eight clusters lived this far.

Figure 3—Non-parametric regression of rural poverty as a function of distance to road

a. 1991-92 **b. 1999**

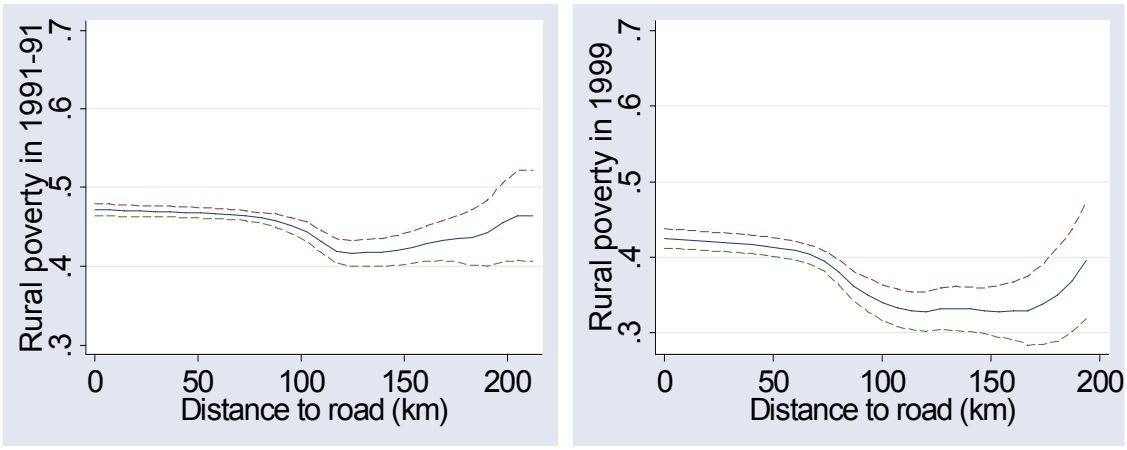


Figure 4—Non-parametric regression of rural poverty as a function of distance to regional center

a. 1991-92 **b. 1999**

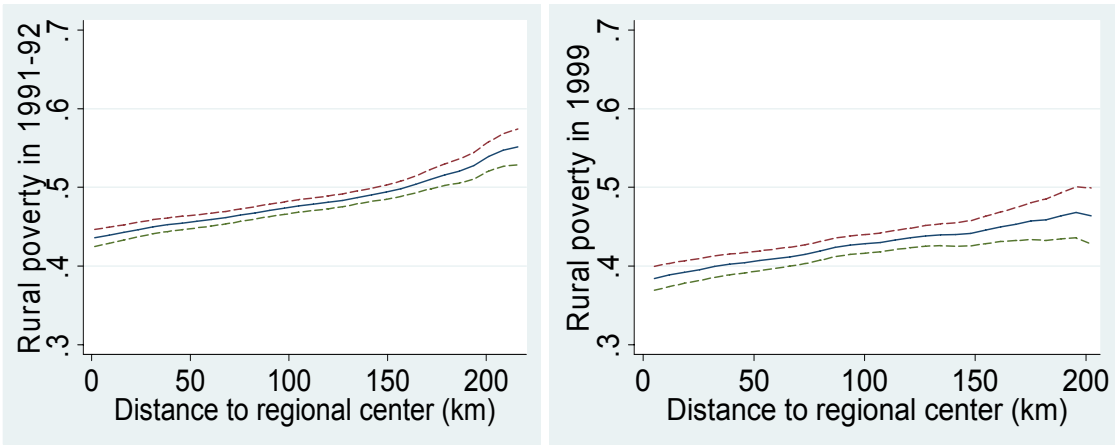


Figure 5—Non-parametric regression of rural poverty as a function of travel time to Dar es Salaam

a. 1991-92 **b. 1999**

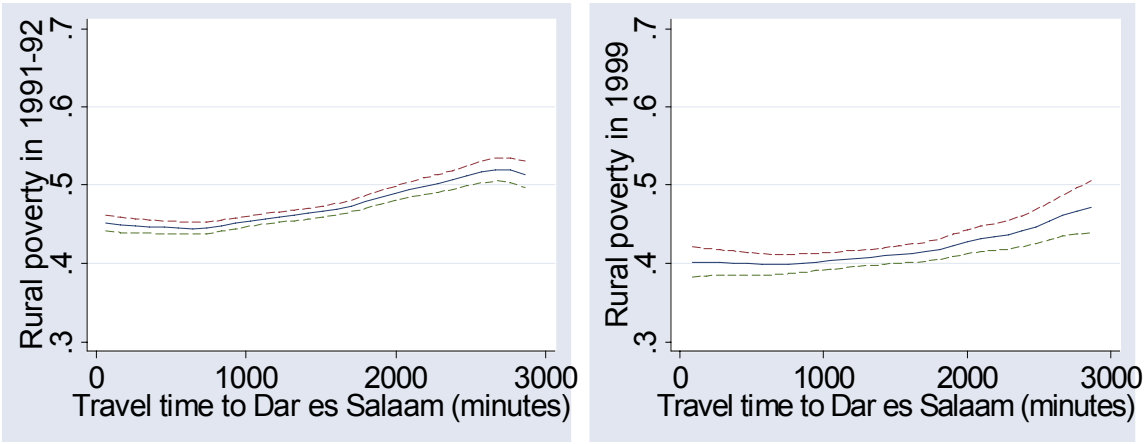


Figure 6—Non-parametric regression of rural poverty as a function of travel time to primary town

a. 1991-92 **b. 1999**

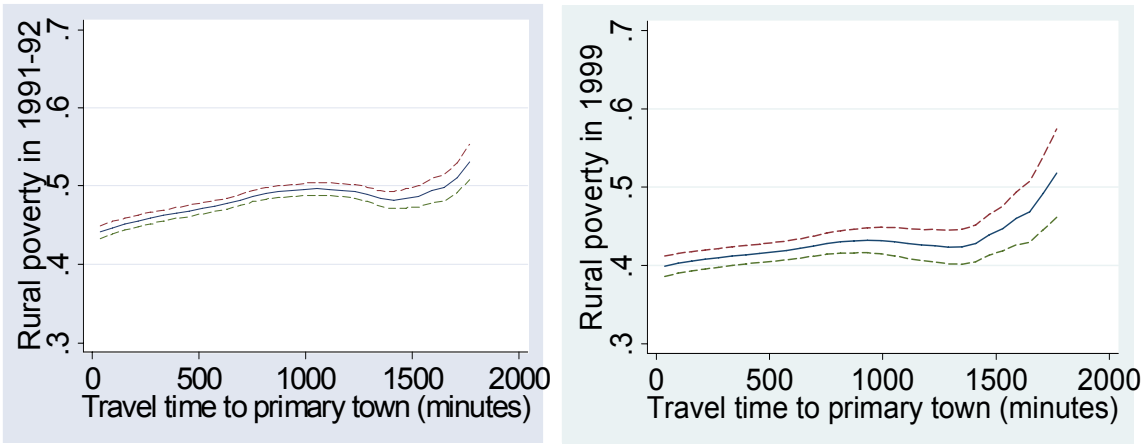


Figure 7—Non-parametric regression of rural poverty as a function of travel time to secondary town

a. 1991-92 **b. 1999**

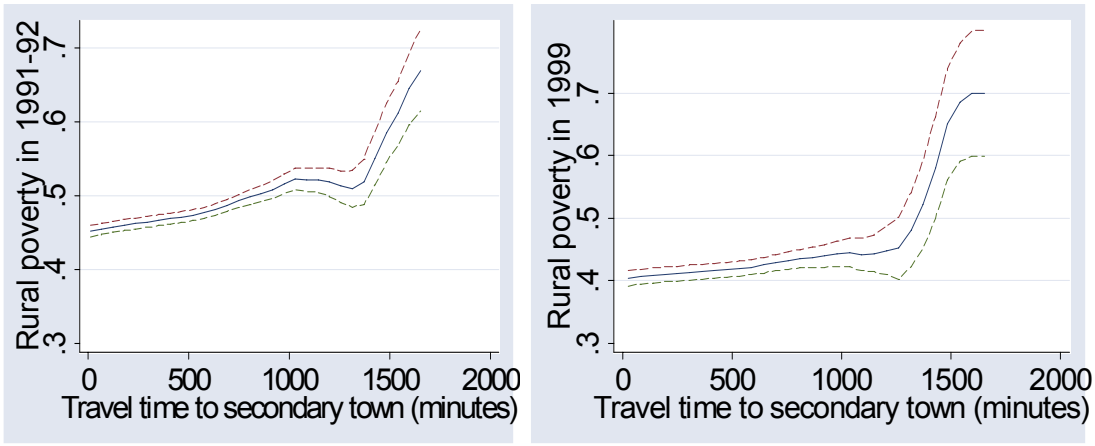
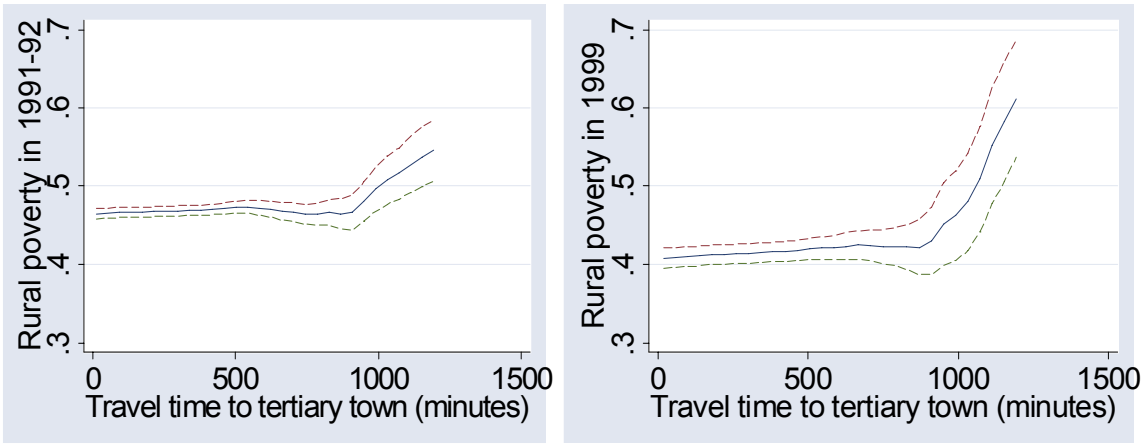


Figure 8—Non-parametric regression of rural poverty as a function of travel time to tertiary town

a. 1991-92 **b. 1999**



These bivariate relationships can also be examined with traditional parametric regression analysis. We run separate models for 1991-92 and 1999 in the context of seemingly unrelated regression (SUR) analysis, which allows us to test the statistical significance of any changes in the market access coefficient between 1991-92 and 1999[16]. In particular, the conventional wisdom that remote rural areas have lost more (or gained less) than rural areas with better market access would be indicated by a statistically significant *increase* in the market access coefficient. The results, shown in Table 4, reveal that the market access coefficient are statistically significant at least at the 10 percent level in most cases[17], but they explain a very small proportion (1-2 percent) of the variation in rural poverty. The measure that perform best is travel time to a secondary town. But the difference between the 1991-92 coefficient and the 1999 coefficient is not statistically significant at the 5 percent level for any of the six measures of market access (in one case, it is significant at the 10 percent level but the coefficient *decreased* over the period).

A similar analysis (not shown) comparing the DHS data from 1991-92 and 1996 (instead of 1999) produced very similar results. Seven of the twelve coefficients are statistically significant at the 5 percent level, but none of the coefficients changes significantly between 1991-92 and 1996.

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[16] This procedure is implemented with the *suest* command in Stata, which calculates Huber/White/sandwich estimates of the standard errors, which are heteroskedasticity consistent and take into account the stratification and clustering in the data.

[17] Of the twelve coefficients, six are significant at the 5 percent level and two more at the 10 percent level.

Table 4—Relationship between rural poverty and each measure of market access

	Year	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	1991-92	N = 5668	N = 5668	N = 5668	N = 5668	N = 5668	N = 5668
		R^2 = 0.002	R^2 =0.023	R^2 = 0.008	R^2 = 0.017	R^2 = 0.023	R^2 = 0.002
	1999	N = 1813	N = 1813	N = 1813	N = 1813	N = 1813	N = 1813
		R^2 = 0.012	R^2 =0.018	R^2 =0.007	R^2 =0.014	R^2 =0.023	R^2 =0.008
Constant	1991-92	.47347***	.40451***	.41783***	.42057***	.41822***	.45270***
	1999	.43104***	.35920***	.36697***	.37534***	.36543***	.38554***
Distance to nearest road	1991-92	-.00033					
	1999	-.00089**					
Distance to nearest regional center	1991-92		.00080***				
	1999		.00070*				
Travel time to Dar es Salaam	1991-92			.00004**			
	1999			.00004			
Travel time to primary town	1991-92				.00009***		
	1999				.00001*		
Travel time to secondary town	1991-92					.00016***	
	1999					.00015***	
Travel time to tertiary town	1991-92						.00006
	1999						.00012
Test of hypothesis that $\beta_{1991\text{-}92} = \beta_{1999}$	F-statistic Prob	F = 3.05 p = .0819	F = 0.08 p = .7795	F=0.01 p=.9185	F=0.07 p= 0.7852	F=0.00 p=0.9745	F=0.61 p=0.4340

Source: Seemingly unrelated regression analysis of poverty rates as a function of indicators of market access.

The market access results presented thus far have been based on bivariate relationships. It is worth asking whether the findings would differ if we controlled for other geographic variables such as land use category, elevation, and climate. Table 5 shows the results of a model estimating rural poverty as a function of five of the six market access indicators[18] and other geographic factors. Again, we use an SUR model to test for changes in the poverty-market access relationship between 1991-92 and 1999. A significant increase in the market access coefficient would confirm the conventional wisdom that remote rural areas have lost (or gained less) more than other rural areas. As

[18] One market access indicator, travel time to tertiary towns, is dropped because it is not significant and it is closely correlated with travel time to secondary towns

shown in Table 5, two of the market access measures show no significant change between 1991-92 and 1999, while two others reveal a significant *decrease* in the coefficient. Only one market access indicator, travel time to a primary town, has a coefficient that increases significantly over the period. A separate SUR model (not shown) comparing 1991-92 and 1996 showed no changes significant at the 5 percent level.

Table 5—Relationship between rural poverty and all measures of market access controlling for agro-climatic characteristics

	1991-92 N = 5668 R^2 = 0.1195		1999 N = 1813 R^2 = 0.1128	
Variable name	Coefficient		Coefficient	
% of land in cropland	-0.0059		-0.0307	
% of land in deciduous forest	-0.01202		0.018389	
% of land in dry	0.002491		-0.00553	
% of land in coniferous forest	-0.11951	*	(dropped)	
% of land in grassland	0.021981		-0.00204	
% of land in mixed forest	0.047575		-0.12655	
% of land in savanna	0.001542		-0.01489	
% of land in shrub land	-0.04326		0.021543	
Mean elevation	3.13E-05		9.71E-05	
Rainfall in growing season	8.99E-05		0.000204	
Evapotranspiration rate	-0.00141	***	0.000506	**
Average max daily temperature	0.029348	**	0.014917	
Distance to road	-0.00183	***	-0.0031	*
Distance to regional center	0.000928	***	0.000788	***
Travel time to Dar es Salaam	2.95E-05		-5.7E-05	
Travel time to primary town	4.79E-05		0.000173	
Travel time to secondary town	5.96E-05		0.000123	***
Constant	0.276426		-0.59789	*
Test of hypothesis that coefficients for distance to road are equal for 1991-92 and 1999	F=4.94		Prob =0.0273	$\beta_{1991\text{-}92} > \beta_{1999}$
Test of hypothesis that coefficients for distance to regional center are equal for 1991-92 and 1999	F=0.13		Prob =0.7191	
Test of hypothesis that coefficients for travel time to Dar are equal for 1991-92 and 1999	F=4.64		Prob =0.0322	$\beta_{1991\text{-}92} > \beta_{1999}$
Test of hypothesis that coefficients for travel time to primary town are equal for 1991-92 and 1999	F=4.51		Prob =0.0348	$\beta_{1991\text{-}92} < \beta_{1999}$
Test of hypothesis that coefficients for travel time to secondary town are equal for 1991-92 and 1999	F=0.86		Prob =0.3549	
Test of hypothesis that all coefficients are equal for 1991-92 and 1999	F=1.72		Prob =0.0308	

Source: Seemingly unrelated regression analysis of rural poverty rates as a function of cluster-level GIS variables including six measures of market

5. DISCUSSION

In Tanzania, as in many other developing countries, the conventional wisdom is that economic reforms may have stimulated economic growth, but the benefits of this growth have been uneven, favoring urban households and farmers with good market access. This idea, although quite plausible, has rarely been tested. In this paper, we develop a new approach to measuring trends in poverty and inequality and apply it to Tanzania in order to explore the distributional aspects of economic growth and the relationship between rural poverty and market access.

We find that, since the early 1990s, a period during which significant reforms were implemented, the overall rate of poverty fell about 9 percentage points. This is greater than the 2.9 percentage point reduction in poverty estimated by comparing the Household Budget Surveys carried out in 1991-92 and 2000-01 (NBS, 2002). It should be noted that the HBS comparison excludes the years after 2000-01 when GDP growth was significantly higher than it was during the 1990s. Furthermore, our estimate of poverty reduction is consistent with (or perhaps a little lower than) what would be expected given Tanzania's GDP growth and international estimates of the elasticity of poverty with respect to GDP.

The results also indicate that the headcount poverty rate declined by roughly equal amounts in urban and rural areas. Somewhat surprisingly, the poverty rate in Dar es Salaam did not decline, so other cities accounted for all the progress in urban poverty reduction. One hypothesis is that urban areas, particularly Dar es Salaam, were more adversely affected by the closure and privatization of state enterprises, the contraction of

fiscal spending, and the elimination of consumer price control (which rarely reached into rural areas). Another thing to keep in mind is that we are measuring poverty reduction in terms of percentage-point reduction. Rural poverty rates are higher, so they have farther to fall. The proportionate reduction in poverty was 29 percent in urban areas and 15 percent in rural areas.

Poverty reduction was greater among male-headed households (10 percentage points) than among female-headed households (3.5 percentage points), particularly in urban areas. This may be related to differential ability to take advantage of opportunities created by market liberalization or to the differential impact of HIV/AIDS.

The gains in poverty reduction were greater among less educated households than among more educated households. This suggests that economic growth has not favored the educated elite over others. It is probably explained by the same factors discussed in reference to urban-rural differences, since there are sharp differences in the average education levels of urban and rural heads of household.

The Coast, the Southern Highlands, and the South Zones have gained the most in terms of poverty reduction. All three regions have seen the incidence of headcount poverty, as estimated in this study, fall by at least 10 percentage points. The Central Zone is the only one not to show any progress in poverty reduction. Poverty reduction in the South Zone may be linked to the dramatic expansion of cashewnut production in the 1990s, while the Central Zone may have been unable to respond to new opportunities due to the poor agro-climatic conditions there. Given the removal of fertilizer subsidies and

maize transport subsidies, which favored the Southern Highlands, it is surprising that this region registered large gains in poverty reduction.

If the data are re-analyzed using the 2000-01 HBS (instead of the 1991-92 HBS), the poverty trends for different types of households are quite similar, though the estimated poverty reduction from the first period (1991-92) to the last (2003) declines from 8.8 percentage points to 5.3 percentage points.

Finally, we find that rural poverty is associated with remoteness, but the relationship is surprisingly weak and it varies depending on the definition used. Rural poverty is more closely related to access to regional urban centers than distance to roads or to Dar es Salaam. Although poverty is somewhat higher in more remote rural areas, we find no evidence that remote areas are being "left behind" in terms of the percentage-point reduction in poverty.

How do we reconcile these results with the conventional wisdom that remote rural areas are much poorer than other rural areas and "left out" of economic progress occurring elsewhere in the country? It may be that other measures of market access would support the conventional wisdom. Perhaps market access needs to take into account the purchasing power of the urban centers or perhaps other geographic features (rivers, lakes, and rail lines) are more important indicators of market access in some parts of the country. Second, our measure of market access is fixed over time. It is possible that taking into account improvements in the transportation network would alter the results. Finally, it is possible that the conventional wisdom holds in general, but that Tanzania is an exception. More research is needed to address these issues, but this paper

raises the question whether the benefits of economic growth are as spatially concentrated as is commonly supposed.

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APPENDIX A: DESCRIPTION OF SURVEY DATA SOURCES

Table A1—Description of household surveys used in analysis

Year	Name	Sample design	Questionnaire
1991-92	Household Budget Survey	The households were selected using a two-stage stratified random sample. The sample included 222 enumeration areas (of which 100 were in rural areas) and 24 households from each, resulting in 5,328 interviews. Of these, 4,750 households were used in this analysis.	Two questionnaires were used to collect the data. Form I covered demographic and social characteristics, housing conditions, durable purchases, asset ownership, and annual income in the past year. Form II was in the form of a daily diary, recording every income or expenditure transaction as it occurred, in cash or in kind.
1991-92	Demographic and Health Survey	The households were selected using a three-stage random sample that included 357 census enumeration areas (of which 262 were in rural areas) and 8,327 households.	The survey used a Household Questionnaire, a Women's Questionnaire, and a Men's Questionnaire. Topics covered included household characteristics, fertility, child-care practices, child nutritional status, vaccination, and other health topics.
1996	Demographic and Health Survey	The households were selected from the same 357 census enumeration areas used in the 1991-92 DHS. The sample size was 7,969 households.	The survey used a Household Questionnaire, a Women's Questionnaire, and a Men's Questionnaire. The questionnnaires were very similar (and the Household Questionnaire almost identical) to the ones used in the 1991-92 DHS.
1999	Reproductive and Child Health Survey	The households were selected using a three-stage random sample that included 176 census enumeration areas. The 176 EAs were a subsample of the 357 EAs used in the 1991-92 and 1996 DHSs. The number of households was 3,615.	The survey used a Household Questionnaire, a Women's Questionnaire, and a Men's Questionnaire. The questionnnaires were very similar (and the Household Questionnaire almost identical) to the ones used in the 1991-92 DHS.
2003	HIV/AIDS Indicator Survey	The households were selected using a two-stage random sample that included 345 enumeration areas (including 258 rural EAs) and 6,499 households. Zanzibar was excluded from the sample.	The survey used a Household Questionnaire and an Individual's Questionnaire. Topics included household characteristics, knowledge of and experience with HIV/AIDS, and reproductive history. The Household Questionnaire was almost identical to the one used in the 1991-92 DHS.

Sources: National Bureau of Statistics and Macro International, 1992, 1997, 2000, and 2005.

APPENDIX B: GENERATING MARKET ACCESS VARIABLES

Six accessibility measures were considered in the analysis:

- Straight-line distance to a primary or secondary road
- Straight-line distance to a regional center
- Travel time to Dar es Salaam
- Travel time to the closest of eight primary towns or Dar es Salaam,
- Travel time to the closest of 11 secondary towns, primary towns, or Dar es Salaam,
- Travel time to the closest of 22 tertiary towns, secondary towns, primary towns, or Dar es Salaam.

These market access variables were generated using geographic information systems (GIS) software and required three spatial data sets: 1) a road network with road quality information, 2) a database of towns and cities with populations, and 3) a database of land use and land cover. The first two databases were initially in vector format (the coordinates of points and line segments), but were then converted to raster format (a grid of uniform squares or "pixels"). The conversion to raster format allowed these two databases to be merged with the third database (land use and land cover), already in raster format. The size of each pixel in the raster database for Tanzania was one km^2.

The distance to the nearest regional center was computed by the GIS software as the straight-line distance between the centerpoint of each one km^2 pixel on the digital

map and the nearest pixel representing one of the 20 regional administrative centers. The distance to roads (primary and secondary) was computed in a similar fashion.

The calculation of the travel times was somewhat more complicated. First, the population centers were classified into four groups: Dar es Salaam, municipalities (8), secondary centers (11), and tertiary centers (22). Categories were created that included each group and any larger towns (e.g. secondary and larger towns). Second, each road type is assigned a specific speed, reflecting an assumed travel speed on that type of road. The travel speeds ranged from 45 kilometers per hour (kph) on paved highways to 5 kph on local unpaved (dirt) roads. Similarly, each land cover/land use category was assigned a speed, reflecting a best-guess off-road travel time. The off-road speeds range from less than 1 kph for crossing bodies of water such as rivers to 3 kph across various types of agricultural land. To compute travel time to a given category of town, the GIS software works pixel by pixel and develops a path to urban centers that gives the shortest travel time from each pixel to the 'nearest' urban center in the category, taking into account the distance to a road and the land cover/land that must be crossed to reach a road, as well as road distance and road quality to get to the urban center that is the shortest travel time from the pixel. The output of these calculations is the four travel-time-based market access "surfaces," each of which contains the travel time values for one definition of market access for each of 1.5 million pixels that make up the digital map of Tanzania at a one km^2 pixel resolution.

The six different accessibility variables from this analysis were brought into the tabular analysis by simply extracting from the market access surfaces the computed value for each pixel in which a DHS sample household cluster was located for the 1991-92, 1996, and 1999 DHS surveys (the coordinates for the 2003 survey are not yet available). These cluster-level data were then converted into the format for Stata software to be merged with the household-level data on the probability that a household is poor, based on the analysis in Stages 1 and 2. The tables and regression analysis were carried out using Stata software.

APPENDIX C: STANDARD ERRORS OF THE HEADCOUNT POVERTY RATES

Table C1—Standard errors of poverty estimates (P_0) by year and by stratum

Year	Place	Sample size (N)	Headcount poverty ratio (P_0)	Standard error of P_0
1991-92	Mainland Tanzania	7,691	0.468	0.019
1996	Mainland Tanzania	7,248	0.429	0.022
1999	Mainland Tanzania	2,728	0.424	0.024
2003	Mainland Tanzania	6,472	0.380	0.024
1991-92	Dar es Salaam	422	0.036	0.015
1991-92	Large towns	324	0.184	0.033
1991-92	Small towns	667	0.345	0.038
1991-92	Rural areas	6,278	0.529	0.023
1996	Dar es Salaam	582	0.041	0.013
1996	Large towns	308	0.165	0.038
1996	Small towns	818	0.305	0.034
1996	Rural areas	5,540	0.484	0.026
1999	Dar es Salaam	270	0.033	0.017
1999	Large towns	219	0.118	0.033
1999	Small towns	407	0.296	0.045
1999	Rural areas	1,832	0.492	0.031
2003	Dar es Salaam	420	0.045	0.016
2003	Large towns	565	0.173	0.027
2003	Small towns	587	0.302	0.041
2003	Rural areas	4,900	0.450	0.031

Source: Estimated using the equations given by Hentschel et al (2000) with an additional component to represent the DHS sampling error.

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