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Poverty, Inequality, and Geographic Targeting: Evidence from Small-Area Estimates in Mozambique

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Abstract

Typical living standards surveys can provide a wealth of information about welfare levels, poverty, and other household and individual characteristics. However, these estimates are necessarily at a high level of aggregation, because such surveys usually include only a few thousand households, with coarse spatial stratification. Larger databases, such as national censuses, provide sufficient observations for more disaggregated analysis, but typically collect very little socioeconomic information. This paper combines data from the 1996–97 Mozambique National Household Survey of Living Conditions with the 1997 National Population and Housing Census to generate small-area (subdistrict) estimates of welfare, poverty, and inequality, with the associated standard errors. These small-area estimates are then used to explore several dimensions of poverty and inequality in Mozambique, particularly with regard to geographical targeting of antipoverty efforts.

Reliably identifying and targeting the poor can be administratively costly, especially in rural Africa, where low population density and weak administrative capacity are common. Geographical targeting, or targeting poor areas, is sometimes proposed as a feasible alternative to targeting poor people, and poverty maps may serve as a valuable tool in this regard. Unfortunately, the notion of poor areas might not always be especially useful, as appears to be the case in Mozambique. The poverty maps do not reveal a particularly strong spatial concentration of poverty; the differences in poverty levels between areas tend to be subtle. This pattern is also observed in the decomposition of small-area inequality estimates, which shows that only about 20 percent of consumption inequality is accounted for by inequality between districts or between administrative posts. The picture that emerges of the poor living alongside the nonpoor indicates that targeting poor areas is likely to result in leakage to the nonpoor in that area, and considerable under-coverage of the significant numbers of poor households in areas that are less poor.

Key words: poverty, inequality, poverty mapping, Mozambique

Contents

Tables

Figures

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1. Introduction

Typical living standards surveys can provide a wealth of information about welfare levels, poverty, and other household and individual characteristics. However, these estimates are necessarily at a high level of aggregation, because such surveys usually include only a few thousand households. In addition, these surveys are typically only representative down to the level of the sample strata, which tend to be the first administrative subdivision, such as provinces or states. Larger data bases, such as national censuses, provide enough observations for more disaggregated analysis, but typically collect very little socioeconomic information.

This paper combines data from the 1996–97 Mozambique National Household Survey of Living Conditions with the 1997 National Population and Housing Census to generate small-area (subdistrict) estimates of welfare, poverty, and inequality, with the associated standard errors. These small-area estimates are then used to explore several dimensions of poverty and inequality in Mozambique, particularly with regard to geographical targeting of antipoverty efforts.

2. Country Setting

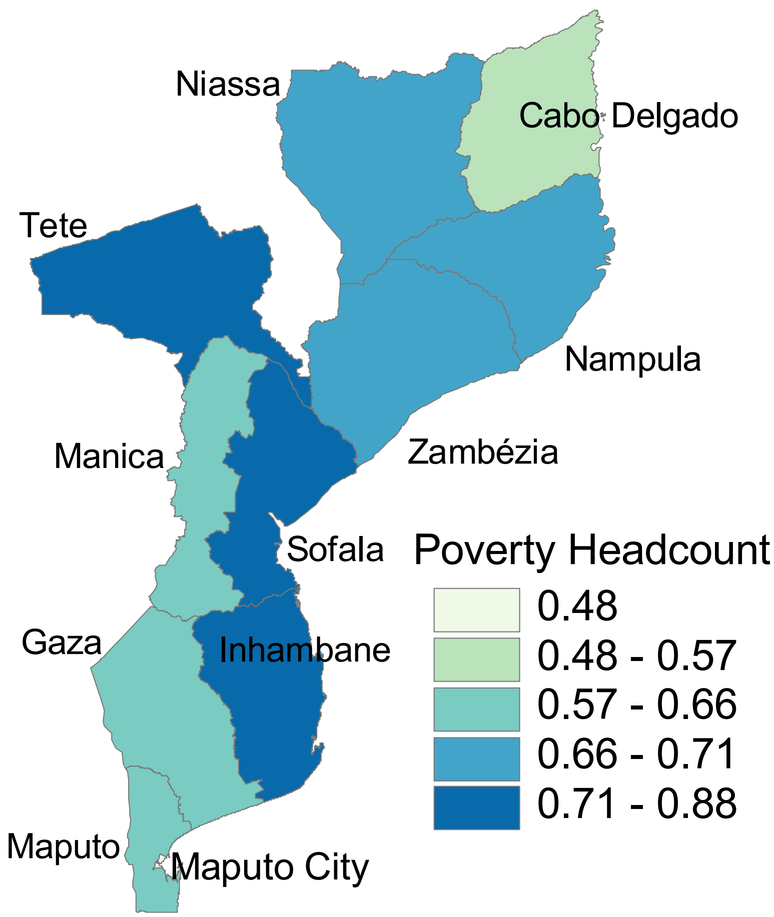
For many years, Mozambique could consistently be found among the poorest five countries listed in the World Bank's annual *World Development Report*, typically in the company of Ethiopia, Cambodia, Sierra Leone, and others. According to Mozambique's first national poverty assessment, in 1996–97 almost 70 percent of the Mozambican population was living below the poverty line (MPF/UEM/IFPRI 1998). The poverty gap index and Foster-Greer-Thorbecke (FGT) P_2 index were also extremely high, at 0.293 and 0.156, respectively. The high levels of consumption poverty are consistent with other indicators of deprivation. The adult literacy rate is only 40 percent, with female literacy especially low at only 26 percent (INE 2000). The educational picture is only slightly better for the current school generation: the gross primary enrollment rate is 67 percent, and the net enrollment rate is only 40 percent. For secondary schools the corresponding rates are 7 percent and 2 percent. According to the 1997 population census, the infant mortality rate stood at 146 per 1,000 live births, with under-five mortality reaching 246 per 1,000 live births, and a life expectancy at birth of only 42 years (INE 2000). The life expectancy figure has since been revised downwards to 35 years, following a recent study of the demographic impact of the HIV/AIDS pandemic (MISAU/INE/MPF/CEP-UEM 2001). Only 33 percent of households have a toilet or latrine, only 15 percent of households have regular access to safe water supplies, 5 percent have electricity in their dwelling, and 28 percent of households own a radio.

From the poverty assessment, which was based on the first nationally representative survey of living standards, poverty rates were somewhat higher in rural areas than in urban areas. More pronounced were the differences across provinces, with the poverty headcount ranging from 48 percent in the capital city of Maputo, to 88 percent in Sofala Province, as shown in Figure 1. Regional disparities have often been a source of tension in Mozambique, a tension that has not abated much even during the past several years of rapid economic growth, as there is a common perception that most of the benefits of this growth have been concentrated in the south of the country. Recent official government statements have spoken to the need to reduce regional disparities, and addressing regional disparities is an explicit objective of the government's poverty reduction strategy (Mozambique 2001). Indeed, the strategy notes: "The most noticeable characteristic of Mozambique's territory is the economic and social inequality between the Maputo-Matola conurbation area and the rest of the country. . . . Dealing with regional disparities is one of the priority objectives of the Government's Programme for 2000–2004" (Mozambique 2001, 35).

3. Methodology

On the surface, the methodology is straightforward. The household survey data are used to estimate the statistical relationship between the empirical variable used to

Figure 1—Provincial-level poverty map from household survey alone



measure welfare (consumption per capita, adjusted for spatial and temporal variation in prices) and a set of independent variables that are expected to be correlated with welfare. The set of variables considered for the right-hand side of the regression equation is limited to those variables that appear in both the household survey and the population census. The estimated regression coefficients are then applied to the census data to produce estimates of consumption per capita for each of the households in the census. The estimates of consumption per capita are used in turn to calculate summary measures of poverty and inequality, such as the Foster-Greer-Thorbecke (FGT) class of P_α poverty measures, the Gini index, or generalized entropy (GE) inequality measures. Because consumption estimates are available for the entire population, it is possible to calculate welfare measures for small subgroups of the population, be they geographic regions (such as subdistricts), occupational classifications (e.g., fishermen), or some other classification. This method for linking surveys with census-type data is used in geography for small-area estimation. It has been adapted for the disaggregated study of poverty and inequality, with an application to Ecuador, by Hentschel et al. (2000). Further refinements of the method are presented in Elbers, Lanjouw, and Lanjouw (2003).

More formally, the natural logarithm of per capita consumption is modeled as a function of a set of observable household characteristics. We estimate this relationship by a linear approximation of the form

$$\ln y_{ch} = X'_{ch}\beta + \eta_c + \varepsilon_{ch}, \tag{1}$$

where y_{ch} is per capita consumption of household h residing in cluster c, $\boldsymbol{X}_{ch}$ are the observable characteristics of that household that are available in both the survey and census data sets, and $\boldsymbol{\beta}$ is a coefficient vector.[1] The disturbance term has two components. The first component, η_c, applies to all households within a given cluster, while the second, ε_{ch}, is specific to the household. These two components are uncorrelated with one another and independent of the regressors. This specification of the disturbance term accommodates the possibility of spatial autocorrelation, i.e., a location-specific effect common to all households within a cluster. It also allows for heteroscedasticity of the household-specific error component.

The unexplained variation in equation (1) is what Elbers, Lanjouw, and Lanjouw (2003) call "model error," which directly affects the precision of the small-area estimates

[1] Here the term cluster refers to the administrative post, the most disaggregated level at which we group the data in the analysis that follows. In the household survey sample design, the first stage of clustering was one level lower, at the level of the *bairro* (urban areas) or *localidade* (rural areas). In the future, we intend to experiment with clustering the census data at these lower levels.

of welfare, poverty, and inequality. Thus there are gains from ensuring that the X_{ch} variables capture as much of the variation in log consumption as possible. We reduce the magnitude of the unexplained location-specific component, μ_c, by including cluster-specific variables among the regressors. These are cluster-level means of the household-level variables that exist in both the survey and the census. Because of the small sample size of the survey, these variables are calculated from the census data, and merged with the survey data for the first-stage regressions. The addition of cluster-level means as regressors not only reduces model error, but also reduces bias in small-area estimates of inequality.

Equation (1) is estimated using generalized least squares (GLS), taking into account the heteroscedasticity of the household component of the disturbance term, ε_{ch}. The survey is not self-weighting, so regressions are estimated using the survey probability weights, which are the inverse of the probability of selection into the sample. Rather than impose an assumption of homogeneous coefficients throughout Mozambique, separate regressions are estimated for each of the strata of the survey data set. The same set of candidate variables is considered for each of the models, with final variable selection determined by a stepwise procedure supplemented with extensive ex post diagnostics. The number of variables in the regressions is constrained not by the number of common variables in the survey and the census, but rather by the number of clusters in the first stage of sampling within each stratum, as the appropriate Wald test for the regression is based on an F distribution with (k, $d - k + 1$) degrees of freedom, where k is the number of terms in the model (excluding the constant) and d is the number of primary sampling units minus the number of strata (Korn and Graubard 1990).

The resulting parameter estimates are then applied to the census data. Estimates of consumption for the census households must take into account the disturbance term, that is, the portion of the variation in consumption in the survey data that is not explained by variation the regressors. Otherwise, poverty estimates for the census data would be biased, with the direction of the bias depending on the position of the poverty line relative to the distribution of consumption and the poverty measure being considered. For example, if the poverty line lies below (above) of the mode of the distribution of consumption, estimates of the poverty headcount will be biased downwards (upwards).[2] In contrast, neglecting the unexplained variation in the welfare estimates would cause a downward bias in estimates of inequality, regardless of the position of the poverty line. To avoid these problems, we use simulation methods to estimate the level of consumption for each household. This is done by using the estimated regression coefficients and converting from logarithms to levels, using the expression

$$\hat{y}_{ch} = e^{X'_{ch}\hat{\beta} + \hat{\eta}_c + \hat{\varepsilon}_{ch}} \quad , \tag{2}$$

where the *c* and *h* now index clusters and households in the census data. Consumption estimates are obtained from 100 simulations. In each simulation a vector of simulated parameters is drawn from a multivariate normal distribution with the variance-covariance matrix estimated in the consumption and heteroscedasticity regressions from the survey data. The cluster- and household-specific disturbance terms are drawn from standardized *t* distributions.[3] The simulated parameters and disturbances are applied to the census data to predict per capita consumption for each household in the census, and poverty and inequality measures are calculated from the simulated consumption vector. The average of the measures over 100 simulations provides the point estimates of poverty and inequality for the small area, and the standard deviations yield the estimate of the standard error.

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[2] For the poverty gap and squared poverty gap, the relationship is more complex, as they are determined not only by the proportion of the distribution that lies below the poverty line, but also the relative distribution of consumption among the poor. In general, the variation below the poverty line will be attenuated. When the poverty line is below the mode of the distribution of consumption, the downward bias of the headcount estimate will be reinforced. When the poverty line is above the mode of the distribution, the two biases will work in opposite directions, with an indeterminate net effect.

[3] Treating the cluster- and household-level disturbances separately also reduces bias in the small-area inequality estimates. If, for example, all of the residual variance were treated as an idiosyncratic household-level phenomenon, predicted inequality would be overestimated, because it would ignore the component of the disturbance that is common to all households in a given cluster.

4. Data

The survey data used in the analysis are from the *Inquérito Nacional aos Agregados Familiares sobre as Condições de Vida, 1996–97* (National Household Survey of Living Conditions). The survey is a multipurpose household and community survey, in the same vein as the World Bank's Living Standards Measurement Study (LSMS) surveys, and was designed and implemented by the National Institute of Statistics. Data collection took place from February 1996 through April 1997, covering 8,250 households living throughout Mozambique. The sample is designed to be nationally representative. It is also representative of each of the 11 sample strata (the ten provinces plus the city of Maputo) and along the rural/urban dimension. It is the first survey of living conditions in Mozambique with national coverage and a welfare measure based on comprehensive income or expenditure data.

The household survey, also known by the shorthand IAF96, has been used for numerous poverty studies in recent years (see, for example, MPF/UEM/IFPRI 1998; Datt et al. 2000; Handa 2002; Handa and Simler 2005; Tarp et al. 2002). Most of those studies, like the present one, use a comprehensive welfare measure based upon per capita consumption. The consumption measure includes food and nonfood items, acquired through home production, market purchases, transfers, or payments in kind. Consumption also includes the imputed use value of household durables, and an imputed rental value for owner-occupied housing. As the survey took place over a period of 14 months, and there is significant temporal variation in food prices corresponding to the agricultural season, nominal consumption values were deflated by a temporal price index. Similarly, spatial differences in the cost of living were incorporated by using a spatial deflator, which is based on region-specific cost of basic needs poverty lines. Additional details are presented in MPF/UEM/IFPRI (1998).

The second data source is the *II Recenseamento Geral de População e Habitação* (Second General Population and Housing Census), which was conducted in August 1997. In addition to providing the first complete enumeration of the country's population since the initial postindependence census in 1980 and basic demographic information, the 1997 census collected information on a range of socioeconomic variables. These include educational levels and employment characteristics of those older than 6 years old, dwelling characteristics, whether the household owned a functioning radio, and possession of agricultural assets. The 1997 census covers approximately 16 million people living in 3.6 million households.

It is convenient that the census and the IAF96 are almost contemporaneous, as a pivotal assumption of the method is that the parameters estimated from the survey data are equally applicable to the period covered by the census.

The empirical modeling of household consumption is limited by the set of variables that is common in the two data sets. Common variables include the age and sex composition of the household, the sex of the head of household, educational levels, employment characteristics, dwelling characteristics, and possession of agricultural and other assets. Close examination of the data revealed that several variables that appear to be the same in the two data sets were really quite different, with differences in the position and distribution of the variables that are inexplicably large, given the close timing of data collection. One possibility is that because of differences in definitions or field protocols, the two exercises measured distinctly different things for these variables. Another possibility is that the survey simply was not representative of the population for those variables. Either explanation is sufficient justification for excluding the variable(s) for consideration in the model. It is unlikely that the timing of data collection (i.e., over 14 months for the household survey versus concentrated in two weeks for the census) is a significant factor, because the common variables are not subject to a great deal of intra-annual variation.

5. Results

Estimation of Models of Consumption

The GLS estimates of the strata-level equations to predict log per capita consumption are presented in Tables 1a-1c. As described earlier, the location-specific component of the disturbance term in equation (1) is captured by variables defined at the level of the administrative post (AP). The most common variables that enter the models are dwelling characteristics (materials of walls, floor, roof; source of water; type of illumination; type of sanitation); asset ownership (land, livestock, poultry, radio); adult educational levels; adult employment characteristics; age and sex composition of the household; and AP-level means of some of these variables. The last category captures a large part of the location effect.

Poverty Indices

The estimated poverty headcount for each of Mozambique's 128 districts is shown in Figure 2. Some of these results closely mirror the more aggregated information from the household survey alone, such as the high poverty rates throughout Sofala Province, with the exception of the port city of Beira and the adjoining district of Dondo. More commonly, however, the map shows considerable inter-district variation within a given province. For example, both Tete and Inhambane Provinces have poverty headcounts over 80 percent, but the rates are noticeably higher in the north of Tete and the interior districts of Inhambane. Conversely, Gaza Province, which has below average rates of poverty, has districts that are among the poorest in the country in its northern interior. As expected, finer disaggregation to the level of the administrative post reveals additional intra-provincial and intra-district variation, as shown in the map of poverty gap index in Figure 2. Similar results obtain when the poverty gap measure is used (Figure 3).

Table 1a—Generalized least squares (GLS) results of strata-level estimations

	Stratum							
	Niassa		Cabo Delgado		Nampula		Zambézia	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	8.656	0.113**	8.660	0.130**	8.066	0.216**	8.606	0.127**
Any member literate			-0.249	0.081**				
Any member with EP1	-0.280	0.130**						
Any member with EP2			0.507	0.144**				
Number of small stock	0.012	0.006**						
Has radio	0.149	0.060**	0.171	0.057**	0.172	0.056**	0.107	0.042**
Good quality floor	0.397	0.122**	0.263	0.156*	0.281	0.100**		
Household head EP1	0.254	0.097**	0.149	0.055**				
Household head EP2	0.294	0.082**						
Good quality roof							0.281	0.138**
Electric lighting	0.281	0.161*	0.382	0.345			0.313	0.153**
Highest education level in household	0.138	0.045**						
Number of males with EP1	-0.188	0.044**					-0.184	0.026**
Number of males with EP2			-0.436	0.124**			0.124	0.041**
Number of literate males	0.128	0.043**						
Number of literate females	-1.291	0.159**	-0.870	0.185**	-1.066	0.112**	-0.484	0.121**
Proportion of adults employed			0.428	0.126**			0.424	0.089**
Good quality walls			0.357	0.471	0.301	0.151**		
PA-level: Proportion of heads with EP1							3.651	2.243
PA-level: Proportion of heads with EP2					-7.533	1.394***		
PA-level: Proportion of heads literate					4.349	0.968**	-4.011	2.939
PA-level: Proportion of dwellings with good quality roof			115.199	25.176**			8.532	3.554**
Proportion of adults employed in commerce or service sectors	0.922	0.454**			0.747	0.293**		
Females 10-16 (proportion)	-1.315	0.217**	-1.064	0.231**	-1.129	0.173**	-0.683	0.124**
Females 16-30 (proportion)			-0.382	0.145**				
Proportion of males literate			0.897	0.206**			0.810	0.122**
PA-level: Proportion of dwellings with latrine or toilet	0.448	0.201**					0.775	0.613
Males 10-16 (proportion)	-0.974	0.233**	-0.893	0.241**	-1.205	0.160**	-0.849	0.160**
PA-level: Highest education level in household							-0.288	0.270
Members 0-5 (proportion)	-1.495	0.166**	-0.767	0.183**	-1.302	0.130**	-0.787	0.129**
PA-level: Proportion of dwellings with good quality walls			121.699	26.844**	2.287	0.542**	-4.621	2.421*
N	657		743		955		884	
Adjusted R^2 (OLS)	0.384		0.362		0.265		0.398	

Notes: ** = $p < 0.01$ * = $p < 0.05$.

Table 1b—Generalized least squares (GLS) results of strata-level estimations

	Stratum							
	Tete		Manica		Sofala		Inhambane	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	6.418	0.438**	8.427	0.357**	7.090	0.165**	7.826	0.167**
Any member literate			-0.087	0.104			-0.181	0.054**
Any member with EP1					-0.415	0.114**		
Any member with EP2					-0.189	0.096**		
Number of large livestock			-0.008	0.004*	0.390	0.153**		
Number of small stock							0.022	0.003**
Has radio					0.125	0.050**		
Good quality floor							0.230	0.047**
Household head EP1					0.167	0.061**		
Household head EP2					0.252	0.083**		
Good quality roof					0.195	0.072**		
Electric lighting	0.644	0.138**					0.934	0.110**
Has latrine or toilet			0.313	0.060**	0.240	0.054**	0.204	0.049**
Highest education level in household			0.112	0.033**	0.164	0.047**		
Number of males with EP1	-0.126	0.032**	-0.155	0.035**	-0.118	0.030**	-0.123	0.021**
Number of males with EP2							0.140	0.037**
Number of females with EP1			0.038	0.044				
Number of literate females	-1.236	0.140**	-0.863	0.243**	-0.695	0.182**	-0.375	0.158**
Proportion of adults employed			0.474	0.187**	0.385	0.123**	0.574	0.112**
Good quality walls			0.234	0.080**	0.177	0.080**		
PA-level: Proportion of heads with EP1			-5.331	2.768*			4.672	0.918**
PA-level: Proportion of heads with EP2	-7.070	1.374**			-3.744	1.168**		
PA-level: Proportion of heads literate	8.382	1.616**	3.374	1.891*	5.446	0.741**	-3.293	1.169**
PA-level: Proportion of heads female	3.705	0.886**	0.492	0.597				
PA-level: Proportion of dwellings with good quality roof			-1.097	0.849				
Proportion of adults employed in commerce or service sectors			0.375	0.224*			0.859	0.202**
Females 10-16 (proportion)	-0.914	0.172**	-0.755	0.297**	-0.499	0.189**		
Proportion of males literate	0.601	0.151**	0.232	0.240	0.992	0.158**	0.969	0.167**
PA-level: Proportion of dwellings with latrine or toilet	-1.014	0.145**					0.662	0.175**
Males 10-16 (proportion)	-1.327	0.178**	-0.462	0.262*	-1.041	0.208**	-0.521	0.197**
Males 16-30 (proportion)							-0.217	0.145
PA-level: Highest education level in household			0.223	0.284	-0.708	0.161**		
Members 0-5 (proportion)	-0.958	0.148**	-0.782	0.239**	-0.621	0.173**	-0.337	0.155**
PA-level: Proportion of dwellings with good quality walls					1.825	0.579**	-2.714	0.718**
PA-level: Proportion of school-age children enrolled in school	-3.063	1.225**	2.623	2.123			-2.690	0.565**
N	610		661		762		729	
Adjusted R^2 (OLS)	0.299		0.352		0.465		0.465	

Notes: ** = $p < 0.01$ * = $p < 0.05$.

Table 1c—Generalized least squares (GLS) results of strata-level estimations

	Stratum					
	Gaza		Maputo Province		Maputo City	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	6.134	0.315**	9.481	0.467**	7.717	0.186**
Any member with EP2			-0.255	0.086**		
Has agricultural land			-0.285	0.091**		
Has radio	0.146	0.053**	0.123	0.056**	0.202	0.061**
Good quality floor			0.260	0.065**		
Household head literate					0.331	0.084**
Household head EP1					-0.253	0.057**
Household head EP2			0.329	0.098**		
Electric lighting	0.485	0.155**	0.651	0.127**	0.413	0.059**
Has latrine or toilet	0.103	0.061*				
Highest education level in household	0.065	0.031**			0.043	0.016**
Number of males with EP1	-0.054	0.027**	-0.141	0.035**	-0.140	0.024**
Number of males with EP2			0.215	0.052**		
Number of literate males			0.085	0.025**	-0.135	0.046**
Number of females with EP1					0.087	0.051*
Number of females with EP2	0.317	0.067**			0.075	0.033**
Number of literate females	-0.303	0.186	-0.234	0.192	-0.654	0.216**
Proportion of adults employed	0.926	0.125**	0.523	0.116**	0.693	0.137**
PA-level: Proportion of heads with EP2	10.265	4.062**	2.264	1.004**	1.402	0.320**
PA-level: Proportion of heads literate	-2.361	1.135**				
PA-level: Proportion of heads female	3.799	0.647**	-1.281	0.701*		
Proportion of members with disabilities			-0.952	0.252**		
Females 10-16 (proportion)	-0.243	0.215				
Proportion of males literate			0.801	0.159**	0.613	0.149**
PA-level: Proportion of dwellings with electric lighting	-7.042	3.211**				
PA-level: Proportion of dwellings with latrine or toilet	-0.527	0.235**				
Males 16-30 (proportion)			-0.312	0.217	-0.419	0.161**
PA-level: Highest education level in household			-0.443	0.158**		
Members 0-5 (proportion)			-0.879	0.200**	-0.627	0.203**
PA-level: Proportion of dwellings with good quality walls	3.295	0.872**				
N	637		718		893	
Adjusted R^2 (OLS)	0.346		0.375		0.547	

Notes: ** = $p < 0.01$ * = $p < 0.05$.

Figure 2—Poverty headcount, by district and administrative post

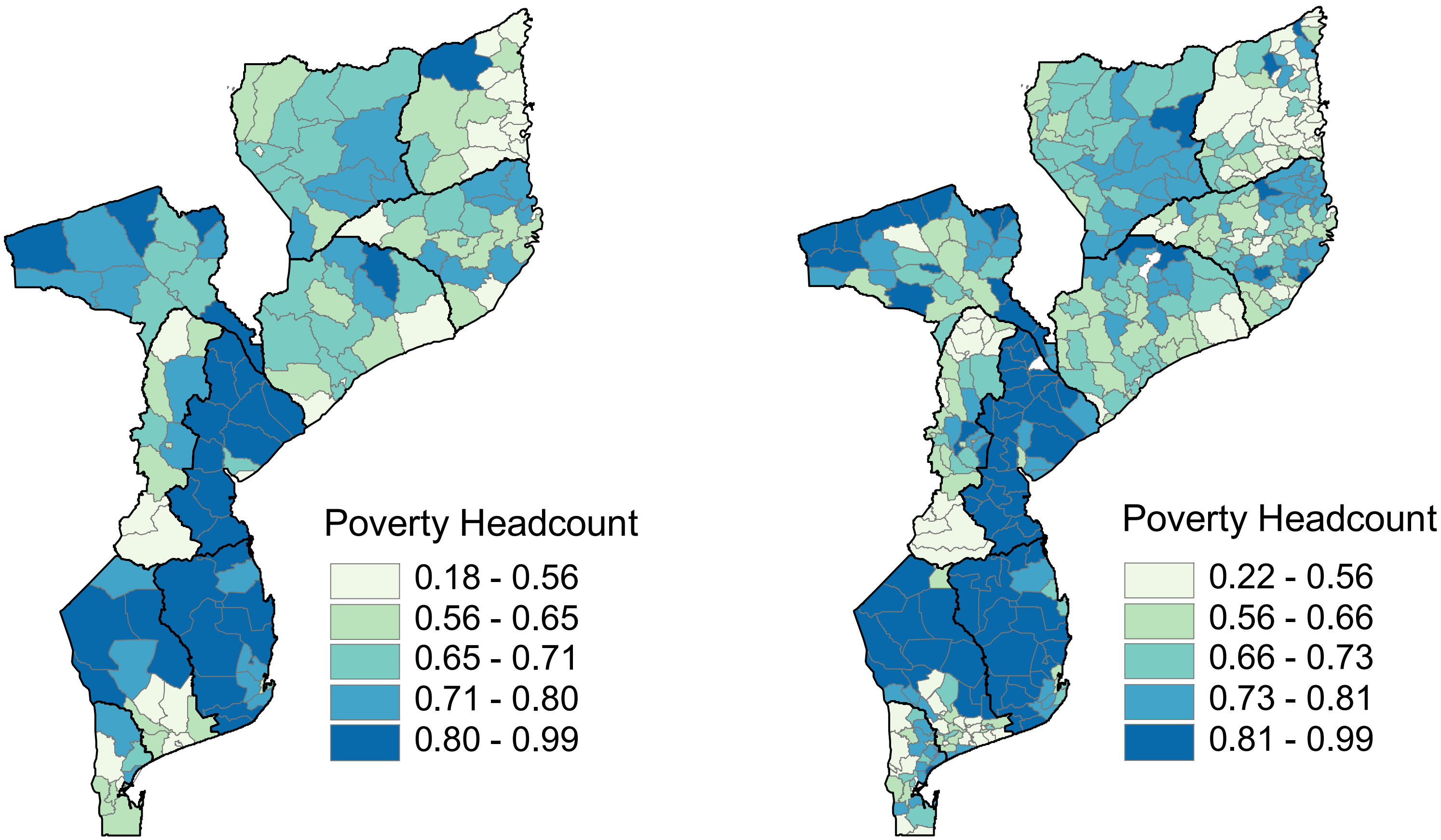
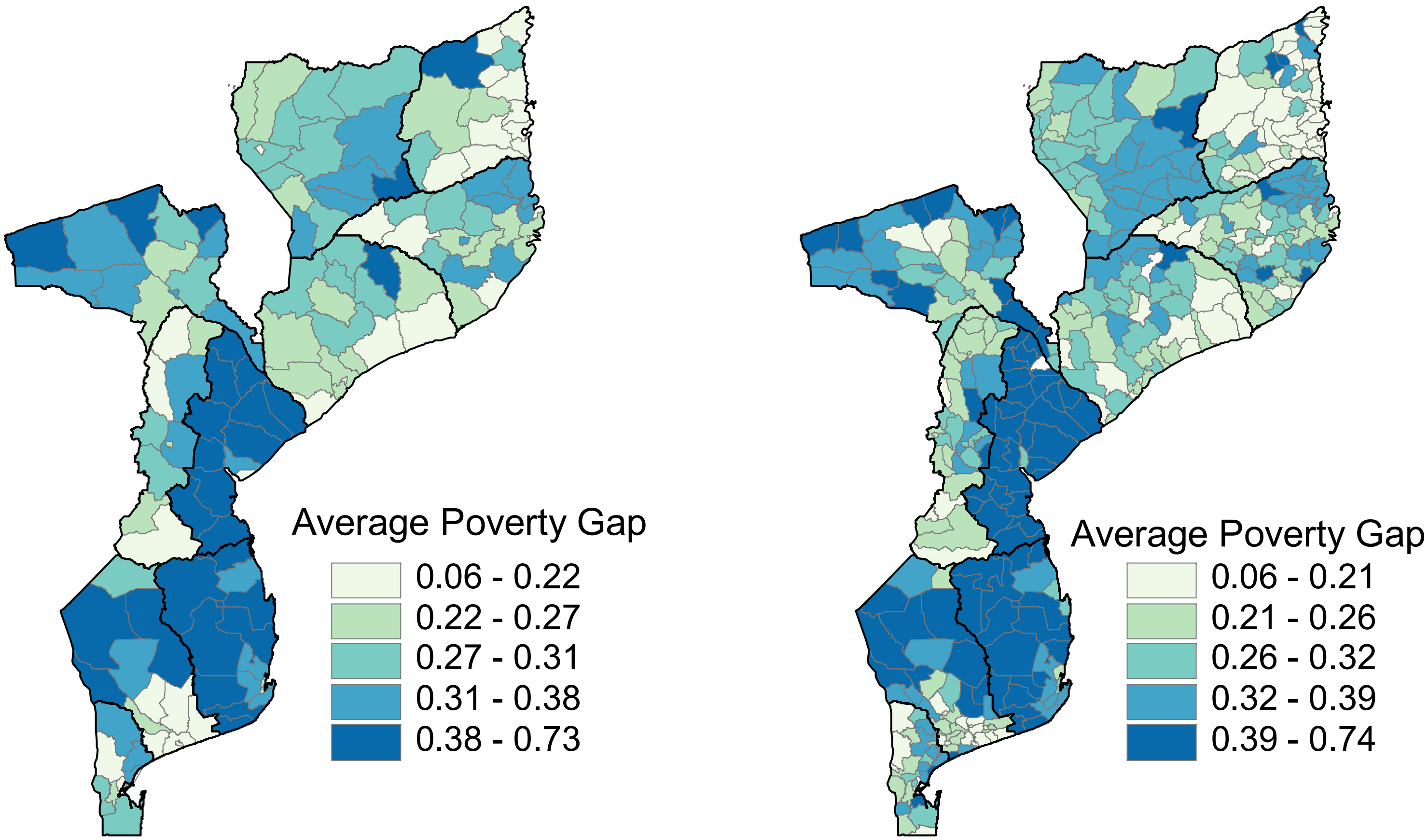


Figure 3—Average poverty gap, by district and administrative post



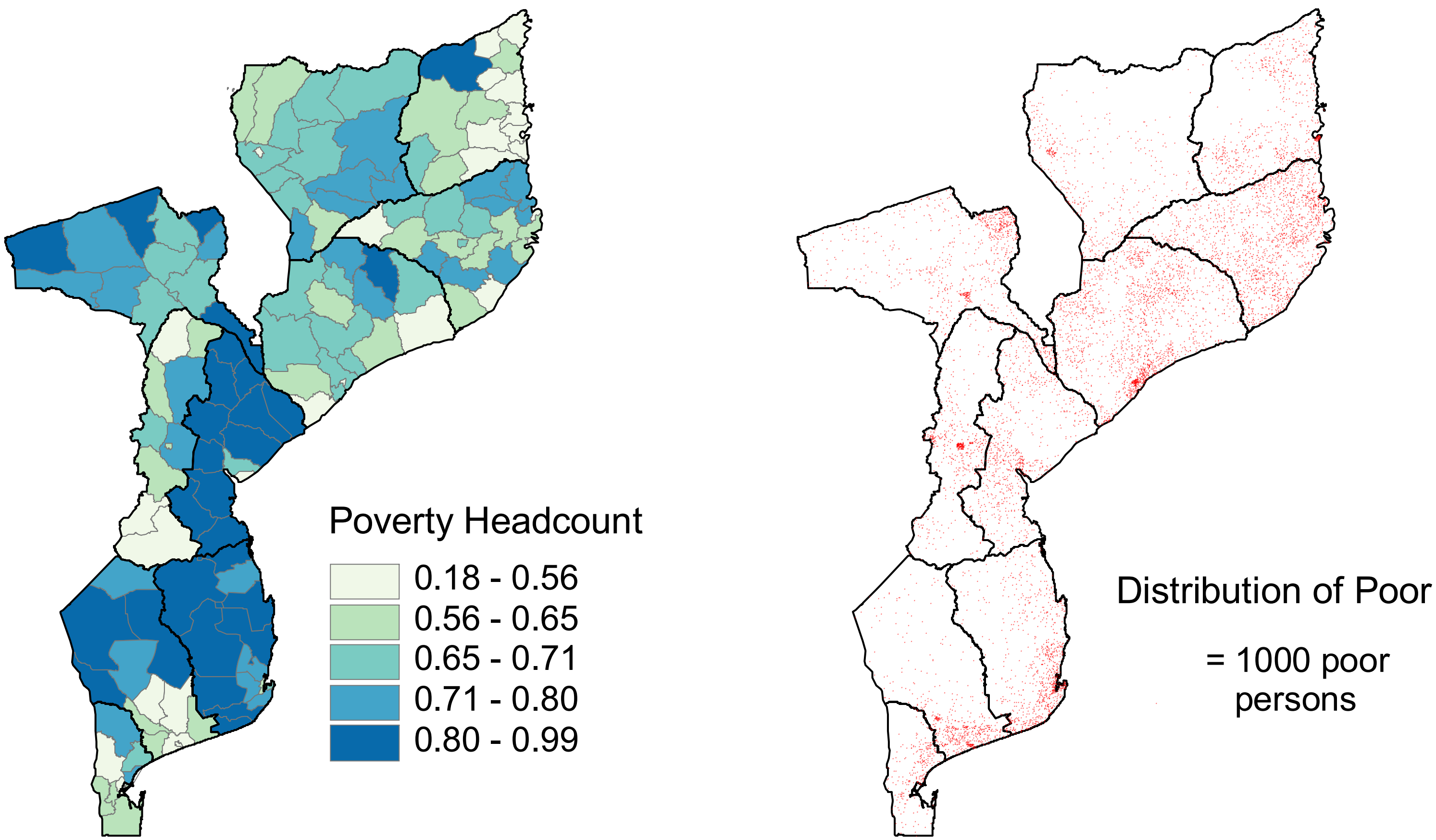
Distribution of the Poor

The distribution of the poor depends upon both poverty rates and the distribution of the population in a country. Figure 4 shows the shaded area map of the poverty headcount index from Figure 2 alongside a dot map illustrating the number of poor in each administrative post. From this map it may be seen that in the south of the country, the bulk of the poor are distributed in a thin band that runs along the coast, which also corresponds to the location of the main national highway. Despite its low poverty indices relative to the rest of the country, the capital city of Maputo is home to a large number of poor by virtue of its large population. The same is true for most provincial capitals. Another concentration of poor people appears along the Beira corridor, the east-west transportation route that forms Mozambique's "waist". Conversely, many of the dark shaded (high poverty index) areas in the southwest and northwest of the country are semi-arid zones that are sparsely populated. Some exceptions to this are found in the "spine" of the country (inland Sofala), and also in Angônia district, which forms the western "collarbone" of the country. In these areas, both poverty rates and populations are high, with a resulting large share of the country's poor. Further north, the poor are more uniformly distributed throughout the two most populous provinces, Zambézia and Nampula.

Distribution of the Total Poverty Gap

One potentially useful way to combine information on poverty indices and the physical location of the poor is to calculate the aggregate gap between current conditions and a hypothetical state in which poverty is eliminated, and map the distribution of that gap. To the extent that poverty may be considered the lack of resources to meet one's basic consumption needs, one could call this the "distribution of the total poverty gap," a measure that reflects not only whether a person is above or below the poverty line, but also how far the poor are below the poverty line. In the simplest example, consider an increase in incomes that is perfectly targeted to the poor, so that each person currently

Figure 4—Poverty headcount, by district and distribution of the poor



below the poverty line exactly reaches the poverty line. This increase could come from economic growth, a transfer program, or some other means. In this context, the total poverty gap (*TPG*) in place *i* may be calculated as

$$TPG_i = P_{1i} * Z_i * N_i \; , \tag{3}$$

where P_{1i} is the poverty gap measure in place *i*, Z_i is the poverty line in place *i*, and N_i is the population of *i*. We estimate that in 1996–97, the total poverty gap in Mozambique was approximately US$2.3 million per day. The share (W_i) of the total poverty gap of subunit *i* among the K subunits within a country is simply[4]

$$W_i = \frac{TPG_i}{\sum_{i=1}^{K} TPG_i} \quad . \tag{4}$$

The distribution of the total poverty gap by district and administrative post is shown in Figure 5. The areas that stand out as accounting for the largest shares of the total poverty gap are the parts of Sofala Province along the Beira corridor, large sections of Zambézia (to the northeast of Beira), and a band stretching further northeast through Nampula Province to the port city of Nacala. Other areas highlighted by these maps include Angônia district in the northwest, coastal areas of Inhambane in the south of the country, and the city of Maputo (which does not stand out because of its small area, but has a large share of the total poverty gap because of its large population).

Poverty and Infrastructure

Up to this point of the paper, mapping has largely been used as no more than a useful presentation tool. The estimated poverty indices and distribution of the total

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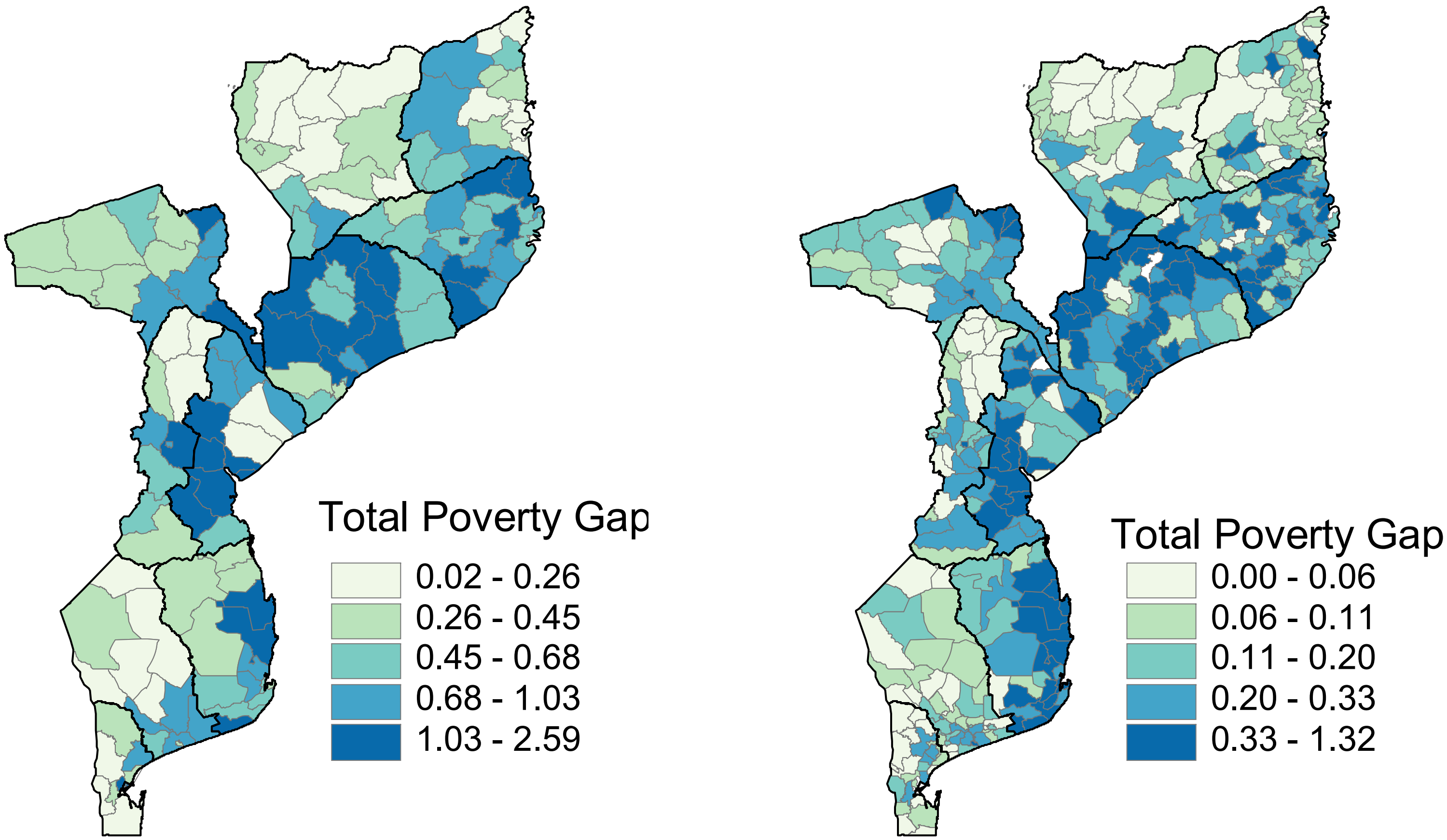
[4] It may be noted that this approach simply combines the average poverty gap—the FGT P_1 index—with information on population distribution. Although the same information is contained in separate maps, or map layers, of P_1 and population distribution, constructing and mapping W_i produces an arguably clearer picture of the distribution of poverty.

Figure 5—Distribution of total poverty gap in percent, by district and administrative post



poverty gap could have been presented as a (rather long) data table, albeit with considerably reduced ability to spot spatial patterns of poverty in Mozambique. Figure 6 makes explicit use of additional geo-referenced information, namely the location of good quality roads in Mozambique. With only few exceptions, the presence of a good road is associated with lower than average poverty indices. However, the converse is not always true. Some of the areas with lower poverty rates (lightly shaded areas), such as those along the Tanzanian border in the north of the country, are sparsely populated, and there are few roads at all. However, many of the better-off areas in Zambézia Province are populous and not particularly well served by the road network.

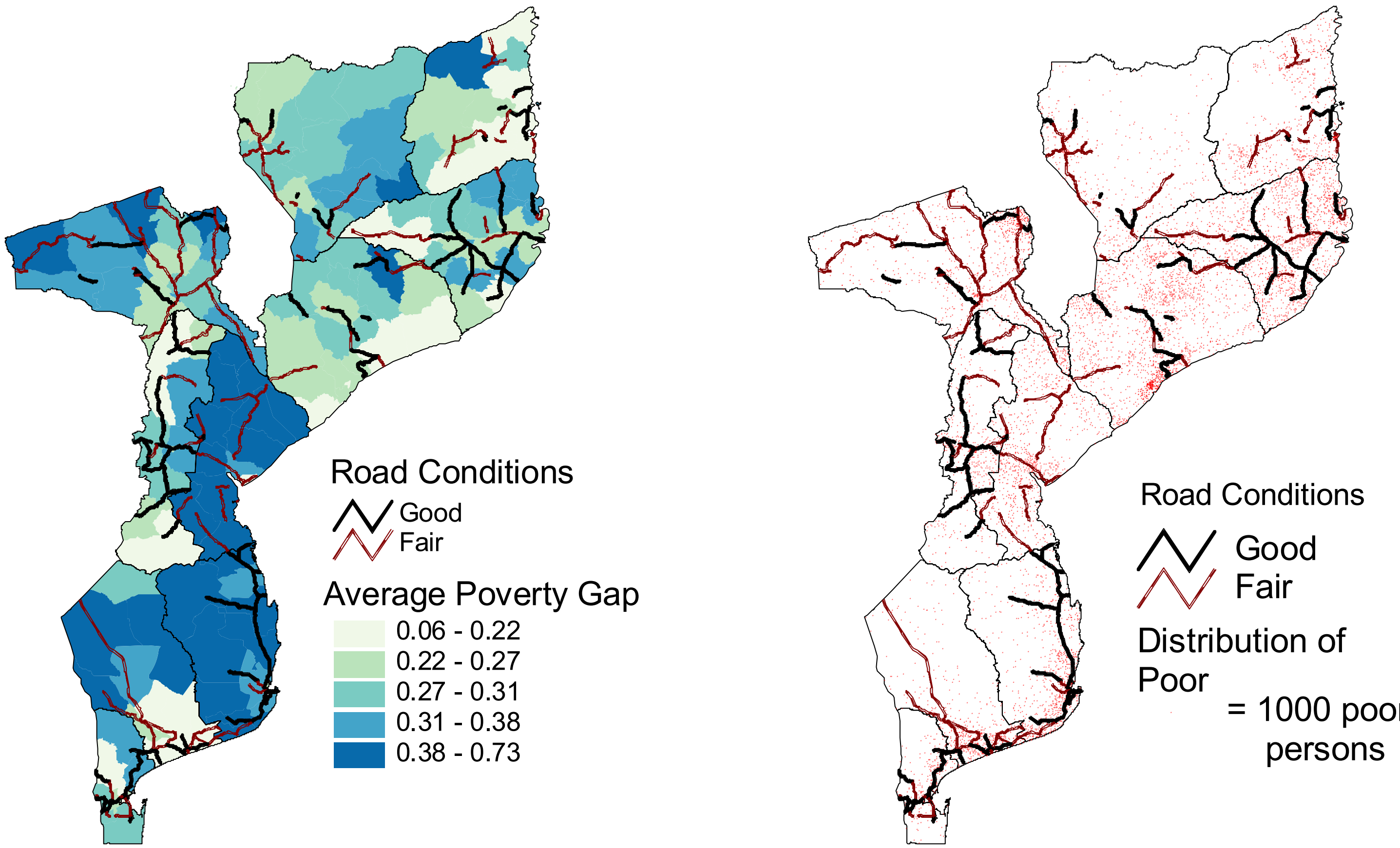
Inequality

Within Mozambique there is considerable interest about regional (spatial) inequality, particularly in inequality trends during the recent years of rapid aggregate economic growth (Mozambique 2001). More generally there is a lively debate in the development economics literature about the distribution effects of economic growth. Putting the causality the other way around, there is also a debate about the extent to which inequality is a catalyst, or a hindrance, to economic development. Much of this debate is based on cross-country growth regressions, as there is little data available on inequality within a country; the small-area estimation process used here can help to alleviate that constraint.

Several inequality measures were estimated from the simulated consumption data, including the Gini index, the Atkinson index, and generalized entropy (GE) indices. Both the Atkinson and GE indices are parameterized: each index has a parameter that may be varied, which increases or decreases the index's sensitivity to inequality over a particular range of the total distribution of consumption.[5] The Atkinson "inequality aversion parameter," e, is strictly greater than 0. The higher the value of e, the more sensitive the

[5] The standard Gini index places greatest weight on inequality around the mode of the distribution, but it, too, may be parameterized, as described by Yitzhaki (1983). The standard Gini index corresponds to their extended Gini when the parameter v takes the value 2.

Figure 6—Condition of road network, average poverty gap, and distribution of the poor



Atkinson index is to inequality at the lower end of the distribution of consumption. In this instance, the Atkinson index was estimated with parameter $e = 2$. The GE parameter a can take both positive and negative values, or zero. The GE inequality measures are more sensitive to inequality at the lower end of the distribution as a becomes more negative, and more sensitive to inequality at the upper end as a becomes more positive. Special cases of the GE index are GE(1), which is the well-known Theil inequality index, and GE(0), which is the mean log deviation. In the present paper, the GE index was estimated with parameter $a = –1$, 0, 1, and 1.5.

Figure 7 maps the GE(0) inequality index at the district and administrative post levels, and Figure 8 maps the GE(1), or Theil, inequality index. The two measures show essentially the same pattern of inequality in Mozambique. The high poverty areas in the central part of the country also tend to have high levels of inequality, with the inequality extending further west to areas in Manica Province, along the border with Zimbabwe. The south of the country, especially Maputo Province and the city of Maputo, also has some of the highest rates of inequality, although poverty rates are relatively low there. Provincial capitals also stand out as having high inequality measures—these are especially visible as small dark spots in the district-level map on the left. Inequality is low in the populous provinces of Nampula and especially Zambézia.

Using the AP-level estimates of poverty and inequality, we note that for almost all of the poverty and inequality measures used, there is a negative and significant correlation between poverty and inequality (Table 2). This is not unexpected, as the larger the proportion of the population below the poverty line, the less scope there is for variance in the per capita consumption measure, and therefore the less inequality there is likely to be.

Table 2—Pearson correlation coefficients of FGT poverty measures and inequality indices

	Gini	**GE(-1)**	**GE(0)**	**GE(1)**	**Atkinson(2)**
P_0	-0.42**	-0.42**	-0.40**	-0.28**	-0.46**
P_1	-0.22**	-0.23**	-0.22**	-0.15**	-0.24**
P_2	-0.14**	-0.14**	-0.14**	-0.09	-0.15**

Note: ** = $p < 0.01$, N = 424.

Figure 7—GE(0) inequality index, by district and administrative post

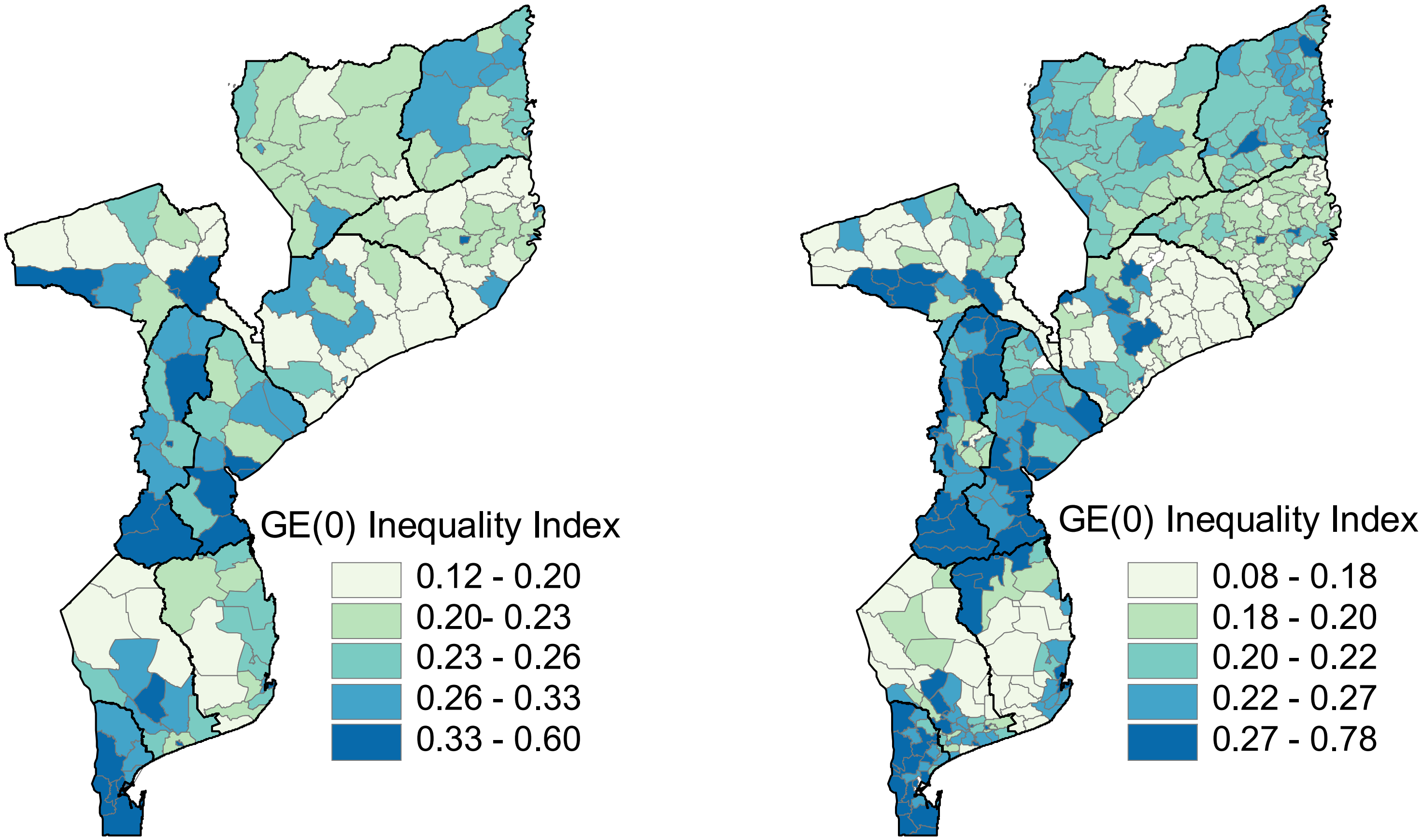
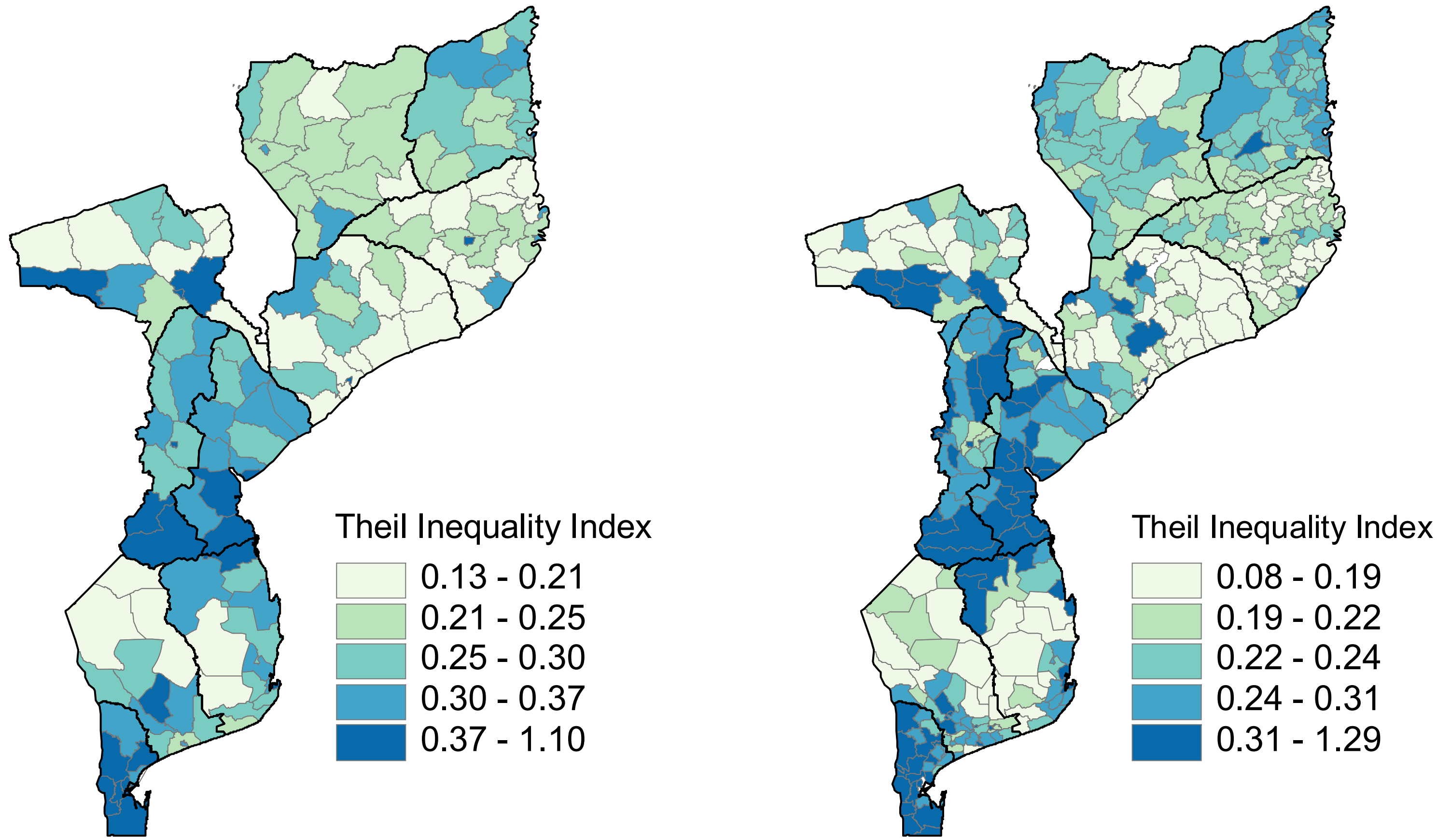


Figure 8—GE(1) (Theil) inequality index, by district and administrative post



An appealing feature of the generalized entropy class of inequality measures is that they may be additively decomposed into between-group and within-group components. The availability of small-area estimates of inequality permits us to ask the question: How much of Mozambique's inequality is attributable to inequality between regions, and how much is attributable to inequality within regions? It is instructive to consider the polar cases. At the national level, all inequality is within-group, by definition. Conversely, at the individual level (or at the household level when intrahousehold distribution is not available, as in the present study), all inequality is between-group. The small-area inequality estimates were decomposed by geographic regions using the standard formulae, where j indexes subgroups, g_j is the population share of subgroup j, μ is average per capita consumption, and GE_j is inequality in subgroup j.

$$GE(c) = \left(\frac{1}{c(c-1)}\right)\left[\sum_j g_j \left(\frac{\mu_j}{\mu}\right)^c - 1\right] + \sum_j GE_j \, g_j \left(\frac{\mu_j}{\mu}\right)^c \text{ for } c \neq 0, 1 , \qquad (5a)$$

$$GE(c) = \left[\sum_j g_j \left(\frac{\mu}{\mu_j}\right)^c - 1\right] + \sum_j GE_j \, g_j \text{ for } c = 0, \text{ and} \qquad (5b)$$

$$GE(c) = \left[\sum_j g_j \left(\frac{\mu_j}{\mu}\right) \log\left(\frac{\mu_j}{\mu}\right)\right] + \sum_j GE_j \, g_j \left(\frac{\mu_j}{\mu}\right) \text{ for } c = 1. \qquad (5c)$$

The first term on the right or the equality is the between-group component of inequality. It is interpreted as what the level of inequality in the population would be if everyone within the group had the same (the group average) consumption level μ_j. The second term on the right reflects what would be the overall inequality level if there were no differences in mean consumption across groups but each group had its actual within-group inequality, GE_j. The ratios of the individual components to the sum of the two components provide a measure of the percentage contribution of between-group and within-group inequality to total inequality.

The generalized entropy inequality indices are decomposed in Table 3, for GE(–1), GE(0), and GE(1). Of the total inequality in Mozambique, between 83 and 86 percent occurs within districts; in other words, differences in the district-level means of per capita consumption only account for about one-sixth of the total variance in per capita consumption. At the more disaggregated level of the administrative post, the share of within-post inequality is still very high, at 78 to 80 percent of the total.[6]

Table 3—Decomposition of inequality

	GE(-1)	GE(0)	GE(1)
Total	**0.441**	**0.363**	**0.411**
Within districts	0.377	0.300	0.353
Within %	85.6	82.7	85.8
Within AP	0.353	0.283	0.330
Within %	80.2	78.0	80.2

There are several possible distributions of per capita consumption that could generate the decomposition results in Table 3. For example, it could be that all of the administrative posts have roughly similar levels of inequality, i.e., that the poor and the nonpoor are both situated more or less uniformly around the country, with high degrees of heterogeneity in all administrative posts. Alternatively, the decompositions could occur if some areas were highly equal and others highly unequal, so that the 80-plus percent of within-area inequality is a composite of vastly different situations. In Figure 9, the administrative posts in Mozambique are arrayed from left to right in ascending order of GE(0), with the vertical axis indicating the estimated GE(0), which is the within-post inequality. The horizontal line at 0.36 corresponds to the national total estimate for GE(0). It may be observed that, with the exception of the sharp upward swing at the right

[6] We have not yet conducted this analysis for smaller administrative units using the census data, but from the IAF survey alone, we observe that at the next level of disaggregation (*localidade* in rural areas and *bairro* in urban areas), between 71 and 75 percent of inequality is within. Even at the level of the village or city block, more than one-half of inequality is found within geographic unit. Caveats about the small sample sizes (typically 9 to 36 households) at these levels of survey data apply.

of the curve,[7] the large majority of the 424 administrative posts in Mozambique have GE(0) indices of approximately 0.2 and slightly higher.

Figure 9—Inequality levels (GE(0)), by administrative post in Mozambique and magisterial districts in South Africa

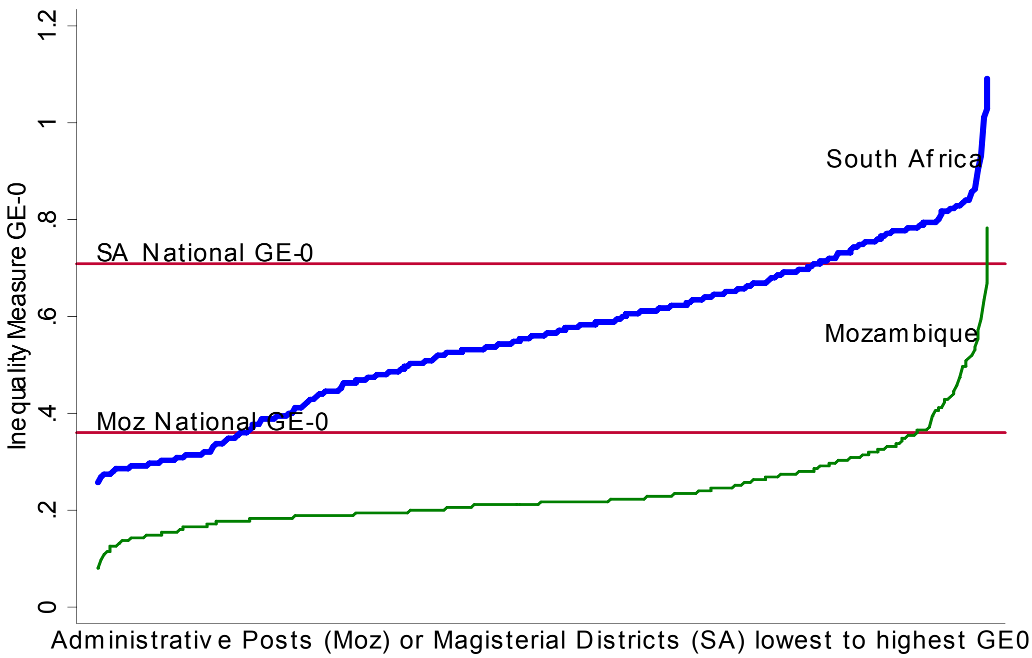


Figure 9 shows the corresponding information for the 354 magisterial districts in South Africa. Like Mozambique's administrative posts, approximately 80 percent of consumption inequality in South Africa is found within magisterial districts (Alderman et al. 2002). However, from the figure we see not only that South Africa has much higher levels of inequality overall, but also that there is much more variation in inequality levels among South African magisterial districts than there is among administrative posts in Mozambique. There are several non-mutually exclusive explanations for the higher overall level of inequality in South Africa, most notably the legacy of apartheid and the higher rates of urbanization. The reasons for greater variation in inequality levels across

[7] The high inequality administrative posts are mostly urban areas, although there are also some rural areas among them. Almost all of the urban areas in Mozambique are in the rightmost 20 percent of the line.

magisterial districts are less obvious, although the race-based settlement patterns established under apartheid are probably a major factor.

6. Discussion

We have used survey and census data to estimate welfare (per capita consumption) for every household in the 1997 Mozambique national census, and estimated poverty and inequality indices—and standard errors—disaggregated to the levels of districts and administrative posts. It was already known that poverty rates varied considerably across the provinces of Mozambique, and this analysis showed that large variation occurs within provinces, and districts, as well. It was also seen that many of the areas with high poverty indices are sparsely inhabited and poorly served by the roads network, while a large proportion of the poor are found in populous areas with only average or below average poverty indices. Consistent with this, we saw that most of the inequality found in Mozambique is explained not by differences in averages from one administrative post to another, but by large variations in consumption levels within administrative posts.

One of the key motivations for poverty mapping is to identify areas where there are concentrations of poor people, or especially high poverty rates, to facilitate the targeting of antipoverty programs geographically. Geographic targeting has the advantage of being less costly to administer than household- or individual-level means testing for poverty programs. It also has the potential for tailoring such programs to the specific environment of these areas, such as focusing on production of certain crops or development of certain infrastructure. However, these results call into question the proposition of targeting antipoverty efforts to "poor areas" of Mozambique. Because the most disaggregated territorial level examined here—administrative posts—are heterogeneous, with poor and nonpoor living in close proximity, it is likely that there would be little efficiency gain from targeting exclusively by administrative post. That is, programs that treated all persons within an administrative post equally will likely result in large errors of inclusion (directing benefits to the nonpoor, or leakage) and exclusion (failing to direct benefits to the poor who live in less poor areas).

The findings in this paper run counter to most of the evidence from South Asia and Latin America, which identifies physically separate poor areas and nonpoor areas (see Ravallion and Wodon 1997; Baker and Grosh 1994). However, it is consistent with findings elsewhere in Sub-Saharan Africa, such as Alderman et al. (2002) in South Africa and Jayne et al. (2001) (with specific respect to land) in five countries in east and southern Africa. Some early poverty mapping studies seemed to assume that the Asian and Latin American patterns of poverty pockets applied in Sub-Saharan Africa as well, without critically examination of the question, often because of data limitations (see Bigman et al. 2000 for an example).

However, there may be an argument for using geographic targeting as an initial step in a multistep targeting procedure. For example, central government funds could be allocated to decentralized governmental units using the poverty mapping results as a guide, with the decentralized units then employing other information (such as information about the characteristics of the poor) to reduce errors of inclusion and exclusion. The feasibility and cost-effectiveness of multistage targeting is a useful avenue for future research.

In future work we intend to investigate these questions, in the context of specific interventions. We will also explore the correlates of consumption inequality.

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