Università di Pisa
Dipartimento di Statistica e Matematica
Applicata all'Economia

Report n. 293

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Pisa, aprile 2007
- Stampato in Proprio -

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Abstract

Over the last decade there has been growing demand for producing estimates of population characteristics at small areas. Unfortunately, cost constraints in the design of sample surveys lead to small sample sizes within small areas and as a result direct estimation- using only the survey data- is inappropriate since it yields estimates with unacceptable levels of precision. Small area models are designed to tackle the small sample size problem. The most popular class of models for small area estimation is random effects models that include random area effects to account for between area variation. However, random effects models also depend on strong distributional assumptions, require a formal specification of the random part of the model and do not easily allow for outlier robust inference. Here we evaluate an alternative approach to small area estimation that is based on the use of M-quantile models (Chambers and Tzavidis 2006). Unlike traditional random effects models, M-quantile models do not depend on strong distributional assumption and automatically provide outlier robust inference.

In particular, in this paper we use M-quantile models to estimate (a) the incidence of poverty within small areas and (b) the corresponding within area distribution of per-capita consumption expenditure. The data we use are obtained from the 2002 Living Standards Measurement Survey (LSMS) in Albania. Our results are consistent with results of previous studies and with expert opinion and indicate that M-quantile small area models can be successfully employed in poverty evaluation studies.

Keywords: Asymmetric data; Quantile regression, Distribution estimation; Robust inference; Weighted least squares

1. Introduction

Over the last decade there has been growing demand for producing estimates of population characteristics at disaggregated geographical levels, often referred to as small areas or small domains. Two popular examples are the estimation of poverty incidence and the estimation of average income at small area level (Bigman *et al.* 2000).

Unfortunately, cost constraints in the design of sample surveys lead to small sample sizes within small areas. As a result direct estimation using only the survey data is inappropriate as it yields estimates with unacceptable levels of precision. In such cases small area estimation can be performed via models that borrow strength by using all the available data and not only the area specific data. The most popular class of models for small area estimation is random effects models that include random area effects to account for between area variation beyond that explained by auxiliary variables (see for example, Fay and Herriot 1979; Battese *et al.* 1988; Rao 2003). However, these models depend on strong distributional assumptions, require a formal specification of the random part of the model and do not easily allow for outlier robust inference.

A new approach to small area estimation is based on M-quantile models (Chambers and Tzavidis 2006; Tzavidis and Chambers 2006). Unlike random effects small area models, M-quantile small area models do not depend on strong distributional assumptions while outlier robust inference is automatically performed.

In this paper we use M-quantile models for poverty mapping and for estimating within small areas distribution functions of per-capita consumption expenditure. Our data are obtained from the 2002 Living Standards Measurement Survey (LSMS) in Albania. The aim is to examine whether applying M-quantile models to these data can produce reasonable estimates of the incidence of poverty at the small area level, rather than to compare M-quantile models with more traditional models for poverty mapping such as those described by Elbers, Lanjouw and Lanjouw (2003). Such a comparison is beyond the scope of this paper and will be tackled elsewhere.

The paper is organized as follows. In section 2 we review linear mixed effects models and M-quantile models for small area estimation. In section 3 we define a unified estimation framework under which target parameters at the small area level are defined as functionals of the small area distribution function. In section 4 we present mean squared error estimation for M-quantile estimators of the small area mean. In Section 5 the alternative methods for small area estimation are compared and the performance of the MSE estimator is evaluated using a Monte-Carlo simulation experiment This is based on the 2002 LSMS in Albania. In section 6 we employ the 2002 LSMS in Albania and M-quantile models to estimate (a) the incidence of poverty in thirty six Albanian districts and (b) district level distribution functions of per-capita consumption expenditure. Finally in section 7 we summarize our findings and give directions for future research.

2. Models for Small Area Estimation

In what follows we assume that a vector of p auxiliary variables x_{ij} is known for each population unit i in small area j and that information for the variable of interest y is available for units in the sample. The target is to use these data to estimate various area specific quantities, including (but not only) the small area mean m_j of y.

Linear mixed effects models are widely used for this purpose. In the general case a linear mixed effects model has the following form

$$y_{ij} = x_{ij}^T \beta + z_{ij}^T \gamma_j + \varepsilon_{ij},\ i = 1, \ldots, n_j,\ j = 1, \ldots, d, \tag{1}$$

where γ_j denotes a vector of random effects and z_{ij} denotes a vector of auxiliary variables whose values are known for all units in the population. Area specific means are estimated by

$$\hat{m}_j = N_j^{-1}\left(\sum_{i \in s_j} y_i + \sum_{i \in r_j}\left[x_i^T \hat{\beta} + z_i^T \hat{\gamma}_j\right]\right). \tag{2}$$

where s_j denotes n_j sampled units in area j and r_j denotes the remaining $N_j - n_j$ units in the area. Estimator (2) is typically referred to as the Empirical Best Linear Unbiased Predictor (EBLUP) of m_j. Note that the role of the random effects in the model is to characterize differences in the conditional distribution of y given x between the small areas.

An alternative approach to small area estimation is based on the use of quantile or M-quantile regression models. In the linear case, quantile regression leads to a family (or "ensemble") of planes indexed by the value of the corresponding percentile coefficient $q \in (0,1)$ (Koenker and Bassett 1978). For each value of q, the corresponding model shows how $Q_q(x)$, the q^{th} quantile of the conditional distribution of y given x, varies with x. A linear model for the q^{th} conditional quantile y given x is $Q_q(\mathrm{x}) = x^T \beta_q$. Quantile regression can be viewed as a generalization of median regression. M-quantile regression (Breckling and Chambers 1988) provides a "quantile-like" generalization of regression based on influence functions (M-regression). A linear M-quantile regression model is one where we assume that $Q_q(x;\psi) = x^T \beta_\psi(q)$ with ψ denoting the influence function associated with the M-quantile. That is, we allow a different set of regression parameters for each value of q. For specified q and ψ, an estimate $\hat{\beta}_\psi(q)$ of $\beta_\psi(q)$ can be obtained by solving

$$\sum_{i=1}^{n} \psi_q(r_{iq\psi})x_i = 0, \tag{3}$$

where $r_{iq\psi} = y_i - x_i^T \hat{\beta}_\psi(q)$, $\psi_q(r_{iq\psi}) = 2\psi(s^{-1}r_{iq\psi})\left\{qI(r_{iq\psi} > 0) + (1-q)I(r_{iq\psi} \le 0)\right\}$ and s is a suitable robust estimate of scale for example, the MAD estimate $s = median\left|r_{iq\psi}\right| / 0.6745$.

Chambers and Tzavidis (2006) extend the use of M-quantile models to small area estimation. Following their development, we index population units by i and characterize the conditional variability across the population of interest by the M-quantile coefficients of the population units. For unit i with values y_i and x_i, this coefficient is the value q_i such that $Q_{q_i}(x_i;\psi) = y_i$. If a hierarchical structure does explain part of the variability in the population data, then we expect units within clusters defined by this hierarchy to have similar M-quantile coefficients. Consequently, if the conditional M-quantiles follow a linear model, with $\beta_\psi(q)$ a sufficiently smooth function of q, an M-quantile estimator of the mean is defined as

$$\hat{m}_j = N_j^{-1}\left(\sum_{i \in s_j} y_i + \sum_{i \in r_j} x_i^T \beta_\psi(\hat{\theta}_j)\right), \tag{4}$$

where a "hat" represents an estimator of the unknown quantity. Here $\hat{\theta}_j$ is the average value of the M-quantile coefficients of the units in area j. However, alternative definitions of $\hat{\theta}_j$ are possible for example, the area j median of the unit M-quantile coefficients. In addition, if we are working within a complex survey design framework, another possibility for defining $\hat{\theta}_j$ is to employ a weighted mean of the unit specific M-quantile coefficients with weights defined by the survey weights. Note however that, accounting properly for the complex survey design requires that we adopt a probability weighted version of the iterative weighted least squares algorithm used to fit M-quantile models. This will be similar to the probability weighted iterative generalized least squares algorithm employed by Pfeffermann *et al.* (1988) and Grilli and Pratesi (2004) to account for the complex survey design in fitting multilevel models.

3. Small Area Estimation via Distribution Functions

An alternative way of looking at small area estimators is as functionals of estimated empirical distribution functions within the small areas. Consider a finite population P of N units clustered within small areas of interest. For small area j the area specific population distribution function is

$$F_j(t) = N_j^{-1}\left(\sum_{i\in s_j} I(y_i \le t) + \sum_{i\in r_j} I\left(y_i \le t\right)\right). \tag{5}$$

The problem of estimating $F_j(t)$ essentially reduces to predicting the y_{ij} 's for the non-sampled units in small area j. This is achieved using a model suitable for small area estimation. Under a general linear model for small area estimation

$$\hat{F}_j(t) = N_j^{-1}\left(\sum_{i\in s_j} I(y_i \le t) + \sum_{i\in r_j} I\left(x_i^T \hat{\beta}_j \le t\right)\right), \tag{6}$$

where $\hat{\beta}_j$ are the estimated model parameters for small area j. If we use an M-quantile model to predict y 's for out of sample units,

$$\hat{F}_j(t) = N_j^{-1}\left(\sum_{i\in s_j} I(y_i \le t) + \sum_{i\in r_j} I\left(x_i^T \hat{\beta}_\psi(\hat{\theta}_j) \le t\right)\right)$$

and the Chambers and Tzavidis (2006) estimator of the small area mean (4) is obtained as

$$\hat{m}_j = \int_{-\infty}^{\infty} t d\hat{F}_j(t) = N_j^{-1}\left(\sum_{i\in s_j} y_i + \sum_{i\in r_j} x_i^T \hat{\beta}_\psi(\hat{\theta}_j)\right). \quad (7)$$

The same is true when a mixed effects model is used

$$\hat{F}_j(t) = N_j^{-1}\left(\sum_{i\in s_j} I(y_i \le t) + \sum_{i\in r_j} I\left(x_i^T \hat{\beta} + z_i^T \hat{\gamma}_j \le t\right)\right)$$

and the EBLUP estimator (2) is obtained as

$$\hat{m}_j = \int_{-\infty}^{\infty} t d\hat{F}_j(t) = N_j^{-1}\left(\sum_{i\in s_j} y_i + \sum_{i\in r_j}\left[x_i^T \hat{\beta} + z_i^T \hat{\gamma}_j\right]\right). \quad (8)$$

Chambers and Tzavidis (2006) observed that (4) can produce biased estimates of small area means, particularly when small areas contain outliers. Hereafter, we refer to small area estimators derived under (6) as naïve estimators.

A bias-correction to the naïve M-quantile estimator (4) has been proposed by Tzavidis and Chambers (2006), based on the Chambers-Dunstan (1986) estimator of the population distribution function. Under a general model and without any reference to the small area problem the Chambers-Dunstan estimator of the distribution function -hereafter denoted in formulae by a subscript CD- is given by

$$\hat{F}_{CD}(t) = N^{-1}\left\{\sum_{i\in s} I(y_i \le t) + n^{-1}\sum_{i\in s}\sum_{k\in r} I\left[x_k^T \hat{\beta} + (y_i - \hat{y}_i) \le t\right]\right\}, \quad (9)$$

where $\hat{\beta}$ is the vector of estimated model parameters and $\hat{y}_i = x_i^T \hat{\beta}$.

A biased adjusted M-quantile estimator of the small area mean in the presence of outliers is defined by combining the M-quantile small area model with (9). In this case the Chambers-Dunstan estimator of the population distribution function of small area j is

$$\hat{F}_{CD,j}(t) = N_j^{-1}\left\{\sum_{i\in s_j} I(y_i \le t) + n_j^{-1}\sum_{i\in s_j}\sum_{k\in r_j} I\left[x_k^T\hat{\beta}_\psi(\hat{\theta}_j) + (y_i - \hat{y}_i) \le t\right]\right\},$$

where $\hat{y}_i = x_i^T\hat{\beta}_\psi(\hat{\theta}_j)$. The corresponding biased adjusted estimator of the small area mean is then

$$\hat{m}_j^{adj} = \int_{-\infty}^{\infty} t\,d\hat{F}_{CD,j}(t) = N_j^{-1}\left(\sum_{i\in s_j} y_i + \sum_{i\in r_j} x_i^T\hat{\beta}_\psi(\hat{\theta}_j) + \frac{N_j - n_j}{n_j}\sum_{i\in s_j}[y_i - \hat{y}_i]\right). \quad (10)$$

Estimator (4) employs a robust β such as the one estimated under an M-quantile model. However, this step does not protect us against the bias introduced when estimating the mean in the presence of outliers. In contrast, the proposed biased adjusted M-quantile estimator (10) provides a bias-correction. Using different definitions for the ψ function, alternative bias-adjusted small area estimators of the small area mean are possible. An alternative, heuristic, approach to reducing the bias in the M-quantile estimate of the small area mean is to use expectile regression (Newey and Powell 1987). This is equivalent to letting $c \to \infty$, where c is the tuning constant of the influence function ψ (Tzavidis and Chambers 2006).

Two further extensions are possible. Firstly, a modified version of the EBLUP estimator (2) can be defined by combining the mixed effects model (1) with the Chambers-Dunstan estimator (Tzavidis and Chambers 2006), leading to

$$\hat{m}_j^{adj} = \int_{-\infty}^{\infty} t\,d\hat{F}_{CD,j}(t) = N_j^{-1}\left(\sum_{i\in s_j} y_i + \sum_{i\in r_j}\left[x_i^T\hat{\beta} + z_i^T\hat{\gamma}_j\right] + \frac{N_j - n_j}{n_j}\sum_{i\in s_j}[y_i - \hat{y}_i]\right), \quad (11)$$

where $\hat{y}_i = x_i^T\hat{\beta} + z_i^T\hat{\gamma}_j$. Secondly, the approach that we followed for defining the M-quantile bias adjusted estimator leads naturally to estimate other quantiles, $q_j \in (0,1)$, of the population distribution function in a small area. This can be achieved using either an M-quantile or a mixed effects model and the Chambers-Dunstan estimator or estimator (6). In the former case a numerical solution to

$$\int_{-\infty}^{m_j} d\hat{F}_{CD,j}(t) = q_j . \tag{12}$$

4. Mean Squared Error Estimation

Mean squared error estimation of the M-quantile based small area estimators is based on the approach described in Chandra and Chambers (2005) and Chambers and Tzavidis (2006). For fixed q, the estimator of the M-quantile regression coefficient $\beta_\psi(q)$ is $\hat{\beta}_\psi(q) = (X_s^T W_s(q) X_s)^{-1} X_s^T W_s(q) y_s$, where X_s denotes the $n \times p$ matrix of sample covariate values and y_s is the n-vector of sample y-values. The diagonal matrix $W_s(q)$ contains the final set of weights produced by the iteratively reweighted least squares algorithm used to compute $\hat{\beta}_\psi(q)$. It immediately follows that $\hat{m}_j^{adj} = N_j^{-1} w_j^T y_s$, where w_j is the vector of area j weights

$$w_j = \frac{N_j}{n_j} 1_{sj} + W_s(\hat{\theta}_j) X_s (X_s^T W_s(\hat{\theta}_j) X_s)^{-1} \left(t_{rj} - \frac{N_j - n_j}{n_j} t_{sj} \right). \tag{13}$$

Here 1_{sj} is the n-vector with i^{th} component equal to one whenever the corresponding sample unit is in area j and is zero otherwise, t_{rj} is the sum of the non-sample covariate values in area j and t_{sj} is the sum of the sample covariate values in area j.

We use the fact that the M-quantile estimator of $\beta_{\psi}(q)$ is linear in the sample values of y to develop an estimator of the mean squared error of the naïve M-quantile estimator. Note that our approach assumes $\hat{\theta}_j$ is constant, which leads to a first order approximation to the actual mean squared error. Mean squared error estimation of $\hat{m}_j^{adj}$ can be carried out using standard methods for robust estimation of the mean squared error of unbiased weighted linear estimators (Royall and Cumberland 1978). That is, the prediction variance can be approximated by

$$var(\hat{m}_j^{adj} - m_j^{adj}) = \frac{1}{N_j^2}\left[\sum_{i\in s_j}\left\{c_j^2 + \frac{N_j - n_j}{n_j - 1}\right\} var(y_{ij}) + \sum_{i\in s-s_j} c_j^2 var(y_{ij})\right]$$

with $c_j = \begin{cases} w_j - 1 & if\ i \in s_j \\ w_j & otherwise \end{cases}$

We can interpret $var(y_i)$ conditionally (i.e. specific to the area j from which y_i is drawn) and hence replace $var(y_{ij})$ in the expression above by $(y_{ij} - x_{ij}^T\hat{\beta}_{\psi}(\hat{\theta}_j))^2$. Alternatively, we may interpret $var(y_i)$ unconditionally and replace $var(y_{ij})$ in the expression above by $(y_{ij} - x_{ij}^T\hat{\beta}_{\psi}(0.5))^2$. However, in our experience the unconditional approach tends to inflate the variance estimates and thus the conditional approach may be preferable. To complete mean squared error estimation we need to obtain an estimate of the bias. To do this we notice that

$$E\left(N_j^{-1}\sum_{i\in s} w_j y_i - m_j^{adj}\right) \approx N_j^{-1}\left(\sum_j \sum_{i\in s_j} w_j x_{ij}^T \beta(\hat{\theta}_j) - \sum_{i\in j} x_{ij}^T \beta(\hat{\theta}_j)\right),$$

where the summation over j on the right hand side above is over the set of areas represented in the sample. An estimate of the bias is

$$\hat{B}_j = N_j^{-1}\left(\sum_j\sum_{i\in s_j} w_j x_{ij}^T \beta(\hat{\theta}_j) - \sum_{i\in j} x_{ij}^T \beta(\hat{\theta}_j)\right). \tag{14}$$

Our final estimator of the mean squared error of is therefore

$$\hat{M}_j = \hat{V}_j + \hat{B}_j^2. \tag{15}$$

Since our bias-adjusted M-quantile estimator is constructed as an approximately unbiased estimator of the small area mean, the squared bias term in (15) will not impact significantly on the mean squared estimator. Finally, a mean squared error for the naïve M-quantile estimator can be developed using the same argument as above but instead of using the weights given by (13) we use the following weights

$$w_j = 1_{sj} + W_s(\hat{\theta}_j)X_s(X_s^T W_s(\hat{\theta}_j)X_s)^{-1}t_{rj}. \tag{16}$$

5. A Simulation Study

In this section we present results from a simulation study that was used to compare the performance of the different small area estimators presented in section 3. The data on which this simulation is based were obtained from a sample of 3591 households spread across 36 districts of Albania. The *y*-variable of interest is the per-capita consumption expenditure.

The study itself was implemented in two steps as follows: (1) a population of N =724782 households was created by sampling N times with replacement from the above sample of 3591 households and with probability proportional to a household's sample weight; (2) two hundred independently stratified random samples of the same size as the original sample were selected from this simulated population. District sample sizes were also fixed to be the same as in the original sample. Small area mean estimates were obtained using both naïve and bias-adjusted estimators of section 3 based on the M-quantile and the random intercepts approaches.

The results set out in Table 1 focus on estimation of district means under the M-quantile and the random intercepts naïve and bias adjusted small area estimators. These results show that the naïve M-quantile estimator of the small area mean is biased. This is consistent with the findings of Tzavidis and Chambers (2006) who pointed out that the naïve M-quantile estimator of the small area mean will produce biased estimates when there are outliers in the data. The random intercepts naïve estimator of the small area mean is also biased but less than the naïve M-quantile estimator. The bias reduces once we consider the M-quantile and the random intercepts estimators that are based on the use of the Chambers-Dunstan estimator of the distribution function. These results show that the bias-adjusted estimators perform well both in terms of bias and mean squared error.

In Table 2 we evaluate the performance of the mean squared error estimator that we developed in section 4. It appears that this mean squared error estimator provides a good approximation to the true mean squared error and has good coverage properties. We also notice that in two districts we have under coverage (district 13 and district 26). This is expected when working with real data and maybe due to the existence of some large outlying values. In additional simulation-based evaluations not reported in this paper the proposed mean squared estimator performs consistently well.

6. An Application: Small area estimation of household per-capita consumption expenditure and poverty mapping for districts in Albania

Poverty maps are important tools that provide information on the spatial distribution of poverty within a country, and are often used to inform decisions relating to poverty alleviation programmes. Poverty is defined both in terms of income deprivation and in terms of inadequacies in a number of non-income measures of welfare such as education, health, access to the basic services and infrastructures. In this study we refer to the poverty as income deprivation. Since the economy of Albania is largely rural and income is not readily and accurately measurable, income poverty in Albania is estimated on the basis of a consumption-based measure (World Bank 2003). A household is considered poor if its level of per capita expenditure falls below a minimum level (poverty line) necessary to meet its basic food and non-food needs. In 2002 a Living Standards Measurement Study (LSMS) was conducted in Albania. The study was established by the World Bank in 1980 to explore ways of improving the type and quality of household data collected by statistical offices in developing countries. Its goal is to foster increased use of household data as a basis for policy decision making. This survey provides valuable information on a variety of issues related to living conditions of the people in Albania, including details on income and non-income dimensions of poverty in the country, and forms the basis of poverty assessment in Albania.

There are twelve prefectures in Albania with a prefecture composed of several districts. There are thirty six districts in total (Figure 1). An attempt to obtain direct estimates at the district level reveals the lack of precision of the estimates particularly for the smaller districts. In order to produce desegregated measures and maps that describe the spatial distribution of poverty and inequality, The World Bank uses the approach of Elbers, Lanjouw and Lanjouw (2003), hereafter refer to as the ELL method. The basic idea of the ELL method is to estimate a linear regression model for the logarithmic transformation of the household per-capita consumption expenditure with local variance components. At the first stage this regression model is estimated using the survey data and aggregated census level covariate information. At the second stage the estimated model parameters are combined with census data for simulating the per-capita consumption expenditure of each household in the population. These household level predictions are used for estimating the incidence of poverty.

An alternative approach for estimating the incidence of poverty at disaggregated geographical levels is via small area estimation models. Under this approach the parameters of a small area model, such as a random effects or an M-quantile model, are estimated using the survey data. The estimated model parameters are then combined with census level covariate information to form predictions of per-capita consumption expenditure for each household in the population. These household level predictions are then used for estimating the incidence of poverty. Although poverty mapping can be performed using either M-quantile or random effects models, in this paper we solely focus on M-quantile models.

We employ an M-quantile small area model for estimating (a) the incidence of poverty in Albanian districts and (b) district level distribution functions of per-capita consumption expenditure. The selection of covariates to fit the M-quantile model is done following other studies on poverty assessment in Albania (Betti 2003). While selecting covariates it is important to consider the various non-income dimensions of poverty and deprivation that can potentially dominate the pure income dimension. We have selected the following household level covariates: the household size, which is a strong indicator of poverty, the presence of facilities in the dwelling (TV, parabolic dish antenna, refrigerator, air conditioning, personal computer), ownership of dwelling, ownership of land and ownership of car.

Figure 2a maps the estimates of the proportion of poor households in each of the Albanian districts while Figure 2b maps the estimates of the proportion of poor individuals in the same districts. The estimates of the poverty incidence at household and individual level are reported in Table 3. The poverty line that we used to obtain the poverty estimates in Albania is set equal to 4,891 Leks per month (World Bank 2003). The results appear to be consistent with experts' opinions and with results obtained by applying the ELL method. Nevertheless, we must point out that our results are not directly comparable with results obtained from the ELL method firstly because we didn't have access to the complete database employed for producing poverty estimates with the ELL method and secondly because the ELL method is applied on the logarithmic scale whereas our approach is applied on the raw scale. Estimating the model on the log scale requires back transformation to the original scale. This back transformation, however, may result in bias (Dorfman and Chambers 2003).

Deriving poverty estimates depends of how one sets the poverty line. The choices made in setting the poverty line can impact upon the estimates and hence have an effect on policy making. For this reason it is important to obtain a picture of the whole distribution of per-capita consumption expenditure in each small area (district).

Estimates of mean per-capita consumption expenditure in each district are derived using the bias-adjusted M-quantile estimator (11) and associated standard errors are derived using mean squared estimator (15) (without the squared bias term) with weights given by (13). In Table 4 we report 95% confidence intervals for estimates of the mean of per-capita consumption expenditure by district. Estimates of different quantiles of the distribution of per-capita consumption expenditure in each district are obtained using the Chambers-Dunstan estimator of the distribution function and estimator (12), which requires numerical integration. These estimates are mapped in Figures 3, 4 and 5 with the actual numbers reported in Table 5.

7. Concluding Remarks

In this paper we demonstrate how M-quantile models can be employed successfully for estimating the incidence of poverty at disaggregated geographical levels and for estimating within small areas distribution functions of per-capita consumption expenditure. In doing so, we employ the methodology of Chambers and Tzavidis (2006) and Tzavidis and Chambers (2006). The application of M-quantile models for poverty mapping in Albania illustrates the potential of employing small area methods in poverty evaluation studies. There are a number of research questions, however, that remain to be tackled. Firstly, a full comparison of the ELL approach with random effects and M-quantile models is needed. Furthermore, mean squared error estimation for estimates of the quantiles of the within area distribution function remains to be developed. Finally, information on the geographical location of the sample units- available in the survey data- is often not taken into account. However, in many practical situations such as with environmental, epidemiological and economic applications the spatial dimension of the data must be explicitly modeled. We are currently evaluating the use of random effects models with spatially correlated random effects and we intend to develop spatial M-quantile models for small area estimation and poverty mapping.

References

Battese, G.E., Harter, R.M. and Fuller W.A. (1988). An Error-Components Model for Prediction of County Crop Areas Using Survey and Satellite Data, *Journal of the American Statistical Association,* vol.83, No. 401, 28-36.

Betti, G. (2003). *Poverty and Inequality Mapping in Albania: Final Report*, Washington, DC and Tirana, World Bank and INSTAT (mimeo).

Bigman, D., Dercon, S., Guillaume, D. and Lambotte, M. (2000). Community Targeting for Poverty Reduction in Burkina Faso, *The World Bank Economic Review*, vol. 14, No. 1, pp. 167-193.

Breckling, J. and Chambers, R. (1988). M-quantiles, *Biometrika*, 75, 4, pp. 761-771.

Chambers, R. and Dunstan, R. (1986). Estimating distribution function from survey data, *Biometrika*, 73, pp. 597-604.

Chambers, R. and Dorfman, A. H. (2003). Transformed Variables in Survey Sampling, Southampton, UK, Southampton Statistical Sciences Research Institute, *S3RI Methodology Working Papers, M03/21.*

Chandra, H. and Chambers, R.(2005). Comparing EBLUP and C-EBLUP for Small Area Estimation, *Statistics in Transition*, Vol. 7, No. 3, pp. 637-648.

Chambers, R. and Tzavidis, N. (2006). M-quantile Models for Small Area Estimation, *Biometrika*, 93, pp. 255-268.

Elbers, C., Lanjouw, J. and Lanjouw, P. (2003). Micro-level estimation of poverty and inequality, *Econometrica*, 71, pp. 355-364.

Fay, R.E. and Herriot, R.A. (1979). Estimates of income for small places: an application of James-Stein procedures to census data, *Journal of the American Statistical Association*, 74, pp. 269-277.

Grilli, L. and Pratesi, M. (2004). Weighted estimation in multilevel ordinal and binary models in the presence of informative sampling designs. *Survey Methodology*, 30, 93–103.

Koenker, R. and Bassett, G. (1978). Regression quantiles, *Econometrica*, 46, pp. 33-50.

Newey, W.K. and Powell J.L. (1987). Asymmetric least squares estimation and testing, *Econometrica*, 55, 819-847.

Pfeffermann, D., Skinner, C.J., Holmes, D.J., Goldstein, H. and Rasbash, J. (1998). Weighting for unequal selection probabilities in multilevel models, *Journal of the Royal Statistical Society B*, 60, 1, pp. 23-40.

Rao, J.N.K. (2003). *Small Area Estimation,* John Wiley & Sons, New York.

Ravallion, M. (2002). Poverty Lines in Theory and Practice, The World Bank, Washington, D.C., *LSMS Working Paper No. 133*.

Royall, R.M. and Cumberland W.G. (1978). Variance estimation in finite population sampling, *Journal of the American Statistical Association*, 73, pp. 351-358.

Tzavidis, N. and Chambers, R. (2006). Bias adjusted distribution estimation for small areas with outlying values, Southampton, UK, Southampton Statistical Sciences Research Institute, *S3RI Methodology Working Papers, M06/09*.

World Bank (2003). Albania Poverty Assessment, World Bank, Washington, D.C., *Report No. 26213-AL*.

Table 1. Relative Bias and Relative Root Mean Squared Error of district level estimates of the mean of per-capita consumption expenditure.

District	Mq Naïve	Mq CD	Random Intercepts Naïve	Random Intercepts CD	Mq Naïve	Mq CD	Random Intercepts Naive	Random Intercepts CD
	Relative Bias (%)				**Relative Root Mean Square Error (%)**			
1	-7.94	0.44	0.14	0.45	7.97	3.36	3.13	3.33
2	-13.74	0.45	3.85	0.39	13.75	3.79	4.72	3.66
3	-20.74	-0.66	-2.27	-0.71	25.55	12.59	9.36	12.64
4	-4.29	-0.27	-9.73	-0.22	7.68	7.71	10.66	7.57
5	-9.57	0.17	0.26	0.17	9.58	2.57	2.52	2.58
6	-13.60	-0.16	0.50	-0.19	13.72	3.39	3.31	3.41
7	-15.16	0.25	0.69	0.24	15.16	4.92	4.69	4.88
8	-12.32	0.19	0.05	0.21	12.32	2.59	2.53	2.61
9	-15.04	-0.26	0.47	-0.26	15.04	5.55	5.22	5.52
10	2.23	0.54	-6.22	0.28	11.04	7.17	8.08	6.67
11	-5.79	0.59	-0.54	0.57	6.71	4.88	4.32	4.85
12	-7.46	0.03	-0.85	0.04	8.30	3.76	3.51	3.74
13	-10.36	-0.59	13.64	-0.44	13.06	10.61	13.67	10.67
14	-11.00	-0.37	-0.34	-0.36	11.02	3.33	3.19	3.34
15	-13.78	-0.23	3.94	-0.20	14.40	6.77	6.31	6.70
16	-6.76	0.98	2.60	0.99	13.02	5.92	5.37	5.92
17	-15.17	0.09	0.86	0.07	15.17	2.47	2.48	2.46
18	-8.89	-0.53	4.36	-0.56	9.71	3.48	4.97	3.47
19	-17.82	0.48	-1.89	0.51	18.29	5.13	4.93	5.13
20	-8.44	0.22	0.69	0.22	8.47	3.00	2.96	3.00
21	-9.99	-0.20	-0.55	-0.21	10.03	2.99	2.89	2.99
22	-16.88	0.49	0.27	0.48	18.28	9.76	7.69	9.70
23	-13.23	0.52	-2.72	0.52	16.72	6.98	6.28	7.01
24	-8.98	0.44	0.58	0.45	9.67	5.03	4.15	5.01
25	-10.65	0.66	4.65	0.67	13.18	7.08	6.27	7.13
26	-29.32	-1.28	2.27	-1.15	29.32	16.46	12.66	16.35
27	-3.51	0.52	-6.60	0.48	10.86	8.15	8.26	8.14
28	-6.26	-0.56	-0.01	-0.55	13.85	5.26	4.59	5.26
29	3.22	-0.27	8.55	-0.27	7.57	4.85	8.69	4.97
30	-7.32	-0.07	-2.30	-0.07	7.98	4.14	4.08	4.24
31	-3.35	0.15	4.08	0.30	15.87	7.30	6.12	7.00
32	-12.99	0.04	-0.01	0.05	12.99	3.01	2.86	3.01
33	-13.92	-0.09	1.70	-0.08	14.34	7.16	6.18	7.16
34	-15.66	-0.18	-0.24	-0.18	15.66	1.79	1.79	1.80
35	-13.28	0.67	2.36	0.61	13.47	4.62	4.70	4.61
36	-8.93	0.44	-0.45	0.42	9.44	3.51	3.36	3.46
Mean	-10.74	0.073	0.61	0.074	13.03	5.58	5.46	5.55

Table 2. Coverage rates of 'two-sigma' confidence intervals. Intervals are defined by the M-quantile bias-adjusted estimates plus or minus twice their corresponding standard errors using (15) (without the squared bias term) with weights given by (13).

District	True Root MSE	Estimated Root MSE	Coverage
1	391.35	406.22	0.96
2	235.50	230.17	0.92
3	1517.69	1484.92	0.90
4	1187.96	1120.82	0.93
5	253.28	245.65	0.95
6	314.30	321.58	0.95
7	475.55	479.72	0.91
8	294.13	311.23	0.96
9	512.37	525.39	0.93
10	1204.45	1156.45	0.94
11	557.39	599.66	0.97
12	458.21	464.41	0.97
13	895.85	930.53	0.87
14	360.70	356.53	0.92
15	543.79	560.41	0.96
16	571.93	589.71	0.95
17	216.88	246.96	0.97
18	245.86	260.69	0.94
19	708.36	768.08	0.97
20	266.01	274.35	0.96
21	350.95	353.17	0.94
22	952.88	965.40	0.90
23	882.83	900.24	0.92
24	499.74	522.09	0.96
25	650.57	727.85	0.95
26	1507.52	1497.50	0.81
27	1138.95	1123.54	0.94
28	525.02	527.89	0.94
29	350.13	371.43	0.97
30	588.71	618.21	0.93
31	707.01	740.81	0.96
32	329.12	355.82	0.96
33	679.40	698.82	0.94
34	208.28	219.93	0.97
35	377.21	406.61	0.97
36	493.02	488.81	0.93

Table 3. District level estimates of Head Count Ratio (HCR) at household and individual level.

District	HCR household level	HCR individual level
BERAT	0.22	0.28
BULQIZE	0.57	0.68
DELVINE	0.12	0.18
DEVOLL	0.10	0.13
DIBER	0.16	0.24
DURRES	0.23	0.31
ELBASAN	0.18	0.25
FIER	0.12	0.16
GRAMSH	0.26	0.34
GJIROKASTER	0.06	0.10
HAS	0.13	0.19
KAVAJE	0.12	0.17
KOLONJE	0.18	0.26
KORCE	0.12	0.18
KRUJE	0.28	0.36
KUCOVE	0.21	0.27
KUKES	0.19	0.29
KURBIN	0.38	0.49
LEZHE	0.13	0.18
LIBRAZHD	0.27	0.35
LUSHNJE	0.14	0.19
MALESI E MADHE	0.19	0.27
MALLAKASTER	0.16	0.21
MAT	0.15	0.23
MIRDITE	0.19	0.28
PEQIN	0.37	0.44
PERMET	0.05	0.08
POGRADEC	0.21	0.28
PUKE	0.40	0.56
SARANDE	0.03	0.05
SKRAPAR	0.19	0.24
SHKODER	0.12	0.19
TEPELENE	0.23	0.29
TIRANE	0.15	0.21
TROPOJE	0.23	0.34
VLORE	0.07	0.11

Table 4. 95% confidence intervals for estimates of the mean of per-capita consumption expenditure by district using estimated standard errors from (15) (without the squared bias term) with weights given by (13).

District	Lower Bound	Mean	Upper Bound
BERAT	6422.38	8331.06	10239.73
BULQIZE	3964.69	4778.07	5591.44
DELVINE	7793.95	10165.35	12536.74
DEVOLL	8450.85	10742.24	13033.64
DIBER	7279.82	8156.45	9033.09
DURRES	6419.35	7641.22	8863.10
ELBASAN	7114.69	8301.25	9487.80
FIER	7397.85	9282.87	11167.88
GRAMSH	6433.02	7326.16	8219.30
GJIROKASTER	10328.36	12219.40	14110.43
HAS	8301.39	9785.44	11269.49
KAVAJE	8345.91	9630.30	10914.70
KOLONJE	5189.91	6919.38	8648.86
KORCE	7746.40	8623.06	9499.71
KRUJE	5789.98	6832.48	7874.99
KUCOVE	6560.63	7644.68	8728.72
KUKES	7156.29	8024.30	8892.31
KURBIN	5000.39	5745.14	6489.89
LEZHE	9317.08	10795.43	12273.77
LIBRAZHD	6689.04	7502.92	8316.81
LUSHNJE	7882.03	9058.31	10234.59
MALESI E MADHE	6325.20	8240.21	10155.21
MALLAKASTER	7605.74	9540.27	11474.79
MAT	7187.81	8262.86	9337.90
MIRDITE	6610.47	8061.28	9512.09
PEQIN	4808.15	7423.50	10038.85
PERMET	9027.05	11303.17	13579.29
POGRADEC	6902.81	8021.51	9140.22
PUKE	4161.45	5538.30	6915.15
SARANDE	10073.17	11342.82	12612.48
SKRAPAR	6186.42	7556.59	8926.75
SHKODER	7285.88	8796.42	10306.95
TEPELENE	6588.81	7961.71	9334.60
TIRANE	7302.76	9596.29	11889.81
TROPOJE	6452.37	7526.35	8600.33
VLORE	8667.40	11205.66	13743.91

Table 5. Estimates of the 10th, 25th, 50th, 75th, 90th quantiles and of the mean of the per-capita consumption expenditure by district.

District	Q10	Q25	Q50	Mean	Q75	Q90
BERAT	3128.77	5135.13	7629.47	8331.05	10711.79	14181.13
BULQIZE	1966.38	3099.46	4466.35	4778.07	6154.99	7900.22
DELVINE	4464.13	6392.56	9141.77	10165.35	12879.86	18023.57
DEVOLL	4986.41	7728.29	10475.63	10742.24	13067.74	15958.05
DIBER	3969.01	5805.52	8075.34	8156.45	10074.35	12489.22
DURRES	3253.40	5031.02	7158.64	7641.22	9594.87	12662.45
ELBASAN	3846.66	5455.79	7414.92	8301.25	9731.09	12927.72
FIER	4783.15	6214.58	8217.88	9282.87	11150.00	15211.29
GRAMSH	3128.76	4836.58	6670.37	7326.16	8884.26	11651.62
GJIROKASTER	5957.92	8506.14	11777.96	12219.40	14859.43	17845.15
HAS	4461.57	7116.74	9797.34	9785.44	12725.49	15329.57
KAVAJE	4318.46	6780.67	9229.32	9630.30	12122.89	15563.54
KOLONJE	4393.22	5240.52	6214.28	6919.38	7883.89	11308.89
KORCE	4622.66	6100.83	7991.49	8623.06	10063.19	13667.02
KRUJE	2988.13	4615.16	6459.10	6832.48	8850.51	11242.25
KUCOVE	3800.78	5257.03	7591.28	7644.68	9872.53	11753.78
KUKES	3624.51	5475.31	7569.16	8024.30	10147.46	12660.86
KURBIN	2874.72	4162.85	5593.04	5745.14	7196.39	9093.25
LEZHE	4164.09	6970.98	10160.73	10795.43	13773.00	17461.80
LIBRAZHD	2669.66	4663.63	7164.63	7502.92	9775.03	12662.71
LUSHNJE	4228.67	6182.29	8554.80	9058.31	11263.82	14433.26
MALESI E MADHE	3779.79	5416.20	7460.97	8240.21	9828.44	13144.61
MALLAKASTER	4078.69	6018.94	8251.58	9540.27	13143.16	16798.50
MAT	4025.78	5948.81	8024.38	8262.86	10390.15	12309.48
MIRDITE	3476.03	5627.70	8116.96	8061.28	10886.36	12410.18
PEQIN	2527.51	3956.12	5783.93	7423.50	8421.67	12759.52
PERMET	5729.37	7624.94	10468.87	11303.17	14528.58	18661.65
POGRADEC	3789.28	5143.47	7323.93	8021.51	10228.12	12881.02
PUKE	2390.40	3710.76	5450.77	5538.30	7221.13	8662.06
SARANDE	6816.06	8490.54	10845.07	11342.82	13671.95	16698.53
SKRAPAR	3409.03	5484.15	7748.40	7556.59	9737.32	11074.94
SHKODER	4525.86	6231.09	8367.32	8796.42	10603.72	13383.71
TEPELENE	2951.18	5110.98	7570.79	7961.71	10435.01	13622.20
TIRANE	3129.01	5144.00	8017.00	9596.29	11880.00	16958.00
TROPOJE	3292.88	5119.64	7192.06	7526.35	9142.42	11845.24
VLORE	5504.34	7608.08	10364.06	11205.66	13421.76	17750.50

Figure 1. Albanian districts.

Figure 2. District level estimates of Head Count Ratio (a) at household and (b) at individual level.

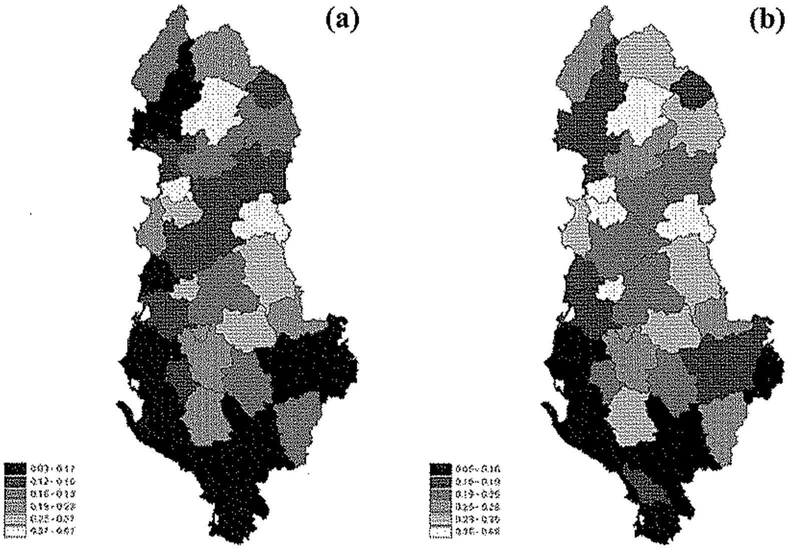


Figure 3. District level estimates of the (a) average per-capita consumption expenditure and (b) median per-capita consumption expenditure.

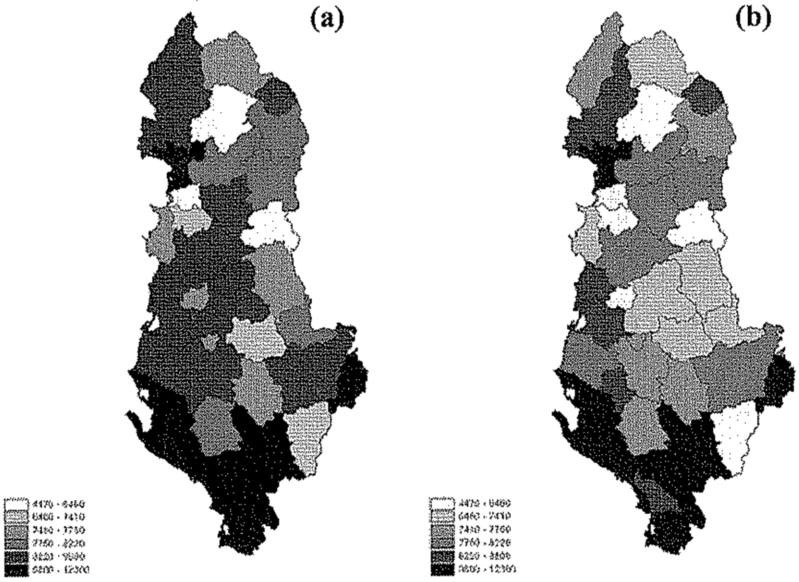


Figure 4. District level estimates of the (a) 10th quantile of per-capita consumption expenditure and (b) 25th quantile of per-capita consumption expenditure.

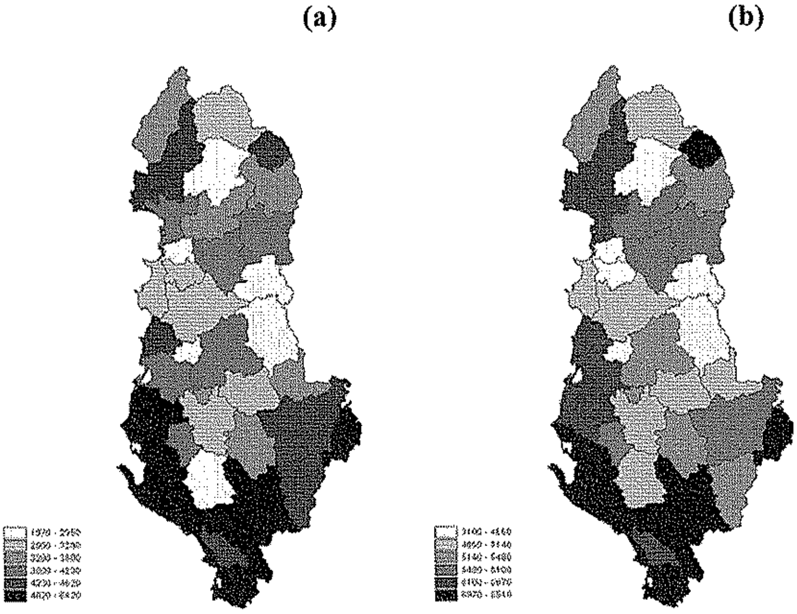
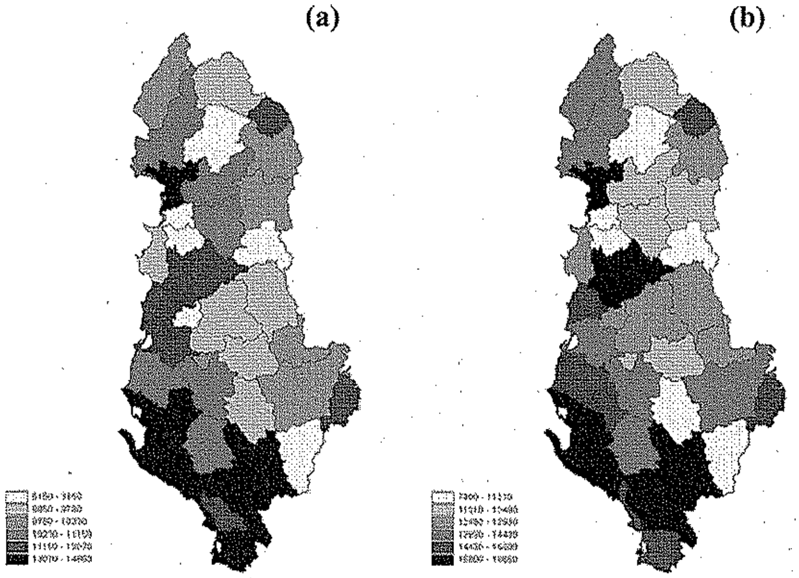


Figure 5. District level estimates of the (a) 75th quantile of per-capita consumption expenditure and (b) 90th quantile of per-capita consumption expenditure.



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