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Spatial EBLUP in agricultural surveys: an application based on Italian Census data

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Spatial EBLUP in agricultural surveys: an application based on Italian Census data.

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Abstract

Knowledge of the area under different crops is important for formulating agricultural policies. Sample survey are usually designed to estimate the average or the total crop areas at regional level. In the context of agriculture, the term "small area" generally refers to a geographical area, such as province or municipality in Italy. Predicting crop area for small areas has often not been attempted, due to a lack of available data from farm surveys for these areas.

The paper describes an application of a modified small area estimator to predict the average olive grove area in each municipality of the Tuscany. The proposed methodology considers an EBLUP estimator with spatially correlated error taking into account the information provided by neighboring areas. The results show the gains from modeling the spatial correlation among small area random effects used to represent the unexplained variation of the small area target quantities.

KEY WORDS: area level random effect model, EBLUP, spatial model, olive grove area.

1 Introduction

In the context of Italian agricultural surveys the term "small area" generally refers to a local geographical area, such as province or municipality. Predicting average or total crop area for municipalities has not often been attempted, both due to a lack of available survey data and the interest focused on Italian provinces (Benedetti *et al.*, 2004). When traditional municipality-specific direct estimator does not provide adequate precision it is possible to employ indirect estimators that "borrow strength" from related areas. The indirect estimators can incorporate specific random area effects that account for between areas variation beyond what is explained by auxiliary variables included in the model. Traditionally the random area effects are considered independent, but in practice, basically in most of the applications on environmental data, it should be more reasonable to assume that the random area effects between the neighboring areas (for instance the neighborhood could be defined by a contiguity criterium) are correlated and the correlation decays to zero as distance increases. The absence of information about neighborhoods could produced a series of failings at national, local and community level; policies could easily be misdesigned or mistargeted and important trends could be missed by national and local government.

The aim of this work is to estimate the average olive grove area in each municipality of the Tuscany, using the EBLUP estimator under a model with spatially correlated errors (Salvati, 2004).

The paper is organized as follows: section 2 recalls the Spatial EBLUP procedure. Section 3 discusses the results of the application of Spatial EBLUP to the estimation of the average olive grove area at municipality level and reports some final remarks.

2 Spatial area level random effect model

Let $\boldsymbol{\theta}$ be the parameter of inferential interest (small area total y_i, small area mean $\bar{y}_i$ with $i = 1...m$) and assume that the direct estimator $\hat{\boldsymbol{\theta}}$ is available and design unbiased

$$\hat{\boldsymbol{\theta}} = \boldsymbol{\theta} + \mathbf{e} \tag{1}$$

with $\mathbf{e}$ independent sampling errors with mean $\mathbf{0}$ and known variance ψ. The spatial dependence among small areas is introduced specifying a linear mixed model with spatially correlated random effects for the $\boldsymbol{\theta}$ parameter:

$$\boldsymbol{\theta} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\mathbf{v} \tag{2}$$

where $\mathbf{X}$ is the matrix of the area specific auxiliary covariates $\mathbf{x}_i = (x_{i,1}, x_{i,2}, ..., x_{i,p})$, $\boldsymbol{\beta}$ is the regression parameters vector $p \times 1$, $\mathbf{Z}$ is a matrix of known positive constants, $\mathbf{v}$ is the second order variation. The deviations from the fixed part of the model $\mathbf{X}\boldsymbol{\beta}$ are the result of an autoregressive process with parameter ρ (spatial autoregressive coefficient) and proximity matrix $\mathbf{W}$ (Cressie, 1993; Anselin, 1992):

$$\mathbf{v} = \rho\mathbf{W}\mathbf{v} + \mathbf{u} \Rightarrow \mathbf{v} = (\mathbf{I} - \rho\mathbf{W})^{-1}\mathbf{u} \tag{3}$$

where $\mathbf{u}$ is a vector of independent error terms with zero mean and constant variance σ_u^2 and $\mathbf{I}$ is the $m \times m$ identity matrix.

Combining (1) and (2), with $\mathbf{e}$ independent of $\mathbf{v}$, the model with spatially correlated errors is:

$$\hat{\boldsymbol{\theta}} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}(\mathbf{I} - \rho\mathbf{W})^{-1}\mathbf{u} + \mathbf{e}. \tag{4}$$

The error terms $\mathbf{v}$ and $\mathbf{e}$ have respectively $m \times m$ covariance matrices:

$$\mathbf{G} = \sigma_u^2[(\mathbf{I} - \rho\mathbf{W})(\mathbf{I} - \rho\mathbf{W}^T)]^{-1} \tag{5}$$

and

$$\mathbf{R} = diag(\psi_i). \tag{6}$$

Then the covariance matrix of the $\hat{\boldsymbol{\theta}}$ is:

$$\mathbf{V} = \mathbf{R} + \mathbf{Z}\mathbf{G}\mathbf{Z}^T = diag(\psi_i) + \mathbf{Z}\sigma_u^2[(\mathbf{I} - \rho\mathbf{W})(\mathbf{I} - \rho\mathbf{W}^T)]^{-1}\mathbf{Z}^T \tag{7}$$

Under the model, the Spatial Best Linear Unbiased Predictor (Spatial BLUP) estimator of θ_i is:

$$\begin{aligned} \tilde{\theta}_i^S(\sigma_u^2, \rho) = \mathbf{x}_i\hat{\beta} + \mathbf{b}_i^T\{\sigma_u^2[(\mathbf{I} - \rho\mathbf{W})(\mathbf{I} - \rho\mathbf{W}^T)]^{-1}\}\mathbf{Z}^T \times \\ \{diag(\psi_i) + \mathbf{Z}\sigma_u^2[(\mathbf{I} - \rho\mathbf{W})(\mathbf{I} - \rho\mathbf{W}^T)]^{-1}\mathbf{Z}^T\}^{-1}(\hat{\boldsymbol{\theta}} - \mathbf{X}\hat{\beta}) \end{aligned} \tag{8}$$

where $\hat{\beta} = (\mathbf{X}^T\mathbf{V}^{-1}\mathbf{X})^{-1}\mathbf{X}^T\mathbf{V}^{-1}\hat{\boldsymbol{\theta}}$ and $\mathbf{b}_i^T$ is $1 \times m$ vector $(0, 0, ...0, 1, 0, ...0)$ with 1 in the i-th position.

The estimator $\tilde{\theta}_i^S(\sigma_u^2, \rho)$ depends on the unknown variance components σ_u^2 and ρ. Replacing the parameters with asymptotically consistent estimators $\hat{\sigma}_u^2$, $\hat{\rho}$, a two stage estimator $\tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho})$ is obtained and it is called Spatial EBLUP:

$$\begin{aligned} \tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho}) = \mathbf{x}_i\hat{\beta} + \mathbf{b}_i^T\{\hat{\sigma}_u^2[(\mathbf{I} - \hat{\rho}\mathbf{W})(\mathbf{I} - \hat{\rho}\mathbf{W}^T)]^{-1}\}\mathbf{Z}^T \times \\ \{diag(\psi_i) + \mathbf{Z}\hat{\sigma}_u^2[(\mathbf{I} - \hat{\rho}\mathbf{W})(\mathbf{I} - \hat{\rho}\mathbf{W}^T)]^{-1}\mathbf{Z}^T\}^{-1}(\hat{\boldsymbol{\theta}} - \mathbf{X}\hat{\beta}). \end{aligned} \tag{9}$$

with $\mathbf{b}_i^T = (0, 0, ...0, 1, 0, ...0)$ with 1 referred to i-th area. Assuming normality of the random effects, σ_u^2 and ρ can be estimated both by ML and REML procedures. The ML estimators, $\hat{\sigma}^2_{u_{ML}}$ and $\hat{\rho}_{ML}$, can be obtained iteratively using the "Nelder-Mead" algorithm (Nelder and Mead, 1965) and the "scoring" algorithm in sequence. The use of these procedures one after the other is necessary because the log-likelihood function have a global maximum and some local maximums. The ML estimator obtained with the "scoring" algorithm depend from the selected starting point, while the "Nelder-Mead" method for the maximization of a function of q variables depends on the comparison of function values at the $(q+1)$ vertices of a general simplex; it adapts itself to the local landscape, and contracts on the final maximum. It does not depend on the selected starting point and it is computationally compact but it is not fully efficient: it achieves a point that is close to the global maximum. For this reason it is necessary to use the "scoring" algorithm selecting as starting point the maximum that has been obtained by the "Nelder-Mead" method.

The ML procedure to estimate σ_u^2 and ρ does not consider the loss in degrees of freedom due to estimating $\boldsymbol{\beta}$. This drawback motivates the use of REML method. The loss in degrees of freedom are taken into account in the REML method by using the transformed data $\boldsymbol{\theta}^* = \mathbf{F}^T\hat{\boldsymbol{\theta}}$, where $\mathbf{F}$ is any $n \times (m-p)$ matrix of full rank orthogonal to the $m \times p$ matrix $\mathbf{X}$. The ML and REML estimators are robust, as they produce acceptable results even under non normal distribution of the random effects (Jiang, 1996).

An approximation to the $MSE[\tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho})]$ is:

$$MSE[\tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho})] \approx g_{1i}(\sigma_u^2, \rho) + g_{2i}(\sigma_u^2, \rho) + g_{3i}(\sigma_u^2, \rho) \tag{10}$$

approximately unbiased estimated by

$$mse[\tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho})] \approx g_{1i}(\hat{\sigma}_u^2, \hat{\rho}) + g_{2i}(\hat{\sigma}_u^2, \hat{\rho}) + 2g_{3i}(\hat{\sigma}_u^2, \hat{\rho}) \tag{11}$$

if $\hat{\sigma}_u^2$ and $\hat{\rho}$ are REML estimators. Otherwise, if ML procedure is used, the $mse[\tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho})]$ is given by

$$mse[\tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho})] \approx g_{1i}(\hat{\sigma}_u^2, \hat{\rho}) - \mathbf{b}_{ML}^T(\hat{\sigma}_u^2, \hat{\rho}) \nabla g_{1i}(\hat{\sigma}_u^2, \hat{\rho}) + g_{2i}(\hat{\sigma}_u^2, \hat{\rho}) + 2g_{3i}(\hat{\sigma}_u^2, \hat{\rho}). \tag{12}$$

The MSE of Spatial EBLUP estimator appears to be insensitive to the choice of the estimator $\hat{\sigma}_u^2$ and $\hat{\rho}$ (Kackar and Harville, 1984). If the term $\mathbf{b}_{ML}(\hat{\sigma}_u^2, \hat{\rho}) \nabla g_{1i}(\hat{\sigma}_u^2)$ is ignored, the use of ML estimators could lead to an underestimation of the MSE approximation. The formulas of g_{1i}, g_{2i}, g_{3i}, $\mathbf{b}_{ML}^T$ and ∇g_{1i} are not reported, more details are in Salvati (2004).

3 Results and final remarks

The application is carried out on a simple random sample of 3000 Tuscany farms selected from the list obtained from the V Agricultural Census (Istat, 2000). The Census data allow us to know the true value of the average olive grove area in each municipality. The main goal of the application is to provide evidence of the performance of Spatial EBLUP ($\tilde{\boldsymbol{\theta}}^S$) in comparison with the traditional EBLUP estimator ($\tilde{\boldsymbol{\theta}}$). In order to asses the achieved results the direct estimator is also calculated at municipality level.

The Tuscany region is divided in 287 municipalities: only 263 are represented in the sample. The objective of inference is the average olive grove area ($\boldsymbol{\theta} = \bar{\mathbf{y}}$) for each of the 287 small areas (municipalities). Auxiliary data at the commune level were available for this study. The following variables are considered as major determinants of the average crop area:

- SAU (Superficie Agricola Utilizzata): utilized surface area (ha);
- UBA (Unità Bovine Adulte): number of bovines;
- UDE (Unità di Dimensione Europea): gross standard income that corresponds to 1200 Euros per European-size unit.

In order to detect the spatial pattern (spatial association and spatial autocorrelation) of the average olive grove area, some standard global spatial statistics have been calculated: Morans I, Gearys C (Cliff and Ord, 1981), G statistics (Ord and Getis, 1995). The Moran's I -if it is standardized- is analogous to the conventional correlation coefficient, and its values range from 1 (strong positive spatial autocorrelation) to -1 (strong negative spatial autocorrelation). Geary's C ranges between 0 and 2. Positive spatial autocorrelation is found with values ranging from 0 to 1 and negative spatial autocorrelation is found between 1 and 2. Finally, G statistic is an index of spatial clustering of a set of observations over a defined neighborhood. Above indexes have been calculated on own sample and they evidence a positive spatial correlation of the average olive grove area and indicate the possibility of clusters of high values of the study variable (see Table 1).

Index	*Value*	*p value*
Moran	0.30	0.0019
Geary	0.89	0.0978
G statistic	9.03	0.0001

Table 1: Value of Moran's, Gearys C and G statistics.

Hence, the Spatial EBLUP method is implemented to this data to estimate the average of olive grove area in each of the 287 small area within the study region using a SAR spatial model. The neighborhood structure $\mathbf{W}$ is defined as follows: spatial weight, w_{ij}, is 1 if area i shares an edge with area j and 0 otherwise. Sampling variances, ψ_i are estimated smoothing the sampling error associated to the population level estimator (Rao, 1998). The estimated variance $\hat{\psi}_i$ is then treated as a proxy to ψ_i. As result the $mse[\tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho}, \hat{\psi}_i)]$ is greater than $mse[\tilde{\theta}_i^S(\hat{\sigma}_u^2, \hat{\rho}, \psi_i)]$.

The value of the estimated spatial autoregressive coefficient $\hat{\rho}$ is 0.154 ($s.e.$ = 0.0036) with ML procedure and 0.155 ($s.e.$ = 0.0039) with REML method, which suggests a positive spatial relationship. Figure 1 displays the map of the Tuscany with the Spatial EBLUP estimates for the average olive grove area. Table 2 shows the value of estimated parameters and their standard error for each of the estimation methods described in Section 2: ML stands for maximum likelihood procedure, while R refers to restricted maximum likelihood procedure.

Estimator	$\hat{\sigma}_u^2$	$\hat{\rho}_s$
$\tilde{\theta}^S(\hat{\sigma}^2_{u_{ML}}, \hat{\rho}_{ML})$	864.85 (325.21)	0.154 (0.0036)
$\tilde{\theta}^S(\hat{\sigma}^2_{u_R}, \hat{\rho}_R)$	951.21 (357.24)	0.155 (0.0039)

Table 2: Value of estimated parameters and their standard error.

The proposed small area estimator (9) is compared with the EBLUP estimator on the basis of the Average Relative Errors (ARE) index in Table 3:

$$ARE = \frac{1}{m} \sum_{i=1}^{m} \frac{(|\hat{\theta}_i - \theta_i|)}{\theta_i} \quad with\ i = 1...m. \tag{13}$$

Estimator	*ARE*
$\tilde{\theta}^S(\hat{\sigma}^2_{u_{ML}}, \hat{\rho}_{ML})$	9.55
$\tilde{\theta}(\hat{\sigma}^2_{u_{ML}})$	12.18
$\tilde{\theta}^S(\hat{\sigma}^2_{u_R}, \hat{\rho}_R)$	9.39
$\tilde{\theta}(\hat{\sigma}^2_{u_R})$	11.98

Table 3: ARE of EBLUP and Spatial EBLUP estimators.

The ARE value of Spatial EBLUP is lower than that of the traditional EBLUP: in average $\tilde{\boldsymbol{\theta}}^S$ is closer to $\boldsymbol{\theta}$ than $\tilde{\boldsymbol{\theta}}$, the reduction in ARE is about 22% with ML and $REML$ procedure.

In Table 4 the average of the estimated standard errors of EBLUP and Spatial EBLUP estimators are reported: the $A.E.se.$ is the average of the square root of the mse for each of 287 areas. Table 4 shows also the average of the estimated mse and its decomposition in g_1, due to the random effects, g_2, which accounts for the variability in the estimator $\hat{\boldsymbol{\beta}}$, g_3 due to the estimation of ρ and σ_u^2.

The Spatial EBLUP estimator provides less variable estimates in comparison with traditional EBLUP: in average, the reduction in se is about 28% and in mse is about 48% both in ML and

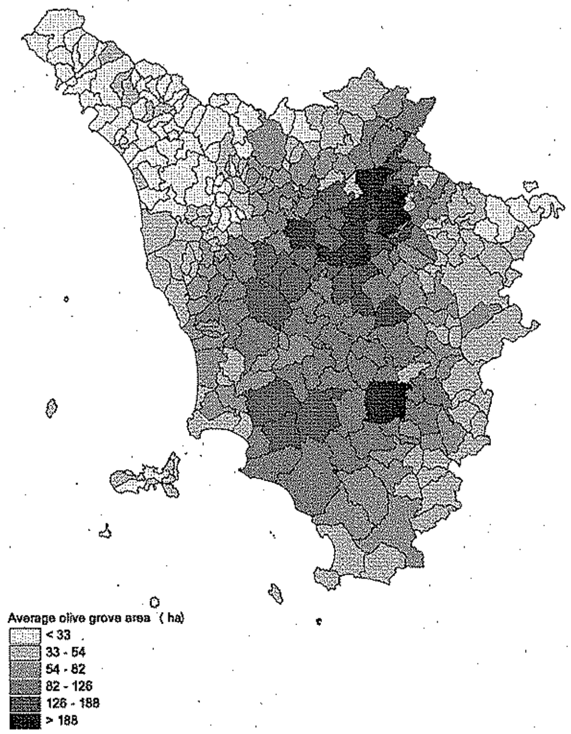

Figure 1: The average olive grove area estimated by REML method for the 287 Communes Tuscany.

Estimator	***A.E.se.***	***A.E.mse***	***A.E.*(g$_1$)**	***A.E.*(g$_2$)**	***A.E.*(g$_3$)**
$\tilde{\theta}^S(\hat{\sigma}^2_{u_{ML}}, \hat{\rho}_{ML})$	30.38	992.75	952.75	25.42	7.23
$\tilde{\theta}(\hat{\sigma}^2_{u_{ML}})$	42.11	1932.63	1880.93	27.42	12.04
$\tilde{\theta}^S(\hat{\sigma}^2_{u_R}, \hat{\rho}_R)$	31.36	1058.39	1016.68	25.68	8.02
$\tilde{\theta}(\hat{\sigma}^2_{u_R})$	43.29	2044.77	1973.94	27.45	21.69

Table 4: Average of the Estimated Standard Errors (*A.E.se.*) and Average of the Estimated *mse* of EBLUP and Spatial EBLUP estimators.

REML procedure. Also for Spatial EBLUP the variability due to estimation of random effects g_1 is the more relevant component of *A.E.mse*, it represents more than the 95% of the whole *mse* for each estimator of Table 4. Inserting the spatial information, the component g_1 reduces its value more than g_2 and g_3 components.

In order to compare the obtained results with the results given by direct estimation we have limited the application of $\tilde{\boldsymbol{\theta}}^S$ and $\tilde{\boldsymbol{\theta}}$ to the 263 sampled communes. The direct estimates of the average olive grove area in each commune is the sample mean in the commune. The sampling variability of the direct estimator at the small area level is approximated smoothing the sampling error associated to the population level estimator. The comparison seems to confirm the good performance of $\tilde{\boldsymbol{\theta}}^S$ (Table 5). The average of the estimated standard errors and mean squared errors significantly decreases to more than an half of the average of the analogous errors in case of direct estimation: the average of the estimated standard errors (A.E. se) for direct estimation is 104.76 versus 32.57 and 33.81 for Spatial EBLUP (respectively, ML and Restricted ML procedure).

Inferences from model based estimators refer to the distribution implied by the assumed model. Model selection and validation play an important role in model based estimation, in fact if the assumed models do not perform a good fit to the data, the estimators will be model biased and

Estimator	***A.E.se.***	***A.E.mse***	***A.E.*(g$_1$)**	***A.E.*(g$_2$)**	***A.E.*(g$_3$)**
$\tilde{\theta}^S(\hat{\sigma}^2_{u_{ML}}, \hat{\rho}_{ML})$	32.75	1081.56	1037.91	27.74	7.89
$\tilde{\theta}(\hat{\sigma}^2_{u_{ML}})$	45.55	2107.20	2050.77	29.93	13.13
$\tilde{\theta}^S(\hat{\sigma}^2_{u_R}, \hat{\rho}_R)$	33.81	1153.19	1107.67	28.02	8.74
$\tilde{\theta}(\hat{\sigma}^2_{u_R})$	46.83	2229.56	2152.27	29.95	23.66
DIRECT	104.76	50705.76	–	–	–

Table 5: Average of the Estimated Standard Errors (*A.E.se.*) and Average of the Estimated *mse* of EBLUP and Spatial EBLUP estimators for sample communes.

can lead to wrong inferences.

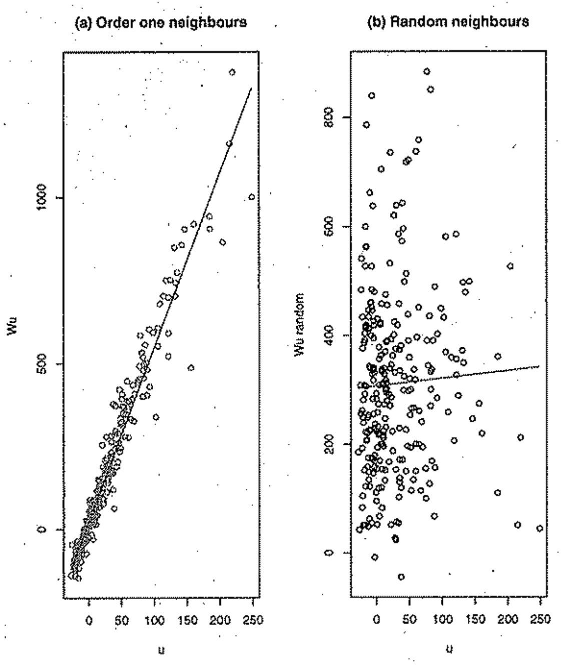

Figure 2: The estimated random effects $\hat{\mathbf{v}}$ against an average of estimated random effects for nearest neighbors $\mathbf{W}\hat{\mathbf{v}}$ (a) and an average of "randomly chosen neighbors" (b).

An evaluation of the resulting model is performed by a simple exploratory device: the plot of estimated random effects $\hat{\mathbf{v}}$ against $\mathbf{W}\hat{\mathbf{v}}$ that corresponds to an average of estimated random effects for nearest neighbors(Figure 2a). It is interesting to contrast this plot with an equivalent one (Figure 2b) when $\mathbf{W}\hat{\mathbf{v}}$ is defined as an average of "randomly chosen neighbors" (rather that near neighbors). If there is no spatial correlation in the area effects, then one would expect that the slope of a least squares line fitted to the data would not be significantly different from zero. This is the case of the plot in Figure 2b: the comparison between plot (a) and (b) suggests that there is spatial correlation.

For the study a new programme, running under the *R* environment, was implemented to estimate the parameters (σ^2_u, ρ) and to calculate the Spatial EBLUP and the EBLUP estimators.

In conclusion, considering the case study, the Spatial EBLUP methodology, which takes into account the SAR spatial model in the small area estimation, suggests a reduction of the width of the confidence interval.

References

ANSELIN, L. (1992): *Spatial Econometrics: Method and Models.* Kluwer Academic Publishers, Boston.

BENEDETTI, R., ESPA, G., PIERSIMONI, F. (2004): Esperienze di Stime provinciali indirette di variabili aziendali. *Contributo al Convegno ISPA 2004*, Università di Cassino.

CRESSIE, N. (1993): *Statistics for Spatial Data.* Jhon Wiley & Sons, New York.

JIANG, J. (1996): REML Estimation: Asymptotic Behavior and Related Topics. *Annals of Statistics, 24*, 255–286.

KACKAR, R.N., HARVILLE, D.A. (1984): Approximations for standard errors of estimators for fixed and random effects in mixed models. *Journal of the American Statistical Association, 79*, 853–862.

NELDER, J.A., MEAD, R. (1965): A simplex method for function minimization. *Computer Journal, 7*, 308–313.

ORD, K., GETIS, A. (1995) Local spatial autocorrelation statistics: distributional issues and application. *Geographical Analysis, 27, 3*, 286–296.

PRASAD, N., RAO, J.N.K. (1990): The Estimation of the Mean Squared Error of Small-Area Estimators. *Journal of the American Statistical Association, 85, 409*, 163–171.

RAO, J.N.K. (1998): Small Area Estimation. *Encyclopedia of Statistical Sciences, 2*, 621–628.

RAO, J.N.K. (2003): *Small Area Estimation.* Wiley , London.

SALVATI, N. (2004): *La correlazione spaziale nella stima per piccole aree: metodi proposti e casi di studio.* Tesi di Dottorato in Statistica Applicata, Dipartimento di Statistica “G. Parenti”, Università degli Studi di Firenze.

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