Analyzing Sectorial and regional Heterogeneity Effects in Agricultural Efficiency: A Mixed Model Approach

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Introduction and Objective:

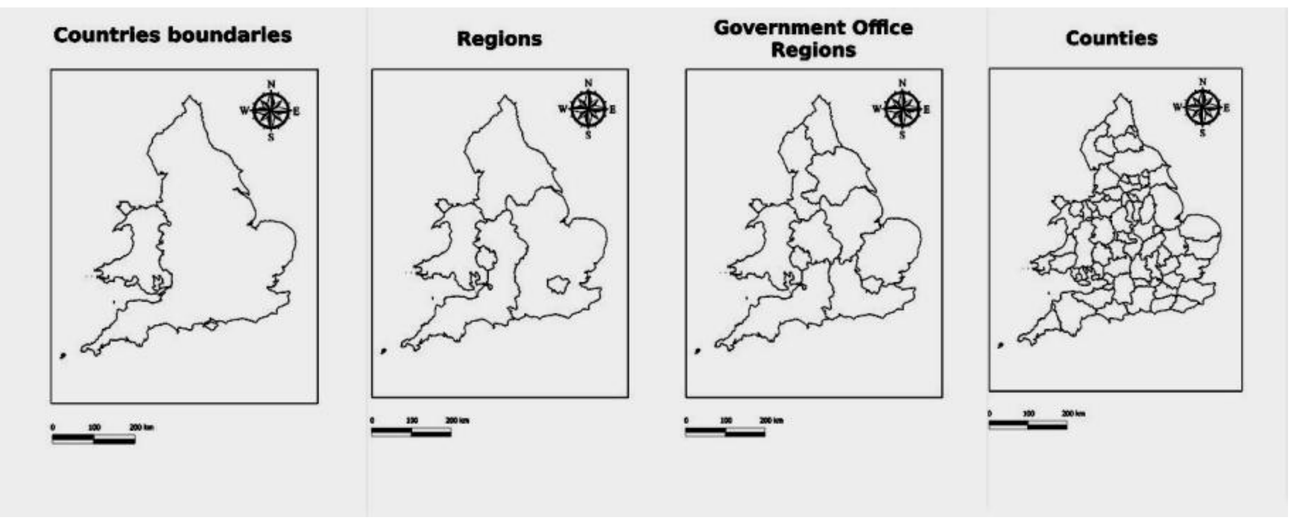
• Standard parametric estimation of efficiency (SFA) often ignores unobserved heterogeneity in farm data.
• One approach to model heterogeneity builds on mixed models (Gori et al; 2002), using the hierarchical structure at the geographical level.
• Our goal is to compare mixed model and standard approaches for efficiency estimation using UK farm level data.

Why Mixed Models?

Hierarchical data might be correlated inside each group. In mixed models, such correlation is not only expected but also explicitly modeled. This allows characteristics of the group to be incorporated into models of individual behavior, while also producing correct estimates of the standard errors (Patterson and Goldstein 1991).

Data and Geographical Hierarchy:

Data were taken from the Farm Business Survey (FBS) done by the DEFRA; this survey is done annually in around 3000 farms in England and the Wales. The period of study is 2003 – 2007. The data is located geographically as follows:



Estimated Model:

$$\ln y_{ijk} = \beta_0 + \sum_{l=1}^{n} \beta_{ijkl} \ln x_{ijkl} + u_{0j} + u_{0k} + \sum_{j=1}^{m} u_j \ln x_{ijl} + \sum_{k=1}^{r} u_k \ln x_{ikl} + e_{ijk}$$

Fixed effects | Random effects

i=farm level
j= County level
k=Government office level
l= Production factor

u **'s** and ***e*** are normally distributed with mean zero and its respective variance.

In this case u_{0j} and u_{0k}, the random intercepts, can be transformed with the same technique used in COLS to calculate efficiencies at the different geographical levels:

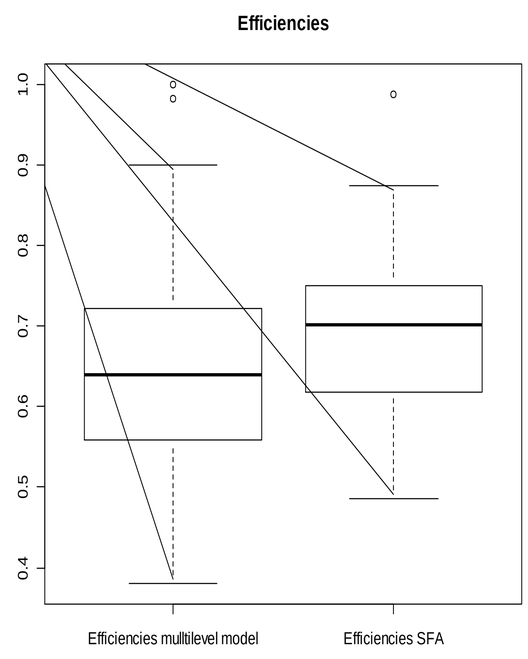
$$Eff_j = \exp(u_{0j} - \max(u_{0j})) \;, Eff_k = \exp(u_{0k} - \max(u_{0k}))$$

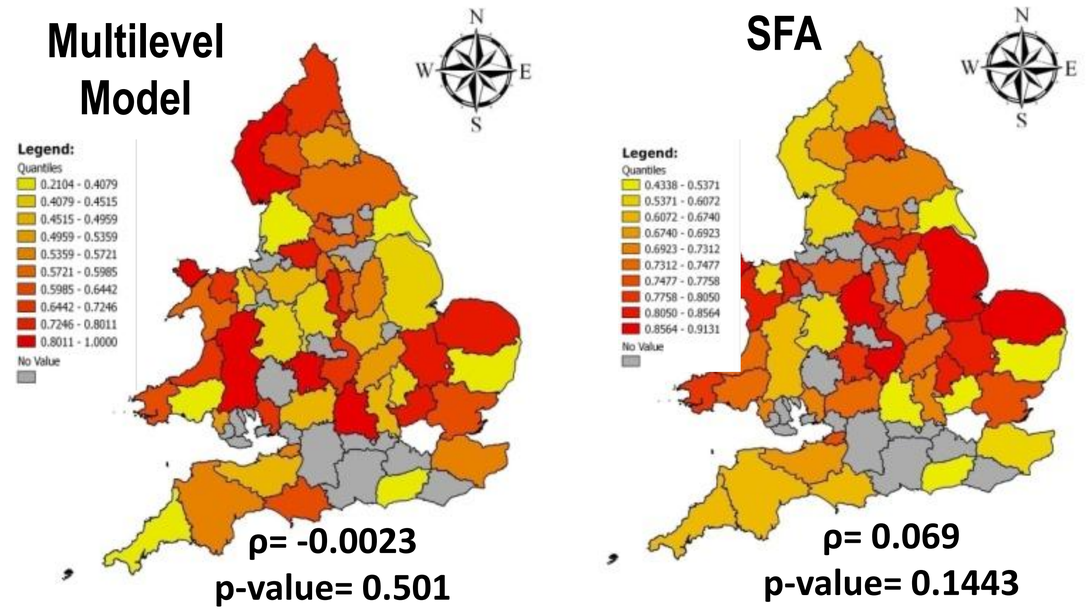
Models were chosen based on the likelihood ratio. In all cases the chosen model was the one with random intercepts and elasticities at the **county level**.

Preliminary results:

Dairy

INPUT	MULTILEVEL MODEL		SFA
	Coefficient	Variance	Coefficient
INTERCEPT	-0.041	0.053	0.378 ***
	(0.039)		(0.030)
LAND	0.123 ***	0.010	0.081 ***
	(0.024)		(0.019)
LABOR	0.166 ***	0.028	0.246 ***
	(0.037)		(0.027)
LIVESTOCK COST	0.648 ***	0.026	0.588 ***
	(0.032)		(0.022)
OTHER COSTS	0.045	0.006	0.046 *
	(0.024)		(0.021)
CAPITAL	0.047 **	0.002	-0.002
	(0.017)		(0.013)
Residual		0.026	
Log-Likelihood	240.700		426.082
Sigma			0.223 ***
			(0.029)
Gamma			0.950 ***
			(0.008)
Mean Efficiency	0.649		0.688
Observations	921		921





Discussion:

Efficiency estimates with both techniques are in general different, at the county level. Almost all the same elasticities are significant in both techniques, but magnitudes are significantly different. In bigger samples and with more number of classifications per level estimations tend to be more alike. Furthermore, counties with more farms tend to have more similar efficiency estimations. Models with less random effects, are even more similar to SFA estimation (random intercept model.)

References:

Gori E., Grassetti L.,and Rossi C. (2002) Linear Mixed Models in Efficiency analysis: Evidence from Validation Procedures, *Statistica Applicata*, 14.
Salvatore R., Technical Efficiency Estimators in Linear Mixed Effects Sthochastic Frontier Models.
Patterson L. and Goldstein H., New Statistical Methods for Analyzing Social Structures: An Introduction to Multilevel Models (1991), *British Educational Research Journal., 17*

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