Extended abstract for Contributed Paper session

Paper Title	**Specialization vs Diversification: An Application of the Dual Measure of Economies of Scope**

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Abstract	***200 words max***

This study estimates an input-oriented stochastic distance function (IDF) to evaluate diversification economies on dairy farms in Southern Germany in a Bayesian framework. Structural change in agriculture often comes along with a trend towards specialization as it allows farms to capture economies of scale and thus reduce costs. However, a considerable number of farms still produce multiple outputs, which can be explained by economies of scope, i.e. cost savings through joint production. We empirically estimate economies of scope between different farm outputs for a panel data set covering the years 2006 - 2014. The results show that for the average farm in this sample, economies of scope exist between milk and livestock production and between livestock and crop production. From a policy perspective, we recommend to not only support diversification beyond agricultural production but also within.

Keywords	Agricultural Management, Bayesian Estimation, Economies of Scope, Farm Diversification, Input Distance Function
JEL Code	Agriculture: Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets Q12

Introduction	***100 – 250 words***

The optimal production structure of firms in terms of size and degree of specialization has been questioned for decades. Especially in agriculture, a significant structural change has been observed in recent years. While the number of farms in the EU-18 decreased by 25 per cent from 14.5 Mio in 2005 to 10.8 Mio in 2013, the average farm size increased by 31 per cent from 21.4 to 28.1 hectares (Eurostat, 2016). This trend towards larger but fewer farms is often critically seen by society and politics. In order to slow down the structural change and to support rural development, the European Union promotes farm activities that go beyond agricultural production such as energy production, farm tourism, or direct marketing. However, the concept of diversification is not limited to activities that take place outside agricultural production. Barbieri and Mahoney (2009) provide an overview of various definitions of farm diversification that are commonly used in the literature. Since our primary interest is in structural change in agriculture, which is defined by the number of farms and the average farm size expressed in utilized agricultural area, we put our focus on farm diversification within agricultural production, for example the joint production of livestock products and cash crops. We use a sample of specialized dairy farms in Bavaria, a federal state in

Southern Germany, and group the outputs into milk, other livestock products, crops sales, and other outputs such as electricity production, farm tourism, or contract services.

Methodology	100 – 250 words

Introduced by Baumol (1977), Baumol et al. (1982), and Willig (1979), economies of scope exist when less costs occur for a multi-output firm than for multiple firms producing the same amount of output separately, i.e. $C(\sum y_i; p) < \sum C(y_i; p)$ where C denotes costs, y_i the i-th output, and p is a vector of input prices. A sufficient condition for the presence of economies of scope is given by

$$\frac{\partial C(y,p)}{\partial y_m y_n} < 0, m \neq n\ . \tag{1}$$

However, estimating a cost function is problematic if input price data are not accessible (e.g. the price of capital) or lack variation across firms. Therefore, we apply the dual measure of economies of scope proposed by Hajargasht et al. (2008). This approach is based on an input distance function (IDF) which is dual to the cost function. The IDF describes the degree to which a farm can contract its input vector without changing its output vector:

$$D^I\ (x, y) = max\ \left\{\lambda: \frac{x}{\lambda}\ \epsilon\ L(y)\right\}, \tag{2}$$

where $L(y)$ is the feasible input set of y. We specify the IDF in a transcendental logarithmic form as $\ln D^i_{it}(x, y, t) = TL(x, y, t)$, which we normalize by one of the inputs to make it empirically estimable following Lovell et al. (1994). The matrix of second order derivatives of the dual cost function in terms of distance derivatives is given by

$$\frac{C_{yy}}{\mathrm{C}} = D_y D'_y - D_{yy} + D_{yx}[D_{xx} + D_x * D'_x]^{-1} D_{xy}, \tag{3}$$

where D_x is a vector of first derivatives and D_{xy}, D_{xx}, and D_{yy} are matrices of second-order derivatives. The resulting matrix holds the scope economies between product m and n defined in (1) in the (m, n)-th element.

Results	100 – 250 words

The distance function was estimated in a Bayesian framework that closely follows the set up described in Koop (2010, pp. 168–172). The main advantage compared to frequentist statistics is that statistical inference on the scope measures can be made by the computation of credibility intervals, while derivation of standard errors for this complex nonlinear function of parameters in frequentist statistics is not straightforward.

Prior to estimation, all variables were divided by their means so that the first-order coefficients of the distance function can be interpreted as elasticities at the sample mean. Table 1 shows the means of the posterior distribution of the distance function parameters. The monotonicity requirements are fulfilled at the sample mean and at most observations in the data set. However, the Hessian matrices of outputs and inputs showed that most observations fail the curvature conditions.

Table 1. Estimated parameters and 95 % credibility intervals of the IDF

Variable	Posterior Mean	95 % CrI	
Milk output	- 0.329	- 0.341;	- 0.317
Livestock output	- 0.034	- 0.040;	- 0.027
Crop output	- 0.027	- 0.030;	- 0.024
Other output	- 0.006	- 0.008;	- 0.004
Land	0.397	0.383;	0.411
Intermediate inputs	0.311	0.299;	0.323
Labor	0.261	0.250;	0.271
Capital	0.031	0.025;	0.037

Next, we used the obtained parameters to estimate economies of scope for the average firm in the sample for all output pairs using Equation (3), which are presented in Table 2. The results show strong evidence of scope economies between milk and livestock products as well as livestock products and crops. Diseconomies of scope ($C_{y_{mn}} > 0$) are likely to exist between milk and crop production and between crops and other outputs. The probability of $C_{y_{mn}} < 0$ was calculated based on the probability density functions of the resulting scope measures.

Table 2. Estimated economies of scope

	Economies of Scope	$P(C_{y_{mn}} < 0)$
Milk-livestock	- 0.084	89.19 %
Milk-crops	0.014	9.09 %
Milk-other	0.010	50.56 %
Livestock-crops	- 0.003	100.00 %
Livestock-other	- 0.002	71.75 %
Crops-other	0.001	3.27 %

Discussion and Conclusion

100 – 250 words

In this study, we found economies of scope between milk production and livestock outputs and between livestock outputs and crops in a representative sample of Bavarian dairy farms. This is in line with the fact that a significant portion of Bavarian farms are grazing livestock farms (49.8 %) that combine dairy and livestock production or mixed crop-livestock farms (9.7 %) (BStMELF, 2014). Other output, which is mainly trade and provision of services, does not show scope economies with any other output. This is not surprising as these activities are less related to the production of primary agricultural outputs but are still operated as additional income sources. Overall, the results show that costs can be saved by diversification, and therefore policy should not only support farm diversification outside agricultural production but also within.

Finally, it must be noted that the results have to be carefully interpreted as the estimated input distance function fails to fulfil the curvature conditions as required by economic theory. Sauer (2006) emphasizes the importance of such. The Bayesian approach applied in this study allows to impose curvature by combining the posterior probability density function with a likelihood function that takes the value zero if the candidate draw does not satisfy the regularity conditions, as shown in O’Donnell and Coelli (2005).

References

Barbieri, C., & Mahoney, E. (2009). Why is diversification an attractive farm adjustment strategy?: Insights from Texas farmers and ranchers. *Journal of Rural Studies*, *25*(1), 58–66.

Baumol, W. J. (1977). On the proper cost tests for natural monopoly in a multiproduct industry. *The American economic review*, *67*(5), 809–822.

Baumol, W. J., Panzar, J. C., & Willig, R. D. (1982). *Contestable markets and the theory of industry structure*. New York, NY: Harcourt Brace Jovanovich.

BStMELF (Ed.). (2014). *Bayerischer Agrarbericht*. Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten.

Eurostat. (2016). *Statistical Database*. Statistical Office of the European Communities. Luxembourg.

Hajargasht, G., Coelli, T., & Rao, D. S. P. (2008). A dual measure of economies of scope. *Economics Letters*, *100*(2), 185–188.

Koop, G. (2010). *Bayesian econometrics*. Chichester: Wiley.

Lovell, C. A. K., Travers, P., Richardson, S., & Wood, L. (1994). Resources and Functionings: A New View of Inequality in Australia. In W. Eichhorn (Ed.), *Models and Measurement of Welfare and Inequality* (pp. 787–807). Berlin, Heidelberg: Springer Berlin Heidelberg.

O'Donnell, C. J., & Coelli, T. J. (2005). A Bayesian approach to imposing curvature on distance functions. *Journal of Econometrics*, *126*(2), 493–523.

Sauer, J. (2006). Economic Theory and Econometric Practice: Parametric Efficiency Analysis. *Empirical Economics*, *31*(4), 1061–1087.

Willig, R. D. (1979). Multiproduct technology and market structure. *The American economic review*, *69*(2), 346–351.