Do Theoretical Restrictions Matter for the Translog Stochastic Production Function? Evidence from the Kansas Farm Sector

Amin W. Mugera\(^1\), Michael R. Langemeier\(^2\), and Allen M. Featherstone\(^2\)

\(^1\)Contact Author, School of Agriculture and Resource Economics (M089), The University of Western Australia, 35 Stirling Highway, Crawley, Western Australia, 6009. Phone: 61-8-6488-3427, Fax: 61-8-6488-1098, Email: mugeraam@cyllene.uwa.edu.au.

\(^2\)Department of Agricultural Economics, 342 Waters Hall, Kansas State University, Manhattan, Kansas 66506.

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Amin W. Mugera1, Michael R. Langemeier2, and Allen M. Featherstone3
1University of Western Australia, Crawley, Western Australia; 2Kansas State University, Manhattan, Kansas

Introduction:
Microeconomic theory suggests that production functions should be monotonically increasing in all inputs. A reasonable interpretation of the relative technical efficiencies of firms is impossible if the efficiencies are estimated from a stochastic production frontier (SPF) that violates the monotonicity assumption. However, many empirical applications of the SPF to the farm sector often present results in which the monotonicity condition is not fulfilled.

Objective:

- To assess the importance of imposing monotonicity in the estimation of a translog stochastic production frontier.
- We accomplish this by comparing the mean technical efficiency scores, partial input elasticities, and in-sample and out-of-sample predictions of the unrestricted and restricted translog stochastic production frontiers for the Kansas farm sector.

Methods: Three-Step Estimation
1. Estimate Unrestricted Frontier
   \( \ln y = \ln f(\beta, x) = \beta_1 x_1 + \cdots + \beta_n x_n + \epsilon \)
   - unrestricted \( \beta \) parameters
   - their covariance matrix \( \Sigma \)

2. Minimum Distance Estimation
   \( \hat{\beta} = \text{argmin} \{ \beta - \beta_0 - \sum_{i} \beta_i \} \)
   s.t. \( MP_i \geq 0 \forall i \)

3. Final Frontier Estimation
   Calculate frontier output of each firm and estimate frontier
   \( y^* = f(\hat{x}, \hat{\beta}) \)
   \( \ln y^* = \ln \hat{f}_1 + \cdots + \ln \hat{f}_n + \epsilon^* \)

Data
- 1 output (gross farm income) and 3 inputs (capital, labour and purchased inputs) for 584 farms for the period 1993 to 2007. All variables are measured in real dollar values with year 2007 as the base year
- 2 variables are used to explain inefficiency (farm size and specialization)

The Empirical Translog SPF Model
\[ \ln y = \ln f(\beta, x) = \beta_1 x_1 + \cdots + \beta_n x_n + \frac{1}{2} \sum_{i} \beta_{ij} x_i x_j + \epsilon \]
with \( \beta_{ij} = \beta_{ji} \)

Empirical Results:
Table 1. Unrestricted Stochastic Frontier Estimation

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<thead>
<tr>
<th>( \hat{\beta} )</th>
<th>Stat.</th>
<th>T-Value</th>
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<tbody>
<tr>
<td>0.022</td>
<td>0.175</td>
<td>1.044</td>
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<td>0.004</td>
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The production function is monotonically increasing at 5403 out of 7579 observations (71.3%). It is quasiconcave at 4779 out of 7579 observations (63.1%).

Note: K is capital, L is labor, P is purchased inputs and T is time. Dummies for farm size categories and specializations are: Ds for very small farms, Dm for small farms and Dn for medium sized farms. St is for livestock farms and Sm is for farms with both livestock and crops.

Summary & Conclusion:
On average, technical efficiency scores for the unrestricted model (0.534) are slightly higher than those from the restricted model (0.528).
Imposing monotonicity decreased the partial elasticities of purchased inputs from 0.350 to 0.348 and capital from 0.232 to 0.230. The partial elasticity of labor increased from 0.099 to 0.102.
The restricted model outperforms the unrestricted model both in-sample and out of sample predictions.

Theoretical restrictions do matter in the estimation of empirical stochastic production functions. Failure to take care of those regulatory conditions may result in improper policy recommendations.

References: