GEOBENE

Evaluating the efficiencies of crop production systems in the EU within an Integrated Data Envelope Framework

C. Heumesser [a], E. Schmid [a], R. Skalsky [b]

[a] Institute for Sustainable Economic Development, University of Natural Resources and Applied Life Sciences (BOKU)

[b] Výskumný ústav pôdoznalectva a ochrany pôdy (Soil Science and Conservation Research institute)

Data Envelopment Analysis (DEA)

- Aim at providing a single efficiency measure for alternative crop production choices in the EU.

- Data driven frontier analysis technique to estimate relative efficiencies of comparable units by linear programming models.

- DEA estimates relative efficiencies: A production unit is rated fully efficient on the basis of available evidence iff the performance of other units does not show that some of its inputs/outputs can be improved without worsening some of its inputs/outputs.

- 3 Efficiency concepts (technical, allocative, scale efficiency)

Data Envelopment Analysis

Model by Chung, Färe, Grosskopf (1997)

$$\max \beta$$

$$\text{s.t.} \quad \sum_{k=1}^{K} z_k y_{km} \geqq y_{k'm} + \beta g_{y_m}, \quad m = 1, \ldots, M,$$

$$\sum_{k=1}^{K} z_k u_{kj} = u_{k'j} - \beta g_{u_j}, \quad j = 1, \ldots, J, \quad (3)$$

$$\sum_{k=1}^{K} z_k x_{kn} \leqq x_{k'n}, \quad n = 1, \ldots, N,$$

$$z_k \geqq 0, \quad k = 1, \ldots, K.$$

production units k= 1,….K

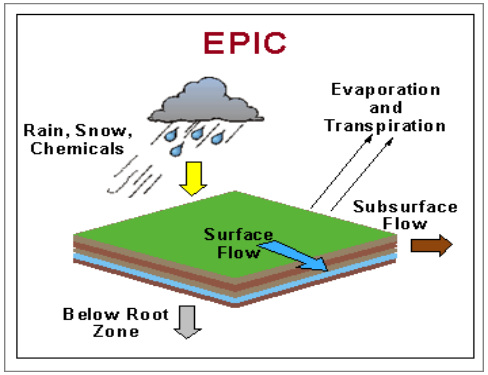
y… positive Outputs m = 1,…,M
u…negative Outputs j = 1,….,J
x… Inputs n = 1,…,N

β… efficiency value for unit k‘
g (y_k, u_k)… direction vector
z… 1xK vector of constants

Data Specification

Biophysical process simulation model EPIC (Environment Policy Integrated Climate)

(i) Land cover/land use
(ii) Topography and soil data
(iii) Cropland management data
(iv) Climate data



Outputs on:

crop yields, soil organic carbon, nitrate emissions, soil sediment losses, etc.

Used to **compare management systems** and their effects on crop yields, water flow, nitrogen emissions, soil organic carbon, etc.

Data Specification for EU Case Study Analysis

1084 Homogenous Response Units

1. Elevation
2. Slope
3. Stoniness
4. Depth to rocks
5. Soil texture (Coarse, Medium, Medium Fine, Fine, Very Fine, Peat)

Crop Rotation Systems by HRU and NUTS2 region

Data Specification for EU Case Study Analysis

6 Management systems:

1. Conventional tillage (~ 5% of crop residue after crop planting)
2. Reduced tillage (~15% of crop residue)
3. Minimum tillage (~40% of crop residue)

all tillage systems **with** and **without** straw removal

DEA Model

Inputs: Nitrogen fertilizer, Phosphorus fertilizer, Irrigation

Positive Outputs: Crop yield, Soil organic carbon

Negative Outputs: Nitrate Emission, Soil sediment loss

Leading Research Questions

1. Which HRUs, given their respective crop rotation system, are rated technical efficient compared to other HRUs? *(horizontal analysis)*

2. Which production choice (tillage system with or without straw removal) is most efficient in Europe? *(horizontal analysis)*

3. Taking the various soil types into account: which management system scores best on which soil type? *(horizontal analysis)*

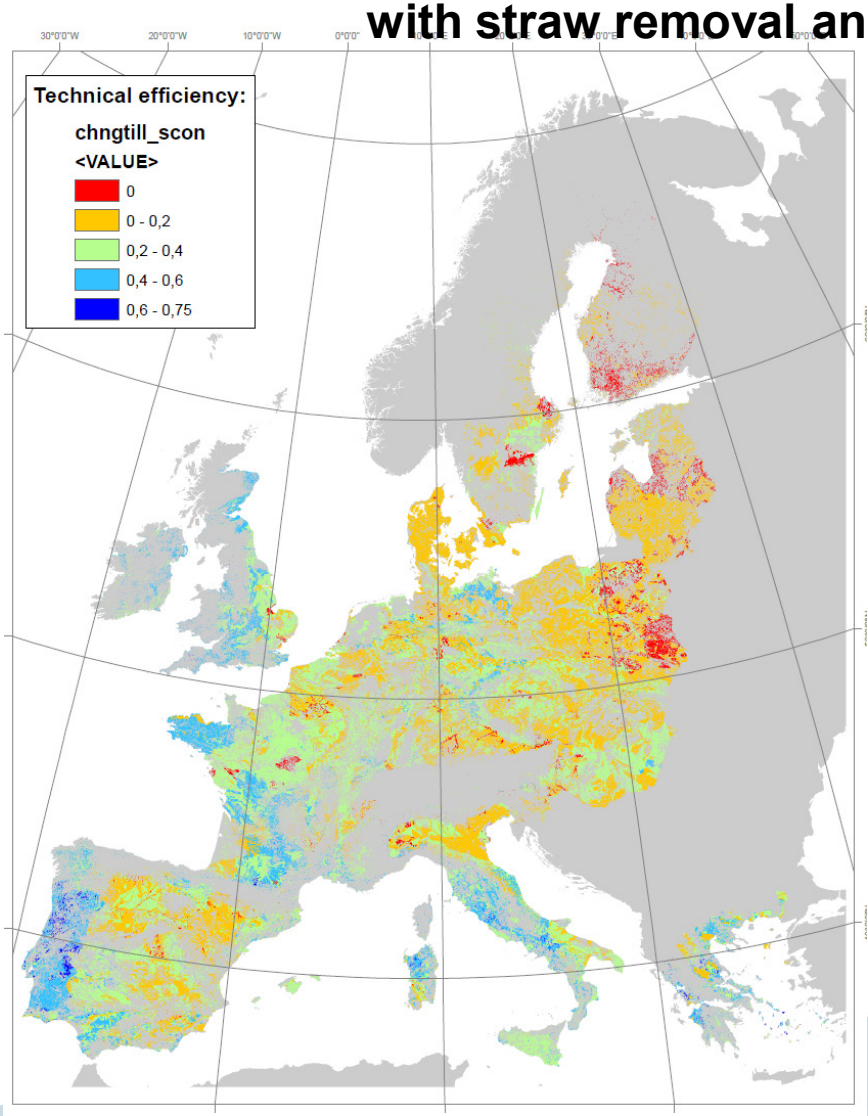
Results of EU Case Study Analysis

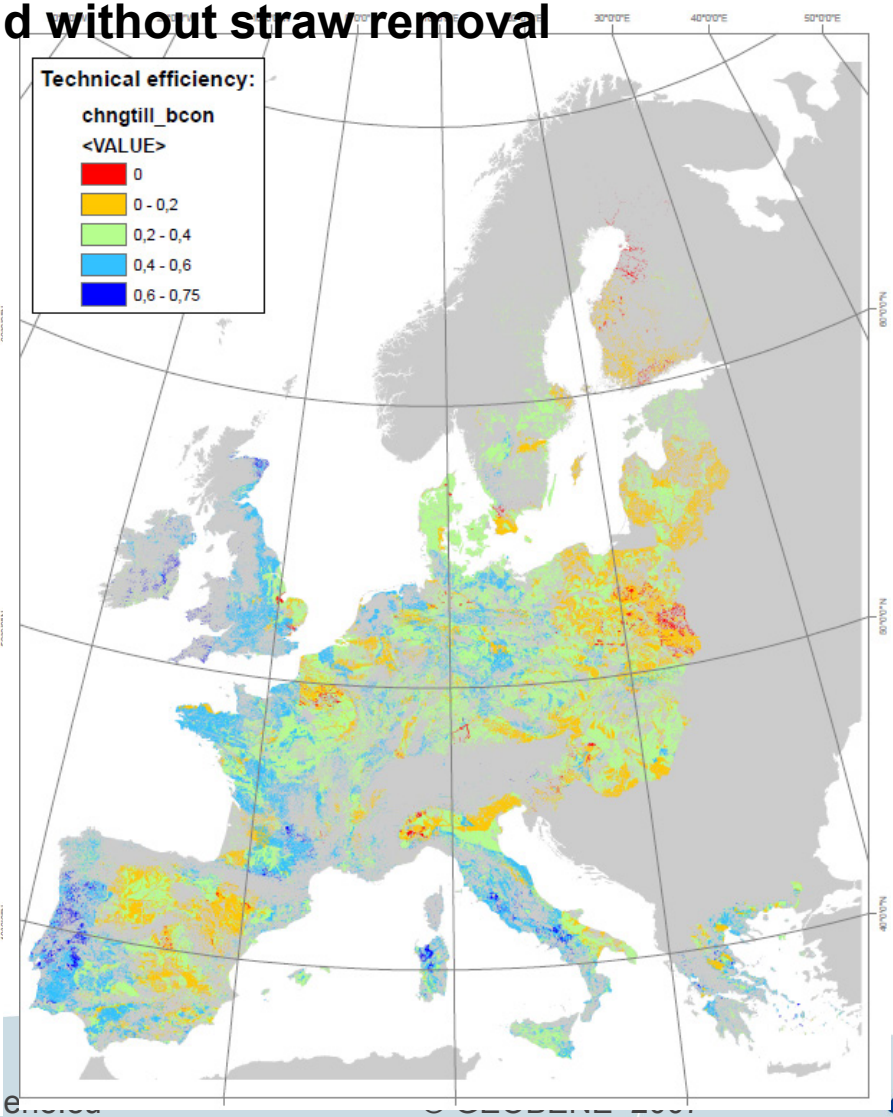
Which production choice (tillage system with or without straw removal) is most efficient in Europe? *(horizontal analysis)*

- Management systems **with straw removal** generally yield more TE units than management systems **without straw removal**.

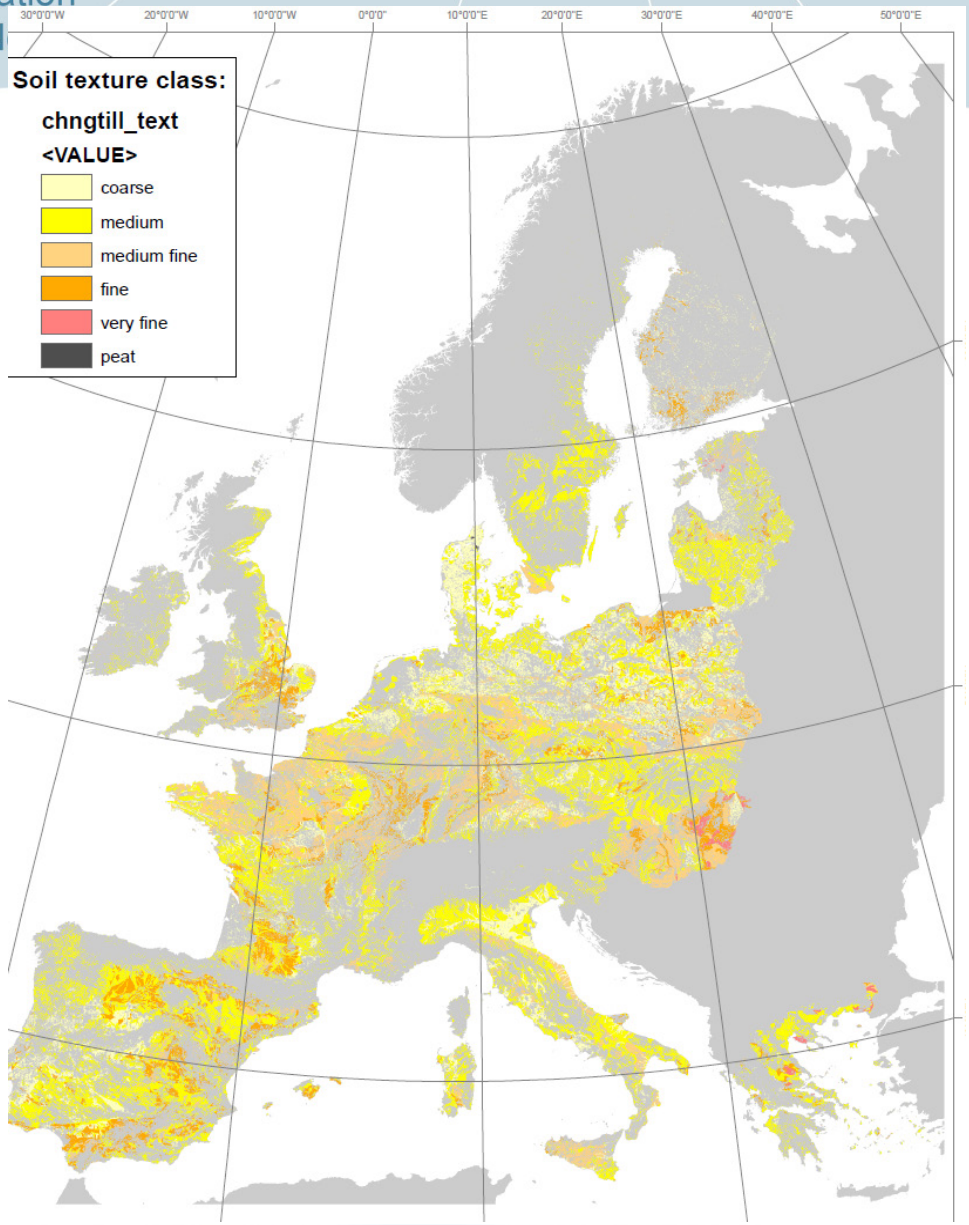
- Management systems **with Straw removal** generally yield less inefficient units (which can improve between 60-75%) than management systems **without straw removal**.

EU Case Study Efficiency Analysis of conventional tillage system with straw removal and without straw removal

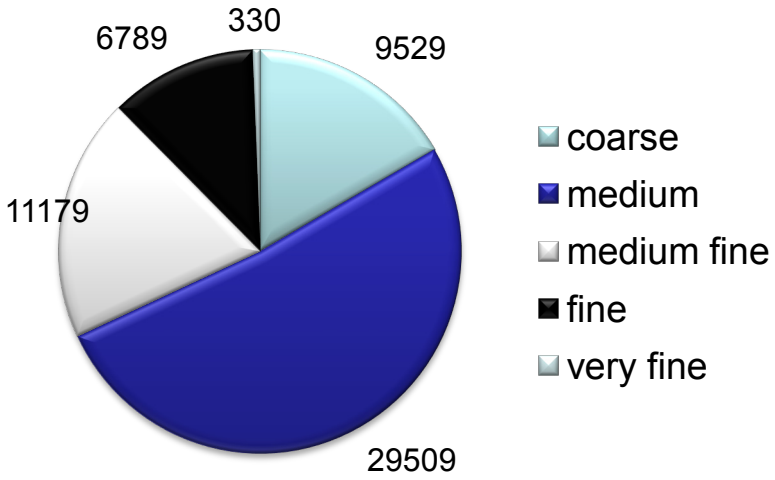




Results

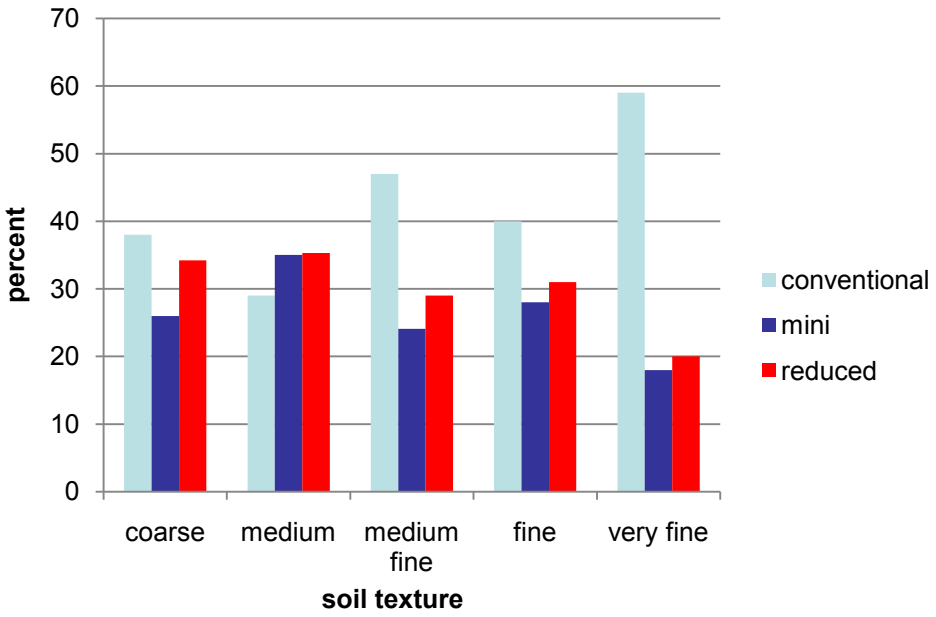


Distribution of soil texture classes



Results

Taking the various soil types into account: which management system is rated technically efficient for which soil type? *(horizontal analysis)*



Conventional tillage for coarse, medium fine, fine, very fine

Reduced tillage for medium

- Ranking of efficient crop management systems given their environmental impact which can be important for agricultural policy making.

- Assessment of crop management systems is more comprehensive when environmental impacts are included.

Outlook

- Specify efficiency ranking for specific crops
- Include allocative efficiency
- Estimate yield potential

christine.heumesser@boku.ac.at