Linking environmental models and economic tools for trade-off analysis – A German case study

Zehetmeier, M., Reindl, A., Karger, V., Strobl, M., Müller, U.K., Dorfner, G., Kapfer, M.
„IDB-Calculator“ - Bio-Economic Decision Support Tool

Basic information on the production process

Breed: Simmental
Replacement rate: 30.0 %
Calving interval: 393.0
Stock supplement via:
First calving in own stock: 0.0 %
Calves per cow and year: 0.86

Milk quantity and prices

Milk sold to the dairy or marketed directly. On average, 85-95% of the milk produced is marketed.

<table>
<thead>
<tr>
<th>Milk yield</th>
<th>kg/cow and year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7451.0</td>
</tr>
<tr>
<td>Less milk fed to calves</td>
<td>48.2</td>
</tr>
<tr>
<td>Less other unsold milk</td>
<td>0.0</td>
</tr>
<tr>
<td>Sold milk</td>
<td>7403</td>
</tr>
</tbody>
</table>
„IDB-Calculator“- Bio-Economic Decision Support Tool

- (Socio-) Economic Indicators
- Open source web-based since 2010
- 130 conventional and organic agricultural production systems
- 1100 requests per day
The Problem

→ DST often display the simplest economic model ignoring factors such as production risk and off-farm impacts (Pannell et al., 2017)

→ Most existing DST that are available are focused on relatively narrow issues (Jones et al., 2017)

→ Farmers cannot start at their biophysical and socioeconomic situation (Jones et al., 2017)
Nitrogen input, farm benefit and additional costs

Nitrogen costs and benefits (€/ha)

Net farm benefit

Farm optimum

N fertilization (kg/ha)

Van Grinsven, 2013
Nitrogen input, farm benefit and additional costs

Nitrogen costs and benefits (€/ha)

Net farm benefit

Farm optimum

N fertilization (kg/ha)

Van Grinsven, 2013
Nitrogen input, farm benefit and additional costs

Nitrogen costs and benefits (€/ha)

- **Farm optimum**
- **Net farm**
- **additional costs**
- **external costs** (erosion, eutrophication, climate change)
- **internal costs** (appointment costs, harmful compaction, manure transport etc.)

N fertilization (kg/ha)

Van Grinsven, 2013
Institute for Agricultural Economics
Nitrogen input, farm benefit and additional costs

Nitrogen costs and benefits (€/ha)

- **Farm optimum**
- **Social optimum**
- **Net farm**
- **additional costs**
  - *external costs* (erosion, eutrophication, climate change)
- **internal costs**
  - appointment costs, harmful compaction, manure transport etc.

N fertilization (kg/ha)

Van Grinsven, 2013
Nitrogen input, farm benefit and additional costs

Nitrogen costs and benefits (€/ha)

Amount of input, field length, crop ratio, herd size, stocking rate, milk yield

Additional costs
- External costs (erosion, eutrophication, climate change)
- Internal costs (appointment costs, harmful compaction, manure transport etc.)

Van Grinsven, 2013
Institute for Agricultural Economics
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Milk yield and profit

Profit (€/kg FPCM)

-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15

Milk yield (kg FPCM/cow and year)

4000
6000
8000
10000
12000
14000

Profit milk branch

Milk breed

Dual-purpose
Milk yield and profit

- Profit milk branch
- Profit milk and beef

Milk breed

Dual-purpose

Profit (€/kg FPCM)

Milk yield (kg FPCM/cow and year)
The Problem

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Institute for Agricultural Economics

Profit and GHG emissions

Dual-purpose Milk breed

GHG emissions (kg CO2eq/kg FPCM)

Profit (€/kg FPCM)

Milk yield (kg FPCM/cow and year)
Profit, GHG emissions and beef output

![Graph showing GHG emissions and profit related to milk and beef production.](image-url)

1. **GHG emissions**: The graph plots GHG emissions in kg CO2e/kg FPCM against milk yield in kg FPCM/cow and year.
2. **Profit milk and beef**: Shows the profit in €/kg FPCM and beef output in kg per kg milk.
3. **Milk yield**: Demonstrates milk production for both Dual-purpose and Milk breeds.
Milk yield and profit

Profit (€/kg FPCM)

-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20

Profit milk branch
Profit milk and beef

Milk yield (kg FPCM/cow and year)

4000 6000 8000 10000 12000 14000

Dual-purpose

Milk breed
Internalising external costs

Profit (€/kg FPCM)

Dual-purpose

Profit milk branch
Profit milk and beef
Profit minus carbon costs (50€/t CO2eq)

Milk yield (kg FPCM/cow and year)

Milk breed
The Problem

→ DST often display the simplest economic model ignoring factors such as production risk and off-farm impacts (Pannell et al., 2017)

→ Most existing DSS tools that are available are focused on relatively narrow issues (Jones et al., 2017)

→ Farmers cannot start at their biophysical and socioeconomic situation
GHG emissions and profit

GHG emissions (kg CO2eq/kg FPCM) vs Milk yield (kg FPCM/cow and year)
GHG emissions and profit

Profit:
- 16% Milk yield
- 10% Concentrate efficiency
- 27% Depreciation (buildings and machinery)
GHG emissions and profit

- **GHG emissions**
  - 14% Milk yield
  - 25% Feed use efficiency
  - 31% Nitrogen use efficiency

- **Profit**
  - 16% Milk yield
  - 10% Concentrate efficiency
  - 27% Depreciation (buildings and machinery)
GHG emissions and profit

GHG emissions (kg CO2eq/kg FPCM) vs Milk yield (kg FPCM/cow and year)

- GHG emissions
- Profit

Profit (€/kg FPCM)
Conclusions

- Focus on narrow issues and neglect of internal and external costs can mislead farmers/advisers in making farming systems decisions
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- Neglection of farmers' biophysical and socioeconomic current situation can misslead in search for relative important drivers → different operating strategies for different farms.
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- Neglection of farmers biophysical and socioeconomic current situation can misslead in search for relative important drivers → different operating strategies for different farms.

- Trade-off between demand for „Ease of use“ tools (Rose et al., 2016) and inclusion of externalities, uncertainties,… in estimates.
Conclusions

- Focus on narrow issues and neglect of internal and external costs can mislead farmers/advisers in making farming systems decisions.

- Neglection of farmers' biophysical and socioeconomic current situation can mislead in search for relative important drivers leading to different operating strategies for different farms.

- Trade-off between demand for "Ease of use" tools (Rose et al., 2016) and inclusion of externalities, uncertainties, ... in estimates.

Thank you!
Milk yield, human edible ratio and concentrate efficiency
Milk yield and concentrate efficiency

Concentrate efficiency (g/kg FPCM)

Milk yield (kg FPCM)
New data generation possibilities
LOD

Visualization

Interdisciplinary modelling
1. Gründe für Unterschiede: Models: too simple to depict reality, unrationales Verhalten der Landwirte, management -> damit umgehen
2. Was dagegen tun: Modelle verbessern, Beratung,
3. Zielkonflikt: Situation genau abbilden plus ease of use, suitable for individual farm situation
4. Modellgrenzen, Tendenzen, Möglichkeiten der Verbesserung, ersetzt keine empirische Datenerhebung, Weiterhin auf empirische Daten setzen und nicht nur auf Tools verlassen!
Soo tiefe Modelle geeignet für Landwirte?
2 Modelle: IDB Plus research

Sinn des tools Verbesserungsmöglichkeiten aufzuzeigen Punktewolke: relevante veränderbare Einflussgrößen
Improve IDB DST -> breiter (partly include external costs), still ease of use (visualization?)

We envision a DSS platform that will connect various models, databases, analysis, and information synthesis tools in an easy-to-use interface for Sizani to set up the analyses and outputs to answer questions about the management of that particular farms' biophysical and socioeconomic situation and the uncertainties in those estimates. Such DSS platforms are possible, but not yet constructed. (Jones et al., 2017)
Gewinn nach Abzug Pachtansatz und Lohnansatz

Akh pro Kuh als erklärende

<table>
<thead>
<tr>
<th>Variablen</th>
<th>Wert</th>
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<tbody>
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<td>remontierung</td>
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<tr>
<td>gewef</td>
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<td>eka</td>
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<td>nsaldogew</td>
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</tr>
<tr>
<td>hauptfutterflaechejekuh</td>
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<tr>
<td>grobfutterleistung</td>
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<tr>
<td>kaelberverlustegesamt</td>
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</table>
Stickstoff und BZA Daten
GHG emissions with different milk yield per cow: model versus practical farms

GHG emissions per kg milk – normative model
GHG emissions with different milk yield per cow: model versus practical farms

GHG emissions per kg milk – normative model

Milk yield in kg FPCM per cow and year
Internalisierung der externen THG Kosten
- THG bewerten
2. Teil: wie spiegeln Modelle die Realität wider
Overview of the method

1. Prototyping with experts
   - Determinants of adoption
     - Adoption model
   - Farmers stated preferences
     - Farmers characteristics

2. Bio-economic farm model
   - Expert knowledge, field data
     - Impacts of innovations
       - Impacts of innovations
         - 2nd Farm survey
   - Policy and market conditions

3. 1st Farm survey
   - Farm Typology
     - AE innov.
● DST -> Ease of use, visual presentation of decision-making information (Rose et al., 2016)

● Economists face the challenge of more effectively communicating the results of their research beyond the pages of academic journals (Pannell et al., 2017)
Fig. 2. Examples of possible tradeoff curves. (a) Increased soil erosion when intensifying agricultural systems. (b) The negative effects on future productivity as a result of soil erosion when intensifying current agricultural production. (c) Increased pesticide leaching as a result of increased erosion rates. (d) The impact of alternative (conservation) technologies on the tradeoff curve.
• Flat earth economics
● New insights into efficiency

  – Traditional insight for farmers/policy makers into efficiency
Hinweise zur Bedienung: alle Detail-Infos einblenden / alle ausblenden

- Mit Hilfe der Schaltflächen und können Sie zum jeweiligen Thema weitere Info ein- bzw. ausblenden.
- Die Eingabefelder sind mit bayrischen Durchschnittswerten vorbelegt. Diese Werte können Sie mit betriebsbezogenen Daten überschreiben.
- Unterstehende Zahlenwerte können zur besseren Vergleichbarkeit verschiedener Verfahren oder unterschiedlicher Szenarien eines Verfahrens auf einen gemeinsamen Vergleichsebene übertragen werden. Diese Daten stehen Ihnen bis zum Verpassen der Anwendung "Deckungsbeiträge und Kalkulationsdaten" zur Verfügung. **Bitte beachten Sie aber: Bei Arbeitsspausen über einer Stunde gehen die bisher gespeicherten Daten verloren!**
- Detailinformationen zu den jeweiligen Punkten erhalten Sie, wenn Sie mit der Maus über das Fragezeichen-Symbol fahren.

Grundlegende Angaben zum Produktionsverfahren

**Kommentar:** 5000

Anzeige der Leistung/Kostenpositionen
- **inkl. MwSt. =** Einstellung für pauschalierende Betriebe
- **ohne MwSt. =** Einstellung für optierende Betriebe

Betrachtungszeitraum: 12 Monate

Kennwerte des Produktionsverfahrens

- **Rasse:** Fleckvieh
- **Abgangsquote:** 30.0 %
- **Zwischenkalbezeit:** 393.0 Tage
- **Bestandsveränderung:** Erstkalbungen im eigenen Bestand: 0.0 % Zukauf von Jungkühen: 100.0 %
- **Kälberverlustquote:** 7.3 %
- **Kälber je Kuh und Jahr:** 0.86

**Milchmenge und Preisansätze**

<table>
<thead>
<tr>
<th>Item</th>
<th>Einheit</th>
<th>Betrag</th>
</tr>
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<tbody>
<tr>
<td>verkaufte Milch</td>
<td>kg/Kuh u. Jahr</td>
<td>4952</td>
</tr>
<tr>
<td>Milchpreis (inkl. 10.7 % MwSt.)</td>
<td>ct/kg</td>
<td>41.67</td>
</tr>
<tr>
<td>Milcherlös (inkl. 10.7 % MwSt.)</td>
<td>€/Kuh u. Jahr</td>
<td>2063.5</td>
</tr>
<tr>
<td>Kalbererlös (inkl. 10.7 % MwSt.)</td>
<td>€/Kuh u. Jahr</td>
<td>358.3</td>
</tr>
<tr>
<td>Altkuherlös (inkl. 10.7 % MwSt.)</td>
<td>€/Kuh u. Jahr</td>
<td>352.7</td>
</tr>
</tbody>
</table>

**Deckungsbeitragsberechnung je Kuh und Jahr**
3.1.1.3. *Decision support tools.* Most existing DSS tools that are available in Apps are focused on relatively narrow issues (e.g., see [www.agroclimate.org](http://www.agroclimate.org)), such as when to apply a fungicide to a particular crop, when to apply the next irrigation, or how much N fertilizer to apply to a particular crop that will be grown on a particular type of soil in a specific setting. There are few DSS tools that make use of more integrated models to help advisors advise farmers in making farming system decisions (but see Keating et al., 1991, Keating and McCown, 2001). We envision a DSS platform that will connect various models, databases, analysis, and information synthesis tools in an easy-to-use interface for Sizani to set up the analyses and outputs to answer questions about the management of that particular farms' biophysical and socioeconomic situation and the uncertainties in those estimates. Such DSS platforms are possible, but not yet constructed.
Economists face the challenge of more effectively communicating the results of their research beyond the pages of academic journals (Pannell et al., 2017)
Production costs and additional costs
Production costs and additional costs

- Production costs
- Internal costs
- Additional costs

Factors influencing costs:
- Amount of input
- Stocking rate
- Field length
- Crop ratio

Heißenhuber, 54
Production costs and additional costs

€/ha

external costs
internal costs

production costs

additional costs
external costs (erosion, eutrophication, etc.)
internal costs (appointment costs, harmful compaction, manure transport etc.)

amount of input
stocking rate
field length
crop ratio
Production costs and additional costs

- External costs (erosion, eutrophication, etc.)
- Internal costs (appointment costs, harmful compaction, manure transport etc.)
- Production costs
- Total costs
- Additional costs

Costs are measured in €/ha and include:
- Production costs
- Total costs
- Additional costs

Factors affecting costs:
- Amount of input
- Stocking rate
- Field length
- Crop ratio