A protocol for designing a database based on production activity concept: a case study using a bio-economic model

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Context and objectives

The development and implementation of farm bio-economic mathematical programming models requires a good understanding of the concept of “agricultural production” for ensuring a consistent integration between biophysical and technical production components (Flichman et al., 2011). With this concept, it becomes possible to i) produce engineering production functions, hence comparing, from biophysical point of view, yield, resource use, and externalities of agricultural production systems (Belhouchette et al., 2011), and ii) explore hypothesis of resource uses and allow defining adaptation strategies to climate change and scenarios of resource availability, as well as defining thresholds of externalities to limit the environmental impact of production systems (Donatelli et Conflonlier, 2011).

The objective of this study is to describe and discuss steps to build “activity components” (figure 1) and a database in order to assess a scenario targeting the reduction of N use in the Midi-Pyrenees region, France.

Methodology

1. Conceptual framework for “Activity” definition and performance evaluation

1. Definition of agricultural activities

Specify the purpose of the study

Limiting nitrogen pollution, strategic choices in changing economic and institutional conditions (PAC);

Determine the activity “dimension”

Variables considered by taking into account the purpose of the study;

3. A bio-economic model to assess farmer’s production strategies

Bio-economic model:

• Based on linear programming;
• Optimizes the farmer’s utilities which include the revenue and the risk aversion coefficient;

2. Activities’ input-output coefficients

Data collection VS data availability/data quality to quantify technical coefficients from:

• Experiments;
• Statical data;
• Bibliography;
• Expert knowledge;
• Farm surveys;

4. Scenarios definition

S0 « Reference scenario »

Current nitrogen use constraint = 180 kg N/farm;

S1 « Reduction scenario »

Limiting nitrogen use at 90 kg N/farm;

Results and discussion

• The reduction of N use at farm scale induces a cultivation of more profitable cereals crops (durum wheat, soft wheat and grain maize) instead of less profitable crops such as sunflower and winter barley (figure 2),

• As a consequence, the total farm income, as well as the average farm TFI, are respectively reduced by 1.4 % and 10 % (figure 3) when the N use scenario is compared to the reference scenario.

• The use of the “activity concept” does not only allow the exploration of complex scenarios, but also the building of a large and shared database with local stakeholders (table 2). This concept is a key issue when strategic decisions concerning production orientation are addressed in a changing socio-economic context.

![Figure 1. Activity components](image)

![Figure 2. The effect of reducing Nitrogen use on the production plan of crops](image)

![Figure 3. Impacts of reducing Nitrogen use at the farm scale: Gross Margin and TFI (Treatment frequency index)](image)

Table 1. Farm type located in the Midi-Pyrenees region, France

<table>
<thead>
<tr>
<th>Activity dimension</th>
<th>Input coefficients</th>
<th>Output coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop</td>
<td>Input</td>
<td>Output</td>
</tr>
<tr>
<td>Soy</td>
<td>162</td>
<td>dry</td>
</tr>
<tr>
<td>Durum</td>
<td>162</td>
<td>dry</td>
</tr>
<tr>
<td>Soft wheat</td>
<td>162</td>
<td>dry</td>
</tr>
<tr>
<td>Winter barley</td>
<td>162</td>
<td>dry</td>
</tr>
<tr>
<td>Grain maize</td>
<td>162</td>
<td>dry</td>
</tr>
</tbody>
</table>

Table 2. Database based on production activity concept

<table>
<thead>
<tr>
<th>Crop</th>
<th>Irrigation</th>
<th>Soil useful reserve (mm)</th>
<th>Soil tillage</th>
<th>Herbicide resistance</th>
<th>Yield (ton/ha)</th>
<th>TFI (ecost / $ha)</th>
<th>Fertil H (ppm)</th>
<th>Fertil P (ppm)</th>
<th>Fertil K (ppm)</th>
<th>Irrigation degree (mm)</th>
<th>Labor (per day)</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durum wheat</td>
<td>Dry</td>
<td>162.45 Simplex irrigation</td>
<td>2.5</td>
<td>162.45</td>
<td>148</td>
<td>0.09</td>
<td>2000</td>
<td>30</td>
<td>0.30</td>
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References: