BIO-REFINING AGRICULTURAL CROP PRODUCTS INTO HIGH-VALUE MATERIALS

- ECONOMIC IMPACTS ON THE AGRICULTURAL SECTOR

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Overview

• Agriculture in the bio-based economy
• The problem
• Methodology
• Scenarios
• Results
• Discussion
Agriculture in the biobased economy

• Increased focus on management, disposal and recycling of natural resources

  • Economic growth and employment in rural areas
  • Reduce fossil fuel dependence
  • Improve economic and environmental sustainability of primary production and processing
  • Better utilization of bio-resources

• Search for new opportunities for agricultural value creation in non-food bio-products
Bio-refining

Biorefining: Transformation of biomass into products via biological, enzymatic or chemical processes.

Biorefinery systems are characterised by four features:

Example:
Sugar cane → sugar → ethanol
What’s in it for agriculture?

• Agriculture can supply feedstock
  • Biomass crops (grain, sugarcane, potatoes, grass, willow, …)
  • Crop residues (e.g. straw)
  • Off-fall from other production

• Agriculture can use biorefined products
  • Refined protein feeds and other nutrients
  • Materials
Objective of the study

- Examine agricultural economic consequences of scenarios, where bio-refining of agriculturally supplied biomass is successfully implemented
  - Refining green biomass (grass etc.) to extract high-value protein feed for pigs and poultry – to replace imported protein feeds, such as soya
  - Refining agricultural biomass to high-value industrial materials and products to be sold outside agriculture
Partial equilibrium agricultural sector economic model

• Effects of biomass production on allocation of agricultural land
• Effects of biomass production on domestic livestock production
• Effects of biomass production on the equilibrium price of biomass
• Effects of biomass production on the agricultural profitability at the sector level
• Effects of biomass production on production and profitability in different farm types
• Effects of biomass production on agricultural employment
ESMERALDA- partial equilibrium agricultural sector model

15 farm types
25 crop sectors
11 livestock sectors
Theoretical approach

• Cost minimization in individual lines of agricultural production

• Zero profit condition in individual lines of agricultural production

• Profit maximizing allocation of farm area on different crops

• Profit maximizing size of livestock and capital input

• Account of physical, technological and political restrictions – regulated by shadow prices
## Farm typology: 15 farm types

<table>
<thead>
<tr>
<th>Type</th>
<th>Approximate number, 2011</th>
<th>Area per farm (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small conventional crop full time farm, clay soil</td>
<td>1302</td>
<td>134</td>
</tr>
<tr>
<td>Large conventional crop full time farm, clay soil</td>
<td>153</td>
<td>377</td>
</tr>
<tr>
<td>Small organic crop full time farm, clay soil</td>
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<td>Large organic crop full time farm, clay soil</td>
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<td>Small conventional crop full time farm, sandy soil</td>
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<td>Large conventional crop full time farm, sandy soil</td>
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<td>Large organic crop full time farm, sandy soil</td>
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<tr>
<td>Conventional cattle full time farm</td>
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<tr>
<td>Organic cattle full time farm</td>
<td>463</td>
<td>181</td>
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<tr>
<td>Small conventional pig (+other) full time farm</td>
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</tr>
<tr>
<td>Large conventional pig (+other) full time farm</td>
<td>10</td>
<td>317</td>
</tr>
<tr>
<td>Small organic pig (+other) full time farm</td>
<td>88</td>
<td>114</td>
</tr>
<tr>
<td>Conventional part time farm</td>
<td>23138</td>
<td>36</td>
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<tr>
<td>Organic part time farm</td>
<td>2022</td>
<td>38</td>
</tr>
</tbody>
</table>

Large farm: > 200 ha
2 bio-refining scenarios

1. Extraction of high-value protein from green biomass (grass etc.) to be used for pig and poultry feeding and use of the residual component for cattle feeding

2. Extraction of high-value components of the biomass for non-food industrial processing, e.g. as a substitute for petrochemical raw materials – biomass area equal to that of scenario 1

Scenario 2 is more flexible than scenario 1 – and potential economic gains may be expected to be largest in scenario 2
Scenario 1 – protein feed from green biomass

• Increase national self-sufficiency rate for protein feed by one third (compared with baseline) via production of green biomass (grass) for bio-refining

• Increased production of biomass -> increased biomass area -> increased opportunity cost of land -> increased unit cost of biomass production -> increased price of biomass (for all) -> increased unit cost of protein feed -> changed allocation of land -> changed livestock activity -> changed economic performance in agriculture -> changed agricultural employment

Scenario 2 – materials from biomass

• Total biomass area (sc. 2 - not necessarily “green”) = Total biomass area (sc. 1) -> Increased opportunity cost of agricultural land

-> increased unit cost of biomass production -> ...
Results – sector level output changes

![Graph showing sector level output changes]
Results – sector level income and employment

- Feed
  - Gross factor income: Baseline = 100
  - Equilibrium price: 80
- Material
  - Baseline biomass price: 120
- Feed
  - Sector employment: 100
- Material
  - Sector employment: 100

Legend:
- Equilibrium price
- Baseline biomass price
Results – sector level

• Unit cost of biomass increases
  • Does the price of biomass increase correspondingly?
  • Does feed price adjust to increased biomass price?

• Area for biomass production drawn from grain production
• Only small employment effect in agricultural sector
Distribution of effects on farm types

• Biomass production occurs on those farm types, where the opportunity cost of land is relatively low

• Derived impacts on feed prices affect livestock production – depending on the farm types’ profitability in these livestock sectors
Distribution of biomass production between farm types

- Organic part time farm
- Conventional part time farm
- Small organic pig (+other) full time farm
- Large conventional pig (+other) full time farm
- Small conventional pig (+other) full time farm
- Organic cattle full time farm
- Conventional cattle full time farm
- Large organic crop full time farm, sandy soil
- Small organic crop full time farm, sandy soil
- Large conventional crop full time farm, sandy soil
- Small conventional crop full time farm, sandy soil
- Large organic crop full time farm, clay soil
- Small organic crop full time farm, clay soil
- Large conventional crop full time farm, clay soil
- Small conventional crop full time farm, clay soil
Distribution of farm-level economic effects

Note: +2: Above average, +1: Positive, but below average, -1: Negative
Discussion

• Scenarios assume that biomass can be sold at production costs – requires that price of products from bio-refining can be remunerate the cost of biomass

• Influence from market shocks and various policy regulations on economy of biomass production

• Uncertainty – economics of biomass production only known at experimental/pilot level – but what about large-scale biomass production

• Work in progress – preliminary results – comments and suggestions welcome
Thanks for your attention

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