Dissertation Defense

Integrating Agriculture into Chinese Mitigation Policies

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Introduction

Research question
How to integrate agriculture into Chinese climate policies in an economic efficient way?

Status
➊ Agriculture is an important source of GHG emissions: 11% in 2005 with 820 MtCO\textsubscript{2}e
➋ but is not mobilized in national mitigation policies

Research methodology: Marginal Abatement Cost Curve (MACC)
➊ First attempt to construct a MACC for Chinese agriculture
➋ Choice of bottom-up approach rather than top-down

Research focus
Croplands, especially N\textsubscript{2}O emissions related to N fertilizer use
Outline

I. Construction of baseline scenarios for agriculture
II. Technical mitigation potential from croplands
III. Economic mitigation potential from croplands
IV. Discussions on the economic incentives to trigger abatement in agriculture

Drivers of baseline emissions/activities

- Priority of safeguarding food security in China
  - Both baseline and mitigation scenarios should meet the national target of food production
  - All mitigation measures should not negatively affect yields

- Agriculture policies and climate policies
  - Climate-related policies indicate measure baseline application level (e.g. the conservation tillage program)
  - Synthetic N fertilizer use growth slows down

- Changing diet for more animal protein
  - Livestock emissions grow faster than croplands emissions
  - Higher demand for animal feed (soybean)
Baseline construction methodology

- Future agriculture activities data from CAPSiM models (endorsed by the Ministry of Agriculture)
- Projection of overall N fertilizer consumption based on historical growth rate and N rate of each crop
- China specific emission factors selected from domestic research
- Rice CH$_4$ emissions: direct projections from studies using CH4MOD model (endorsed in national inventory)

Baseline emission scenario to 2020

![Graph showing GHG emissions from different sources from 2005 to 2020]
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MACC construction steps - China as one farm

Methodological approach is based on Moran et al. (2011) and adjusted to accommodate China’s conditions.
III. Technical mitigation potential

<table>
<thead>
<tr>
<th>No.</th>
<th>Measure</th>
<th>Weighted abatement rate (tCO₂e/ha)</th>
<th>Additional application area (Mha)</th>
<th>Total mitigation potential in 2020 (MtCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Fertilizer best management practices - Right rate</td>
<td>0.412</td>
<td>58.63</td>
<td>30.65</td>
</tr>
<tr>
<td></td>
<td>Fertilizer best management practices (Wheat)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>Fertilizer and water best management in rice paddies</td>
<td>1.337</td>
<td>17.93</td>
<td>23.98</td>
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<tr>
<td></td>
<td>Fertilizer best management practices (cash crops) -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>Right products, right time and right placement</td>
<td>1.219</td>
<td>17.94</td>
<td>21.86</td>
</tr>
<tr>
<td>C5</td>
<td>Enhanced-efficiency fertilizers</td>
<td>0.271</td>
<td>57.23</td>
<td>15.54</td>
</tr>
<tr>
<td>C6</td>
<td>More efficient recycling of organic manure</td>
<td>0.596</td>
<td>120.11</td>
<td>40.19</td>
</tr>
<tr>
<td>C7</td>
<td>Conservation tillage for upland crops</td>
<td>0.489</td>
<td>22.98</td>
<td>1.46</td>
</tr>
<tr>
<td>C8</td>
<td>Straw return in upland crops</td>
<td>0.210</td>
<td>30.06</td>
<td>0.95</td>
</tr>
<tr>
<td>C9</td>
<td>Biochar addition</td>
<td>0.329</td>
<td>9.90</td>
<td>3.26</td>
</tr>
</tbody>
</table>


Regional disparities:
GHG intensity of cereal production

- High geographic variations of baseline GHG
- Regional variations of mitigation potential of N management practices
- Potential use as baseline/benchmark for offset/ETS programs

IV. Economic mitigation potential

Mitigation measures

- Implementation cost (€/ha)
- Cost effectiveness (€/tCO₂e abated)

Economic potential

- Fertilizer
- Labor
- Machinery
- Irrigation
- Yield

Mitigation measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>N input</th>
<th>Labor</th>
<th>Yield</th>
<th>Implementation cost</th>
<th>Cost-effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>-31%</td>
<td>-132€/ha</td>
<td></td>
<td>-260€/tCO₂e</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td></td>
<td></td>
<td>+7.5</td>
<td></td>
<td>+150€/tCO₂e</td>
</tr>
</tbody>
</table>

Example: C1 synthetic N management practices for wheat

Province X or national average

MACC results - national level

- Maximum feasible technical potential in 2020: 402 MtCO₂e (207Mt emission reduction +195Mt carbon sequestration)
- Importance of negative-cost mitigation potentials (common in all bottom-up MACCs)
- Relative cost effectiveness of N fertilizer and manure best management practices
MACC results - regional disparities

Cost-effectiveness (¥ tCO2e⁻¹)

Mitigation potential in 2020 (Mt CO2e)

-1500  -1000  -500  0  500

C1 synthetic N fertilizer best management practices
- right rate for wheat production

Emission and mitigation scenarios

Maximum mitigation potential: 34% of baseline emissions
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Carbon pricing progress in China

Pricing carbon to internalize negative externality of excessive GHG emissions; emission trading and carbon tax are the two major economic instruments.

- Cap & Trade: agriculture is excluded from the sectors covered by the 7 Chinese ETS pilots
- Offset programs: agriculture will have limited potential due to high transaction costs and problem of aggregation
- Carbon tax: subsidy for N fertilizer producers and farmers could be considered an equivalent negative carbon tax at a rate of €4.2/tCO₂e (author’s calculation)
Difficulties of pricing carbon in agriculture

The high transaction costs

- Diffuse nature of agriculture emissions and mitigation actions calls for aggregator: example of NZ scheme
- Difficulties in accurate measurement and verification of emissions and abatements
- The specialty of soil carbon storage and reversal risk

Implications of research outcome on pricing carbon in Chinese agriculture

- Restructure N fertilizer subsidies
  - Send a clear signal to farmers on reasonable fertilization
  - Redistribute public funds to improve the infrastructure, extension services and professional service groups, subsidy organic fertilizers and finance agriculture offsets/ETS programs.

- Up-scaling carbon crediting schemes
  - Refer to CDM PoA procedures
  - Use regional GHG intensity as standardized baseline

- ETS pilot covering the agricultural sector
  - Accelerate financial flows from industry and energy sectors to agriculture/countryside
  - Use GHGI as benchmark for allowance allocation
Summary and further research

- **Major research contribution**
  - Quantify mitigation potentials available in agriculture
  - Estimate cost-effectiveness of agriculture abatement options
  - Provide pointers for both policy and research to realize the indicated potentials

- **Limits and further research**
  - Requirement on more detailed regional analysis (except for cereal N fertilizer management measures)
  - Barriers to the realization of win-win options: needs to consider wider social costs and farmers’ behaviors
  - An holistic approach to integrate land cultivation and livestock activities
  - Detailed uncertainty analysis

Publications during the PHD

- Quemin S, **Wang W**, 2014. Overview of climate change policies and development of emissions trading in China, Series Information and Debates n° 30 of Climate Economics Chair.
- Nayak DR, Saetnan ER, Cheng K, **Wang W**, et al., 2014. Management opportunities to mitigate greenhouse gas emissions from Chinese agriculture. Accepted by AEE, upcoming publication.
Thanks!