
John Antle
Oregon State University

Roberto Valdivia
Montana State University

tradeoffs.oregonstate.edu

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What is the TOA-MD Model?

• The **TOA-MD Model** is a unique simulation tool for **multi-dimensional impact assessment** that uses a statistical description of a heterogeneous farm population to simulate the adoption and impacts of a new technology or a change in environmental conditions.

• TOA-MD is designed to simulate what would be observed if it were possible to conduct a controlled experiment to measure the effects of farms adopting a new production technology.

• In fact it is never possible to carry out such ideal experiments, so TOA-MD is designed to utilize the available data to attain the best possible approximation, given the available time and other resources available to conduct the analysis.

• Additionally, TOA-MD is designed to facilitate analysis of the inevitable uncertainties associated with impact assessment.
There are two components in the TOA analysis:

• First, the model simulates the proportion of farms that would adopt the new system
• Second, based on the adoption rate of the new system, the TOA-MD model simulates selected economic, environmental and social impact indicators for adopters, non-adopters and the entire population.
TOA-MD approach: modeling systems used by heterogeneous populations

A system is defined in terms of household, crop, livestock and aquaculture sub-systems

Systems are being used in heterogeneous populations
Opportunity cost, system choice and adoption

Opportunity cost $\omega = v_1 - v_2$ follows distribution $\phi(\omega)$

System 1: $\omega > 0$ (non-adopters)

System 2: $\omega < 0$ (adopters)

$\omega$ opportunity cost

Map of a heterogeneous region
Adoption, Outcome Distributions and Impact Indicators

• Outcome distributions are associated with system choice
  – Farms select themselves into “non-adopter” and “adopter” sub-populations, generating corresponding outcome distributions for these sub-populations

• Impact indicators are based on system choice and outcome distributions
  – TOA-MD produces mean indicators and threshold-based indicators

• Analysis shows that impacts depend on the correlations between adoption (opportunity cost) and outcomes
  – Many impact assessments ignore correlations
Adoption and outcome distributions

System 1 before adoption: 25% > threshold $\tau$

System 1: 20% > $\tau$

System 2: 90% > $\tau$

Entire Population with adoption: 55% > $\tau$
Components of TOA-MD Analysis

**Design**
- Population (Strata)
  - System characterization
  - Impact indicator design

**Data**
- Opportunity cost distribution
  - Outcome distributions

**Simulation**
- Adoption rate
  - Indicators and Tradeoffs
The Malawi Case Study: Integrated Agriculture-Aquaculture

- Based on Dey et al (2010) *Agricultural Economics*: economic analysis of IAA
  - stratified survey of farms, without and with IAA
  - estimate adoption model but cannot predict adoption rate...
- Design of TOA-MD analysis
  - population: farm households in southern Malawi where aquaculture is feasible
  - strata: 5 southern districts
  - systems:
    - Subsistence crops
    - Crops + aquaculture, low or high integration
Adoption Rate and Opportunity Cost of Adopting IAA in Southern Malawi – Predicted Adoption Rate is Point Where Curves Cross the Horizontal Axis
Poverty Rate and Adoption Rate of IAA, Southern Malawi

![Graph showing the relationship between poverty rate and adoption rate in Southern Malawi, with data points for Zomba, Mwanza, Mulanje, Thyolo, and Mangochi.]
Mean Monthly Protein Consumption and Adoption of IAA, Southern Malawi
Relationship between adoption and Protein Consumption, Non-adopters and Adopters of IAA, Mulanje Dist., Malawi

Slope of relationship between indicator and adoption rate has same sign as the correlation between opp cost and the outcome variable (negative in this case)

Non-adopter sub-population and entire population are equal at 0% adoption

Adopter sub-population and entire population are equal at 100% adoption
Relationship between adoption and Mean Returns per Farm, Non-Adopters and Adopters of IAA, Mulanje District, Malawi

Economic outcomes that are positively related to net returns have a maximum in the entire population at the predicted adoption rate (41% in this example)
## Summary: Impacts of IAA Adoption on Farm Population and IAA Adopters

<table>
<thead>
<tr>
<th>Strata</th>
<th>Adoption rate (%)</th>
<th>Ave. farm income ($/year)</th>
<th>% Change on population</th>
<th>% Change on adopters</th>
<th>Poverty rate (%)</th>
<th>% Change on population</th>
<th>% Change on adopters</th>
<th>Mean Monthly Protein Consumption (kg/person)</th>
<th>% Change on population</th>
<th>% Change on adopters</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZOMBA</td>
<td>49.22</td>
<td>112.47</td>
<td>54.60%</td>
<td>135.62%</td>
<td>87.50</td>
<td>-15.81%</td>
<td>-42.48%</td>
<td>1.41</td>
<td>12.86%</td>
<td>38.95%</td>
</tr>
<tr>
<td>MWANZA</td>
<td>49.40</td>
<td>89.01</td>
<td>50.77%</td>
<td>137.61%</td>
<td>99.16</td>
<td>-16.01%</td>
<td>-51.88%</td>
<td>1.94</td>
<td>0.30%</td>
<td>10.64%</td>
</tr>
<tr>
<td>MULANJE</td>
<td>40.81</td>
<td>81.01</td>
<td>54.46%</td>
<td>179.51%</td>
<td>84.30</td>
<td>-11.38%</td>
<td>-44.26%</td>
<td>0.65</td>
<td>53.10%</td>
<td>191.35%</td>
</tr>
<tr>
<td>THYOLO</td>
<td>41.92</td>
<td>170.85</td>
<td>41.85%</td>
<td>116.92%</td>
<td>95.93</td>
<td>-16.48%</td>
<td>-56.11%</td>
<td>1.75</td>
<td>-0.49%</td>
<td>28.63%</td>
</tr>
<tr>
<td>MANGONI</td>
<td>37.95</td>
<td>188.62</td>
<td>30.77%</td>
<td>116.63%</td>
<td>72.24</td>
<td>-10.53%</td>
<td>-53.66%</td>
<td>0.77</td>
<td>56.42%</td>
<td>178.33%</td>
</tr>
<tr>
<td>REGION</td>
<td>44.49</td>
<td>123.90</td>
<td>45.23%</td>
<td>132.70%</td>
<td>87.11</td>
<td>-11.25%</td>
<td>-30.45%</td>
<td>1.29</td>
<td>15.32%</td>
<td>59.00%</td>
</tr>
</tbody>
</table>
Conclusions

• TOA-MD is a unique simulation tool for multi-dimensional impact assessment of agriculture and aquaculture systems.
• The Malawi case study illustrates how it can be used with available data to simulate:
  • the adoption rate of a new technology
  • the economic, environmental or social impacts of the new technology
• The model can also be used for analysis of ecosystem services, and impacts of climate change and other environmental change.
• Training in use of the model, and the model software are available from the TOA Team.
• More info is available at: http://tradeoffs.oregonstate.edu