Household economic assessment of clean cooking stove:
Why Perfect Stoves Are Not Always Chosen?

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"Why clean stove osen?"
Biomass

2.5 Billion people live on ...
Biomass usage

For cooking & heating:

80% of biomass is used for cooking!

For industry:

36 EJ

9 EJ
Bio ethanol

16, Feb, 2012, TERI, New Delhi
HHEA: clean cooking stove

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Cooking energy demand VS. Transportation energy demand

1. Necessity to live
2. The energy demand of the developing countries
3. Fuel demand for cooking for developing country

More significant

\[
\text{The necessity of the car} > \text{The energy demand of the advanced countries} > \text{Traffic fuel demand for advanced country}
\]
The clean fuel and cooker are solutions!

“150 million people die…”

“More than HIV and Malaria”
What are important factors to make them use clean stoves?

The clean fuel and cooker are solutions!
Finding important factors to buy stoves

APPROACHES AND METHODS
VALUE OF TIME

• Suppose:

Bus1: Time = 10, Cost = 100

Bus2: Time = 20, Cost = 50
• Suppose:

Bus1: Time = 10, Cost = 50
Bus2: Time = 20, Cost = 100
U(Ethanol) = B1 * Price_E + B2 * Smoke_E
U(Firewood) = B1 * Price_F + B2 * Smoke_F

**Ethanol stove**
- Price: EUR 50
- No Smoke

**Firewood stove**
- Price: EUR 30
- Very Smoky

Cheap! I buy this

I like clean stove

Need to trade-off between factors
What you can **test**

What you see in real

![Diagram](attachment:image.png)

\[
U(\text{Ethanol}) = B_1 \times \text{Price}_E + B_2 \times \text{Smoke}_E \\
U(\text{Firewood}) = B_1 \times \text{Price}_F + B_2 \times \text{Smoke}_F
\]
\[
\text{Prob}(E) = \frac{\exp[U(\text{Ethanol})]}{\exp[U(\text{Ethanol})] + \exp[U(\text{Firewood})]}
\]

\[
U(\text{Ethanol}) = B1 \times \text{Price}_E + B2 \times \text{Smoke}_E + \text{Error}
\]

\[
U(\text{Firewood}) = B1 \times \text{Price}_F + B2 \times \text{Smoke}_F + \text{Error}
\]
Methodology: (Design summary)

- Three alternatives
- Four attributes
- Fractional factorial design

<table>
<thead>
<tr>
<th></th>
<th>Ethanol</th>
<th>Kerosene</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stove price (Birr)</td>
<td>{500, 250, 100}</td>
<td>{150, 70, 30}</td>
<td>{120, 50, 20}</td>
</tr>
<tr>
<td>Usage cost (Birr)</td>
<td>{60, 120, 160, 320}</td>
<td>{50, 100, 150, 300}</td>
<td>{40, 80, 140, 250}</td>
</tr>
<tr>
<td>Indoor smoke</td>
<td>{No smoke, Very little smoke}</td>
<td>{Very little smoke, Moderately smoky}</td>
<td>{Very little smoke, Highly Smokey}</td>
</tr>
<tr>
<td>Safety risk</td>
<td>{Little unsafe, Highly safe}</td>
<td>{Highly unsafe, Little unsafe}</td>
<td>{Moderately, Unsafe, Highly safe}</td>
</tr>
</tbody>
</table>
Utility function

Ethanol: \( V_i^E = \alpha^E + \beta^{\text{cost}}(\text{cost}_e) + \beta^{\text{price}}(\text{price}_e) + \beta^{\text{smoke}}(\text{smoke}_e) + \beta^{\text{safety}}(\text{safety}_e) \)

Kerosene: \( V_i^K = \alpha^K + \beta^{\text{cost}}(\text{cost}_k) + \beta^{\text{price}}(\text{price}_k) + \beta^{\text{smoke}}(\text{smoke}_k) + \beta^{\text{safety}}(\text{safety}_k) \)

Wood: \( V_i^W = \alpha^W + \beta^{\text{cost}}(\text{cost}_w) + \beta^{\text{price}}(\text{price}_w) + \beta^{\text{smoke}}(\text{smoke}_w) + \beta^{\text{safety}_w}(\text{safety}_w) \)

\[
P(\text{Ethanol}) = \frac{\exp (U_i^E)}{\exp (U_i^E) + \exp (U_i^K) + \exp (U_i^W)}
\]
### Factors influencing choice

#### Too Much Focus

<table>
<thead>
<tr>
<th>Specific to:</th>
<th>Product specific factors</th>
<th>Socio-economic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
<td>Product&lt;br&gt;Universal in nature&lt;br&gt;Within individuals&lt;br&gt;Relatively easy&lt;br&gt;Product design</td>
<td>Person&lt;br&gt;Specific to context&lt;br&gt;Between individuals /groups&lt;br&gt;Difficult&lt;br&gt;Market segmentation</td>
</tr>
<tr>
<td>Variation in choice:</td>
<td></td>
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<tr>
<td>Change in short-term:</td>
<td></td>
<td></td>
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<tr>
<td>Useful for:</td>
<td></td>
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</table>

**47 non-income factors in 20 academic journals!!**
Chains of challenges!

No access to PC & laptop!

Paper & pen

local surveyors

Cannot read & write!!

Too complex for them!!

training, checking, spying

Pictures & Symbol

Give extra biases

Multi photos, randaming
16, Feb, 2012, TERI, New Delhi
HHEA: clean cooking stove

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RESULTS
Results: (Usage Cost)

• Affect poor:
  2.8 more than rich
  1.2 times more than middle income

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Results: (Stove price)

- Affect poor:
  - 6.3 times more than rich
  - 1.5 times more than middle income.
Result: Use cost vs Stove Price

![Graph showing cost and stove price comparison across different income levels.](image_url)
Results: (Smoke)

“Positive for poor?”

“… smoke doesn't matter much”

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## Demand evaluation: Simulation

### Cost of Ethanol vs. By income

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
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<tbody>
<tr>
<td>1</td>
<td>Cost of Ethanol</td>
<td>Cost of Kerosene</td>
<td>Cost of Wood</td>
<td>Stove Price Ethanol</td>
<td>Stove Price Kerosene</td>
<td>Safety of Ethanol</td>
<td>Safety of Kerosene</td>
<td>Safety of Wood</td>
<td>Smoke Ethanol</td>
<td>Smoke Kerosene</td>
<td>Smoke Wood</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>min</td>
<td>60</td>
<td>150</td>
<td>100</td>
<td>250</td>
<td>120</td>
<td>100</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>max</td>
<td>320</td>
<td>150</td>
<td>100</td>
<td>250</td>
<td>120</td>
<td>100</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
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<tr>
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<td>diff</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<td>5</td>
<td>min tested</td>
<td>60</td>
<td>50</td>
<td>40</td>
<td>100</td>
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<td>4</td>
<td>4</td>
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</tbody>
</table>

### Graphs

- **Cost of Ethanol**: The graph shows the relationship between the cost of ethanol and income. Different lines represent different scenarios: P_E, P_k, and P_w.
- **By income**: The graph illustrates the decline in cost for different income levels. The lines represent P_E-h, P_E-m, and P_E-l.
Results and Impact

• Product factors
  – usage cost ↓, stove price ↓, smoke ↓, safety ↑

• Socio economic factors
  – "Need stoves fitting to the market"

• They need:
  • "Good enough" stove
  • "Not a perfect" stove
  • Cheap!!!!

• But, not just cheap, i.e. bad experience from "cheap stove"
Lessons Learned

Socio-economic factors

- Income
- Opportunity cost
- Gender
- Education
- Household size

Product-specific factors

- Stove Price
- Fuel cost
- Maintenance Cost
- Safety
- Risk
- Aesthetics

Monetary

Non-Monetary

Q-1

Q-3

Q-2

Q-4

Need more focus on this!!
Long term issue to make change

ONE MORE THING
Which do you like to see more?

Which gives higher experience?
... higher pleasure need education, cultivation ...

by John Stuart Mil

16, Feb, 2012, TERI, New Delhi
HHEA: clean cooking stove
"Education", "Experience", "Knowledge", will change the world!
Thanks you!

We report it to the Ethiopian President

16, Feb, 2012, TERI, New Delhi
HHEA: clean cooking stove

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Results: (basic model)

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Description</th>
<th>(coefficient)</th>
<th>P-value</th>
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<tr>
<td>$\alpha^E$</td>
<td>Alternative Specific constant ethanol</td>
<td>0.415</td>
<td>0.05</td>
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<td>$\alpha^K$</td>
<td>Alternative Specific constant Kerosene</td>
<td>-0.392</td>
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<td>$\alpha^W$</td>
<td>Alternative Specific constant wood</td>
<td>Fixed to 0</td>
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<td>$\beta^{\text{cost}}$</td>
<td>Usage Cost</td>
<td>-0.002</td>
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<td>$\beta^{\text{price}}$</td>
<td>Stove Price</td>
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<td>Indoor Smoke emission</td>
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<td>Safety Explosion</td>
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<td>$\beta^{\text{safety}_w}$</td>
<td>Safe Burn</td>
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</table>

Summary Statistics
Number of observations: 1795

$L(0) = -1972.009$
$L(\beta) = -1828.821$
$\rho^2(\beta) = 0.073$
Results: (by socio-economic)

<table>
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<tr>
<th>Models</th>
<th>$\alpha^E$</th>
<th>$\alpha^K$</th>
<th>$\beta_{\text{cost}}$</th>
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<td>Red 6%</td>
<td>Green 1%</td>
<td>Blue 1%</td>
<td>Yellow 2%</td>
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<table>
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<th>B: White 90%</th>
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<td>D: Prob.</td>
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<td></td>
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<td>6%</td>
<td>1%</td>
<td>3%</td>
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