Biofuels, Food & Feed Tradeoffs

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Using Stated Preferences to Estimate Environmental Benefits of Biodiesel in Diesel Engines

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Rationale and Research Questions

- **Rationale**
  - Clean air vital for a healthy environment
  - Economy depends on polluting activities
  - Diesel engines play a key role in the economy, yet cause environmental degradation
  - Policy-makers have focused on using biodiesel as a way to reduce emissions
  - However, implementing a project to produce and use more biodiesel would be costly.
- **Research questions**
  - Would citizen consumers be willing to partake the cost?
  - How much would they be willing to contribute?
  - What are the determinants of willingness to pay (WTP)?

Why Biodiesel?

Figure 1: Tailpipe Emissions of Biodiesel relative to Conventional Diesel[+]

Source: Union of Concerned Scientists, 2004

PM: Particulate matter   NOx: Nitrogen Oxides

HC: Hydrocarbons or Aromatics

Background

- **Approaches for benefit estimation**
  - Indirect or behavioral methods
  - Direct or stated preference methods
- **Behavioral methods**
  - Behaviors are observed
  - Value of changes in public goods is inferred
- **Stated preference methods**
  - Respondents are asked contingent or hypothetical questions
  - Responses trading off improvements in public goods for money are induced
  - From responses, value of changes in public goods is inferred

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Objectives and Hypotheses

- **Objectives**
  1. Design and implement a contingent valuation survey to measure individuals' WTP for air quality improvements arising from using blended biodiesel in Ohio's on-road and off-road diesel engines
  2. Determine factors affecting WTP
  3. Estimate aggregate WTP dollar value representing an upper bound estimate of environmental benefits of using blended biodiesel in diesel engines.

- **Hypotheses**
  1. Strong background on air pollution and health implication is likely to influence WTP
  2. People's WTP depends on their residential location
  3. Individuals' socio-economic situation affects WTP

Theoretical Framework

- Constrained utility maximization
- Theoretically, welfare change is measured by a change in indirect utility function or expenditure function
- CVM can be viewed as a direct measure of welfare change
- WTP = Amount of income that compensates an individual for a welfare change
- $V(y-WTP, P, Z, Q_1)=V(y, P, Z, Q_0)$ (1)
- $WTP=F(Y, P, Z, Q_0, Q_1)$ (2)
  - With $Q_1>Q_0$

Methods and Procedures

- **Survey Methods and Elicitation format**
  - Mail survey
  - Half of the sample received questionnaires with the conventional double-bounded format (Two consecutive yes/no questions)
  - The other half received questionnaires with a stochastic double-bounded format
    - A first yes/no question
    - A second likelihood question with answer choices being: Definitely no (DN), Probably No (PN), Not sure (NS), Probably Yes (PY), and Definitely Yes (DY)
  - Payment vehicle: Money contribution to a trust fund

- **Estimation Procedures**
  - Single bounded models (Probit and Logit)
  - Conventional double-bounded model (Bivariate probit)
  - Stochastic Double-bounded models (Bivariate probit)

Recoding procedures

- Model 1:
  - Answers to the two yes/no questions are used to estimate the conventional double bounded model
- Model 2:
  - DN and PN recoded as "no"
  - NS, PY, and DY recoded as "yes"
- Model 3
  - DN, PN and NS (if Y1="no") recoded as "no"
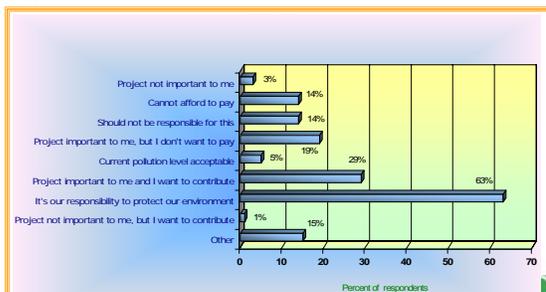 - NS (if Y1="yes"), PY, and DY recoded as "yes"

Distribution of First and Second Responses (stochastic follow-up)
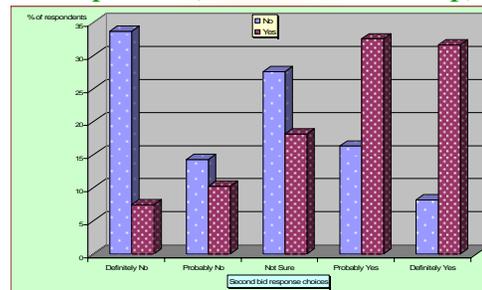
Bus Running on Biodiesel

Reasons for Zero or Positive WTP

Determinants of WTP

- **Probability of a yes decreases when:**
  - Bid price higher
  - Respondent older
  - Respondent air pollution knowledgeable

- **Probability of a yes increases when the respondent:**
  - Concerned about air pollution in her area
  - Views pollution as causes of many lung diseases
  - Belongs to at least one environmental group
  - Married or living together
  - Has high schooling and income levels
  - Finds information in survey useful and is comfortable with the survey materials

Levels of WTP

Mean/Median WTP ($)

Statistics	Conventional DC-DB Model 1	Stochastic DC-DB[b] Model 2	Model 3
Mean WTP*	157	547	347
σ	384	896	637
ρ	0.56	0.58	0.88
Delta Method[a]	119 - 195	390 - 705	234 - 461
Krinsky-Robb[a]	117 - 194	431 - 783	245 - 463
LogL	-380.82	-355.36	-340.00
N	323	313	313

*: All mean WTP estimates are significant at the one percent significance level.
a: 95% confidence interval
b: Mean and variance of WTP are constrained to be the same for both questions

Aggregate WTP ($10^6)

	Conventional follow-up Model 1	Stochastic follow-up Model 2	Model 3
Benefits	123.05	428.70	271.95
Delta	93.26 - 152.83	305.66 - 552.53	183.39 - 360.52
Krinsky-Robb	91.70 - 152.04	337.79 - 613.66	192.01 - 362.87

Annual benefits per gallon of diesel ($)						
	Conventional follow-up		Stochastic follow-up			
	Model 1		Model 2		Model 3	
Benefits	0.089		0.311		0.197	
Delta	0.068	0.111	0.222	0.401	0.133	0.261
Krinsky-Robb	0.066	0.110	0.245	0.445	0.139	0.263

Implications of the Results

- **For energy policy**
  - Citizen-consumers seem to be ready to contribute to a policy to reduce diesel related emissions
  - A premium charged to the price of biodiesel would not be protested.
  - Compensation or subsidy to biodiesel producers would be justified
- **Issues and arena for further research**
  - Biodiesel vs. Ultra Low Sulfur Diesel
  - Supply of biodiesel
  - Impact of producing more biodiesel on livestock sector