Bednets, Information and Malaria in Orissa

2009 ES Summer Meetings

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May 2009
Plan of Talk

1. Introduction and Motivation
2. Background: Larger Project
   - Motivating Questions
   - Population and Interventions
   - Baseline recorded Information (Beliefs and Expectations)
3. This talk: Modelling the Adoption decision
   - Simple Model of Net Adoption
   - Identification (Semi-Parametric)
   - Estimation (Parametric, Semiparametric)
4. Data: Observational (Baseline)
5. Model Estimation and Implications
6. Conclusions and next steps
Motivation: Malaria

- Caused in humans by four species of *Plasmodium*, *(P. falciparum)* *(Pf)* the deadliest, transmitted through the bite of *Anopheles* mosquitoes.

- Huge global burden
  - In 2002, \( \approx \frac{1}{3} \) of humans estimated to live in malarious areas
  - Recent estimates of 300-660 million PF cases annually, 80 million in India alone
  - > 1 million deaths per year, mostly young children (U5)

- Even when not fatal, health effects can be dire:
  - Long, debilitating febrile episodes
  - Anemia, respiratory problems, Hypoglycemia
  - Pregnancy complications, increased risk of low birth weight
  - Permanent neurologic and developmental impairment for children

- No vaccine currently. Only vector control, prophylaxis and treatment.
Motivation: ITNs

- Multiple randomized evaluations have demonstrated ITN effectiveness in reducing malarial burden.
- Improvements in hg levels and child nutritional status, fewer premature births
- Positive community effects

However,

- ITN usage rates remain very low
- ITNs require periodic chemical retreatment to remain effective
Question 1: Why are ITN adoption rates so low?

- Many possible explanations:
  - Preferences/discomfort.
  - Lack of adequate information.
  - Liquidity/credit constraints.
  - Biases/Issues in decision making.

- Several examples studied recently: e.g. immunization, indoor pollution, condom use, fertilizer use.

- Can we use directly elicited information on subjective expectations, preferences and probabilities along with a net provision intervention to assess different explanations?
  - Use specifically designed survey instrument to learn about the cognitive process adopted by households in deciding about ITN purchase and use
  - Combine this with information on take-up of ITN offers made by project in a random subsample of villages.
This Talk

- Write down a simple model of individual optimization to highlight the kind of information and assumptions required to recover preferences.

- Evaluate alternative approaches to account for heterogeneity (observed and unobserved) in the population and its effect on take up.

- Discuss identification and estimation of model given the data specifically collected for this purpose.

- Preliminary estimation results.
150 villages in 150 different Panchayats in five districts of Orissa (India): Balangir, Bargarh, Kandhamal (Phulbani), Keonjhar, Sambalpur.

Malaria is the “number one public health problem in Orissa” (Orissa HDR, 2004). 2003 Dept of Health and Family Welfare data show 417,000 cases of malaria (83% *falciparum*), a likely underestimate.

No previous household level testing data prior to our survey. Almost 12% tested individuals were positive, almost all *falciparum*.
Sampling Frame

- **Sample**
  - 2 stage sampling with PSUs all villages with MF partner BISWA operates. Second stage SRS of households.
  - 1,969 households from 141 villages where our BISWA operates
  - Households selected among members of “Self-Help Groups” (SHGs) in place before December 1st, 2006

- **Timeline**
  - Baseline survey (completed in May-June 2007)
  - Follow up survey currently in the field (May 2009)
Data: Nets, Consumption, Health

- **LSMS type consumption module.** Assets/Liabilities, Detailed monthly consumption expenditures.

- **Information on Nets**
  - Net price, condition, treatment status.
  - Net use “Census” of sleeping spaces.
  - Pros/Cons of net use
  - Reasons for use/lack of use/treatment
  - Information on other villagers’ use
  - Willingness to pay for cash and credit, including/excluding re-treatments

- **Self-reported health events for all hh members in 6 months before interview**
  - Event type, monetary costs, days of work/school lost
Disease and Malaria: Knowledge and Perceptions

• Perceptions about disease
  • Diarrhea, Malaria, Tuberculosis, Lymphatic Filariasis
  • Frequency of disease in village
  • Ease of prevention, diagnosis and cure
  • Likelihood of recovering with or without cure

• Malaria
  • Knowledge about causes, prevention, diagnosis, cure
  • Direct and indirect Cost of Illness (separately for a working men, working woman, non-working hh member)
Malaria and ITNs: Subjective Beliefs

- Subjective beliefs of future events are elicited using raised fingers
  - All 10 fingers “will certainly happen”
  - 0 fingers “will certainly not happen”
  - Intermediate allocations to express uncertainty

- Others have used similar tools in developing countries: e.g. Attanasio, Meghir & Vera-Hernandéz (2005), Santos and Barrett (2006), Dalavande & Kohler (2007), Giné, McKenzie, Gibson & Stillman (2007), Townsend and Vickery (2007), Lybbert, Barrett & McPeak (2007)

- Elicit probabilities that someone will contract malaria:
  - Separately for children, adults, pregnant women
  - Without use of a net, with regular use of an untreated and with regular use of a treated net
Road Map

- Introduction
- Model Basics
- Parametric and Non-Parametric Utility Specifications.
- Parametric and Semi-Parametric Error Specifications.
- Outline identification results
- Monte Carlos
- Estimation Results
Individual Problem: Discrete Choice

- Consider individual optimization problem. Agent chooses consumption \( (c) \), whether to buy a ITN \( (b \in \{0, 1\}) \) for a price \( p \). Ignore: peer effects (but allow for correlated preferences) and intrahousehold allocation issues

- Individual’s malaria contraction probability \( \pi (b) \)

\[
\pi (b) = \pi - \delta b
\]

\( \delta \) is the reduction in likelihood of malaria when using an a net. Ignore: usage.
Optimization Problem

- Random Utility Model

- Let $\tilde{u}(b, s, c; z)$ denote utility defined over net ownership ($b$), malaria status ($s \in \{L, H\}$), consumption ($c$) and shifted by exogenous covariates $z$.

- Agent maxes utility subject to a budget constraint (given prices and income). Agent will buy net if

$$
E_{\pi(1)}(\tilde{u}(1, s, c^*(p, 1, s, z), z)) \geq E_{\pi(0)}\tilde{u}(0, s, u(c^*(p, 0, s, z), z))
$$

$c^*$: optimal consumption given $(p, z, s)$. Expectations taken with respect to the probability of contracting malaria.

Econometrician only observes net purchase and a subset of $z \equiv (\tilde{x}, \epsilon_1, \epsilon_0)$.

- $\tilde{x}$ is “observed heterogeneity ”

- $\epsilon_b$ are choice specific unobservables “unobserved heterogeneity ”
Economist observes $x \equiv (b^*, c^*, \tilde{x}, \pi, \delta)$ What can we learn about $u(\cdot)$ given an i.i.d. sample of clusters each containing $H$ observations on $x$

- Depends on what we’re willing to assume about $u(\cdot), x$ and $\epsilon$!
- In general, $\epsilon_b$ and $\tilde{x}$ may be correlated
- Without further assumptions, model not identified.
- Impose
  \[
  \tilde{u}(b, s, c^*, z) = u(b, s, c^*, \tilde{x}) + \epsilon_b h(\tilde{x})
  \]
- Multiplicative separability b/w observeables and unobserveables in second part not general. But separability useful when thinking about cluster specific unobserved heterogeneity in preferences.
• Rewrite model as \( b = \mathbb{1} \{ g (u (\cdot), x) + \Delta \epsilon h \geq 0 \} \) where
(suppressing \((c^*, \tilde{x})\))

\[
g (u (\cdot), x) = \mathbb{E}_{\pi (0)} (u (1, s) - u (0, s)) + \delta (u (1, h) - u (1, m))
\]

\[
\Delta \epsilon = \epsilon_1 - \epsilon_0
\]

• **Term 1:** Expected \( \Delta \) in utility from owning a net under the probability \( \pi_0 \). If \( b \) only enters through budget constraint, should be negative

• **Term 2:** Product of (a) incremental utility from avoiding malaria when \( b = 1 \) and (b) the incremental probability of avoiding malaria when \( b = 1 \). In general should expect this term to be positive.
Econometric Issues Need to assume more about $u(\cdot)$ and $\Delta \epsilon$.

- First Choice: Is $u(\cdot)$ parametrically specified or left non-parametric.
- Second Choice: Is $\Delta \epsilon$ parametrically specified or left non-parametric.
- We have 4 possible models. What can we learn about $u(\cdot)$ in each of these models.
- Show identification results for all 4 possible combinations.
Road Map

- Parametric and Non-Parametric Utility Specifications.
- Parametric and Semi-Parametric Error Specifications.
- Outline identification results
- Monte Carlos
- Estimation Results
Non-Parametric Utility (NPU)

- Easiest link between theory and estimation
- Define

\[
\begin{align*}
\Delta_1(x) & \equiv u_1M(x) - u_0M(x) \\
\Delta_2(x) & \equiv u_1H(x) - u_0H(x) \\
\Delta_3(x) & \equiv u_1H(x) - u_1M(x)
\end{align*}
\]

- Rewrite the index model as

\[
\tilde{b} = \mathbb{1}\{\pi\Delta_1(x) + (1 - \pi)\Delta_2(x) + \delta\Delta_3(x) + \Delta\epsilon \geq 0\}
\]

- Object of Interest: The functions \((\Delta_j(\cdot))_{j=1}^3\)
- Since index only depends upon differentials.
- Rate of convergence of parameters is slow (needs smoothing parameters etc.)
- What if object of interest was household’s attitudes to risk? (Need: first and second derivatives of \(u(\cdot)\), but not identified)
Parametric Preferences

\[
    u(c, b, s; x_a, x_b) = (\alpha_0 + \alpha_1 b) c(b, s)^{1-\gamma(x_a, s; \tau)} + b\alpha_2 + bx'_b\alpha_3 + \mathbb{I}(s = m)\alpha_4 + x'_m\alpha_5\mathbb{I}(s = m) + \alpha_6 b\mathbb{I}\{s = m\} + \epsilon(b)
\]

- \(\gamma(x_a, m; \tau)\) measures risk aversion (with respect to consumption). Varies with observables and malaria status. Restrict \(\gamma \in (0, c)\) to facilitate estimation.
- \(\alpha_2\) captures the direct effect of net ownership on utility.
- \(\alpha_1\) allows marginal utility of consumption to vary by net ownership.
- \(\alpha_3\) captures effects of exogenous characteristics.
- \(\alpha_4\) captures the (dis)utility from contracting malaria.
- Object of Interest \((\alpha, \tau)\) which fully characterizes utility
Rewriting the model

\[ \mathbf{b} = \mathbf{I} \{ g(\alpha, \tau, x) + \Delta \varepsilon h(\tilde{x}) \geq 0 \} \]

\[ g(x, \alpha, \tau) \equiv \alpha_2 + \alpha_3 x_b + \alpha_4 \mathbb{I}\{s = m\} + \alpha_5 \mathbb{I}\{s = m\} x_m + \alpha_6 b \mathbb{I}\{s = m\} + (\alpha_0 + \alpha_1) h_1(\pi, \delta, c, x_a, \tau) - \alpha_0 h_0(\pi, c, x_a, \tau) \]

- Index function non-linear in parameters (because of \( \tau \)).
- Particular attention for Identification (e.g. note \( \tau \) is not identified if \((\alpha_0, \alpha_1) = 0\))
Road Map

- Parametric and Non-Parametric Utility Specifications.
- Parametric and Semi-Parametric Error Specifications.
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ERROR SPECIFICATION: PARAMETRIC

- The unobserved term $\Delta \epsilon_{hc} h(x_{hc}) = f_c + \eta_{hc}$ where $f_c$ is unobserved village level heterogeneity and conditional on $\{(x_{hc})_{h=1}^{H_c}, f_c\}$ the household specific error terms $(\eta_{1c}, ..., \eta_{H_c})$ are i.i.d. with standard logistic distribution.

- Standard fixed effect - conditional logit assumption on the errors in PU case, if index function $g(\cdot)$ where linear in $(\alpha, \tau)$ the problem would be standard

- Implement ML procedure in both PU and NPU cases
ERROR SPECIFICATION: SEMI-PARAMETRIC

- The error term $\Delta \epsilon_{hc}$ satisfies

$$median (\Delta \epsilon_{hc}|\{x_{hc}\}_{h=1}^{H}) = 0$$  \hspace{1cm} (1)

- Can allow for arbitrary $h (x_{hc})$

- This is potentially very important because unobserved term can include
  - Measurement error in Beliefs
  - Random coefficient Terms
  - Unobserved and observed heterogeneity not separable

- No specification of error distribution.

- No parametric likelihood based procedure available.
Disadvantages

- Requires location and scale normalizations on the index $g(\cdot)$
- Strong support conditions.
- Estimation requires highly non-smooth objective function
- Rate of convergence of parametric components is $n^{1/3}$ and limiting distribution is non-normal
Non-parametric Utility and Logit Errors

Assumption: Sufficient (conditional) variation in household reported beliefs

Consider the model given by non-parametric utility with conditionally logit errors. Under Assumptions (4) and (5) the utility differential functions $\Delta_j(\cdot)$ for $j = 1, 2, 3$ are identified.

- Assumptions above holding at a.e. $x$ are enough to identify $\Delta(\cdot)$.
- Proof uses variation in beliefs as key component.
Parametric Utility and Logit Errors

With parametric utility, can recover entire structure of preferences. However, need a couple of additional assumptions. In particular,

- The distribution of consumption (conditional on covariates) is continuously distributed over some range
- A second moment condition for the differenced regressors in the index (at the true parameter value)

Under these additional assumptions, the parameter vector \((\tau, \alpha)\) is point identified (Lemma 2 in paper)
Proof uses continuity of support to differentiate index and uses variability in beliefs to isolate relevant parameters.
Simulation

\[ b_{ch}^* = \mathbb{I} \{ g(x_{ch}; \alpha, \tau) + f_c + \epsilon_{ch} \geq 0 \}, \]

\( f_c \) unobserved village level preference component.

\[ g(x; \alpha, \tau) \equiv \alpha_3 x_b - \alpha_4 \delta - \alpha_5 x_m + \alpha_6 (\pi - \delta) \]
\[ + (\alpha_0 + \alpha_1) h_1 (\pi, \delta, c, x_a, \tau) - \alpha_0 h_0 (\pi, c, x_a, \tau) \]

True Parameter Vector:
\[(\tau_0, \tau_1, \alpha_0, \alpha_1, \alpha_3, \alpha_4, \alpha_5, \alpha_6) = (-.5, 0, 1, 0, 3, 1, 1, -1)\]

- Use gradient based methods (likelihood not concave though).
- Computationally intensive when number of households per cluster is large. Use Arellano and Honore (2001) M-estimator.
- Monte-Carlo results are encouraging (use 5 households per cluster)
Monte Carlo Results

Table 1: Parametric Utility and Parametric Errors

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>IQR</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N = 150$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_0$</td>
<td>0.0462</td>
<td>0.0022</td>
<td>0.7357</td>
<td>0.0331</td>
</tr>
<tr>
<td>$\tau_1$</td>
<td>-0.5737</td>
<td>-0.5683</td>
<td>0.2166</td>
<td>0.2861</td>
</tr>
<tr>
<td>$\alpha_0$</td>
<td>0.9719</td>
<td>0.9599</td>
<td>0.2206</td>
<td>0.2829</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>-0.0014</td>
<td>0.0005</td>
<td>0.0107</td>
<td>0.0086</td>
</tr>
<tr>
<td>$\alpha_3$</td>
<td>3.0157</td>
<td>3.0129</td>
<td>0.1386</td>
<td>0.1853</td>
</tr>
<tr>
<td>$\alpha_4$</td>
<td>1.0065</td>
<td>1.0057</td>
<td>0.1082</td>
<td>0.1490</td>
</tr>
<tr>
<td>$\alpha_5$</td>
<td>1.0866</td>
<td>1.1165</td>
<td>0.8568</td>
<td>1.3036</td>
</tr>
<tr>
<td>$\alpha_6$</td>
<td>-1.0292</td>
<td>-1.0131</td>
<td>0.2026</td>
<td>0.2768</td>
</tr>
<tr>
<td>$N = 600$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_0$</td>
<td>-0.0002</td>
<td>-0.0002</td>
<td>0.0105</td>
<td>0.0129</td>
</tr>
<tr>
<td>$\tau_1$</td>
<td>-0.5186</td>
<td>-0.5191</td>
<td>0.1005</td>
<td>0.1173</td>
</tr>
<tr>
<td>$\alpha_0$</td>
<td>0.9891</td>
<td>0.9907</td>
<td>0.1115</td>
<td>0.1431</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>-0.0002</td>
<td>0.0003</td>
<td>0.0036</td>
<td>0.0036</td>
</tr>
<tr>
<td>$\alpha_3$</td>
<td>3.0044</td>
<td>3.0023</td>
<td>0.0678</td>
<td>0.0925</td>
</tr>
<tr>
<td>$\alpha_4$</td>
<td>0.9968</td>
<td>0.9989</td>
<td>0.0549</td>
<td>0.0773</td>
</tr>
<tr>
<td>$\alpha_5$</td>
<td>1.0591</td>
<td>1.0443</td>
<td>0.4496</td>
<td>0.6268</td>
</tr>
<tr>
<td>$\alpha_6$</td>
<td>-1.0113</td>
<td>-1.0041</td>
<td>0.0941</td>
<td>0.1289</td>
</tr>
</tbody>
</table>

Notes: Each model was simulated 150 times. The true parameter vector is given by $(0, -0.5, 1, 0, 3, 1, 1, -1)$. 
Summary Statistics

Net Ownership

Table 2: Net Ownership

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH owns any nets</td>
<td>0.657</td>
<td>0.475</td>
</tr>
<tr>
<td>Tot nets owned by hh</td>
<td>1.589</td>
<td>1.754</td>
</tr>
<tr>
<td>Nets per head</td>
<td>0.303</td>
<td>0.317</td>
</tr>
<tr>
<td>N</td>
<td>1807</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Net Origin

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH bought some nets privately or Gov.</td>
<td>0.951</td>
<td>0.216</td>
</tr>
<tr>
<td>N</td>
<td>1187</td>
<td></td>
</tr>
</tbody>
</table>
Summary Statistics: Beliefs

Table 4: Subjective Probability of Malaria

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(malaria—no net, adult)</td>
<td>0.901</td>
<td>0.182</td>
</tr>
<tr>
<td>P(malaria—untreated net, adult)</td>
<td>0.457</td>
<td>0.206</td>
</tr>
<tr>
<td>P(malaria—ITN, Adults)</td>
<td>0.046</td>
<td>0.021</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>1807</td>
</tr>
</tbody>
</table>

Actual household incidence

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>No net</th>
<th>Any net</th>
<th>Any ITN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any malaria reported</td>
<td>0.49</td>
<td>0.48</td>
<td>0.53</td>
<td>0.55</td>
</tr>
<tr>
<td>Any +ve malaria RDT</td>
<td>0.15</td>
<td>0.16</td>
<td>0.14</td>
<td>0.08</td>
</tr>
</tbody>
</table>
### Summary Statistics: Costs

#### Actual/Expected Household Costs of Malaria

#### Actual Total Cost Per Episode

<table>
<thead>
<tr>
<th>Category</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs</td>
<td>1497</td>
<td>817</td>
<td>1981</td>
</tr>
<tr>
<td>Direct costs</td>
<td>962</td>
<td>500</td>
<td>1544</td>
</tr>
<tr>
<td>Indirect costs</td>
<td>535</td>
<td>250</td>
<td>839</td>
</tr>
<tr>
<td>Missed School or Work Days</td>
<td>10</td>
<td>7</td>
<td>13</td>
</tr>
</tbody>
</table>

#### Expected Total Cost Per Episode

<table>
<thead>
<tr>
<th>Category</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working male</td>
<td>2791</td>
<td>2300</td>
<td>2175</td>
</tr>
<tr>
<td>Working female</td>
<td>1897</td>
<td>1550</td>
<td>2009</td>
</tr>
<tr>
<td>Non-Working member</td>
<td>1829</td>
<td>1430</td>
<td>1801</td>
</tr>
</tbody>
</table>
Summary Statistics

Table 5: Attributes: Demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH members under 5</td>
<td>0.491</td>
<td>0.705</td>
</tr>
<tr>
<td>hhsize</td>
<td>5.469</td>
<td>2.216</td>
</tr>
<tr>
<td>Max yrs school completed in hh (17 and 18 recoded)</td>
<td>8.334</td>
<td>3.637</td>
</tr>
<tr>
<td>log(exp/hhsize), itemized</td>
<td>6.408</td>
<td>0.548</td>
</tr>
<tr>
<td>Total Expenditure (itemwise)</td>
<td>3638.279</td>
<td>2509.847</td>
</tr>
<tr>
<td>Per Capita Expenditure (itemwise)</td>
<td>711.234</td>
<td>486.568</td>
</tr>
<tr>
<td>N</td>
<td>1807</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Attributes: Malaria Related

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reason to dislike using nets</td>
<td>0.317</td>
<td>0.465</td>
</tr>
<tr>
<td>Bednet useful: sound sleep</td>
<td>0.129</td>
<td>0.336</td>
</tr>
<tr>
<td>Bednet useful: no bites</td>
<td>0.398</td>
<td>0.49</td>
</tr>
<tr>
<td>Bednet useful: no malaria</td>
<td>0.621</td>
<td>0.485</td>
</tr>
<tr>
<td>Thinks &gt; 50% of village uses nets</td>
<td>0.336</td>
<td>0.472</td>
</tr>
<tr>
<td>List at least one source of malaria OTHER than mosq.</td>
<td>0.287</td>
<td>0.452</td>
</tr>
<tr>
<td>Expenditure on Malaria (in '000 Rs)</td>
<td>2.839</td>
<td>2.179</td>
</tr>
<tr>
<td>N</td>
<td>1807</td>
<td></td>
</tr>
</tbody>
</table>
Estimation

- Estimate the economic model on data collected as part of designed intervention.
- Have observational (baseline) data on net ownership and will have experimental data (follow up).
- Can estimate model on both types of data, but problems with both.
- Observational Data uses information on previously purchased nets and current observeables to infer preferences.
- Belief information was collected pre-intervention and intervention may have changed these.
• Preferences

\[ v(c, b, s; x_a, x_b, x_m) = (\alpha_0 + \alpha_1 b)c(b, s)^{1-\gamma(x_a, s; \tau)} + b\alpha_2 + bx'_b\alpha_3 \\
+ \mathbb{I}(s = m)\alpha_4 + x'_m\alpha_5 \mathbb{I}(s = m) + \alpha_6 b\mathbb{I}\{s = m\} + \epsilon \]

• \( \gamma(x_a, s; \tau) \) risk aversion (wrt consumption). Varies by observeables and malaria status. Parametrize as logit.

• Net ownership affects utility directly, heterogeneity in utility from net ownership (malaria status) as well as through the budget constraint.

• Malaria directly affects utility, also heterogeneity in disutility from malaria.
## Results

### Table 7: Parametric Utility with Parametric Errors

<table>
<thead>
<tr>
<th>Variable</th>
<th>Point Estimate</th>
<th>Std.Dev</th>
<th>T-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CRRA function parameters (τ)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH Size</td>
<td>0.1187</td>
<td>0.5518</td>
<td>0.21</td>
</tr>
<tr>
<td>H. Head Education</td>
<td>1.8980</td>
<td>0.4729</td>
<td>4.01</td>
</tr>
<tr>
<td>U5</td>
<td>0.9186</td>
<td>0.4892</td>
<td>1.87</td>
</tr>
<tr>
<td>H. Head Age</td>
<td>1.7950</td>
<td>0.6278</td>
<td>2.86</td>
</tr>
<tr>
<td>Malaria Status</td>
<td>0.4569</td>
<td>0.4582</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Parameters entering Linearly (α)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchase\times Consumption (α₁)</td>
<td>-0.7194</td>
<td>0.6691</td>
<td>-1.07</td>
</tr>
<tr>
<td>Purchase\times Community Effects (α₃)</td>
<td>0.7095</td>
<td>0.1354</td>
<td>5.24</td>
</tr>
<tr>
<td>Malaria Status (α₄)</td>
<td>-0.3468</td>
<td>0.4384</td>
<td>-0.79</td>
</tr>
<tr>
<td>Malaria\times HH Size (α₅₁)</td>
<td>-0.0588</td>
<td>0.0312</td>
<td>-1.88</td>
</tr>
<tr>
<td>Malaria\times U5 (α₅₂)</td>
<td>-0.1954</td>
<td>0.1068</td>
<td>-1.82</td>
</tr>
<tr>
<td>Purchase\times Malaria (α₆)</td>
<td>0.4658</td>
<td>0.3701</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Notes: Estimated on a cluster of 129 villages with 1865 total households. Maximization was carried out using a gradient based algorithm and standard errors were computed by bootstrapping clusters with 250 replications.
Results: Maximum Score

Table 8: Parametric Utility with Semi-Parametric Error Specification

<table>
<thead>
<tr>
<th>Variable</th>
<th>Point Estimate</th>
<th>2.5 Percentile</th>
<th>97.5 Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CRRA function parameters (τ)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH Size</td>
<td>-1.54</td>
<td>-2.76</td>
<td>3.76</td>
</tr>
<tr>
<td>H. Head Education</td>
<td>-2.14</td>
<td>-4.63</td>
<td>0.43</td>
</tr>
<tr>
<td>U5</td>
<td>0.95</td>
<td>-2.68</td>
<td>4.54</td>
</tr>
<tr>
<td>H. Head Age</td>
<td>-0.30</td>
<td>-1.45</td>
<td>0.19</td>
</tr>
<tr>
<td>Malaria Status</td>
<td>1.53</td>
<td>0.57</td>
<td>3.67</td>
</tr>
</tbody>
</table>

| **Parameters entering Linearly (α)** |                |                |                 |
| Purchase×Community Effects (α₃)      | 2.53           | 0.63           | 4.57            |
| Malaria Status (α₄)                  | -1.91          | -5.10          | -0.18           |
| Malaria×HH Size (α₅₁)                | 0.02           | -0.41          | 0.25            |
| Malaria×U5 (α₅₂)                     | -0.22          | -1.82          | -0.09           |
| Purchase×Malaria (α₆)                | 1.76           | -0.01          | 6.65            |

Notes: Estimated on a cluster of 129 villages with 1865 total households. Maximization was carried out using a genetic algorithm and standard errors were computed using subsampling with subsample size set to 103 and 250 replications.
First Step Results

- Utility (and MU) depend upon net ownership.
- Malaria affects Risk Aversion: Results suggest MU of consumption is lower in malaria state.
- Malaria also has direct negative effect on utility.
- Different demographic markers associated with different preferences
- Perceptions of other’s behaviour is very important. Even after controlling for demographics and village level fixed effects (so village level net use) individual perceptions about others net use is significantly associated with a purchase decision. (but could be: rationalization. Need experimental data)
- Next, use results to conduct counterfactual exercises.
Results

Potential Questions of Interest

- What are the effects of price changes on net take up?
- What are the effects of changes in beliefs about the efficacy of nets and the incidence of malaria on net take up?
- What are the effects of changes in beliefs about community level net use on take up?

Usually, look at (changes in) choice probabilities resulting from shifts in assumed exogenous regressors.

However, in FE-BC model, choice probability $P(b_{hc} = 1 | x_{hc}, f)$ not identified.
Constructing Counterfactuals

- Instead of placing assumptions on the fixed effect to identify a choice probability, use bounding strategy.
- \( g(x_{hc}, \hat{\alpha}, \hat{\tau}) \) index function evaluated at observed \( x_{ch} \).
- \( g(x'_{hc}, \hat{\alpha}, \hat{\tau}) \) index function evaluated at policy change \( x'_{hc} \).
- Count the number of households who do not purchase a net and for whom
  \[ g(x_{hc}, \hat{\alpha}, \hat{\tau}) < 0 < g(x'_{hc}, \hat{\alpha}, \hat{\tau}) \]
- This is an upper bound on the effect of the intervention. Use this upper bound to evaluate alternative scenarios.
## Results

**Table 9: Counterfactual Exercises: Parametric Errors**

<table>
<thead>
<tr>
<th>Exogenous Shift</th>
<th>Point Estimate</th>
<th>2.5 Percentile</th>
<th>97.5 Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price of Nets Falls by 50%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average change in index</td>
<td>.002</td>
<td>.001</td>
<td>.0035</td>
</tr>
<tr>
<td>% change in index (/100)</td>
<td>.24</td>
<td>.01</td>
<td>.69</td>
</tr>
<tr>
<td>Upper bound on households “switching”</td>
<td>4</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td><strong>Beliefs in net efficacy increase by 50%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average change in index</td>
<td>.03</td>
<td>.0314</td>
<td>.0351</td>
</tr>
<tr>
<td>% change in index</td>
<td>.10</td>
<td>.002</td>
<td>.33</td>
</tr>
<tr>
<td>Upper bound on households “switching”</td>
<td>23</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td><strong>Beliefs of Community ownership increase by 50%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average change in index</td>
<td>.38</td>
<td>.35</td>
<td>.41</td>
</tr>
<tr>
<td>% change in index</td>
<td>.89</td>
<td>.62</td>
<td>.91</td>
</tr>
<tr>
<td>Upper bound on households “switching”</td>
<td>90</td>
<td>83</td>
<td>114</td>
</tr>
</tbody>
</table>

Notes: Standard errors were computed by bootstrapping clusters using 250 replications. The Average change in index is the sample average of the change in the estimated index $g(\hat{\alpha}, \hat{\tau})$ associated with the indicated exogenous shift.
Results

Table 10: Counterfactual Exercises: Maximum Score

<table>
<thead>
<tr>
<th>Exogenous Shift</th>
<th>Point Estimate</th>
<th>2.5 Percentile</th>
<th>97.5 Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of Nets ↓ by 50%</td>
<td>24</td>
<td>1</td>
<td>62</td>
</tr>
<tr>
<td>Beliefs in net efficacy ↑ by 50%</td>
<td>2</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Beliefs of Community ownership ↑ by 50%</td>
<td>18</td>
<td>2</td>
<td>58</td>
</tr>
</tbody>
</table>

Notes: The figures are estimates of the upper bound of the number of households switching to purchase as a consequence of the exogenous shift. Counterfactuals computed using parametric utility and parameter estimates from the semi-parametric error specification. Standard errors were computed using subsampling at the cluster level with subsample size set to 103 and using 250 replications.
Further Questions and Results

- Do wealthier households tend to derive higher utility from net ownership regardless of malarial status and even after controlling for other elements of preferences over nets? (Qualified Yes)
- Are wealthier and more educated households seem to be better able to smooth utility across differing malaria states? (Yes)
- Even after controlling for the direct costs of nets, do measured preferences over nets play a significant role in utility. (Yes)
- At least as measured, cost of the nets themselves is not a significant determinant of utility differentials.
Conclusions

- Developed a model of behaviour and established conditions for identification provided information on beliefs.

- Next Steps
  - Develop multinomial version of model to account for trinomial (no net, net, ITN) choice set
  - Develop a dynamic version of model to account for retreatment decisions (some results already). Time Preference Issues