The Microsimulation Approach to Policy Evaluation

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Module 7 DEC Course on Poverty and Inequality
April 14-15, 2008
Introduction

- Basic **issues**: nature, relevance and usefulness of microsimulation methods for policy evaluation
- Policy evaluation requires a social policy model that clearly links policy instruments to social outcomes.
  - Such a model has two components: one serves to explain outcomes while the second is used to assess social desirability.
- Recall fundamental determinants of outcomes
  - The distribution of economic welfare in a given society depends critically on individual *endowments* and *behavior*, and the socio-political arrangements that govern social *interaction*. 
Introduction

- **What is a microsimulation model?**
  - A logical representation of the behavior of individual agents and their economic environment used to simulate the consequences of a policy reform on the level of activity or welfare for each individual in a representative sample for the whole population.
Building and running a microsimulation entails three basic inputs (Bourguignon and Spadaro 2006):

- The policy rules to be evaluated (e.g. tax schedule)
- A theoretical model of individual response to policy
  - Standard economic analysis relies on the optimization principle and the market system to explain behavior and social interaction.
- A micro-data set with information on observed economic and socio-demographic characteristics of individuals or households
Introduction

- Two basic approaches commonly used to build microsimulation models. The both rely of the optimization principle.
  - **Envelope approach**: represents optimal behavior by an envelope or maximum value function (Dixit 1990)
  - **Discrete choice framework**: seeks to explain the behavioral process leading to choices made by an agent facing a discrete choice opportunity set.
Introduction

- A choice set is discrete if it contains a finite number of all possible and mutually exclusive alternatives (e.g. not working, working part time and working full time).

- Usefulness of the microsimulation approach is better understood when compared with the alternative based on representative agents.
Introduction

- Representative agent approach can hide much of the heterogeneity in agents’ behavior that explains variation in outcomes.

- **Microsimulation** uses micro-data sets, it is therefore possible to fully account for (at least) the observed heterogeneity of socioeconomic agents
  
  - Hence, microsimulation provides a more precise way of identifying likely winners and losers from a policy reform
Introduction

- Microsimulation also improves the accuracy in evaluating the impact of a policy on the government budget.
Introduction

Outline

1. The Envelope Approach
   - Structure
   - Fiscal Incidence Analysis
   - Interaction with a CGE model

2. Discrete Choice Framework
   - Structure
   - Distributional Impact of Education Policy
The Envelope Approach

- **Structure**
  - Consumer has exogenous budget $y$ to spend on a set of commodities at fixed prices within a period of time
  - Maximum attainable utility (Deaton and Muellbauer 1980)
    \[ v(y, p) = \max_q [u(q); p \cdot q = y] \]
  - Corresponding expenditure function, similarly defined: minimum level of expenditure required to achieved given level of utility at prevailing prices
    \[ e(u, p) = \min_q [p \cdot q; v(q) = u] \]
The Envelope Approach

- Channel of transmission of policy impact:
  - Budget constraint: a parameterized representation of the socioeconomic environment which mediates the effect of policy on welfare.
  - Any policy affecting prices or disposable income would affect individual welfare through budget constraint.
- Simulation of welfare impact of policy based on envelope theorem
The Envelope Approach

- Theorem shows how to compute the impact of a parametric change on the objective function at the optimum.
- Change in objective function induced by change in the parameter while the choice variable adjusts optimally is equal to the partial derivative of the optimal value of the objective function with respect to the parameter of interest (Varian 1984).
The Envelope Approach

- **Fiscal Incidence Analysis**
  - Fiscal incidence analysis entails a comparison of the original distribution of economic welfare (without government activity) with the ex post distribution.
  - Welfare impact of a marginal change in income tax equal marginal utility of income (unobservable) times change in income:
    \[ \Delta v = v_y \Delta y \]
  - Expression in terms of equivalent variation in income (Bourguignon and Spadaro 2006)
    \[ \Delta y^* = \Delta v / v_y \]
The Envelope Approach

- Welfare impact of a marginal reform of \textit{indirect taxes} channeled through changes in commodity prices.
  
  - Indicators of tax burden
    
    - Equivalent variation: maximum an individual would be willing to pay to avoid the tax and induced change in prices
      
      \[ EV = [e(p^1, u^1) - e(p^0, u^1)] \]

    - Compensating variation is the minimum amount of income an individual should be given in compensation for the price change in order to keep her as well off as before the change
      
      \[ CV = [e(p^1, u^0) - e(p^0, u^0)] \]
The Envelope Approach

- If using indirect utility function, invoke Roy’s identity (a manifestation of the envelope theorem) to compute equivalent variation in income induced by price indirect tax reform:
  - Marshallian demand function of a commodity equals the negative of the first-order derivative of the indirect utility function with respect to the commodity price, divide by the marginal utility of income. Hence following indicators of the welfare impact of indirect taxes:
    \[ \Delta v = -v_y \sum_{k=1}^{m} q_k \Delta p_k \]
    - In terms of equivalent variation in income.
    \[ \Delta y^* = -\sum_{k=1}^{m} q_k \Delta p_k \]
The Envelope Approach

- Ratio of equivalent variation to total expenditure is an indicator of progressivity

Table 1 Alternative Tax Options for Australia

<table>
<thead>
<tr>
<th>Expenditure Group</th>
<th>Option A</th>
<th>Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clothing and Footwear</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Furniture and Appliances</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Motor Vehicles and Parts</td>
<td>0.40</td>
<td>0.30</td>
</tr>
<tr>
<td>Recreation Items</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>House-Building Payments</td>
<td>0.40</td>
<td>0.30</td>
</tr>
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</table>

Source: Creedy (2001)
The Envelope Approach

Table 2. Ratio of Equivalent Variations to Total Expenditure

<table>
<thead>
<tr>
<th>Weekly Expenditure</th>
<th>Option A</th>
<th>Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>0.075</td>
<td>0.078</td>
</tr>
<tr>
<td>400</td>
<td>0.098</td>
<td>0.102</td>
</tr>
<tr>
<td>600</td>
<td>0.116</td>
<td>0.118</td>
</tr>
<tr>
<td>800</td>
<td>0.128</td>
<td>0.129</td>
</tr>
<tr>
<td>1000</td>
<td>0.138</td>
<td>0.138</td>
</tr>
<tr>
<td>1200</td>
<td>0.147</td>
<td>0.145</td>
</tr>
<tr>
<td>1400</td>
<td>0.160</td>
<td>0.157</td>
</tr>
</tbody>
</table>

Source: Creedy (2001)
The Envelope Approach

- Table 2 above shows normalized equivalent variations for a range of weekly total expenditures is dollars.
- Both Tax options would be progressive since the normalized EV increases with the level of expenditure.
- Poverty-focused evaluation: Assess progressivity of indirect taxes on the basis of the price elasticity of poverty measures (e.g. Watts or members of the Foster-Greer-Thorbecke family)
The Envelope Approach

- Let $\psi(y \mid z)$ be a measure of poverty at individual level ($y$ is same as above and $z$ is poverty line)
- Assume: (1) indicator is zero when $y$ greater or equal poverty line; (2) a decreasing convex function of $y$, given $z$. Hence first-order derivative with respect to $y$ is negative.
- Then poverty impact of tax induced price change is:

\[
\frac{\partial \psi(y \mid z)}{\partial p_k} = -\psi'(y \mid z)q_k
\]
The Envelope Approach

- Additively Separable Poverty Measures

\[ \theta = \int_0^\infty \psi(y|z)f(y)dy \]

- Aggregate impact of price change

\[ \frac{\partial \theta}{\partial p_k} = -\int_0^z q_k \psi'(y|z)f(y)dy \]

- Price elasticity of real income

\[ \frac{\partial y}{\partial p_k} \cdot \frac{p_k}{y} = -\frac{p_k q_k}{y} = -w_k(y) \]

- Price elasticity of poverty

\[ \phi_k(\theta) = -\frac{1}{\theta} \int_0^\infty y w_k(x) \psi'(y|z)f(y)dy \]
The Envelope Approach

- An increase (reduction) in price of commodity $k$ (possibly induced by a tax reform) is pro-poor if it leads to an absolute increase (reduction) in poverty smaller (greater) than it would in a benchmark case.
- Chosen benchmark: situation of equal relative impact i.e. a one percent change in price of $k$ would have the same relative impact on real income $x$.
- If everybody assigned same proportion of real income, $w_{ok}$, to the purchase of $k$.

$$w_{ok} = \frac{\int_0^{\bar{y}} y w_k(y) f(y) dy}{\int_0^{\bar{y}} y f(y) dy}$$
The Envelope Approach

- Benchmark price elasticity of poverty

\[ \varphi_{ok}(\theta) = -\frac{w_{0k}}{\theta} \int_0^y y\psi'(y | z) f(y) \, dy \]

- A one percent increase in the price of commodity \( k \) would increase poverty by \( \theta \varphi_k \) under the observed budget shares, and by \( \theta \varphi_{0k} \) in the hypothetical case.

- Whether the change is pro-poor depends on which term dominates
The Envelope Approach

- Decision Rule
  - Based on a comparison of the poverty impact given the observed distribution of budget shares and the hypothetical impact
  - Choice between ratio or additive comparison
    - Focus on ratio comparison
  - Normalize budget shares
    \[ a_k(y) = \frac{w_k(y)}{w_{0k}} \]
  - Ratio measure of pro-poorness is a weighted average of normalized budget shares among the poor (i.e. along the distribution of real income up to the poverty line)
    \[ \xi_k(\theta) = \frac{\int y a_k(y) \psi(y \mid z) f(y) dy}{\int y \psi(y \mid z) f(y) dy} \]
  - Price increase would hurt the poor less than the non-poor if this indicator less than one.
Table 3. Guinea (1994): Distributional Characteristics of Components of Food Expenditure

<table>
<thead>
<tr>
<th>Item</th>
<th>Poverty Gap</th>
<th>Squared Poverty Gap</th>
<th>Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>0.65</td>
<td>0.56</td>
<td>0.61</td>
</tr>
<tr>
<td>Palm Oil</td>
<td>1.22</td>
<td>1.16</td>
<td>1.19</td>
</tr>
<tr>
<td>Bread</td>
<td>0.78</td>
<td>0.72</td>
<td>0.75</td>
</tr>
<tr>
<td>Fresh Fish</td>
<td>0.53</td>
<td>0.45</td>
<td>0.49</td>
</tr>
<tr>
<td>Smoked Fish</td>
<td>1.10</td>
<td>1.14</td>
<td>1.12</td>
</tr>
<tr>
<td>Local Rice</td>
<td>1.33</td>
<td>1.30</td>
<td>1.30</td>
</tr>
<tr>
<td>Imported Rice</td>
<td>1.17</td>
<td>1.23</td>
<td>1.30</td>
</tr>
<tr>
<td>Sugar</td>
<td>1.10</td>
<td>1.07</td>
<td>1.09</td>
</tr>
<tr>
<td>Cereals</td>
<td>1.57</td>
<td>1.57</td>
<td>1.57</td>
</tr>
<tr>
<td>Roots</td>
<td>1.53</td>
<td>1.56</td>
<td>1.55</td>
</tr>
<tr>
<td>Grains</td>
<td>1.56</td>
<td>1.61</td>
<td>1.59</td>
</tr>
<tr>
<td>Fruits</td>
<td>0.99</td>
<td>0.91</td>
<td>0.95</td>
</tr>
<tr>
<td>Vegetables</td>
<td>1.26</td>
<td>1.28</td>
<td>1.28</td>
</tr>
<tr>
<td>Meats</td>
<td>0.83</td>
<td>0.76</td>
<td>0.79</td>
</tr>
<tr>
<td>Livestock</td>
<td>0.94</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Beverages</td>
<td>0.57</td>
<td>0.47</td>
<td>0.52</td>
</tr>
<tr>
<td>Oils</td>
<td>1.14</td>
<td>1.08</td>
<td>1.10</td>
</tr>
<tr>
<td>Sweets</td>
<td>1.04</td>
<td>1.01</td>
<td>1.03</td>
</tr>
<tr>
<td>Canned Food</td>
<td>0.42</td>
<td>0.37</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Source: Essama-Nssah (2007)
The Envelope Approach

- Application to data for Guinea
  - Table 3: estimates of the distributional characteristics for 19 components of food expenditure based on the Watts index of poverty and two measures from the FGT family.
  - 11 food items might deserve special consideration in the context of marginal commodity tax reform
    - Palm oil, smoked fish, rice (both local and imported), sugar, cereals, roots, grains, vegetables, oils and sweets.
The Envelope Approach

- Interaction with a CGE Model
  - Boccanfuso and Savard (2007) show how one could embed a microsimulation module base on the envelope approach within a CGE.
  - Approach illustrated in the case of Mali: study of the poverty and inequality implications of the removal of cotton subsidies from developed countries.
  - CGE component is standard representation of small open economy.
  - Communication between modules is top-down.
  - Bottom based on sample of 4,966 households.
The Envelope Approach

- Single Representative Household (RH) in CGE share specification of income and expenditure as households in the sample
- Behavioral heterogeneity achieved by calibrating these functions not on the aggregate data in the SAM but on household-specific information found in the survey.
- Specification of income equation for each household is based on the sources and relative factor endowments found in the survey.
- Observed factor endowments are considered exogenous.
The Envelope Approach

- For tax incidence analysis in this framework:
  - Simulate structural changes induced by fiscal reform using CGE (including variation in factor payments induced by policy reform).
  - Bring these results into the microsimulation and use income equations to estimate variations in gross and disposable income.
  - Use variation in disposable income to infer variation in real consumption.
  - Standard indicators (poverty, inequality) can then be computed to assess the distributional implications of the policy reform under consideration.
Discrete Choice Framework

- **Structure**
  - Two fundamental constituent elements: *Choice set* (labor supply models: not working, working part time and working full time) and *decision rule*.
  - Decision process assumes utility-maximizing behavior.
  - Utility is unobservable, hence *random utility framework*.
    - Two parts: representative utility and random factors (Train 2003)
    - Representative utility is a function of some observable characteristics of the decision maker and possibly of the alternatives.

\[
U_{hj} = V_{hj} + \epsilon_{hj}
\]
Discrete Choice Framework

- Can only make probabilistic statements about decision maker's choice.
  - Decision maker would choose alternative $j$ if and only if
    \[ U_{hj} > U_{hi} \quad \forall i \neq j \]
  - Probability that option $j$ is chosen by agent $h$ is defined as follows
    \[ P_{hj} = \Pr \left( \varepsilon_{hi} - \varepsilon_{hj} < V_{hi} - V_{hj} \right) \quad \forall i \neq j \]
  - Assuming that the random factors are independently and identically distributed (iid) extreme value variables for all options leads to the common logit model.
There are situations where probabilities estimated from a discrete choice model can be interpreted as expected demand for a service and distributional analysis can proceed mainly on the basis of these probabilities.
Discrete Choice Framework

- Distributional Impact of Education Policy
  Glick and Sahn (2006) estimate a discrete choice model of primary schooling for rural Madagascar and evaluate several policy options on the basis of their distributional impact and of cost to the government.
  - Choice set facing parents with primary school-age children: no schooling, public school, and private school.
Discrete Choice Framework

- Parents derive utility from the human capital of their children and from the consumption of other goods.
- Determinants of representative utility: school quality, individual and household characteristics, household income and the cost associated with the chosen option.
- A generalized extreme value specification is chosen for the random component of utility leading to a nested multinominal logit model.
- The estimated probabilities of choosing a schooling option are interpreted as expected enrollment and provide the basic inputs for distributional analysis.
Discrete Choice Framework

- Policy options: (1) add teachers to schools to reduce multigrade teaching by 50 percent; (2) option 1 combined with increase public fees by FMG 200 (Franc Malgache, local currency); (3) school consolidation to eliminate multigrade teaching.

- Progressivity of each policy option based on the changes in the distribution of expected enrollment across expenditure quantiles.
Discrete Choice Framework

- **Specific measures:**
  - Let $R$ and $N$ stand for overall primary school enrollment and the total population of primary school age children. The corresponding value for each quantile are: $R_q$ and $N_q$.
  - The average enrollment in quantile $q$ is:
    $$A_q = \frac{R_q/R}{N_q/N}$$
  - The relative marginal shares in enrollments id:
    $$M_q = \frac{\Delta R_q/\Delta R}{N_q/N}$$
Table 4 Distributional Impact of Education Policy Options in Madagascar

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Baseline Average Benefits</th>
<th>Policy 1</th>
<th>Policy 2</th>
<th>Policy 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$A_q$</td>
<td>$M_q$</td>
<td>$A_q$</td>
</tr>
<tr>
<td>1</td>
<td>0.77</td>
<td>0.78</td>
<td>0.97</td>
<td>0.76</td>
</tr>
<tr>
<td>2</td>
<td>1.01</td>
<td>1.02</td>
<td>1.13</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>0.98</td>
<td>0.99</td>
<td>1.13</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>1.18</td>
<td>1.16</td>
<td>0.88</td>
<td>1.19</td>
</tr>
<tr>
<td>5</td>
<td>1.38</td>
<td>1.34</td>
<td>0.69</td>
<td>1.38</td>
</tr>
<tr>
<td>All</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Source: Glick and Sahn (2006)
Discrete Choice Framework

- First policy would be progressive: the increase in the primary enrollment rate is larger for the bottom 3 quintiles than for the top 2.
  - Relative marginal shares indicate that both the second and third quintiles’ share of the increase in the enrollment induced by the policy is proportionately 13 percent higher than their shares of the rural primary school age population (marginal incidence).

- Lower quintiles would lose under the second policy while the top ones would gain.
  - The bottom two quintile would get only 38 and 46 percent of their school age population shares. This outcome might be avoided by structuring the cost recovery program in such a way that richer households or communities pay substantially higher fees with the proceeds going to subsidize poor communities.
  - Distributional implications of the last policy option are analogous to those of the first.
References


References


References


• The End.