



Strategies for reconstruction of houses damaged by earthquakes

Hiroyuki Sakakibara
Yamaguchi University, Japan

Introduction

- Tottori-Seibu (Western Tottori) Earthquake (2000)
- Miyagi-Hokubu (Northern Miyagi) Earthquake (2003)
- Niigata-Chuetsu Earthquake (2004)

- Subsidizing policy was positively evaluated from the viewpoint of keeping community's sustainability.
- Subsidizing policy may have affected households' decision (rebuilding or repairing).
- Subsidizing policy may reduce incentives to purchase insurance, retrofit in advance
- Feasibility in case of larger natural disasters

- ◆ Questionnaire survey (2003-2005)
- ◆ Decision model construction



Viewpoints of Analysis

- Which factor has affected households' choices?
 - Physical damage to houses
 - Family attribution
- Effects of subsidizing policy
- Differences between regions



Rebuilding and Repairing

- Rebuild: To construct a new house after a damaged house is demolished
- Repair: To restore a damaged house to its original condition
- In each region, the amounts of subsidies depend on reconstruction activities (rebuilding or repairing).

Questionnaire Survey Outline

- Tottori-seibu earthquake damaged area
 - Subsidies: 3 million yen for rebuilding, 1.5 million yen for repairing
 - Hino and Sakaiminato
 - 965 delivered, 371 returned (38.4%)
- Miyagi-hokubu earthquake damaged area
 - Subsidies: 1 million yen for rebuilding, 0.5 million yen for repairing
 - Yamoto and Kanan
 - 814 delivered, 289 returned (35.5%)
- Niigata-Chuetsu earthquake damaged area
 - Subsidies: Depending on resident's income, age and damage level of houses.
 - Kawaguchi
 - 1533 delivered, 451 returned (29.4%)

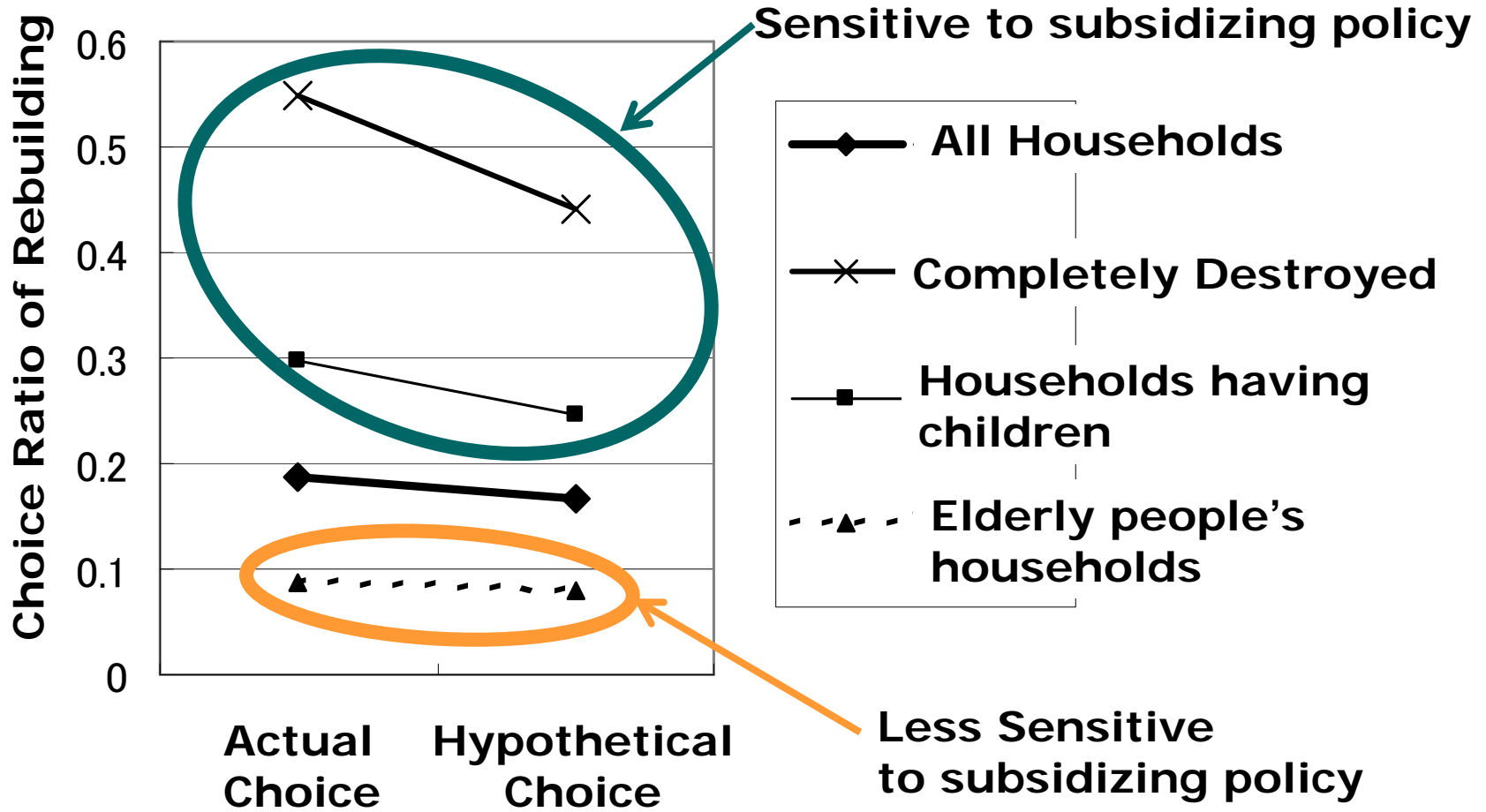
Examples of items asked in questionnaires

- ◆ Lifetime of a House
- ◆ Purchase of Earthquake Insurance or Mutual Fund
- ◆ Evacuation after Earthquake
- ◆ Damage Level of the Earthquake on a House (judged by local authority)
- ◆ Damaged Part
- ◆ Choice on Reconstruction (**Actual Choice**) (Rebuild, Repair, Giving up Reconstruction)
- ◆ Cost for Reconstruction / Repairing
- ◆ **Hypothetical choice in no subsidy case** (Rebuild, Repair, Giving up Reconstruction)
- ◆ Measures Taken after the Earthquake
- ◆ Properties of a Family (age, number of members)

“Actual” and “Hypothetical” Choices

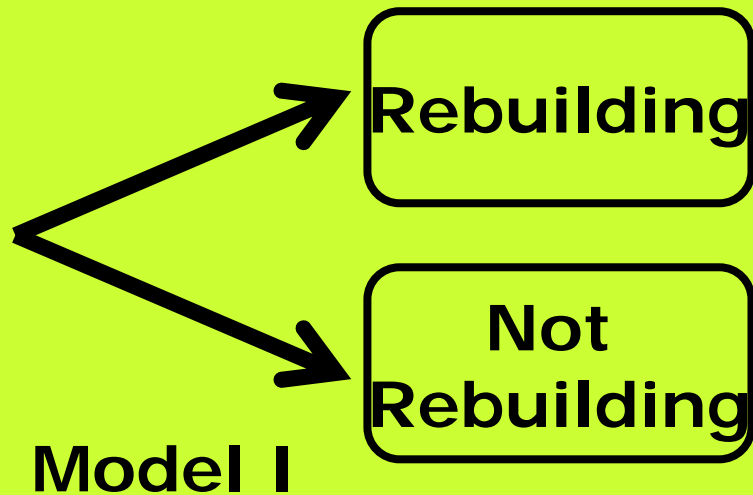
- Actual choice: Choices taken actually by the corresponding household
- Hypothetical Choice
 - Choices stated by households assuming the case where subsidizing policies were not introduced
 - “If subsidies for reconstruction of damaged houses were not provided, which action would you choose?”

Choice Ratio of “Rebuilding”

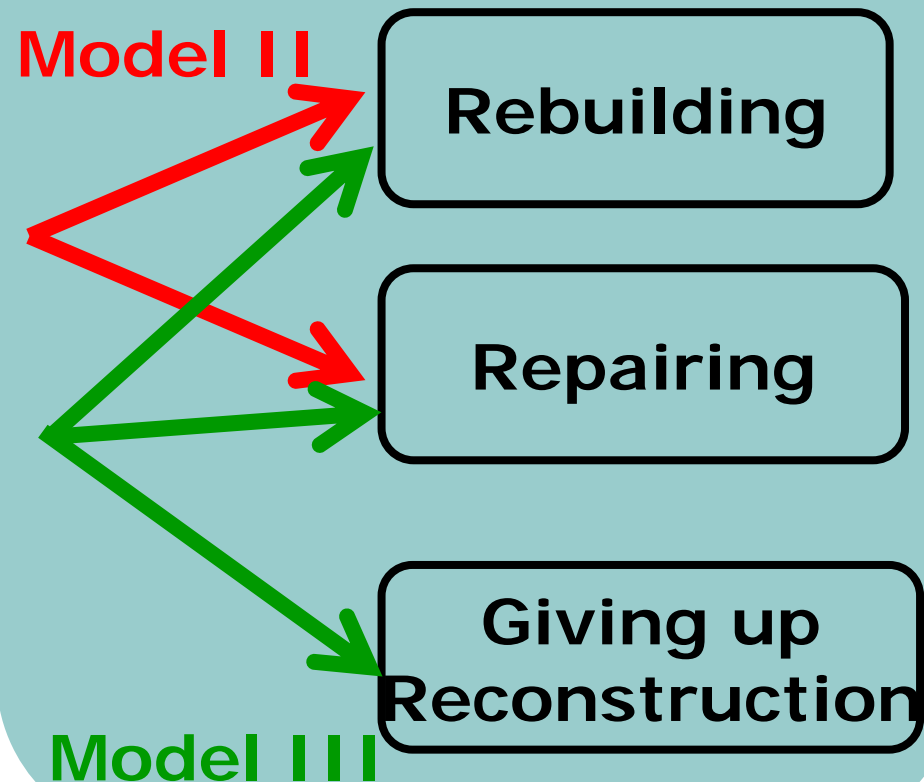


Choice Model Construction

Actual Choice



Hypothetical Choice in No Subsidy Case



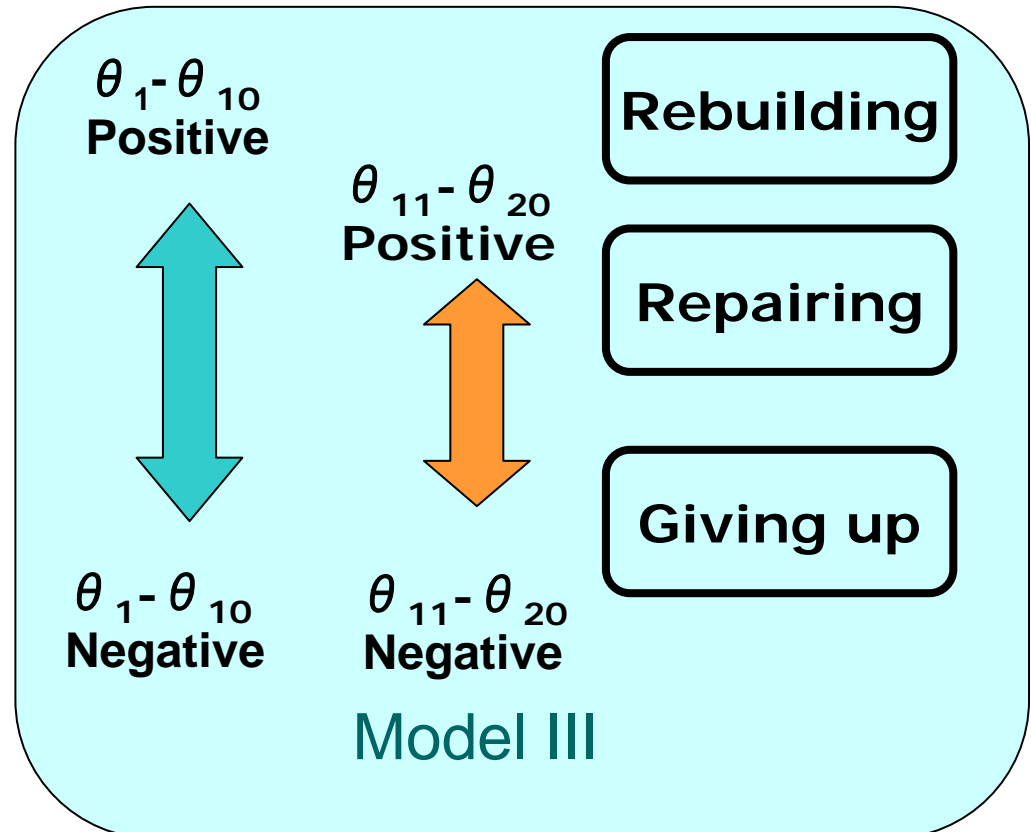
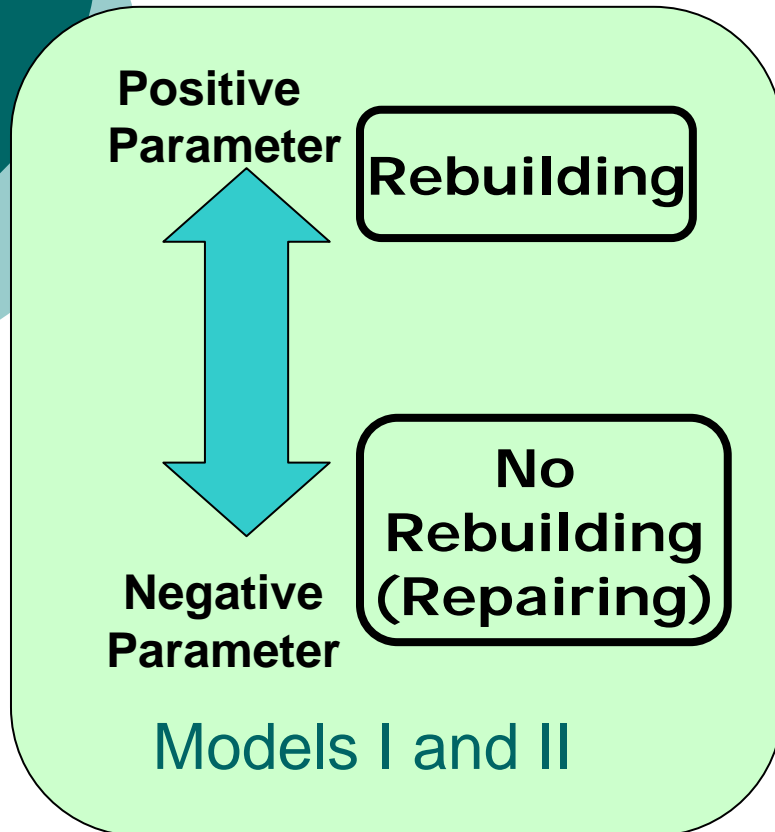
Parameters for Discrete Choice Models

| Parameter | | Name of Variable X_{kn} | Definition |
|---------------|---------------|----------------------------|--|
| θ_1 | θ_{11} | | Constant |
| θ_2 | θ_{12} | Lifetime of a House | The number of years |
| θ_3 | θ_{13} | Insurance | Purchase of insurance or mutual fund = 1 |
| θ_4 | θ_{14} | Evacuation | Evacuation from houses = 1 |
| θ_5 | θ_{15} | Completely Destroyed | Completely destroyed = 1 |
| θ_6 | θ_{16} | Structural Damages | Damage on basement, column, or beam = 1 |
| θ_7 | θ_{17} | Other Damages | Other damages = 1 |
| θ_8 | θ_{18} | Children | Children younger than 10 years old = 1 |
| θ_9 | θ_{19} | Elderly People's Household | Incomes mainly from elderly people = 1 |
| θ_{10} | θ_{20} | Location Dummy | Hino or Kawaguchi =1, Other areas = 0 |

“Location Dummy”

- One of the reasons that Tottori prefectural government introduced subsidies was to mitigate damages in depopulated areas and to support local communities.
- In order to analyze characteristics of choices in depopulated areas, “location dummy” was introduced.
- National census shows that decrease of population is significant in Hino in Tottori and Kawaguchi in Niigata.
- Location dummy becomes 1 when a household live in Hino or Kawaguchi.

Relationships between Parameters and Choices



Parameter Estimation Results of Model I (Actual Choice) (1)

| Parameters | Estimated Value | <i>t</i> Value |
|---|-----------------|----------------|
| θ_1 (Constant) | -3.964 | -9.142** |
| θ_2 (Lifetime of a House) | 0.027 | 6.820** |
| θ_3 (Insurance) | 0.199 | 0.829 |
| θ_4 (Evacuation) | 1.24 | 4.082** |
| θ_5 (Completely Destroyed) | 3.501 | 14.694** |
| θ_6 (Structural Damages) | 0.51 | 1.809* |
| θ_7 (Other Damages) | -0.122 | -0.409 |
| θ_8 (Children) | 0.621 | 2.355** |
| θ_9 (Elderly People's Household) | -1.762 | -5.641** |
| θ_{10} (Location Dummy) | -1.273 | -4.237** |

* 10% Significance ** 5% Significance

Likelihood Ratio: 0.566, Hitting ratio: 87.1%

Parameter Estimation Results of Model I (Actual Choice) (2)

- The households whose houses were heavily damaged tend to choose rebuilding (Positive θ_5).
- The parameter for “children” (θ_8) is positive and significant. The households including children tend to choose rebuilding.
- The parameter for “Elderly People’s Household” (θ_9) is negative and significant. The elderly people’s households tend to avoid rebuilding.
- The parameter for “Location Dummy” (θ_{10}) is negative and significant. The households in depopulated areas tend to avoid rebuilding.

Parameter Estimation Results of Model I I (Hypothetical Choice) (1)

| Parameters | Estimated Value | <i>t</i> Value |
|---|-----------------|----------------|
| θ_1 (Constant) | -2.255 | -5.554** |
| θ_2 (Lifetime of a House) | 0.012 | 3.097** |
| θ_3 (Insurance) | -0.089 | -0.342 |
| θ_4 (Evacuation) | 0.474 | 1.716* |
| θ_5 (Completely Destroyed) | 2.689 | 11.077** |
| θ_6 (Structural Damages) | 0.552 | 1.924* |
| θ_7 (Other Damages) | -0.439 | -1.465 |
| θ_8 (Children) | 0.319 | 1.208 |
| θ_9 (Elderly People's Household) | -1.197 | -3.867** |
| θ_{10} (Location Dummy) | -1.049 | -3.877** |

* 10% Significance ** 5% Significance
Likelihood Ratio: 0.485, Hitting ratio: 85.7%

Parameter Estimation Results of Model I I (Hypothetical Choice) (2)

- The parameter for “Children” (θ_8) is not significant .
- Some households including children may give up rebuilding if subsidy is not provided.
- There is a possibility that subsidy accelerated rebuilding of houses by the households having children.

Parameter Estimation Results of Model III (Hypothetical Choice) (1)

| Variables | Rebuild Parameters | | | Repair Parameters | | |
|----------------------|--------------------|-----------------|----------------|-------------------|-----------------|----------------|
| | | Estimated Value | <i>t</i> Value | | Estimated Value | <i>t</i> Value |
| Constant | θ_1 | -1.709 | -4.167** | θ_{11} | 0.442 | 1.684* |
| Lifetime of a House | θ_2 | 0.013 | 2.987** | θ_{12} | 0.002 | 0.619 |
| Insurance | θ_3 | 0.529 | 2.012** | θ_{13} | 0.428 | 2.466** |
| Evacuation | θ_4 | 0.521 | 1.845* | θ_{14} | 0.074 | 0.388 |
| Completely Destroyed | θ_5 | 1.513 | 5.718** | θ_{15} | -1.215 | -5.848** |
| Structural Damages | θ_6 | 0.557 | 1.831* | θ_{16} | -0.035 | -0.192 |
| Other Damages | θ_7 | 0.092 | 0.313 | θ_{17} | 0.6 | 3.281** |
| Children | θ_8 | 0.537 | 1.815* | θ_{18} | 0.283 | 1.186 |
| Elderly People's | θ_{10} | -1.309 | -4.233** | θ_{19} | -0.092 | -0.493 |
| Location Dummy | θ_{11} | -1.315 | -4.641** | θ_{20} | -0.12 | -0.623 |

* 10% Significance ** 5% Significance

Likelihood Ratio: 0.284, Hitting ratio: 67.0%

Parameter Estimation Results of Model III (Hypothetical Choice) (2)

- Both of the parameters for “Insurance” (θ_3 and θ_{13}) are positive and significant. Insurance and mutual fund can play a critical role in reconstruction of houses in no subsidy case.
- The signs of the parameters for “Completely Destroyed” (θ_5 and θ_{15}) are opposite. When houses are completely destroyed by an earthquake, some households try to rebuild even in no subsidy case (positive θ_5), and others may give up reconstruction (negative θ_{15}).



Effects of Subsidizing Policy

Sensitive to Rebuilding Subsidies

- Households whose houses are completely destroyed
- Households including children

Less sensitive to Rebuilding Subsidies

- Elderly people's households
- Households in depopulated areas

(Subsidies for repairing may be effective for such households)

Policy for Housing Reconstruction

- Two types of subsidies (depending on purposes)
 - Subsidies to sensitive households
 - Subsidies for elderly people or depopulated areas
- Coordination with mitigation activities

Retrofitting



Decrease of Damaged houses



Decrease of Costs for Reconstruction
(subsidies, demolishing)