被災者の居住地選択行動の動学モデルと異質性分析

Dynamic Model and Heterogeneity Analysis of Post-Disaster Residential Choice Behavior

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After The Great East Japan Earthquake in Tohoku…

Stage	When	Where	Decision
0 Emergency Evacuation	～a few days	Home, workplace, etc.	Emergency evacuation site
1 Evacuation Life	～a few months	Evacuation shelters, Relatives' homes, etc.	Evacuation shelters/ Relatives' homes
2 Temporary Housing	～around 2013	Evacuation shelter, etc →	Temporary housing / Relative's home / Disaster public housing/ Relocation

Housing shortage
: Apporx. 49,000 prefabricated temporary units vs. 69,000 privately rented units leased by governments

Evacuees found rental properties themselves, which were later leased by local governments

Moving out of such housing ended assistance, making the new residence ineligible for rent support.

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2 Temporary Housing	2011～2013	Evacuation shelter, etc.	Temporary housing / Relative's home / Disaster public housing/ Relocation
3 Settling in/ Returning home	2012～a long term	**Outside the Area originary living**	**Returning home／Settling in a new place**

Housing shortage → Prolonged stays in temporary housing → Residents unable or unwilling to return

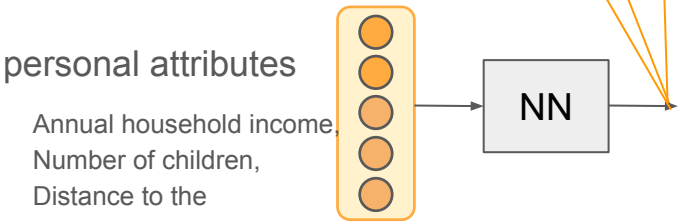
→ Accelerated population decline in rural areas

Taste Net

Taste Net:

$$V_{t,returning} = \alpha_n + \beta_n X_{Housing\ supply\ rate,t}$$

$$V_{t,staying} = \gamma_n X_{Years\ after\ evacuation,distance,}$$



Inter-individual heterogeneity in policy sensitivity:

"Individuals with high annual incomes are less sensitive to the provision of public housing because they can afford to purchase a home on their own."

"Individuals who have had children are highly sensitive to the length of time spent at an evacuation site."

	mean	median	sd
α_n	-0.98	-0.98	0
β_n	0.32	0.30	0.05
γ_years	0.56	0.50	0.24
γ_distance	0.51	0.42	0.25

The log-likelihood is no better than that of a constant model, and the sample size is too small to perform stable machine learning.

MXL & DDCM

Dynamic Model of Return Timing

Let the choice set be $a_{nt} \in \{R, W\}$, where ***R*** denotes returning home and ***W*** denotes continuing to live outside the affected area

$$\boxed{c_n = z_n^\top \gamma + \sigma u_n, \qquad u_n \sim N(0,1)}$$

$$z_n = \begin{pmatrix} Disaster_n \\ Income_n^* \\ Children_n \\ Distance_n^* \end{pmatrix}$$

- c_n : Individual-apecific resistance to retrun that persists over time
- $z_n^T \gamma$: Component explained by observed attributes
- σu_n : Unobserved individual heterogeneity
- * : Implemented transformations and standardization are specified in the footnote

MXL & DDCM based modeling

Choice-Specific Value Functions

Cumulative housing supply progress rate in the municipality of origin

Return $v_{R,nt}(c_n) = \beta_R R_{m_n t} - c_n$ threshould

Wait $v_{W,nt}(c_n) = v_W = \delta V_{来年}$

V : Value derived from optimal future choices

δ : Annual discount factor(0.95)

$c_n = \gamma_1 * D_{Disaster} + \gamma_2 * L_{income} + \gamma_3 * N_{child} + \sigma_n$

Individual Features

Individual Fluctuation

Data

Tohoku_History

- Residential history over the 20 years since 2004 for individuals who have lived in Iwate, Miyagi, or Fukushima.
- **Housing Recovery Schedule** (Reconstruction Agency)
- Supply status of housing sites for public disaster-recovery housing, private housing, etc., listed by fiscal year.
- Shikoku Statistics (e-Stat, local governments)

Estimation Results

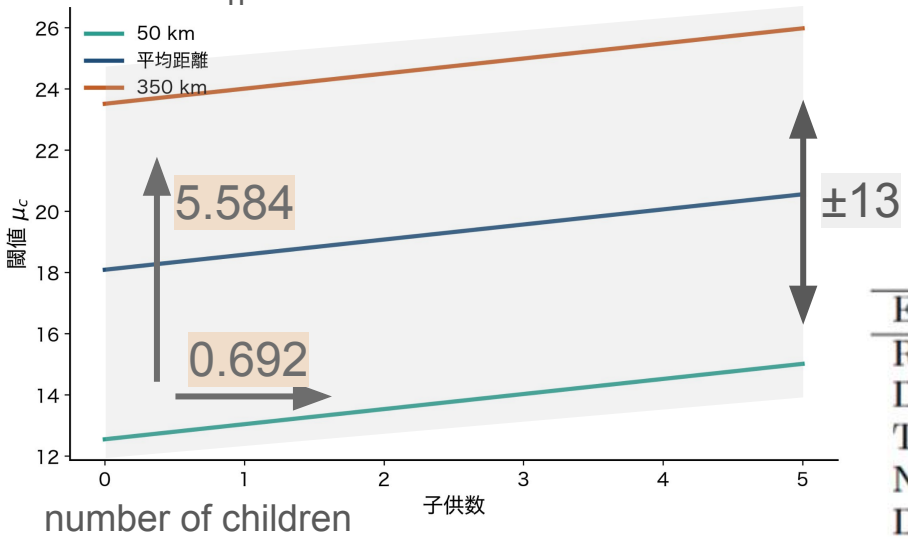
- Housing supply encourages return but remains unstable.
- Distance from the evacuation site significantly and positively raises the threshold.

Explanatory Variable	Parameter	DDCM		DDCM-choice	
Reconstruction supply	β_R	-1.334	**	0.692	
Disaster	γ_{disaster}	3.349	***	18.523	***
Transformed income	γ_{income}	0.151		-0.030	
Number of children	γ_{children}	-0.064		0.569	
Distance from origin	γ_{distance}	1.009	**	5.584	***
Individual heterogeneity	σ	–		13.653	***
Initial log-likelihood		-196.516		-150.281	
Final log-likelihood		-152.154		-133.805	

Note: $^{*}p < 0.05$, $^{**}p < 0.01$, and $^{***}p < 0.001$.

- The final likelihood has improved.
- ↔ The value of σ is large; the model fit has improved because inter-individual heterogeneity cancels out the effects of other attributes.

threshold c_n



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Given the large variability, there was insufficient data, and both NN and MXL still faced challenges in effectively capturing inter-individual heterogeneity.

appendix

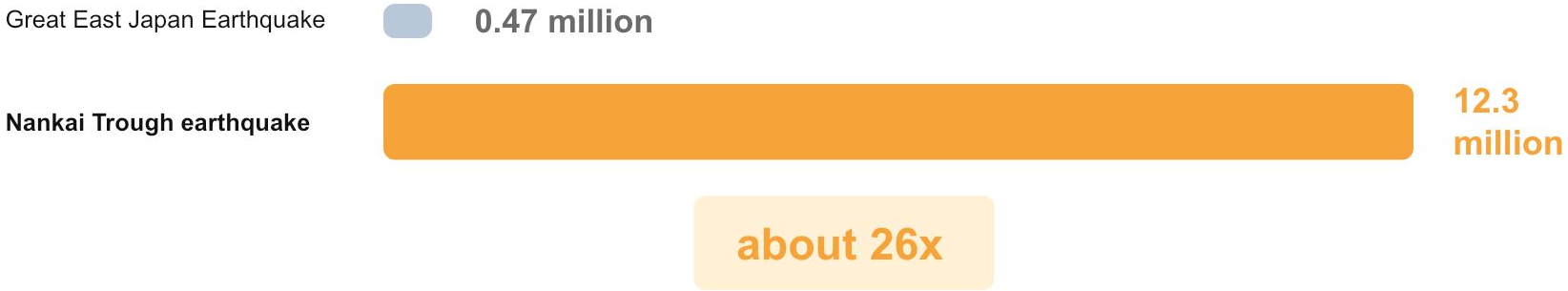
南海トラフで何が起きるのか

南海トラフ巨大地震では、最大避難者数が**約1,230万人**（東日本大震災の47万人の**約26倍**）

→避難時の住宅政策は喫緊の課題であり、向こう50年の国土構造を決める人口配置政策である

Nankai Trough Earthquake: Evacuation at an Unprecedented Scale

Up to 12.3 million evacuees



Housing choices after evacuation shape where people rebuild their lives

Housing policy

Temporary housing, public housing, and access to private rentals

>

Where recovery begins

Return to the home region, settle, or relocate again

>

Japan's geography in 50 years

Population distribution, employment, and demand for public services

Housing policy for evacuees will influence Japan's long-term population distribution

Demographic Simulation -Nankai Trough Earthquake

Synthetic Population Data —using the Tohoku data

- Sample size: 3,000 people
- Time period: 20 years (time=0–19)
- Choices: 10 candidates per person per year
- Number of individual-year rows: 60,000
- Number of candidate rows per individual-year: 600,000
- Total population weight: 260,713 people

Representing out-of-region evacuees from the four prefectures of Shikoku.

Pseudo-individual records aligned with official statistics

Comparing scenarios by varying coefficients, distance resistance, and housing supply in the Tohoku data

Demographic Simulation -Nankai Trough Earthquake

Synthetic Population Data —using the Tohoku data

$$O_{\text{Shikoku}} = \sum_{r=1}^{R} \text{round}\left(E_r^{\text{L2}} p_r\right) = 260{,}713$$

R = Total number of origin regions

O_{Shikoku} = Total initial number of out-of-area evacuees from Shikoku

E_r^{L2} = Number of evacuees in origin region r one month after the L2 earthquake

p_r = Baseline out-of-area evacuation rate for region r

O_r = Initial number of out-of-area evacuees from region r

Number of people who moved from their original evacuation location (r) to their new residence (d):

$$\widehat{N}_{rd} = \sum_{i=1}^{n} w_i \mathbf{1}\left(r(i) = r\right) \mathbf{1}\left(y_i = d\right)$$

Probability of Selecting an Initial Relocation Destination

$$P_{rd} = \frac{W_{rd}}{\sum_{k \in \mathcal{C}_r} W_{rk}}$$

Due to time constraints, we were unable to compare scenarios using simulations.