Explaining the Differences in Evacuation Decisions with the Great East Japan Earthquake Data

東日本大震災データを用いた避難意思決定における相違に関する分析

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1. Introduction and objectives

In Japan earthquakes occur frequently, so that we not only need to make efforts to recover but also to learn from past earthquakes. This thesis contributes to the latter by analyzing differences in evacuation decisions during the Great East Japan Earthquake. Factors related to "Social capital", such as government advice and field effects have been considered by many to play an important role in explaining the evacuation decisions.

We aim to quantify these effects through analyzing survey data collected after the Great East Japan Earthquake. Firstly we analyze differences in evacuation patterns between the cities included in the survey and try to understand how and why evacuation patterns differ between cities in Tohoku. We then create a series of models with individual evacuation decisions as dependent variables. With these different models we aim to illustrate the effect of field effects.

2. City Level Analysis with Proportion of Evacuees by Evacuation Starting Time

With an initial cluster analysis we find that in some cities the proportion of evacuees grows smoothly whereas in other cities evacuation shows a pronounced peak. After noticing this difference, we perform another cluster analysis (Fig. 2-1) and discriminant analysis to explain the difference between cities.

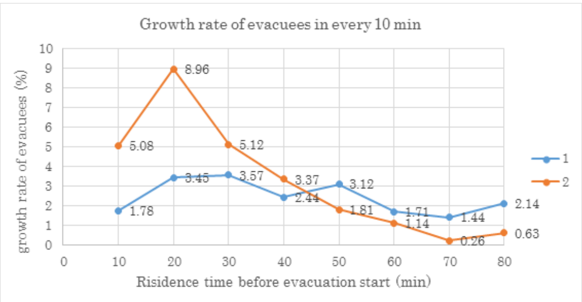

Figure 2-1 Growth rate of evacuees in every 10 min

To characterize cities we define 3 indices. V1 denotes the growth rate of tsunami evacuees during time 10 to time 20, compared with the total evacuees. V2 denotes the proportion of tsunami evacuees by time 20 among all the tsunami evacuees. We wonder whether the evacuation during the first 20 minutes contributes significantly to the total evacuation now that we notice the sudden increase at time 20. Furthermore, V3, denotes the proportion of evacuees among the sample respondents. Result are shown in Table 2-1, Fig . 2-2.

Table 2-1 City level result

Cluster	Description
Cluster1	people start to evacuate smoothly and few people start to evacuate for the reason of tsunami
Cluster2	people start to evacuate quickly but few people evacuate for the reason of tsunami
Cluster3	people start to evacuate smoothly and more people evacuate for the reason of tsunami
Cluster4	people start to evacuate quickly and many people evacuate for the reason of tsunami

Figure 2-2 City level result in map

In our subsequent discriminant analysis we find that tsunami warning time can explain evacuation starting time when people start to evacuate, however tsunami warning time does not explain whether many people can evacuate or not.

We also conduct a 2 stage model about fatalities and we found that tsunami warning did not help to explain fatalities.

3. Evacuation Choice Model

We then perform evacuation modelling at individual level. Our first model is a base model explaining the differences in evacuation decisions without field effect. (Fig. 3-1). In the model with clusters we find that tsunami warning from government is insignificant but other explanatory variables at the city level are significant. We consider that there might be correlation between Tsunami warning and city cluster though. In the model without cluster we accordingly find that tsunami warning time becomes significant. Since the estimate results are in different measurement, we standardized them and we can tell Tsunami warning is the most important factor for evacuation decisions in both model.

Variable	Model1 with cluster			Model1 without cluster		
	estimate	Stdz	t-stat	estimate	Stdz	t-stat
Alternative Specific Constant						
Constant	**1.61**		**17.8**	**1.26**		**18.33**
Person specific						
Male	*-0.05*	*-0.11*	*-1.83*	*-0.05*	*-0.11*	*-1.88*
Heard Tsunami Warning	**0.37**	**0.83**	**13.13**	**0.39**	**0.86**	**13.74**
Family at home	**0.14**	**0.16**	**2.76**	**0.13**	**0.15**	**2.57**
Family at work	*-0.09*	*-0.11*	*-1.86*	**-0.11**	**-0.13**	**-2.15**
Family at kindergarten	*0.2*	*0.11*	*1.79*	*0.19*	*0.11*	*1.73*
Live near harbor	0.05	0.06	0.79	**0.24**	**0.29**	**4.2**
Preparation	**0.27**	**0.64**	**8.96**	**0.28**	**0.67**	**9.49**
Seen sign	**0.07**	**0.17**	**2.26**	**0.1**	**0.23**	**3.15**
City specific						
Tsunami warning time [min after 2.46p	0	-0.01	-1.08	**-0.01**	**-0.21**	**-3.94**
Population density	*-0.01*	*-0.13*	*-1.9*	*-0.01*	*-0.11*	*-1.72*
Flooded area density	**0.02**	**0.24**	**2.92**	*0.01*	*0.12*	*1.81*
Harbor city [dummy]	*0*	*0.11*	*1.66*	0	0.09	1.56
Cluster1(slow, few)	**-0.46**	**-0.42**	**-5.45**	NE	NE	NE
Cluster2(quick, few)						reference
Cluster3(slow, many)	**-0.64**	**-0.39**	**-4.9**	NE	NE	NE
Cluster4(quick, many)	**-0.38**	**-0.41**	**-4.47**	NE	NE	NE
Cluster5(others)	**-0.56**	**-0.47**	**-5.8**	NE	NE	NE
Model Summary						
Sample Size N		10384			10384	
AIC		10620			10620	
R-squared		0.05			0.05	
Note: Bold p value<0.05; Italic p value <1; NE = Not estimated; Stdz: standardized value						

Figure 3-1 base model result

Next we obtain a naïve model explaining the differences in evacuation decisions with field effect. The field effect here is percentage of persons choosing to evacuate in each city. The interesting part of this naïve model is that at the city level the warning from government is not significant. However, this model does not make any attempt to correct or reduce the endogeneity issues.

We correct the endogeneity problem with a 2-stage model. In first stage the fitted field effect is the expected decisions by firstly obtaining the estimated aggregate using all person specific variables. Then in the second stage we tie together the Person specific variable with the City-specific variable and the social effects. From the result we can see the influence of the field effect is reduced to more than half compare to the naïve model. In this model the endogeneity problem with respect to the personal characteristics will be reduced, though not completely removed.

An alternative approach to correct the endogeneity problem is be the BLP approach described in Walker (2011). The BLP procedure involves decomposing the error into two part: the endogenous cousing part and the random portion. In this study we choose to use the average evacuation of the surrounding cities as the instrument for the endogenous field effect term.

A linear regression with country specific constants as the dependent variable and field effect as the explanatory variable show that the field effect is significant (Fig. 3-2). Model 2a performs the first stage of instrumental variable regression. Result shows that the instrumental variable is significant. After obtaining the field effect, for the second stage we then perform a linear regression with city specific constant as the dependent variable. The independent variable is the fitted field effect. We find that the fitted field effect is not significant. The reason for the insignificant result might be partly because we have not found an appropriate instrumental variable to correct for the endogeneity as the low R-square value for Model2a shows.

Variable	Estimate	T-stat
Model 1 (uncorrected spatial)		
dependent variable (City specific constant from choice model)		
intercept	**-1.07**	**-3.4**
Field Effect	**3.11**	**7.01**
Model Summary		
R-square	0.56	
Model 2a (corrected spatial)		
dependent variable (field effect)		
Intercept	**0.45**	**3.56**
Average Evacuation Adjacent Location (instrumental Variable)	*0.34*	*1.93*
Instrumental Variable dummy	**0.34**	**2.14**
Model Summary		
R-square	0.11	
Model 2b (corrected spatial)		
dependent variable (City specific constant from choice model)	C~F1^	
Intercept	0.34	0.24
Fitted Field Effect	1.1	0.55
Model Summary		
R-square	0.01	
Note: Bold p value<0.05; Italic p value <1; NE = Not estimated		

Figure 3-2 Regression results for the city-specific constants

4. Conclusion

In this research we divide the cities into 4 clusters considering the proportion of evacuees by evacuation starting time. We found it is difficult to explain why city are classified to a specific cluster. Although tsunami warning time can explain the starting time, however it cannot explain whether many people can evacuate or not. Also tsunami warning does not help to explain fatalities.

In individual level we found preparation before tsunami and having seen sign information have positive significate impacts on evacuation decisions. Also, Tsunami warning and field effect appear to have (weakly) significant impacts on evacuation decisions. Removing endogeneity issues is important though to not overestimate field effects.

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