BUSINESS MODEL FOR PROMOTION OF RETROFITTING EXISTING LOW EARTHQUAKE – RESISTANT STRUCTURES

REI TAKADA[1], MIHO YOSHIMURA[2] AND KIMIRO MEGURO[2]
[1]The Tokyo Electric Power Co., Inc.
[2]The University of Tokyo, Institute of Industrial Science

ABSTRACT

The implementation of business oriented model to promote retrofitting of existing pre-code-revision residential housing for earthquake disaster reduction in Japan has been proposed in this paper.

Keeping in mind there are few economic incentive programs to encourage retrofitting existing residential housing to meet current codes, this paper explores the impacts of the proposed model, which gives significant benefits to house owners in terms of investment versus return by simulating the net present value for the owners' lifetime duration and the probable return period of destructive earthquake. Besides, the paper investigates the possibility that the proposed model can be also beneficial to house builders by forming a consortium, which continuously supplies jobs and shares innovative retrofit methods in cooperation with universities.

Based on the research by Meguro et al. (2001), the proposed model has been elaborated and has 3 main functions: seismic performance labeling for housing, seismic performance assurance for housing retrofit and construction payment guarantee for house builders. First, the function of seismic performance labeling, which is certified under the governmental law, helps to foster the housing market by supplying high earthquake-resistant houses. Second, seismic performance assurance, which guarantees repair the house in case the structure is damaged under predictable earthquakes, secures housing safety in a better way than seismic insurance. Third, construction payment guarantee for house builders plays an important role in improving financial condition of house builders and getting them involved in the circulation of the model.

The fact that there are very few house owners have been aware of the importance of retrofitting their houses is fairly reasonable because earthquake occurrence is very low, retrofit cost is high, and earthquake damages vary by location, structure, soil condition and so on. In order to draw house owners' attention to retrofit their housing, there have to be regulatory approaches and/or commercial based approaches like this model. Considering the regulatory approaches adopted by governments and/or local communities are important for understanding local enforcement of pre-code-revision residential housing retrofit, those approaches have to be implemented prior to the commercial based approaches. However, this

paper shows that it lays the groundwork for future efforts to further examine the contributions of private entrepreneurs to seismic mitigation efforts.

1. INTRODUCTION

Japan is a country, which fairly often experiences disasters by earthquake. In order to build more sustainable society, Japan has taken various countermeasures to mitigate earthquake related hazards. However, those countermeasures by government and/or local governmental agencies have to be quite different by whether household economy activities are based on a rational risk aversion action. If premised on risk aversion action, the countermeasures will be based on market mechanisms, such as disaster risk information disclosure, earthquake insurance. The conventional seismic hazard mitigations are shown in Table 1.

Table 1: Examples of mitigation options by governmental agencies

	Contents	**Main Service Providers**
Newly built housing	Seismic Performance Labeling	Designated housing labeling institutes
Existing housing	- Supporting funds for seismic performance evaluation - Low interest loan for rebuilding low seismic performance housing	Local governmental agencies

On the other hand, it is obvious that existing low earthquake resistant structures is the biggest factor that enlarges damage. Many of victims in the Hyogoken-Nanbu earthquake died due to fall of furniture and/or collapse of buildings and this forms about 84% of the whole. Moreover, as shown in Table 2, the wooden housing stock in Japan has turned into about 90% of the housing stock; among these about 43% of housing built before 1981, when the building code was revised, are the existing low earthquake resistant residences (residences which require seismic evaluation).

Table 2: Building stock in Japan (in Thousand)

	Residential building			**Non residential building**	**Total**
	Wooden	**Non wooden**	**Total**	**Total**	
Before 1981	18,600	1,500	20,100	3,600	23,700
(Low resistant)	11,100	900	12,000	2,200	14,200
After 1981	7,300	1,300	8,600	2,200	10,800
Total	25,900	2,800	28,700	5,800	34,500

If the risk aversion action of a rational household economy is taken, enforcement of the retrofitting of the existing low earthquake resistant residence should be the most rational risk aversion action. However, in many household economies, housing retrofit still needs much more progress.

Yamaga et al. (2003) have shown that consumers are acting in risk aversion about selection of location, or structure for rental housing. Assuming earthquake risk information is given, a risk aversion-household economy will (i) avoid living in high earthquake risk area, (ii) build the earthquake-proof residence against the given earthquake risk. For the latter case, disaster prevention investment should be performed and specified as more advantageous as an investment in the household economy in mid-term span compared with other risk aversion actions.

In this paper, it is examined that the business model can let consumers take risk aversion actions as the market mechanism driven disaster measures by analyzing various risk aversion actions of a household expenditure.

2. OVERVIEW OF PROPOSED BUSINESS MODEL

Meguro et al (2001) have shown that public countermeasures before earthquakes result less expenditure than those after earthquakes, and proposed the system to assure that governmental agencies compensate some portion of repair cost if the residence has been properly retrofitted.

In this paper, based on the system, the new business model is proposed, which the service provider provides the whole repair cost instead of governmental agencies, which can only cover some portion of it. Besides, this model includes the consortium that supplies jobs of retrofitting housing to house builders. The schematic figure of the proposed business model is shown in Figure 1.

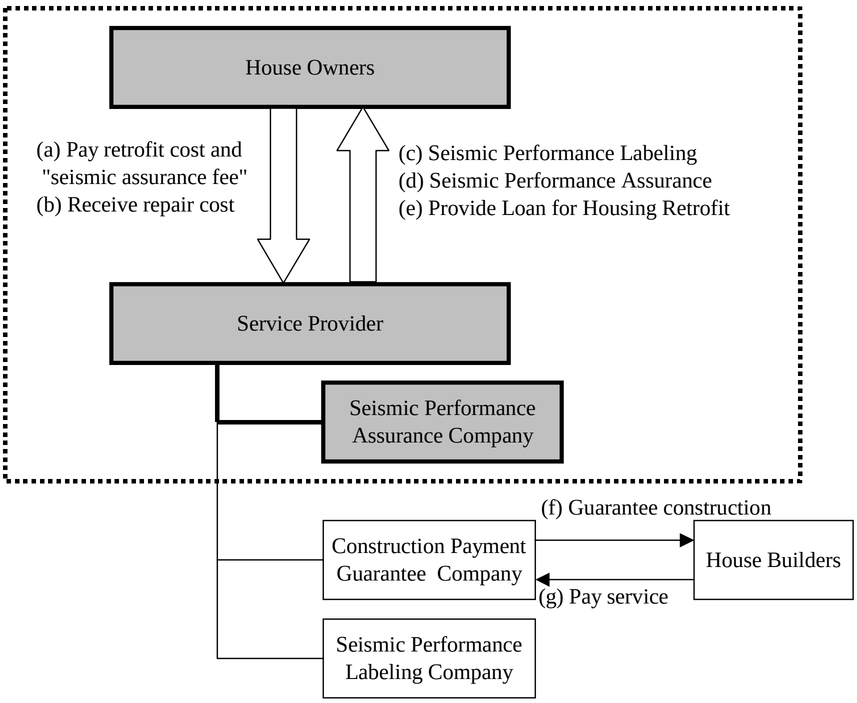

Figure 1: The schematic figure of the proposed business model

The business model plans to mainly acquire profits by collecting "seismic assurance fee" adding on retrofit cost from clients. Based on this, the business model can provide repair cost to customers in case insured residence is damaged.

Main players of the business model are the following,

- Customers
  - (a) Pay retrofit cost of residence and "seismic assurance fee"
  - (b) Receive repair cost according to the damage level
- Service provider
  - (c) Label seismic performance for housing
  - (d) Assure seismic performance for housing retrofit
  - (e) Provide customized loan for housing retrofit
  - (f) Guarantee construction payment for house builders
- House builders
  - (g) Pay service fee to join the consortium, which supplies jobs of house retrofitting and progress payment system.

Since this paper mainly focuses on the possibility that the business model can indicate retrofit is the most effective investment among other risk aversion activities in mid-term household economy, two of services by the service provider; seismic performance assurance and loan for housing retrofit, as shown in the dotted area of Figure 1, will be discussed.

3. BALANCE SHEET OF HOUSEHOLD ECOMONY

3.1 Assumption of model household economy

In order to confirm that the business model is competitive enough to have influence to investment to earthquake insurance, which doesn't necessarily require housing retrofit, the model household economy is assumed based on the following information.

Annual income of house owners is assumed by The 1998 Housing and Land Survey, Statistics bureau of Ministry of Public Management, Home Affairs, Posts and Telecommunications. As shown in Figure 3, the annual income of house owners is mostly in the range from 5,000 to 10,000 (Thousand Yen), which equals to 40,000 and 80,000 (US Dollar). In this paper, annual income of the target house owner is 7,000 (Thousand Yen) as a typical house owner.

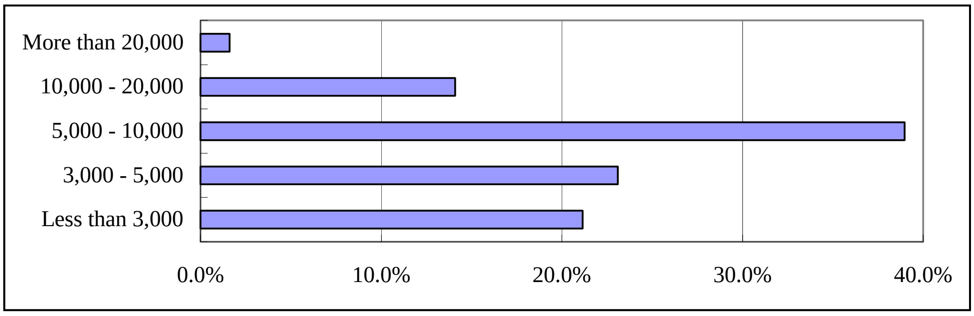

Figure 3: Distribution of Annual income of house owners (in Thousand Yen)

Based on the annual income of model household, the floor area of 72 (m2) is assumed by tatami units of dwelling rooms for the target annual income category based on The 1998 Housing and Land Survey.

Based on the data and assumption mentioned above, the model household economy is assumed as Table 3.

Table 3: Model household

Floor Area	72.0(m2)
Annual Income	7,000(Thousand Yen)
Housing Property	Assumed to be 70% of annual income, 5,000(Thousand Yen)

The ratios of annual income and housing property are calculated based on data from Japan Association for Financial Planners.

3.2 Assumption of seismic performance of housing of the model household economy

In order to show housing retrofit has significant impacts under destructive earthquakes, the model household is assumed to live in the relatively old housing; wooden residence built in from 1962 to 1971.

In this section, it is assumed that the earthquake, which causes the ground motion of 70 (kine), will happen in coming 10 years, since the main objective is to confirm the most effective investment for reasonable household economy in the area expected to happen destructive earthquakes in the near future.

For the assumption above, the possibility that the model residence collapses and is moderately damaged based on survey data of The Hyogoken-Nanbu Earthquake done by Murao (1999) is calculated as shown in Figure 5 and Table 4.

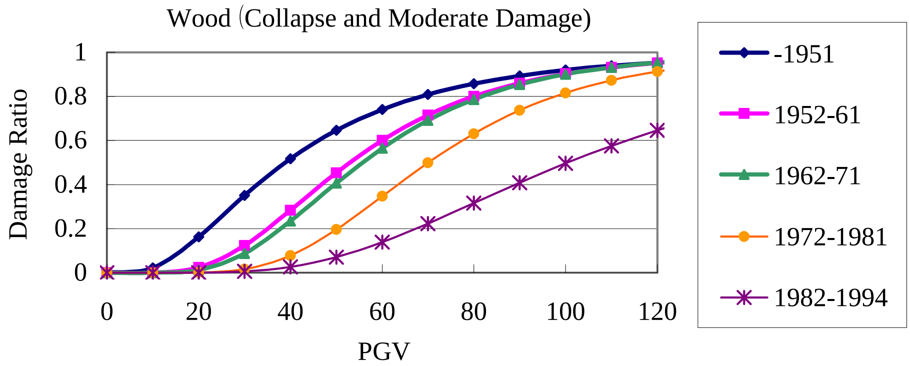

Figure 5: Probability of wooden housing collapse and moderate damage

Table 4: Probability of wooden housing collapse and moderate damage

PGV	1962-1971	1982-1994 (or Retrofitted)
70	69.2	22.3

3.3 Simulation of model household economy

In this simulation, the following assumptions are employed.

- The unit cost to retrofit residence is 15 (Thousand Yen/m2), which equals to 120 (US Dollar/m2).
- The expected damage of residence is calculated by multiplying the possibility of collapse and moderate damage by the property asset value.
- The expected cost of retrofitting residence is calculated by multiplying the possibility of collapse and moderate damage by the building area times 50 (Thousand Yen/m2), which equals to 400 (US dollar).
- Insurance coverage of the model residence is 5,000 (Thousand Yen), which equals to 40,000 (US dollar) and its annual insurance rates are 17,750 (Yen) for housing built before 1971, 15,975 (Yen) for retrofitted housing.

Based on the assumptions above, the model household economy is set up as Figure 6 and Table 5.

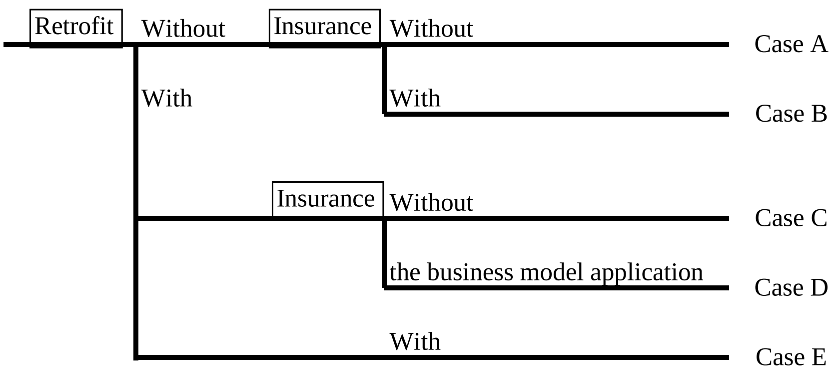

Figure 6: Model expenditure of household economy

Table 5: Model expenditure of household economy

Case	Housing retrofit	Seismic performance	Earthquake Insurance	Annual insurance fee
A	Without	As before 1971	Without	
B			With	17,750 (Yen)
C	With	As after 1981	Without	
D			(Covered by seismic performance assurance)	
E			With	15,975 (Yen)

4. IMPACTS ON MODEL HOUSEHOLD ECONOMY BY THE PROPOSED BUSINESS MODEL

To estimate the impacts on the model household economy, the net present values of the cost of several mitigation options are calculated in this chapter.

For the simulation, discount rate of 3.52 % is used, which is the average actual mortgage rate from 1987 to 1999. It is not considered that any governmental agencies will support disaster victims to rebuild housing so that this business model can show the applicability of the model under the market mechanism that an individual has to be responsible for his/her private property to the last.

In this paper, the following services are focused on in order to find whether this business model can attract house owners to retrofit their residences and explore the undeveloped market of retrofitting housing.

- Seismic performance assurance

In case damages to insured housing occur, service provider financially supports house owners in accordance with the damage level.

Service provider collects 5 % of retrofit cost as an assurance fee to run the business.

- Loan for housing retrofit

Service provider offers equal monthly payment with interest of retrofit cost for house owners who intend to retrofit their housing. The interest is 2.52 %, which is 1% discount of the average actual mortgage rate from 1987 to 1999. This is based on housing loan tax incentive for retrofitting offered by governmental agency, which owners enjoy income tax reduction of 1 % interest reduction for retrofit loan.

The result of the calculation is shown in Table 6.

Table 6: Calculation of net present values for 5 models of expenditure

Year	Case A	Case B	Case C	Case D	Case E
1	0	0	-1,080,000	0	-1,080,000
	0	-17,750	0	-129,703	-15,975
2	0	-16,563	0	-121,033	-14,907
3	0	-16,000	0	-116,917	-14,400
4	0	-15,456	0	-112,942	-13,911
5	0	-14,931	0	-109,101	-13,438
6	0	-14,423	0	-105,392	-12,981
7	0	-13,932	0	-101,808	-12,539
8	0	-13,459	0	-98,346	-12,113
9	0	-13,001	0	-95,002	-11,701
10	-4,405,635	-867,883	-1,418,975	0	0
NPV	-4,405,635	-1,003,399	-2,498,975	-990,244	-1,201,964

As obviously shown in Table 6, Case A, a house owner doesn't retrofit housing and isn't insured, is the worst case that needs the most expenditure. The least cost case is Case D, the application of the proposed business model. However, expenditure of Case D is pretty much the same as Case B, a house owner is insured but doesn't retrofit the residence. Case C forces house owners to repair the damage by themselves because house retrofit is not assured. The expenditure of Case E seems to be too much and ineffective way to spend money compared with Case B or Case D.

This shows Case D can be acceptable for house owners because Case B may cause daily life interruptions such as a couple of weeks leave from residence due to severe damage to residence. On the other hand, Case D may cause least damage to residence thanks to housing retrofit.

5. SUMMARY

This paper indicates that the proposed business model can more obviously show the financial merits to house owners compared with conventional public hazards mitigation, even though this business model needs to elaborate more. For further development of this business model, it is necessary to ponder how house builders participate and how much house owners and house builders pay service fees to make this business profitable. In addition to that, this model also needs the participation and involvement of public agencies and research institutes, such as policy making, research and development of new technology for housing retrofit.

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