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An Investigation of Residential Insurance Demand-side Reactions After a Natural Catastrophe: The Case of the 2010–11 Christchurch Earthquakes

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Abstract: This study gives an empirical analysis of residential insurance demand-side reactions after an earthquake disaster using survey data. The paper discussed the study hypothesis from economic analysis perspective with significance econometric tests to explain how insurance demand for residential property changed post-catastrophe. Our empirical results observe higher risk perception from those who have had prior experience of catastrophes than those who have not. This positively influence the demand for residential insurance cover in the aftermath of a natural disaster with higher demand observed in the regions with higher seismic risk. These results support the research hypothesis and are consistent with the findings in our literature. A change in insurance level is less likely when the cost of the insurance is high, when the expected loss is low, and individuals becomes wealthier. We also find evidence of effects that remain to be explained, such as the greater sensitivity to both cost of insurance coverage and risk perception than to the size of the potential loss. We observe a positive relationship between household characteristics and the degree of risk aversion and how this changes with change in level of income, change in value of insured assets and change in insurance premiums. An increase in individual's income alone has no major effect on insurance demand if the premium rates are within the demanders' price range. However, positive loading of premiums to reflect transaction costs and possibility of adverse selection might affect insurance coverage level if premium rates become too high. In such cases, the direction of the effect depends on whether an increase in income increases both the premium rates and the insured asset and on whether the insurance demander has increasing or decreasing absolute risk aversion.

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1 Introduction

In 2010–2011 Christchurch city and its surrounding regions of Canterbury in New Zealand experience two major earthquakes. Estimated economic cost of the earthquakes was more than $40billion (Chang-Richards and Wilkinson 2016; Doyle and Noy 2015). Homeowners, insurance and reinsurance markets and New Zealand government agencies were faced with a major difficult task of rebuilding Canterbury region in the aftermath of the two earthquakes.

Natural disasters presents difficult position for insurance market players because there is substantial ambiguity associated with the probability of such events occurring and the loss events are often highly correlated. Existing evidence of how post-catastrophe experience affects demand for insurance varies. A study by Slovic, Kunreuther, and White (1974) was the first to postulate over-reaction by economic agents in the aftermath of a new disaster. Various studies observe that insurance consumers over-react to the occurrence of a new disaster (Dumm et al. 2015; Aseervatham et al. 2015). Seog (2008) theoretically demonstrated that catastrophic events lead to increase in insurance demand when there is increase in public information regarding a disaster. Browne and Hoyt (2000) looks at effects of catastrophic events on demand for insurance, and observe that higher premium rates post-disaster leads to depressed demand. Michel-Kerjan and Kousky (2010) observed that policy limits associated with flood insurance program are increased and more policies are purchased after a flood event. In a recent study, Gallagher (2010) estimated the change in probability that occurs in the aftermath of floods using panel dataset of floods and the uptake of flood insurance in the US. Gallagher's work observes consumption of insurance is completely flat in the years before a flood, prickle immediately following a flood, and then steadily diminishes to pre-floods level. Studies (Camerer and Kunreuther 1989; McClelland, Schulze, and Coursey 1993; Shanteau and Hall 1992; Palm 1995; Cohen, Etner, and Jeleva 2008; Kirsch 1986; Ganderton et al. 2000) analysed insurance demand reactions in the aftermath of a catastrophe, suggesting that the insured have the belief that the probability of an event is lowered when that event has already occurred. Papon (2008) also suggested that prior risk occurrences influence subsequent insurance choices. Although several works make the case for risk perceptions affecting natural disaster insurance decisions (Kunreuther 1984; Kunreuther et al. 1995; Manson 2006; Braun and Muermann 2004; Kousky, Luttmer, and

Zeckhauser 2006; Michel-Kerjan and Kousky 2010), there is very little empirical work on how insurance demanders use their heuristic probability rule to update their past insurance coverage. Born and Viscusi (2006) observes that major catastrophes may reduce the quantity of insurance written because of the higher rates and insurance rationing, as well as exiting of firms from the market.

This study looks at the period's pre- and post-disaster to examine how various key stakeholders in natural disaster insurance are impacted by catastrophic losses from extreme disaster events. The present study gives empirical analyses of pre- and post-Christchurch earthquakes insurance reactions using survey data. Demand-side reactions are examined to provide results that are critical to understand insurance market demand-side shifts post-catastrophe. The key interest in the demand-side reaction centres on analysis of the change in the level of insurance coverage and other variables that contribute to change in insurance demand post-catastrophe based on regression model.

1.1 Hypotheses of the Study

Standard theoretical model of demand for property insurance assumes that insurance consumers are able to specifically estimate the probabilities associated with all possible loss events, and then decide on the level of insurance coverage to purchase. While prior research suggests that the demand for natural disaster insurance would be negatively related to the price of coverage, the insurance demand by property owners pre- and post-disaster might suggest otherwise. Insurance demand for properties exposed to catastrophe risk is generally considered to be price elastic than those exposed to non-catastrophe risk. The expected relationship between the demands for catastrophe insurance and the cost of insurance coverage is, however, complicated by the interaction of risk aversion and perception of risk post-loss on both demand and price.

It would be expected that properties in an epicentre of disaster event to be more likely to purchase higher levels of insurance coverage post-loss than properties far from the epicentre. However, if insurers use risk-based underwriting approach, then we expect that there would be a positive relationship between perception of risk and cost of insurance coverage, and a change in risk aversion and risk perception would positively influences the insurance demand by property owners in the aftermath of a major disaster. Thus, at higher levels of risk perception both price of coverage and insurance demand of disaster coverage would be higher.

General economic theory indicates a positive relationship between income and demand for normal good. However, the general economic theory is at odd with insurance economics which indicates that optimal insurance decreases with wealth. This implies that, only in a very restricted set of circumstances can insurance be categorised as a normal good where the demand for insurance curve shifts outward at all prices as wealth increases. It is implicitly assumed that the level of risk aversion has an impact on decision made post-disaster and hypothesised that both risk aversion and risk perception is positively correlated with insurance coverage at all level of wealth.

2 Data and Analysis

2.1 Data

The data used in this analysis comes from online survey conducted through random sampling of Christchurch dwellers. The survey was designed collect data on pre- and post-catastrophe reactions for homeowners insured prior to the 2010–2011 earthquakes. A survey questionnaire composed of 24 different questions was designed to collect key individual-level information that determines insurance demand for residential property owners in the period pre- and post-loss. This study examined the influence and effect of each of these questions on insurance demand using regression model with appropriate econometric test. A total of 1600 survey questionnaires were distributed, and responses from 254 participants received representing 16 % response rate. Summary results of the survey data is reported in Table 1.

2.2 Empirical Model

The modelling framework in this study is based on the econometric model used to analyse demand in form of logistic regression analysis, and the empirical modelling equation to estimate the change in the level of insurance coverage is given in eq. (1),

$$\begin{aligned}
&\textit{level of insurance}\ \text{coverage} = \alpha + \beta_1(\textit{change in INCOME})\\
&\quad + \beta_2(\textit{change in PREMIUM post} - \textit{loss})\\
&\quad + \beta_3(\textit{change in LEVEL OF RISK post} - \textit{loss})\\
&\quad + \beta_4(\textit{change in PROPERTY VALIUE insured})\\
&\quad + \beta_5(\textit{NATURAL DISASTER consideration on before purchace of property})\\
&\quad + \beta_6(\textit{dummy household demographic features} : \textit{AGE}, \textit{GENDER EDUCATION}\\
&\quad + \textit{error term}
\end{aligned} \tag{1}$$

Table 1: Case processing summary for the survey questionnaire.

		N	Marginal Percentage
Change in level of coverage	0.00	125	59.2 %
	1.00	86	40.8 %
Young age	0.00	194	91.9 %
	1.00	17	8.1 %
Middle age	0.00	82	38.9 %
	2.00	129	61.1 %
Male	0.00	89	42.2 %
	1.00	122	57.8 %
High school graduate	0.00	194	91.9 %
	1.00	17	8.1 %
University graduate	0.00	144	68.2 %
	2.00	67	31.8 %
Low income	0.00	199	94.3 %
	1.00	12	5.7 %
High income	0.00	22	10.4 %
	2.00	189	89.6 %
Lower property value	0.00	176	83.4 %
	1.00	35	16.6 %
Medium property value	0.00	128	60.7 %
	2.00	83	39.3 %
Natural disaster consideration before purchase	0.00	85	40.3 %
	1.00	126	59.7 %
Increase in premium rates post- earthquakes	0.00	199	94.3 %
	1.00	12	5.7 %
Decrease in premium rates post- earthquakes	0.00	28	13.3 %
	2.00	183	86.7 %
Increase in level of coverage due to higher risk	0.00	196	92.9 %
	1.00	15	7.1 %
Valid		211	100.0 %
Missing		0	
Total		211	
Subpopulation		99[a]	

[a]The dependent variable has only one value observed in 76 (76.8 %) subpopulations.

Where level of insurance coverage is used to measure the insurance post-catastrophe, change in property value is given by eq. (2)

$$PV_{t+1} = \beta PV_1 \Rightarrow PV_1 = \frac{1}{\beta} PV_{t+1}$$

$$\Delta PV_{t+1} = (\beta - 1) PV_t = \frac{(\beta - 1)}{\beta} PV_{t+1} = \beta^{\star} PV_{t+1} \tag{2}$$

And change in income is given by eq. (3),

$$INVCOME_{t+1} = \beta\ INCOME_t \Rightarrow INCOME_t = \frac{1}{\beta} INCOME_{t+1}$$

$$\Delta INCOME_{t+1} = (\beta - 1) INCOME_t = \frac{(\beta - 1)}{\beta} INCOME_{t+1} = \beta^{*} INCOME_{t+1} \tag{3}$$

The introduction of these two variables is of relevance to the explanation of the change in the level of insurance coverage post-Christchurch earthquakes. The survey data doesn't capture the changes in income and property values for the period: this adjustment introduces improvement to the model such that income and property value vary by time to explain insurance demand.

Level of insurance coverage is used to proxy insurance demand; change in the level of insurance coverage post-loss is used to demonstrate main effects of catastrophe on insurance demand. Eight explanatory variables are used to address the hypotheses of the study.

3 Results and Discussion

The regression results of this analysis are reported in Tables 2 and 3, and are in principal consistent with the hypotheses of this study. Table 3 shows the effect of a number of the explanatory variables is not-statistically significantly. For example, one statistically significant predictor variable, increase in level of coverage due to higher risk, affects more significantly the level of coverage than other predictor variable with *p-value* 0.000. This can also be seen from Table 1, the total proportion, 92.9 %, of those who perceive high risk as the cause of change in the level of insurance coverage.

Table 2: Model fitting information.

Model	Model fitting criteria	Likelihood ratio tests		
	−2 Log Likelihood	Chi-Square	Df	Sig.
Intercept only	189.558			
Final	148.734	40.824	13	0.000

The initial run of the model shows that, when looked as a whole, the model is significant with a *p-value* 0.000 and associated chi-square statistics 40.824. This implies that at least one or more of the regression coefficients in the model are not equal to zero.

Table 3: Parameter estimates.

Change in level of coverage[a]		B	Std. Error	Wald	Df	Sig.	Exp(B)	95 % confidence interval for Exp(B)	
								Lower bound	Upper bound
.00	Intercept	−21.297	1.867	130.175	1	0.000			
	[Young Age = 0.00]	0.531	0.632	0.706	1	0.401	1.701	0.493	5.874
	[Young Age = 1.00]	0^b	.	.	0	.	.	.	.
	[Middle Age = 0.00]	0.060	0.365	0.027	1	0.869	1.062	0.519	2.173
	[Middle Age = 2.00]	0^b	.	.	0	.	.	.	.
	[Male = 0.00]	−0.110	0.323	0.116	1	0.733	0.896	0.476	1.687
	[Male = 1.00]	0^b	.	.	0	.	.	.	.
	[High School Graduate = 0.00]	−0.490	0.661	0.549	1	0.459	0.613	0.168	2.239
	[High School Graduate = 1.00]	0^b	.	.	0	.	.	.	.
	[University Graduate = 0.00]	0.125	0.357	0.124	1	0.725	1.134	0.563	2.281
	[University Graduate = 2.00]	0^b	.	.	0	.	.	.	.
	[Low Income = 0.00]	0.404	1.011	0.160	1	0.689	1.498	0.207	10.861
	[Low Income = 1.00]	0^b	.	.	0	.	.	.	.
	[High Income = 0.00]	0.159	0.747	0.045	1	0.831	1.172	0.271	5.064
	[High Income = 2.00]	0^b	.	.	0	.	.	.	.
	[Lower Property Value = 0.00]	−0.010	0.486	0.000	1	0.084	0.991	0.382	2.566
	[Lower Property Value = 1.00]	0^b	.	.	0	.	.	.	.
	[Medium Property Value = 0.00]	−0.108	0.360	0.091	1	0.003	0.897	0.443	1.818
	[Medium Property Value = 2.00]	0^b	.	.	0	.	.	.	.
	[Natural Disaster consideration before purchase = 0.00]	0.327	0.326	1.005	1	0.016	1.386	0.732	2.625
	[Natural Disaster consideration before purchase = 1.00]	0^b	.	.	0	.	.	.	.
	[Increase in premium rates post- earthquakes = 0.00]	2.176	1.053	4.267	1	0.039	8.808	1.118	69.416

(*continued*)

Table 3: (*continued*)

Change in level of coverage[a]	B	Std. Error	Wald	Df	Sig.	Exp(B)	95 % confidence interval for Exp(B)	
							Lower bound	Upper bound
[Increase in premium rates post- earthquakes = 1.00]	0[b]	.	.	0	.	.	.	.
[Decrease in premium rates post- earthquakes = 0.00]	2.498	1.207	4.284	1	0.038	12.160	1.142	129.503
[Decrease in premium rates post- earthquakes = 2.00]	0[b]	.	.	0	.	.	.	.
[Increase in level of coverage due to higher risk = 0.00]	18.728	0.000	.	1	.	135975952.541	135975952.541	135975952.541
[Increase in level of coverage due to higher risk = 1.00]	0[b]	.	.	0	.	.	.	.

[a]The reference category is: 1.00. [b]This parameter is set to zero because it is redundant.

The data summary in Table 1 shows that, 59.2 % of the sampled insurance demanders reported an increase in the level of their coverage with 92.9 % attributing this change increase in their perception of risk and 94.3 % attributing the change to increase in premium rates post- earthquakes. This points out that the change in the level of insurance coverage may not always imply a change in insurance demand. An increase in coverage level could be due to increase in price of insurance coverage post-catastrophe or increase in property value.

Table 2 indicates the parameters of the regression model for which the model fit is calculated: with Intercept Only as 189.558 and Final as 148.734. The small *p-value* from the LR test, $0.000 < 0.00001$, would lead us to conclude at least one of the regression coefficients in the model is not equal to zero.

In order to estimate the regression model, thirteen explanatory variables derived from eight main survey questions are used in the overall model fit in Table 2, while Table 3 reports the parameter estimates for the explanatory variables coefficient and the associated p-values.

The parameter estimates are relative to the reference group, in each dummy variable, thus our standard interpretation of the regression results in Table 3 is that for a unit change in the predictor variable, the logistic of outcome significance level relative to the reference group is expected to change by its respective parameter estimate given the variables in the model are held constant. The logistic for probability of increase in insurance coverage level relative to no change in insurance coverage level is −21.297.

The results of the regression further give likelihood ratio chi-square of 40.824 with an associated *p-value* < 0.0001. This is an indication that the regression model as a whole fits significantly better than a model with no predictor variables. Thus a conclusion can be drawn from the regression results that, age, gender, education, income, property value, natural disaster, premium rates and risk perceptions substantially affect the level of insurance coverage post-natural disaster. From the parameter estimates of our regression model, property value, vulnerability to natural disaster, change in premium rates and change in risk perception are the most statistically significant explanatory variables. Majority of insurance consumers who had previously filed claims for natural disaster or lived in the epicentre of the quakes reported to have higher risk perception. This is in line with the research hypotheses, and previous research findings (Eeckhoudt and Kimball 1992; Showers and Shotick 1994), demand would increase with an increase in risk. Our empirical results also observed higher risk perception from those who have had prior experience of catastrophes than those who have not. This positively influence the demand for residential insurance cover in the aftermath of a natural disaster with higher demand observed in the regions with higher seismic risk. Contrary to our hypothesis of positive relationship between insurance demand and cost of insurance coverage, the study is unable to demonstrate whether change in insurance level post-catastrophe is majorly due to increase in cost of coverage or change in the value of insured value. However, past studies (Nelson 1994; Kelly and Kleffner 2003) shows that consumer would choose insurance policy that yields the highest benefit per additional dollar of insurance expenditure holding other factors constant.

4 Conclusion

Our results support the research hypothesis and are consistent with the findings our literature. A change insurance level is less likely when the cost of the insurance is high, when the expected loss is low, and individuals becomes wealthier. We find evidence of effects that remain to be explained, such as the greater sensitivity to both cost of insurance coverage and risk perception than to the size of the potential loss. We observe that a change in risk perception and insurance costs are key drives in the increase of insurance coverage post-loss: 93 % of our sample respondents attributed their increase in coverage to higher risk perception post the earthquakes while 94 % of our sample respondents attributed their increase in coverage to increase in insurance premiums.

We observe a positive relationship between household characteristics and the degree of risk aversion and how this changes with change in level of income, change in value of insured assets and change in insurance premiums. An increase in individual's income alone has no major effect on insurance demand if the premium rates are within the demanders' price range. However, positive loading of premiums to reflect transaction costs and possibility of adverse selection might affect insurance coverage level if premium rates become too high. In such cases, the direction of the effect depends on whether an increase in income increases both the premium rates and the insured asset and on whether the insurance demander has increasing or decreasing absolute risk aversion.

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