Precautionary Intentions and Risk Perceptions: Empirical Evidence from the Victims of Typhoon Morakot

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Selected Paper prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco, CA, July 26-28.

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1. Introduction

It has been widely considered that when faced with natural hazard risks in the future, people adopt precautionary measures in order to alleviate the impact of a hazardous event. This indicates that perceived natural hazard risk is a crucial determinant of the adoption of precautionary behaviour. Empirical evidence emerges inclusively with respect to the relation between perceived risk and precautionary behaviour. Perception of hurricane risks was found strongly correlated with people's adoption of precautionary measures (Peacock, 2003; Lindell and Hwang, 2008). By contrast, Bubeck, Botzen and Aerts (2012) investigated the relationship between people's flood risk perceptions and their adopted mitigation behaviour and found that a positive relationship was hardly observed. Solberg et al. (2010), examining the studies that looked into the correlation between seismic risk perception and hazard adjustment, concluded that risk perception was only weakly correlated to hazard adjustment in a small magnitude. As suggested in Bourque et al. (2012), risk perception may be a necessary but not a sufficient determinant of people's precautionary behaviour.

Our literature review reveals that the effects of certain factors –previous experience of natural hazards, trust and individuals' socio-demographic background - can exhibit on individuals' risk perceptions and on their precautionary behaviour, respectively. This implies that these factors may have direct effect on behaviour and indirect effect on behaviour mediated by risk perceptions. However, investigations based on a single-stage model, like most of the empirical studies have done, can hardly demonstrate such compound effects. To the authors' knowledge, only a few studies to date have demonstrated the mediating effects as described in the context of natural hazard risk perception and precautionary behaviour. (Lindell and Hwang, 2008)

The deadliest typhoon Morakot made a landfall in central Taiwan on August 7 2009 and brought in tremendous amount of rainfall triggered enormous mudslides and severe flooding throughout southern Taiwan. More than 700 people were confirmed killed in Taiwan, and total economic damages amounted to $3.3 billion USD. Despite its devastating impact on the society, most of published research papers are disproportionately focused on atmospheric phenomena and issues in the field of geo-science revolving around this event. To our knowledge, there is surprisingly limited documentation about the associated social impact. Other than this, we end up discovering a serious lack of empirical investigations into other equally important dimensions of this disaster event. They concern mainly the extent to which a human society had interacted or will respond to a source of threat endogenous to their living environment. One ought to ask: did people take precautionary actions before the event? Did this event have any influence on their perception of risk exposure? And how would they accordingly adjust the ways of coping with typhoon risks in the future?

This paper contributes to current literature by addressing the knowledge gaps identified above. We investigate the causal relationship between risk perceptions and precautionary actions, i.e. the influence of previously adopted protection actions on risk perceptions observed at the time of observation and in turn the effects of risk perceptions on individuals' intention to take precautionary actions in the future. To meet this purpose, a two-stage approach will be adopted – firstly to predict perceived risk levels and secondly to examine its influence on precautionary intentions - and this approach will also allow us to explore the co-existence of mediating effects.

It, therefore, sets out in section 2 a literature review to put forward the knowledge gaps to be looked at, in section 3 the research methods and in section 4 the results, and finally concludes itself in section 5.

2. Literature review

In most of the existing empirical studies[1] 'perceived risk' is used as the generic term referring to 'perceived probability', 'perceived consequences' or the combined measurement of perceive probability and consequences (Bubeck, Botzen and Aerts, 2012). Perceived probability refers to people's subjective estimation of the probability/likelihood that a hazardous event would occur in the future (Peacock, 2003; Siegrist and Gutscher, 2006; Lin, Shaw and Ho, 2008; Lindell and Hwang, 2008; Miceli, Sotgiu and Settanni, 2008); perceived consequences gauge people's judgement of the consequences of a hazardous event (Knocke and Kolivras, 2007; Lin, Shaw and Ho, 2008). Employing conjoint measurement of perceived probability and consequences as an indicator for risk perception has also been seen (Grothmann and Reusswig, 2006). In recent development, affect – worry and dread – has been considered to serve as a cues for risk assessment (Zaleskiewicz et al, 2002; Miceli, Sotgiu and Settanni, 2008; Lin, Shaw and Ho, 2008).

Empirical evidence, however, emerges inclusive with respect to the relation between perceived risk and precautionary behaviour. Perception of hurricane risks was found strongly correlated with people's adoption of precautionary measures (Peacock, 2003; Lindell and Hwang, 2008). By contrast, Bubeck, Botzen and Aerts (2012) reviewed empirical literature that investigated the relationship between people's flood risk perceptions and their already adopted mitigation behaviour and found that a positive relationship was hardly observed – either weakly significant or insignificant. Solberg, Rossetto and Joffe (2010), examining the studies that looked into the correlation between seismic risk perception and seismic hazard adjustment, concluded that risk perception was only weakly correlated to hazard adjustment in a small magnitude. As suggested in recent studies, risk perception may be a necessary but not a sufficient determinant of people's precautionary behaviour (Bourque et al., 2012; Bubeck, Botzen and Aerts, 2012).

The influence of coping appraisal offers an explanation for the weak linkage between risk perceptions and protective behaviour. Coping appraisal, based on the Protection Motivation Theory (Rogers and Prentice-Dunn, 1997), is a main cognitive process, in

[1] Only refer to those related to hurricane/typhoon risks, flood risks and rainfall-caused landslides risks.

addition to risk perceptions, that leads to protective actions against a certain threat in life. Decision makers exercise coping appraisal in order to evaluate the benefits of possible actions and decision makers' competence to carry out these actions (Schwarzer and Fuchs, 1996) and hence the process involves decision makers' subjective assessment of their ability to implement a given measure (self-efficacy), of the effectiveness of a measure (response efficacy) and of the costs required to carry out a measure (response costs) (Bubeck, Botzen and Aerts, 2012). An individual with a high risk perception may not adopt a precautionary measure if he/she has a low coping appraisal. Empirical evidence has confirmed the influence of coping appraisal on prompting people's precautionary behaviour against, for example, terrorist risks (Bourque et al., 2012), health-related risks (Milne et al., 2000) and flood risks (Kreibich et al., 2002; Grothmann and Reusswig, 2006; Zaalberg et al., 2009).

Another explanation lies in the limitation inherent in data. Studies that examined the relation between risk perceptions and observed precautionary behaviour based on cross-sectional datasets are most likely faced with a methodological criticism (Weinstein, Rothman and Nicolich, 1998; Bubeck, Botzen and Aerts, 2012). This is because cross-sectional datasets usually contain information observed at a given point in time, and the dynamic interactions between behaviour and risk perceptions over time can rarely be observed. This means that one is not able to say with confidence if the correlation observed between the two indicates a causal relation. Whilst it has been dominantly presumed in existing literature that risk perception is a predictor for observed precautionary behaviour, a possibility that has notably received little empirical examination is that risk perceptions could become lower as a result of the adopted precautionary actions and in this case, a positive correlation might not be observed. An more appropriate way to reassure that risk perception influences precautionary behaviour, rather than the other way around, is to investigate the effects of risk perception on people's *intentions* to take precautionary measures in the future[2] (Bubeck, Botzen and Aerts, 2012).

The influences of other factors on precautionary actions have been extensively documented. External compensation for natural hazard damage from the government or insurance companies has also been found to dissuade households from taking mitigation actions (Grothmann and Reusswig, 2006; Siegrist and Gutscher, 2006; Botzen, Aerts and van den Bergh, 2009; Botzen and van den Bergh, 2012). Households' experience with a natural hazard, especially when happening in recent past or with greater severity, can influence precautionary actions (Grothmann and Reusswig, 2006; Siegrist and Gutscher, 2008). Households' feeling of trust was found directly related to preparedness actions (Lin, Shaw and Ho, 2008; McIvor, Paton and Johnston, 2009). The feeling of trust can be with an infrastructure or with authorities' ability to undertake protection measures. At last, the influence of socio-demographic and geographic factors on precautionary behaviour has been extensively considered and they, by and large, include age, gender, marital status, education, income, ethnicity, house ownership, residential regions, etc. (Bubeck, Botzen and Aerts, 2012)

[2] For example, studies that elicit the intention to undertake a flood mitigation measure do find significant relations with risk perceptions. (Bubeck, Botzen and Aerts, 2012)

The term of 'perceived' risk indicates the nature of its subjectivity and such subjectivity is attributed to individual persons' complex cognitive processes and preferences that yet are unknown to researchers. Quantifying risk perceptions and investigating how the differences in people's background could explain the formation of their risk perceptions therefore become a primary approach for researchers to gain more understanding risk perceptions. Recent studies (Kellen, Terpstra and Maeyer, 2012; Wachinger et al., 2012) provide thorough reviews of current empirical studies and outline predictors for natural hazard risk perceptions. Factors with evident relationship with individuals' risk perceptions include: socio-demographic characteristics (e.g. gender, educational attainment and income), previous experience of hazards, in particular when interacting with incurred damaged (Halpern-Felsher et al, 2001) and trust in experts, the authorities or protective measures). These reviews in the same time demonstrate the lack of empirical evidence of the influence of already-adopted measures on risk perceptions.

The review above infers that the effects of certain factors –previous experience of natural hazards, trust and individuals' socio-demographic background, for example - can exhibit on individuals' risk perceptions and on their precautionary behaviour, respectively. This implies that these factors may have direct effect on behaviour and indirect effect on behaviour mediated by risk perceptions. However, investigations based on a single-stage model, like most of the empirical studies have done, can hardly demonstrate such compound effects. To the authors' knowledge, only a few studies to date have demonstrated the mediating effects as described in the context of natural hazard risk perception and precautionary behaviour. (Lindell and Hwang, 2008)

This paper contributes to current literature by addressing the knowledge gaps identified above. It will explicitly investigate the causal relationship between risk perceptions and precautionary actions, i.e. the influence of previously adopted protection actions on risk perceptions observed at the time of observation and in turn the effects of risk perceptions on individuals' intention to take precautionary actions in the future. To meet this purpose, a two-stage approach will be adopted – firstly to predict perceived risk levels and secondly to examine its influence on precautionary intentions - and this approach will also allow the authors to explore the existence of mediating effects. Finally, this is the first empirical study to reveal the precautionary behaviour and risk perceptions of the victims of Typhoon Morakot.

3. Methods

3.1 Data

This study used the data from the Household Survey of Post-Morakot Social Impact and Recovery-Wave 1.This survey was implemented in June, 2010 via face to face interview with the representatives of the households that were forced to relocate after the typhoon Morakot. Qualified interviewees must be aged over 20 at the time of interview, and should be household heads, primary financial supporters or the ones most capable of answering questions in an interview. The raw data contains 1658 observations, representing 1658 households. The survey collected a wide range of information about these households, including their socioeconomic characteristics, their preparation for a

typhoon event, actions taken during the typhoon Morakot, the impact caused by the typhoon and the conditions of recovery in the aftermaths of the event.

During the interview, every household representative was asked –Please indicate which of the following measures you took before the typhoon Morakot. In addition, please indicate which of the following measures you intend totake in the future (before next typhoon event).

- Obtain the information about this typhoon from the TV, radio and other sources (INFORMATION)
- Take part in local disaster drills(DRILLS)
- Strengthen your house's resistance to typhoons, e.g.sandbags, water pumping machines (HOUSE)
- Prepare food, clothes and other necessities (FOOD)
- Understand and make plans of evacuation routes and temporary shelters (EVACUATION)
- Purchase or renew personal accident insurance (INSURE_ACCIDENT)
- Purchase or renew typhoon and flood insurance for your property (INSURE_PROPERTY)

The information revealed is two-folds: the first question exhibits whether or not households took precautionary measures *before* the typhoon Morakot and the second shows whether or not households, at the time of interview, had the *intention* to take the same precautionary measures in the future. Precautionary measures, according to Lindell and Perry (2004) can be classified into 'mitigation measures', preparedness measures' and 'recovery measures' according to the phases of the hazard life cycle. Measures of the first type are usually implemented when a hazardous event is absent and the measures of 'DRILLS' and 'EVACUATION' are classified as this type. Preparedness measures, in comparison, are usually undertaken shortly before or during an event and the actions of 'INFORMATION','HOUSE' and 'FOOD' are considered to fit this category. The purpose of recovery measures is to support people in returning to a normal state of living and the measures of 'INSURE_ACCIDENT' and 'INSURE_PROPERTY' provide such function. Table 1 reports the precautionary measures adoption rates of the survey respondents before and after Typhoon Morakot.

In addition, household representatives were asked to state their risk perceptions in the following questions –

- In a scale from '1' (very unlikely) to '4' (very likely), how likely do you think that a typhoon disaster would occur in the region of your residency? (PROB_DISASTER)
- In a scale from '1' (very mildly) to '4' (very seriously), to what extent do you think a typhoon disaster would threat the safety of your life? (IMPACT_SAFETY)
- In a scale from '1' (very mildly) to '4' (very seriously), to what extent do you think a typhoon disaster would result in the loss of your personal property? (IMPACT_PROPERTY)

The first question measures one's subjective judgment of the chances of a typhoon-induced disaster in the future. The others stated one's perceived levels of potential impact

on his/her personal safety and of the loss of his/her personal property, as a result of a typhoon disaster. The corresponding distributions of risk perceptions across the sample are reported in Table 2.

Table 3 describes the socio-economic background of the sample being surveyed along with their geographic distribution, level of trust with the government and experience of disasters.

3.2 Statistical Analysis

Based on a two-stage approach, we, in the first stage, investigate the determinants of three types of households' risk perceptions for the future, respectively, instead of considering a combined measure for risk perception. This is because the three different indicators are only weakly or intermediately correlated[3] with each other. Drawing inferences from existing studies, we consider in the model specification the following explanatory variables: one's experience with disaster with damage incurred, one's trust in the authorities as well as local communities regarding their capacity of emergency response, one's socio-demographic backgrounds and one's residential areas.

In addition, this study considers the influence of precautionary actions which had already been adopted by households *before* typhoon Morakot took place. It is anticipated that one would perceive lower levels of risk if he/she had already taken precautionary measures but related empirical evident is yet absent. Three proxy indicators were constructed to measure the levels of households' involvement in precautionary actions before typhoon Morakot. The first indicator represents the number of preparedness measures that individual household had taken and according to previous classification, the corresponding values can range between '*0*', meaning no preparedness measure had been taken, and '*3*', meaning all preparedness measures had been taken. The second indicator measures the number of mitigation measures and thus the values vary between '*0*' and '*2*'. The third indicator measures the number of recovery measures and therefore the values range between '*0*' and '*2*'.

The reasons for investigating people's trust in the central government and local communities separately lie in the differences in their functions in a top-down emergency response framework in Taiwan. The central government often is in charge of monitoring hazards, issuing early warning and facilitating emergency evacuation. In comparison, local communities, despite having limited resources, are expected to execute instructions from the authorities atop and yet in reality, they could respond more directly to contingency as they possess better information of the vulnerable in the locality. In recent years, the necessity of enhancing local communities' emergency response has been emphasized and government-funded programmes are regularly implemented to facilitate capacity building.

Subject to the categorical characteristics of dependent variables, an ordered probit model was employed. In the following stage, we assess the power of previously

[3] The correlation coefficient between 'PROB_DISASTER' and 'IMPACT_SAFETY' is estimated at 0.23, 0.10 between 'PROB_DISASTER' and 'IMPACT_PROPERTY', 0.53 between 'IMPACT_SAFETY' and 'IMPACT_PROPERTY'.

investigated risk perceptions, as well as of other factors, in explaining households' intention to adopt measures for preparedness, for mitigation and for recovery, respectively. Referring to Carroll, Dynan and Krane (2003) and Benito (2004), this paper uses the predicted probabilities[4] obtained in the first stage of estimation as the indicators for risk perceptions, i.e. the probabilities that households consider it to be *very likely* that a typhoon disaster would occur, the probabilities that they think a typhoon disaster would have *very serious* impact on their health and the probabilities that they think a typhoon disaster would have *very serious* impact on their property. This method normalizes the values of a given type of risk perception, with defined determinants controlled for.

Moreover, the influence of previously adopted precautionary measures on households' intention to take the same measures in the future is taken into account. Compared to their counterparts, households who had already adopted a measure should have better knowledge of the effectiveness of a measure and of the cost of implementing the measure, and have a higher level of self-efficacy, which suggests combined effects of coping appraisal. In addition, this paper investigates the extent to which post-disaster financial compensation could weaken individuals' intention to take precautionary actions, particularly recovery measures (i.e. insurance). It was hypothesized that excessive post-event financial compensation would reduce households' intention to take precautionary actions. 'Excessiveness' of compensation, in this paper, describes the condition in which households received financial support yet did not report the need of it during the first month after the event. On the other hand, 'shortage' of compensation refers to the situation that households did not receive financial support yet reported the need of it. Finally, we take account of the effects of households' trust in the central government and local communities in terms of their disaster response capacity, as well as those of households' socio-demographic background (gender, income level, age and literacy), in understanding households' intention to take precautionary measures.

The determinants of households' intention to perform precautionary behaviour were explored for individual measure. This is because each measure has a unique function in mitigating the impact of a disaster either before or after the event. A probit model is employed as the estimation method.

4. Results

4.1 Risk perceptions

Table 4 reports the estimation results for three different types of risk perception. They confirm the association between precautionary behaviour taken before Morakot and households risk perceptions after typhoon Morakot. However, it is inconclusive regarding whether or not former actions could reduce risk perceptions in a later stage. On one hand, households who had taken more preparedness measures or recovery measures tend to perceive a lower likelihood of a typhoon disaster; on the other hand, households who adopted more mitigation measures tend to perceive a higher probability of encountering a

[4] This paper used the predicted probabilities that households would report the highest levels of risk perceptions, i.e. 'very likely' for the chance of a typhoon disaster, 'very seriously' for the impact on the safety of life and on property.

typhoon disaster, higher threat on personal safety and more serious property loss. A negative correlation between trust in the central government and perceived impact of property loss is observed and this may suggest that the central government's emergency response takes effect on reducing the damage on property. In comparison, households with higher trust in local communities tend to have lower perceived likelihood of a typhoon disaster.

Households' socio-demographic background and the locations of their residency are related to risk perceptions, primarily perceived probability and impact on property. Gender effect is noticeable only on the levels of perceived probabilities. Household income levels are positively associated with perceived probabilities and the perceived seriousness of property loss. These results are in line with the findings in existing literature. Concerning one's educational attainment on his/her risk perceptions, this paper is interested in the effect of illiteracy as literacy suggests the capacity of receiving and processing rewritten information. The result shows illiteracy is linked with lower perceived probability of encountering a typhoon disaster. This forms an important message that people perceive lower risk to some extent due to knowledge deficiency. Other factors that influence one or more types of risk perception include being aboriginal and county of residency.

In predicting households' perceived impact on personal safety, this paper especially identifies the effect of households' loss of human life/health as a result of typhoon Morakot. Compared to the experience of disaster before Morakot, the most recent experience, as results suggest, emerges significantly more powerful in explaining perceived health impact. The results confirm that perceived health impact increases with the severity of the loss of human lives and of injury. As suggested in the literature, the effect of disaster experience can fade away in time.

The corresponding predicted values – in means and standard deviations – for each type of risk perception are shown in Table 5. It is confirmed that majority of the sampled households have high or very high risk perceptions.

4.2 Precautionary intentions

This section is focused on the determinants of households' *intentions* to take 7 different types of precautionary measures, respectively. As previously discussed, one measure is not a substitute for one another in that each measure functions uniquely towards reducing the impact of typhoon events on households. Despite this, households may exhibit various degrees of willingness to take each of these measures - as this paper intends to unfold below - and the knowledge behind, the authors propose, conveys useful implications for hazard risk management strategies at the household level. Table 6 reports the estimation results based on the probit model, Table 7 for mitigation measures and

for recovery measures. Results include both the estimated coefficients and the marginal probability effects[5], denoted as *dy/dx*.

[5] In a probit model, the estimated coefficients do not represent directly the partial effects of explanatory variables on the dependent variable but on the probit index function. For the convenience of interpreting the results, this paper also reports the marginal probability effects which stand for the partial effects of explanatory variables on the probability that the observed dependent variable Y=1.

Risk perceptions – both the perceived probability and perceived impact on personal safety and property – are evident determinants of households' intention to take precautionary measures. The findings with respect to the first two types of risk perceptions conform to the general assumption that households with higher risk perceptions are more likely to take precautionary actions. Estimated marginal probability effects further show that the scale of influence of perceived probabilities is the largest on households' intention to take the measure of 'EVACUATION' and the smallest for the measure of 'INSURE_ACCIDENT'. Concerning the case for perceived health impact, the scale is the largest for the measure of 'DRILLS' and the smallest for the measure of 'EVACUATION'.

At the same time, it is noted that households with higher perceived property loss are more likely to take property insurance but on the contrary, exhibit lower intention to take any of the preparedness measures. One reason is that households may consider that only property insurance is useful to counterbalance property loss due to the availability of compensation. The measure of 'HOUSING' perhaps is considered the least helpful in this respect as its estimated marginal probability effect emerges, interestingly, the lowest.

Positive coefficients of 'previously adopted the same measure' are found in response to the measures of 'HOUSE', 'DRILLS' and 'INSURE_ACCIDENT'. This may suggest that these measures are useful in the case of contingency so that households have the intention to take the same actions in the future. Previous experience of disasters reduces, instead of increases, one's intention to preparedness measures, and such effect is insignificant on mitigation and recovery measures.

The extent to which one trusts the central government and local communities in their disaster response capacity explains his/her intention to take precautionary actions. Higher trust in the central government is associated with weaker intention to take preparedness and mitigation measures. On the contrary, higher trust in local communities' capacity is correlated to stronger intention to take preparedness, mitigation and recovery measures. These results imply that households' trust in the central government indicates their dependency on the government and hence results in weaker intention to take self-protect actions. Furthermore, households who trust in local communities do not consider that it is the communities' responsibility to take protection measures and being part of the communities, they recognise the necessity of precautionary actions at the community level.

The effects of socio-demographic factors are to a certain degree apparent. Gender effect is limited: female-headed households have weaker intention to take the measure of 'EVACUATION'. Older ages are correlated with weaker intention to take preparedness, mitigation and recovery measures and this is the most obviously observed in the case of preparedness measures. Households with higher income have weaker intention to take mitigation measures. Illiterate heads of households demonstrate stronger intention to take the measure of 'EVACUATION'. Results show that households with an aboriginal background have stronger intention to take recovery measures and yet weaker intention to take preparedness and mitigation measures than those without.

Furthermore, the effect of financial compensation from the central government or private institutions on households' intention to purchase insurance is shown in Table 8. It

is found that excessive compensation is correlated with weaker intention to purchase property insurance but a similar effect is not observed with respect to the intention to take up insurance against personal accidents. This, the authors argue, can be explained by the fact that the authorities offered to the households affected by typhoon Morakot a financial compensation package that had extensive coverage on flooded or damaged housing and this can disincentivize households to purchase property insurance. Insurance against personal accidents can compensate not only for the health impact caused by natural hazards but also by other accidents in one's daily life; therefore, the fact that compensation for the loss of life or injury was provided to households did not reduce households' intention to buy/renew an insurance against personal accidents.

Finally, the results confirm that certain predictors have both direct and indirect effects on the intentions to take certain precautionary measures, when indirect effects are mediated by risk perceptions. These predictors include trust in the central government in the case of preparedness and mitigation measures, trust in local communicates for preparedness, mitigation and recovery measures, age for preparedness measures, income and illiteracy for mitigation measures and ethnicity for recovery measures. Moreover, the direct and indirect effects in some cases, as shown, can counteract with each other. For example, aboriginal households, on one hand, have lower perceived impact concerning property loss and hence are less likely to buy/renew property insurance. On the other hand, they are more likely to buy/renew property insurance, when the influence of perceived impact remains constant. These findings can further infer that if risk communication is to be sought in order to promote households' precautionary behaviour against typhoon hazards, not only the information about the possibility and potential impact associated with a hazard but also households' attitudes and socio-demographic factors ought to be taken into account in the development of communication strategies.

5. Conclusion and policy implications

Based on a two-stage approach, we, in the first stage, investigate the determinants of three types of households' risk perceptions for the future, respectively, with the following explanatory variables: one's experience with disaster with damage incurred, one's trust in the authorities as well as local communities regarding their capacity of emergency response, one's socio-demographic backgrounds and one's residential areas. In the second stage, we assess the power of previously investigated risk perceptions, as well as of other factors, in explaining households' intention to adopt measures for preparedness, for mitigation and for recovery, respectively. Subject to the categorical characteristics of dependent variables, an ordered probit model was employed.

Our estimation results confirm the association between precautionary behaviour taken before Morakot and households risk perceptions after typhoon Morakot. However, it is inconclusive regarding whether or not former actions could reduce risk perceptions in a later stage. A negative correlation between trust in the central government and perceived impact of property loss is observed which suggests that the central government's emergency response takes effect on reducing the damage on property. In comparison, households with higher trust in local communities tend to have lower perceived likelihood of a typhoon disaster. The corresponding predicted values confirmed that majority of the sampled households have high or very high risk perceptions. Households' socio-demographic background and the locations of their

residency are related to risk perceptions, primarily perceived probability and impact on property.

On the determinants of households' *intentions* to take precautionary measures, the estimation results show that risk perceptions – both the perceived probability and perceived impact on personal safety and property – are evident determinants. Estimated marginal probability effects further show that the scale of influence of perceived probabilities is the largest on households' intention to take the measure of 'EVACUATION' and the smallest for the measure of 'INSURE_ACCIDENT'. At the same time, it is noted that households with higher perceived property loss are more likely to take property insurance but on the contrary, exhibit lower intention to take any of the preparedness measures. One reason is that households may consider that only property insurance is useful to counterbalance property loss due to the availability of compensation. Previous experience of disasters reduces, instead of increases, one's intention to preparedness measures, and such effect is insignificant on mitigation and recovery measures.

The extent to which one trusts the central government and local communities in their disaster response capacity explains his/her intention to take precautionary actions. Higher trust in the central government is associated with weaker intention to take preparedness and mitigation measures. On the contrary, higher trust in local communities' capacity is correlated to stronger intention to take preparedness, mitigation and recovery measures. These results imply that households' trust in the central government indicates their dependency on the government and hence results in weaker intention to take self-protect actions. Furthermore, households who trust in local communities do not consider that it is the communities' responsibility to take protection measures and being part of the communities, they recognise the necessity of precautionary actions at the community level.

Furthermore, we found that excessive compensation is correlated with weaker intention to purchase property insurance but a similar effect is not observed with respect to the intention to take up insurance against personal accidents. This can be explained by the fact that the authorities offered to the households affected by typhoon Morakot a financial compensation package that had extensive coverage on flooded or damaged housing and this can dis-incentivize households to purchase property insurance.

Finally, the results confirm that certain predictors have both direct and indirect effects on the intentions to take certain precautionary measures, when indirect effects are mediated by risk perceptions. These predictors include trust in the central government for preparedness and mitigation, trust in local communicates for preparedness, mitigation and recovery, age for preparedness measures, income and illiteracy for mitigation measures and ethnicity for recovery measures. Moreover, the direct and indirect effects in some cases can counteract with each other. Thus if risk communication is to be sought in order to promote households' precautionary behaviour against typhoon hazards, not only the information about the possibility and potential impact associated with a hazard but also households' attitudes and socio-demographic factors ought to be taken into account in the development of communication strategies.

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Table 1: Precautionary measures

Precautionary measure	Description	Before Morakot % of the sample	After Morakot % of the sample
Preparedness measure			
INFORMATION	Obtain the information about this typhoon from the TV, radio and other sources	91%	76%
FOOD	Prepare food, clothes and other necessities	85%	76%
HOUSE	Strengthen your house's resistance to typhoons, e.g. sandbags, water pumping machines	62%	66%
Mitigation measure			
EVACUATION	Understand and make plans of evacuation routes and temporary shelters	44%	69%
DRILLS	Take part in local disaster drills	39%	61%
Recovery measure			
INSURE_ACCIDENT	Purchase or renew personal accident insurance	24%	48%
INSURE_PROPERTY	Purchase or renew typhoon and flood insurance for your property	6%	35%

Table 2: Risk perceptions

Risk Perception	Description	Mean	Std Devi.
PROB_DISASTER	In a scale from '1' (very unlikely) to '4' (very likely), how likely do you think that a typhoon disaster would occur in the region of your residency?	3.29	0.87
IMPACT_SAFETY	In a scale from '1' (very mildly) to '4' (very seriously), to what extent do you think a typhoon disaster would threat the safety of your life?	3.58	0.60
IMPACT_PROPERTY	In a scale from '1' (very mildly) to '4' (very seriously), to what extent do you think a typhoon disaster would result in the loss of your personal property?	3.50	0.67

Table 3: Breakdown of the sample

Variable	Mean	Variable	Mean
Already adopted precautionary measures		**Geographic factors**	
The number of preparedness measures taken	2.38	Natou	3%
The number of mitigation measures taken	0.83	Chiayi	14%
The number of recovery measures taken	0.30	Tainan	5%
Experience_disaster	0.63	Kaohsiung	48%
Level of trust		Pintong	17%
In central government	3.10	Taitong	11%
In community	3.66	Tainancity	1%
Socio-demographic factors		**Health impact in Morakot**	
Female	40%	The number of death	0.15
Age	52.37	The number of injury	0.11
Income			
Below 12k	21%		
12k and above, below 36k	38%		
36k and above, below 60k	27%		
60k and above, below 108k	11%		
108k and above	3%		
Education (illiterate)	11%		
Aboriginal	39%		

Table 4: Predictors of risk perceptions

	PROB_DISASTER		IMPACT_SAFETY		IMPACT_PROPERTY	
Ordered probit estimation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Already adopted precautionary measures before Morakot						
The number of preparedness measures taken	-0.166***	0.046	-0.022	0.048	0.078	0.046
The number of mitigation measures taken	0.175***	0.049	0.238***	0.056	0.194***	0.053
The number of recovery measures taken	-0.140**	0.065	-0.113	0.072	-0.028	0.070
Experience_disaster before Morakot	-0.037	0.075	0.043	0.082	0.125	0.079
Level of Trust						
In central government	0.209***	0.041	-0.010	0.046	-0.168***	0.046
In community	-0.154***	0.044	-0.053	0.049	-0.039	0.048
Socio-demographic factors						
Female	0.256***	0.074	0.146	0.079	0.071	0.077
Age	0.005	0.003	-0.009***	0.003	-0.004	0.003
Income	0.098***	0.028	0.051	0.030	0.140***	0.031
Education (illiterate)	-0.341***	0.124	0.049	0.134	0.032	0.130
Aboriginal	0.140	0.084	-0.183	0.095	-0.329***	0.090
Geographic factors (base = Tinancity)						
Natou	1.126***	0.385	-0.206	0.402	-0.035	0.386
Chiayi	0.562	0.332	0.370	0.363	0.702**	0.347
Tinan	-0.001	0.346	-0.384	0.375	-0.053	0.359
Kaohsiung	0.741**	0.323	0.436	0.352	0.606	0.335
Pintong	0.719**	0.335	0.129	0.366	0.116	0.347
Taitong	0.615	0.342	0.420	0.376	0.760**	0.360
Health impact in Morakot						
Death			0.248***	0.095		
Injured			0.414***	0.126		
Number of observations	1135		1135		1135	
Log likelihood	-1194.26		-860.91		-941.80	
Pseudo R2	0.055		0.068		0.083	

'***' denotes at 99% confidence level; '**' for at 95% confidence level

Table 5: Predicted levels of risk perceptions

PROB_DISASTER	**Very low**	**Low**	**High**	**Very high**
Mean	0.048	0.132	0.297	0.522
Std. Devi	0.046	0.064	0.054	0.153
IMPACT_SAFETY	**Very mildly**	**Mildly**	**Seriously**	**Very seriously**
Mean	0.006	0.040	0.322	0.631
Std. Devi	0.009	0.034	0.109	0.146
IMPACT_ASSET	**Very mildly**	**Mildly**	**Seriously**	**Very seriously**
Mean	0.006	0.081	0.316	0.598
Std. Devi	0.009	0.069	0.101	0.172
Number of observations	1135	1135	1135	1135

Table 6: Predictors of the intention to take preparedness measures

	INFORMATION		FOOD		HOUSE	
Probit model estimation	*Coef.* *(Std. Err.)*	*dy/dx* *(Std. Err.)*	*Coef.* *(Std. Err.)*	*dy/dx* *(Std. Err.)*	*Coef.* *(Std. Err.)*	*dy/dx* *(Std. Err.)*
PREVIOUSLY ADOPTED THE SAME MEASURE	-0.177 (0.186)	-0.050 (0.052)	-0.055 (0.145)	-0.015 (0.041)	0.633*** (0.096)	0.212*** (0.030)
RISK PERCEPTION						
Prob_Disaster (very high)	1.864*** (0.593)	0.522*** (0.165)	2.182*** (0.605)	0.612*** (0.168)	2.660*** (0.532)	0.889*** (0.172)
Impact_Safety (very seriously)	2.000*** (0.706)	0.560*** (0.196)	1.383** (0.690)	0.388** (0.193)	1.434** (0.624)	0.480** (0.207)
Impact_Property (very seriously)	-3.473*** (0.652)	-0.973*** (0.177)	-3.427*** (0.652)	-0.962*** (0.177)	-3.228*** (0.585)	-1.079*** (0.189)
EXPERIENCE_DISASTER	-0.399*** (0.095)	-0.112*** (0.026)	-0.325*** (0.094)	-0.091*** (0.026)	-0.296*** (0.086)	-0.099*** (0.028)
LEVEL OF TRUST						
Central government[+]	-0.311*** (0.079)	-0.087*** (0.022)	-0.342*** (0.082)	-0.096*** (0.023)	-0.401*** (0.073)	-0.134*** (0.023)
Local community[+]	0.169*** (0.060)	0.047*** (0.017)	0.190*** (0.061)	0.053*** (0.017)	0.284*** (0.056)	0.095*** (0.018)
SOCIO-DEMOGRAPHIC FACTORS						
Female	-0.139 (0.102)	-0.039 (0.028)	-0.121 (0.102)	-0.034 (0.029)	-0.124 (0.093)	-0.041 (0.031)
Age	-0.011** (0.004)	-0.003** (0.001)	-0.015*** (0.004)	-0.004*** (0.001)	-0.012*** (0.004)	-0.004*** (0.001)
Income[+]	0.031 (0.043)	0.009 (0.012)	0.026 (0.042)	0.007 (0.012)	-0.005 (0.039)	-0.002 (0.013)
Education (illiterate)	0.101 (0.173)	0.028 (0.048)	0.112 (0.171)	0.031 (0.048)	0.205 (0.160)	0.069 (0.053)
Aboriginal	-0.937*** (0.116)	-0.262*** (0.030)	-0.998*** (0.119)	-0.280*** (0.031)	-0.643*** (0.113)	-0.215*** (0.036)
CONSTANT	2.253*** (0.446)		2.568*** (0.434)		1.030*** (0.397)	
Number of obs.	1135		1135		1135	
Log likelihood	-563.46		-564.75		-666.89	
Pseudo R2	0.099		0.101		0.082	

'***' denotes at 99% confidence level; '**' for at 95% confidence level

'+' For the purpose of simplicity, these variables were treated as quasi continuous variables. However, these variables are categorical in nature. One must note that a general trend of their association with households' intention to take precautionary actions can be confidently identified in this approach but at the same time, one must interpret the corresponding marginal effects with caution.

Table 7: Predictors of the intention to take mitigation measures

	DRILLS		EVACUATION	
Probit model estimation	*Coef.* *(Std. Err.)*	*dy/dx* *(Std. Err.)*	*Coef.* *(Std. Err.)*	*dy/dx* *(Std. Err.)*
PREVIOUSLY ADOPTED THE SAME MEASURE	0.278*** (0.103)	0.095*** (0.035)	-0.335*** (0.099)	-0.104*** (0.030)
RISK PERCEPTION				
Prob_Disaster	2.086*** (0.484)	0.714*** (0.161)	4.808*** (0.529)	1.492*** (0.147)
Impact_Safety	1.857*** (0.595)	0.636*** (0.201)	1.014 (0.624)	0.315 (0.193)
Impact_Property	-0.825 (0.577)	-0.283 (0.197)	-0.813 (0.589)	-0.252 (0.183)
EXPERIENCE_DISASTER	-0.078 (0.086)	-0.027 (0.030)	-0.088 (0.089)	-0.027 (0.028)
LEVEL OF TRUST				
Central government+	-0.136** (0.068)	-0.047** (0.023)	-0.389*** (0.072)	-0.121*** (0.021)
Local community+	0.226*** (0.056)	0.077*** (0.019)	0.340*** (0.058)	0.105*** (0.017)
SOCIO-DEMOGRAPHIC FACTORS				
Female	-0.028 (0.093)	-0.009 (0.032)	-0.271*** (0.097)	-0.084*** (0.030)
Age	-0.006 (0.004)	-0.002 (0.001)	-0.015*** (0.004)	-0.005*** (0.001)
Income+	-0.085** (0.039)	-0.029** (0.013)	-0.151*** (0.040)	-0.047*** (0.012)
Education (illiterate)	0.107 (0.156)	0.037 (0.054)	0.457*** (0.162)	0.142*** (0.050)
Aboriginal	0.066 (0.107)	0.023 (0.037)	-0.498*** (0.114)	-0.155*** (0.034)
CONSTANT	-1.338*** (0.433)		-0.399 (0.432)	
Number of obs.	1135		1135	
Log likelihood	-683.38		-623.55	
Pseudo R2	0.101		0.114	

'***' denotes at 99% confidence level; '**' for at 95% confidence level

'+' For the purpose of simplicity, these variables were treated as quasi continuous variables. However, these variables are categorical in nature. One must note that a general trend of their association with households' intention to take precautionary actions can be confidently identified in this approach but at the same time, one must interpret the corresponding marginal effects with caution.

Table 8: Predictors of the intention to take recovery measures

Probit model estimation	INSURE_ACCIDENT		INSURE_PROPERTY	
	Coef. *(Std. Err.)*	*dy/dx* *(Std. Err.)*	*Coef.* *(Std. Err.)*	*dy/dx* *(Std. Err.)*
PREVIOUSLY ADOPTED THE SAME MEASURE	0.436*** (0.097)	0.159*** (0.035)	0.150 (0.164)	0.050 (0.054)
RISK PERCEPTION				
Prob_Disaster	0.792 (0.484)	0.289 (0.176)	1.112** (0.475)	0.370** (0.157)
Impact_Safety	1.558*** (0.353)	0.568*** (0.125)	-	-
Impact_Property	-	-	0.995*** (0.331)	0.331*** (0.109)
EXPERIENCE_DISASTER	0.040 (0.080)	0.014 (0.029)	0.077 (0.084)	0.025 (0.028)
LEVEL OF TRUST				
Central government[+]	-0.057 (0.063)	-0.021 (0.023)	0.012 (0.069)	0.004 (0.023)
Local community[+]	0.216*** (0.055)	0.079*** (0.019)	0.219*** (0.057)	0.073*** (0.019)
SOCIO-DEMOGRAPHIC FACTORS				
Female	-0.056 (0.091)	-0.021 (0.033)	-0.024 (0.094)	-0.008 (0.031)
Age	-0.006 (0.004)	-0.002 (0.001)	-0.008** (0.004)	-0.003** (0.001)
Income[+]	0.042 (0.035)	0.015 (0.013)	0.010 (0.037)	0.003 (0.012)
Education (illiterate)	0.192 (0.158)	0.070 (0.057)	0.264 (0.161)	0.088 (0.053)
Aboriginal	0.283*** (0.095)	0.103*** (0.034)	0.704*** (0.105)	0.234*** (0.033)
FINANCIAL COMPENSATION FROM GOVERNMENT OR PRIVATE INSTITUTION (base = received and needed)				
Received not needed (Excessiveness)	-0.016 (0.111)	-0.006 (0.040)	-0.247** (0.116)	-0.082** (0.038)
Needed not received (Shortage)	-0.154 (0.546)	-0.056 (0.199)	0.436 (0.544)	0.145 (0.181)
CONSTANT	-2.153*** (0.387)		-2.367*** (0.388)	
Number of obs.	1135		1135	
Log likelihood	-723.63		-666.40	
Pseudo R2	0.079		0.095	

'***' denotes at 99% confidence level; '**' for at 95% confidence level

'+' For the purpose of simplicity, these variables were treated as quasi continuous variables. However, these variables are categorical in nature. One must note that a general trend of their association with households' intention to take precautionary actions can be confidently identified in this approach but at the same time, one must interpret the corresponding marginal effects with caution.