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Jan-Jan Soon, Roslina Kamaruddin, Abdul Rahim Anuar,

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Flood victims' evacuation decisions: a semi-nonparametric estimation

Jan-Jan Soon and Roslina Kamaruddin
School of Economics, Finance and Banking, Universiti Utara Malaysia, Sintok, Malaysia, and
Abdul Rahim Anuar
School of International Studies, Universiti Utara Malaysia, Sintok, Malaysia

Abstract

Purpose – The purpose of this paper is to analyse the determinants of actual evacuation decisions of victims of the unprecedented 2014 year-end flood disaster which wreaked havoc across two east-coast states in Malaysia.
Design/methodology/approach – The target population of this study is the group of victims affected by the December 2014 flood in the Malaysian east-coast states of Kelantan and Pahang. Sampling frames of the flood victims were obtained from the National Security Council offices of the two states. The empirical analysis of this paper is based on a unique data set obtained from a questionnaire survey of the flood victims. The final working sample consists of 372 respondents.
Findings – Important findings from this study are: victims who were given evacuation notices were five times more likely to evacuate, victims who participated in flood awareness programmes were less likely to move to evacuation centres, the further away victims' homes were from the evacuation centres the more likely they were to evacuate, older victims were less likely to evacuate, larger households were more likely to evacuate, and victims with tertiary education were also less likely to evacuate.
Originality/value – This paper is unique because previous studies of Malaysian flood-related disasters are confined to floods of regular magnitude. This paper is also unique because it uses a semi-parametric estimation approach to obtain the marginal effects of the explanatory variables on evacuation decisions.

Keywords Disaster management, Evacuation decision, Flood victims, Semi-nonparametric estimation
Paper type Research paper

1. Overview and selected literature

Malaysia experienced an unprecedented flood catastrophe in December 2014. The east-coast states of Peninsular Malaysia, Kelantan and Pahang (as shown in Figure 1), bore the brunt of the massive and sudden flood onslaught. There are two features of this flood – its geographical magnitude (i.e. areas with no previous records of flood were inundated) and the suddenness of its occurrence (i.e. the unexpected speed at which riverbanks were breached). Towards the end of every year, Malaysia encounters the tropical monsoon which brings along with it torrential rains and floods. This period of the year, usually between November and March, is known as the rainy season. This season is a result of the north-east monsoon blowing from across the South China Sea. Since the east-coast states of Peninsular Malaysia are the monsoon's first point of contact, these states are especially vulnerable to heavy tropical rains which often lead to floods. The December 2014 flood hits the states of Kelantan and Pahang the hardest. Note that another east-coast state, Terengganu, was not as hard hit by the flood due to it having the best flood disaster management system in the country (Malaysian Ministry of Communications and Multimedia, 2015).

Table I tabulates the amount of rainfall in the month of December in selected areas of the states. The table clearly shows that the amount of rainfall in that particular year was exceptionally high in December 2014 compared to that month in previous years.

In Malaysia, natural disasters such as floods are managed by a set of standard operating procedures known as Directive 20, issued by the Malaysian National Security Council (NSC).

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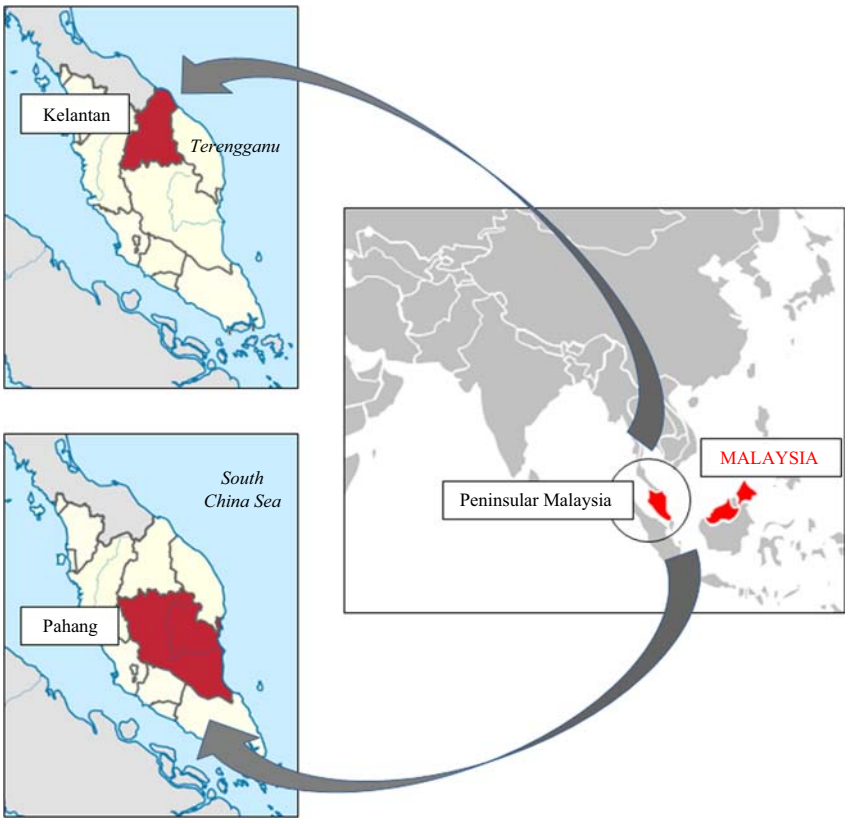

Figure 1.
Map of the affected states

	Amount of rainfall (mm) in the month of December				
	2010	2011	2012	2013	2014
Areas in the state of Kelantan					
Kota Bharu	358.4	213.8	263.2	46.6	494.0
Kuala Krai	353.6	308.4	228.2	244.2	1,267.0
Areas in the state of Pahang					
Kuantan	367.6	334.0	231.0	274.0	1,675.0
Temerloh	91.4	137.4	78.0	33.8	225.0

Source: The rainfall figures are tabulated from data available from www.ortechnologies.net/gallery/tableau-vizzes/rainfall-in-malaysia-2008-2015/

Table I.
Amount of rainfall

The NSC is responsible for the national disaster management system. One of the NSC's roles in the event of floods, via its Directive 20, includes the setting up of evacuation centres, personnel and equipment mobilisation, and dissemination of evacuation notices to flood victims. One of the most important aspects of the NSC's Directive 20 is to evacuate flood victims to safe areas such as designated evacuation centres, although flood victims still have the final decisions as there is no directive on mandatory evacuation.

The current study is an analysis of the determinants of the actual evacuation decisions of the victims of the unprecedented December 2014 flood disaster. This study is unique since previous studies on Malaysian flood-related disasters are confined to floods of regular or typical scales, unlike the unanticipated extraordinary scale of the 2014 flood that wreaked havoc across the two east-coast states.

There are only a handful of studies, in the Malaysian context, related to the current study. Padlee and Nik Razali (2015) studied flood victims' satisfaction with services provided at evacuation centres in the east-coast states of Kelantan, Pahang, and Terengganu. They concluded that flood victims were generally satisfied with the quality of services provided, especially in terms of food preparation and medical supplies. In an another Malaysian study, Raman *et al.* (2015) studied how to best manage flood disasters from the perspective of flood victims. Specifically, their study proposed a disaster risk reduction model and recommended ways to manage and cope with flood disasters. Based on their proposed model, the motivation for preparedness in facing flood disasters should come from the people themselves, while rescue agencies and emergency services should focus primarily on ensuring the safety of vulnerable segments of communities and mechanisms for information dissemination. In fact, for disaster information dissemination and management Malaysia has already put in place a web-based integrated community emergency management and awareness system, although the system is still at the prototype stage (Dorasamy *et al.*, 2017; Skar *et al.*, 2016; Raman *et al.*, 2014). Rahman's (2012) work represents a qualitative study on how knowledge of the NSC's Directive 20 amongst various disaster-related agencies in Malaysia's state of Kedah could translate into preparedness in the event of actual disasters. He came to the conclusion that knowledge of the directive did indeed translate into better preparedness for disasters, not only in the event of floods but also landslides, tsunamis, industrial pollution, and droughts. All the aforementioned Malaysian studies are done in the context of floods of typical magnitude.

Flood disasters in Malaysia are distinctly different from the natural disasters in some other geographical regions. In the USA for example, flood-related disasters are usually caused by hurricanes. In Malaysia, floods are often caused by heavy incessant tropical rains. Since the international literature is replete with studies on natural disasters, only relatively recent studies (both on actual behaviour and on hypothetical expected behaviour) of the determinants of evacuation decisions or behaviour at the household level are reviewed here. Thompson *et al.* (2017) provided an excellent systematic review of the much broader international literature concerning evacuation from natural disasters.

Solis *et al.* (2010) and Mesa-Arango *et al.* (2013) studied evacuation choices of hurricane disaster victims in the USA. Using a simple probit model, Solis *et al.* concluded that households affected by hurricanes were more likely to evacuate than to stay if: they were living in mobile homes, they were in flood-prone areas, they had experienced some form of hurricane disaster threat in the past, and they had young children. Mesa-Arango *et al.*, on the other hand, examined types of evacuation destination using a nested logit model, rather than analysing the binary yes-no evacuation decision. Low-income households were found to be more likely to evacuate to public shelters; households that received evacuation notices in advance were more inclined to move to hotels; and households that had experienced past hurricanes tended to stay with relatives and friends.

Medina and Moraca (2016) discussed the determinants of households' evacuation decisions in flood-prone areas of The Philippines. Using a simple logit model, they concluded that tertiary-level education, presence of young children in the household, poverty, and depth of the flood level all had significant impacts on households' evacuation decisions. While Medina and Moraca focused on the actual evacuation decision, Mozumder *et al.* (2008) emphasised instead the evacuation intentions of communities facing wildfire disasters in the USA. Evacuation intentions were assessed in two hypothetical scenarios: voluntary vs

mandatory evacuation orders. Results from their bivariate probit model showed that respondents who were more concerned that their homes might be endangered by wildfires expressed the intention to evacuate with higher probability, even when evacuation was voluntary. Mozumder *et al.* highlighted how different types of evacuation orders from the authorities result in different evacuation outcomes. Their findings were largely congruent with previous studies (Dixit *et al.*, 2012; Petrolia and Bhattacharjee, 2010; Fu *et al.*, 2007), with victims of natural disasters exhibiting more positive evacuation behaviour if mandatory evacuation orders are issued compared to voluntary evacuation notices.

One of the most crucial tasks for the authorities during flood disasters is search-and-rescue or relief operations, in which victims are evacuated from the affected areas. There are no mandatory evacuation orders in Malaysia, only voluntary evacuation notices. This gives rise to situations of victims choosing to remain in their homes instead of evacuating. This non-compliant behaviour could be due to a number of reasons; for example, whether they are first-time flood victims, whether there are any evacuation notices from the authorities, whether there have been any flood disaster awareness programmes held in their community to prepare them for such eventualities, whether the victims have participated in those flood awareness programmes, and the distance between the nearest evacuation centre and the victims' homes. This paper is an empirical analysis on how the five aforementioned flood-related variables of interest determine victims' evacuation decisions.

2. Methodology

2.1 Data

There are three phases of data collection involved. In the first phase, key personnel (district officers and village heads) were interviewed. These initial interviews provided an overview of the situation at Ground Zero when the December 2014 flood was at its most devastating form. Inputs from these interviews were used to design the questionnaire to solicit responses from flood victims. The approval and cooperation of district officers and village heads were also sought to conduct surveys in their areas of jurisdiction.

Questionnaire surveys were conducted in the second phase. For these surveys, the target population was the group of victims affected by the December 2014 flood in the Malaysian east-coast states of Kelantan and Pahang, the two states most ravaged by the flood. These victims included those who evacuated and those who did not evacuate. Sampling frames of the flood victims were obtained from the NSC offices of Kelantan and Pahang. The surveys were conducted in various districts of Pahang (Sg. Isap, Sg. Lembing, and Kg. Tiram) and Kelantan (Bertam, and Lebir). The empirical analysis of this paper is based on the unique data set obtained from the questionnaire surveys. The final working sample size of this study is 372 respondents.

The questionnaire is made up mainly of sections seeking information on demographic profile, whether or not a victim of the December 2014 flood evacuated and the reasons for evacuating/not evacuating, and their perceptions of how the flood was managed at the pre-disaster stage, when the disaster was at its peak, and at the post-disaster stage. Table II lists the dependent variable and the study's five flood-related explanatory variables of interest, along with the actual questionnaire items asked in the questionnaire and how the variables were operationalised.

In the third phase, empirical findings from the questionnaire surveys were verified through focus group discussions (FGDs). Two FGDs were conducted, one each in Kelantan and Pahang. Those invited for the discussions included district officers, village heads, flood victims, representatives from flood-related agencies, and other relevant authoritative bodies such as the police, military, fire department, utilities and telecommunication companies, district office, municipal council, the Ministry of Health, the Ministry of Education, the Department of Irrigation and Drainage, the Department of Social Welfare, the Department of

Variables	Questionnaire items	Variable operationalisation
Dependent variable		
Evacuee	Did you evacuate?	1 if evacuated; 0 otherwise
Explanatory variables of interest		
First-time victim	Is the December 2014 flood your first experience as a flood victim?	1 if first-time victim; 0 otherwise
Notified to evacuate	Did you get any evacuation notices from the authority?	1 if notified; 0 otherwise
Programme existence	Were there any flood awareness programmes held at your community prior to the flood?	1 if yes; 0 otherwise
Joined programme	Did you participate in any of those programmes?	1 if participated; 0 otherwise
Distance to centre	How far away would you say your home is from the designated evacuation centre?	Estimates given in kilometres

Table II. Questionnaire items and variable operationalisation

Survey and Mapping, the Malaysian Meteorological Department, as well as NGOs such as the Red Crescent Society. In addition to verifying the study's empirical findings, these two FGDs were also used as platforms to seek recommendations for policy improvements.

2.2 Model specification

The flood victims' actual evacuation decision ($\mathbf{y}$) is regressed on a vector of explanatory variables ($\mathbf{X}$) such that $\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}$, where $\mathbf{y}$ and $\boldsymbol{\varepsilon}$ are $n \times 1$ vectors, and $\boldsymbol{\beta}$ a $k \times 1$ vector. $\boldsymbol{\varepsilon}$ is the vector of error terms. $\mathbf{X}$ is an $n \times k$ matrix with k explanatory variables for n observations. The $\mathbf{X}$ matrix consists of a sub-vector of the five explanatory variables of interest, i.e. first-time victims, evacuation notices, flood disaster awareness programmes, participation in such awareness programmes, and the location of evacuation centres. The dependent variable (y) has a binary outcome with $y = 1$ for an evacuee and 0 otherwise. y^* is a latent continuous random variable related to its observable counterpart y, with $y = 1$ ($y^* > 0$). The $\mathbf{X}$ matrix also consists of controls such as demographic-related, job-related and education-related variables. In contrast to the majority of empirical papers on flood disasters, this paper uses a semi-parametric estimation to obtain the marginal effects of the explanatory variables of interest.

Relative to parametric estimation, there are fewer distributional assumptions in semi-parametric estimations; that is, there are weaker assumptions on the error term distribution. Without the imposition of strong distributional restrictions, semi-parametric estimators are therefore more robust. Though robust, semi-parametric estimators are less efficient, although the efficiency loss is modest (Klein and Spady, 1993). Having said that, however, parametric estimators only perform better if their distributional assumption is correct, and this is seldom the case (Horowitz and Savin, 2001). If the distributional assumption concerning the underlying error term is wrong, parametric estimators are inconsistent. Consequently, one would be better off with robust, though relatively less efficient semi-parametric estimations, than inconsistent parametric estimations. Semi-parametric estimations also have the advantage of overcoming the curse of dimensionality, which is a disadvantage of purely nonparametric estimations. These are the motivations for using the semi-parametric approach in the estimations here.

The semi-parametric estimation approach used here is borrowed from Gallant and Nychka (1987) and is known as the semi-nonparametric (SNP) approach. Their estimation approach has the advantage that it can be applied to any models (Van der Klaauw and

Koning, 1996). It is built on that of Phillips (1983). The SNP approach can handle a broader class of error distributions (De Luca, 2008). As noted by De Luca, the SNP approach approximates the unknown distribution of the latent error term using a flexible functional form, specifically, in the form of a Hermite polynomial expansion. This approximation is used to derive a pseudo maximum likelihood estimator for the model parameters. The parametric estimation of the probit model assumes a standardized Gaussian distribution for the error terms. In the less restrictive semi-parametric or, equivalently, a SNP setting, the mean of the error term is assumed to be 0, whereas its variance has no imposition placed on it (De Luca, 2008; Melenberg and Van Soest, 1996; Gabler *et al.*, 1993). Following Phillips (1983) and Gallant and Nychka (1987), approximation of the unknown density of the error term (ε) takes the form of a Hermite series $h(\varepsilon) = (P^2(\varepsilon)/Q^2(\varepsilon))\phi^2(\varepsilon|\tau, \Sigma)$, where $P(\varepsilon)$ and $Q(\varepsilon)$ are polynomials and $\phi(\varepsilon|\tau, \Sigma)$ is the multivariate normal density function with mean τ and covariance matrix Σ. This Hermite series is flexible enough to approximate any density function (Van der Klaauw and Koning, 1996).

3. Results and findings

3.1 Summary statistics

Table III presents the summary statistics of the variables used in the study. Variables which are continuous in nature include age, household size, and distance to evacuation centres. The means are reported for these variables. The remaining variables are dummies, reported in proportions. The means and proportions of each variable are reported by evacuee status. The "All" column in Table III reports the overall means and proportions of the variables for the whole sample. About two-thirds of the respondents are evacuees. The *p*-value column shows whether there is any statistically significant difference between each mean or proportion for evacuees and non-evacuees. The paper's explanatory variables of interest are the five flood-related variables. The controls to be included in the estimation consist of demographic, socioeconomic, job-related, and education-related variables.

Variables	Evacuees	Non-evacuees	*p*-values	All
Demographic and socioeconomic				
Age	49.6 (14.9)	54.7 (16.7)	0.0032***	51.2 (15.6)
Male	0.57 (0.49)	0.62 (0.48)	0.3693	0.59 (0.49)
Malay	0.86 (0.34)	0.71 (0.45)	0.0010***	0.81 (0.38)
Married	0.75 (0.43)	0.80 (0.40)	0.2982	0.77 (0.42)
Household size	4.5 (2.4)	3.6 (2.2)	0.0012***	4.2 (2.4)
Income ⩽ RM500	0.41 (0.49)	0.33 (0.47)	0.1856	0.38 (0.48)
Income > RM500-RM1,000	0.27 (0.44)	0.39 (0.48)	0.0216**	0.31 (0.46)
Job and education				
Have own business	0.37 (0.48)	0.47 (0.50)	0.0643*	0.40 (0.49)
Tertiary education	0.12 (0.32)	0.16 (0.36)	0.3176	0.13 (0.33)
Secondary education	0.41 (0.49)	0.31 (0.47)	0.0530*	0.38 (0.48)
Flood related				
First-time victim	0.51 (0.50)	0.49 (0.50)	0.9351	0.50 (0.50)
Notified to evacuate	0.94 (0.22)	0.42 (0.49)	0.0000***	0.77 (0.41)
Programme existence	0.54 (0.49)	0.38 (0.48)	0.0068***	0.49 (0.50)
Joined programme	0.51 (0.50)	0.35 (0.48)	0.0128**	0.46 (0.49)
Distance to centre	2.2 (2.3)	1.6 (2.2)	0.0902*	2.0 (2.2)
n	251 (67.5%)	121 (32.5%)		372 (100%)

Notes: Figures in parentheses are standard deviations. Figures are either means or proportions depending on whether the variables are continuous or categorical. *,**,***Significant at 10, 5, and 1 per cent levels, respectively

Table III.
Summary statistics

As shown in Table III, slightly more than half of the evacuees were first timers (51 per cent), i.e., the December 2014 massive flood was their first flood experience. Almost all of the evacuees received evacuation notices (94 per cent). About 54 per cent of the evacuees stated that they knew of the existence of flood awareness programmes being conducted in their communities, and about 51 per cent of the evacuees participated in such awareness programmes. The distance to designated evacuation centres was reported to be much further for evacuees, i.e., on average about 2.2 kilometres away from their flood-affected homes. Note that the *p*-values are significant for four out of the five flood-related variables, indicating statistically significant differences between evacuees and non-evacuees. These significant *p*-values may be indicative of variables that affect evacuation decisions. Such differences are subject to confirmation by the estimation of the semi-parametric model.

3.2 Estimation result discussion

Table IV reports the marginal effects from three different estimation models: the parametric linear probability model which serves as a baseline model, the parametric binary probit model, and the SNP binary probit model. The SNP binary probit model is the paper's model of interest. The first two parametric approaches follow the restrictive distributional assumptions of a Gaussian distribution for their error terms, i.e., zero mean and unit variance. The third approach, the SNP approach, has less rigid distributional assumptions, i.e., it only requires the error terms to have zero mean and relaxes the assumption of unit variance.

From the marginal effects reported in Table IV, the SNP binary probit model appears to be able to capture statistical significance for a larger number of variables, compared to the two parametric models. Three of the five explanatory variables of interest (i.e. the flood-related variables) are statistically significant. Important findings from the SNP model include the following: victims who were given evacuation notices were more likely to

DV: evacuated	LPM		Probit		SNP	
	dy/dx	Rob. SE	*dy/dx*	Rob. SE	*dy/dx*	Rob. SE
Demographic and socioeconomic						
Age	0.004	0.011	0.002	0.013	−0.131***	0.040
Male	−0.012	0.049	−0.029	0.061	−0.616	0.580
Malay	−0.084	0.079	−0.071	0.063	−0.071	0.415
Married	0.013	0.058	0.002	0.064	−0.428	0.329
Household size	0.041	0.029	0.048	0.029	0.865***	0.314
Income ⩽ RM500	−0.003	0.057	−0.021	0.075	−0.371	0.821
Income > RM500-RM1,000	−0.044	0.054	−0.079	0.082	−0.416	1.302
Job and education						
Have own business	−0.081	0.054	−0.108	0.069	−1.135	1.152
Tertiary education	−0.157*	0.087	−0.223*	0.122	−2.138**	1.008
Secondary education	0.018	0.047	0.048	0.065	−0.641	0.450
Flood related						
First-time victim	0.034	0.055	0.054	0.062	0.779	0.711
Notified to evacuate	0.714***	0.077	0.771***	0.071	4.343***	0.402
Programme existence	0.006	0.096	−0.018	0.125	−0.271	0.692
Joined programme	−0.200	0.124	−0.862	0.078	−4.552***	0.996
Distance to centre	0.031	0.021	0.044	0.030	0.778***	0.166

Table IV.
Marginal effects from different estimation approaches and models

Notes: Squared and interaction terms have been included into the model specification, i.e., squared terms for age, household size, distance to evacuation centres, and an interaction term between programme existence and programme participation. The *dy/dx* and Rob. SE columns report the marginal effects and robust standard errors. *,**,***Significant at 10, 5, and 1 per cent levels, respectively

evacuate, victims who participated in flood awareness programmes were less likely to move to evacuation centres, the further away victims' homes were from the evacuation centres, the more likely they were to evacuate, older victims were less likely to evacuate, larger households were more likely to evacuate, and victims with tertiary education were also less likely to evacuate.

3.2.1 Flood-related variables of interest. Victims who were given evacuation notices were reported to be 5.3 times more likely to move to evacuation centres than those not notified. The relatively large magnitude of this marginal effect implies a strong association between evacuation notices and the actual decision to evacuate. Victims who had participated in flood awareness programmes were found to be 5.5 times less likely to evacuate. This may sound counterintuitive, but the logic behind this finding is obvious. It is plausible that victims possessing knowledge acquired from participating in flood awareness programmes could have taken pre-emptive precautions, therefore negating the need to move to evacuation centres (e.g. the victims could have moved out prior to the flood becoming critical and stayed with relatives, or they could have installed flood barriers at their homes). Programme participation seemed to be more important to evacuation decisions than whether or not such flood awareness programmes existed at the community level. This finding is consistent with that of Ahmad *et al.* (2015) which concluded that victims' self-efficacy and social support amongst themselves were important in the event of flood disasters. In fact, in a hypothetical study of flood disaster evacuation behaviour in India, individuals with high levels of self-efficacy were reportedly expressing higher intentions to evacuate (Samaddar *et al.*, 2012).

Being statistically insignificant even at the 10 per cent level, the mere existence of such awareness programme did not appear to be associated with evacuation decisions. Findings from the two FGD sessions implied that the flood awareness programmes at the district/community/village level were somewhat inconsistently held, as the programmes were dependent on whether there were sufficient budget allocations. The FGDs also revealed that there was a lackadaisical attitude and mentality towards flood preparedness among most members of the community. Flood awareness programmes, however, could still pave way for community capacity building. Such capacity building is also consistent with the concept of adaptive capacity as defined by Yohe and Tol (2002), in which resource availability and distribution, as well as human and social capital stock, are required for capacity building.

As an aside, there might be concerns that programme participation is endogenous to evacuation decisions. A seemingly unrelated bivariate probit model (results unreported here) was used to check for possible endogeneity issues. First, in the selection equation, programme participation was instrumented with the existence of flood awareness programmes. The evacuation decision was then regressed on programme participation in the outcome equation. For the remaining explanatory variables, the same vector of variables was used for both the selection and outcome equations. Results from this bivariate probit model did not reject the null hypothesis of exogeneity, i.e., the ρ did not differ statistically from zero. Given this, concerns over programme participation being endogenous are perhaps unwarranted. Note that $\rho = \text{Corr}(e_1, e_2)$ is the correlation between the error terms from the selection and outcome equations (Wooldridge, 2010, p. 595).

Results from Table IV also show that the further away victims' homes were from the evacuation centres, the more likely they were to evacuate. A kilometre increase in distance from the centre increased the likelihood of evacuating by about 78 per cent. This could be because the immediate vicinity of a designated evacuation centre would probably be the least likely area to be flooded; the further away from the evacuation centre, the higher the probability of the area being inundated. Victims whose homes were further away from the evacuation centre were therefore more likely to evacuate. Two out of the five variables of

interest are statistically insignificant (programme existence as mentioned earlier, and being a first-time victim). Whether or not a victim is a first timer in experiencing floods did not appear to have any significant association with their evacuation decision. A number of previous studies also found similar conclusions in which past disaster experiences displayed no significant association with the likelihood of evacuating (Tinsley *et al.*, 2012; Lindell *et al.*, 2005).

3.2.2 Other statistically significant variables. As shown in Table IV, older victims were less likely to evacuate, with an additional year in age decreasing the probability of evacuating by about 13 per cent, *ceteris paribus*. This finding is consistent with that of studies by Reininger *et al.* (2013) and Meyer *et al.* (2013), who also found age to be negatively correlated with the probability of evacuating. This is understandable especially in the case of elderly, fragile, physically, or mentally impaired victims (Christensen *et al.*, 2013); these victims are physically deterred from evacuating without any special equipment and assistance from the authorities. Indeed the logistics of coordinating emergency service personnel and equipment is critical to ensure no human lives and assets are jeopardised (Owusu-Kwateng *et al.*, 2017).

Larger households were more likely to evacuate, with an additional household member increasing the probability of evacuating by about 86 per cent, *ceteris paribus*. Large households typically consist of households with young children. This finding on household size and its positive association with the probability of evacuating is in line with the findings of many past studies, such as those by Medina and Moraca (2016), Smith and McCarty (2013), Hasan *et al.* (2011), and Solis *et al.* (2010), amongst others. It is therefore very plausible that the heads of such households evacuate for the children's safety. This empirical result is consistent with that of the summary statistics. Table III shows that evacuees have an average household size of 4.5 people compared to 3.6 people for non-evacuees, with the difference in means being statistically significant.

Victims with tertiary-level education were three times less likely to evacuate, compared to those with primary-level education and below. This finding is consistent with those by Paul (2012) and Reininger *et al.* (2013). Those with higher education are typically the ones with the resources and economical means to move out from the affected areas and stay in hotels, for instance.

By way of graphical evidence, Figure 2 further enhances the motivation for using the less conventional semi-parametric estimation for the paper's empirical analysis. Figure 2 shows two marginal density plots of the error term. The dotted bell-shaped plot is the Gaussian

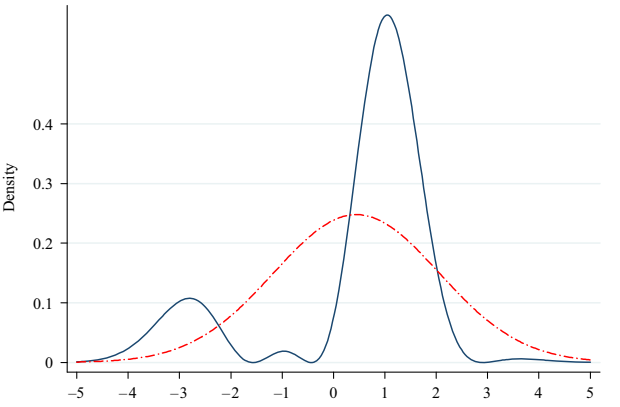

Figure 2.
Density plots of the error term

density of the estimated mean and variance of the error term; the non-normal plot shows the distribution of the error term when its distributional assumption is relaxed. Figure 2 clearly shows that the error term follows a non-normal distribution. To reiterate a point made earlier, in the model specification section, a parametric estimator only performs better if its distributional assumption is correct. It is obvious here that the normality assumption is unwarranted and therefore using a parametric estimator would result in inconsistent estimation. The non-normal distribution of the error term shown in the figure justifies the use of a semi-parametric estimator, which gives robust consistent estimates although is slightly less efficient.

4. Conclusion and policy implication

This study contributes to the literature in two ways. This study is perhaps the first in providing empirical evidence of flood victims' evacuation behaviour/decisions in the context of an unprecedented flood disaster in Malaysia. The study focuses on the east-coast states of Kelantan and Pahang; these two states bore the brunt of the December 2014 flood. Unlike typical empirical studies on floods, a semi-parametric estimation approach is used for the empirical analysis.

From the estimation results discussed earlier, it is fairly reasonable to conclude that issuing evacuation notices would be an effective way to evacuate flood victims to evacuation centres. This would ensure their safety and welfare. Relevant authorities could perhaps come up with a mechanism for mandatory evacuation. Mandatory evacuations would mean more strategic search-and-rescue or relief operations and organised evacuation procedures, as opposed to unnecessarily diverting the already thinly spread resources (rescue personnel and equipment) to retrieve stranded victims who have ignored voluntary evacuation notices. Search-and-rescue authorities should also be well-equipped with special tools and equipment, especially when it comes to evacuating elderly, fragile, and immobile victims. Such equipment could also be further complemented with medically trained rescue personnel. The federal government could perhaps approve a larger budgetary allocation for the purchase and upkeep of search-and-rescue assets (e.g. boats, amphibian vehicles, helicopters) and equipment (e.g. telecommunication tools). Based on the findings, this study recommends that there is a need to consider the use of mandatory evacuation directives for future massive floods. This study recommends a four-phase mechanism for mandatory evacuation: awareness, preparedness, personal and asset safety, and evacuation. Throughout these four phases, disaster management authorities such as the NSC, National Disaster Management Agency (NADMA), Civil Defence Department, as well as the Village Security and Development Committee should instil an element of compliance at the grass-roots level. To further lessen any unnecessary chaos during evacuation and relief operations, there should be an integrated system to manage voluntary emergency responders who could prove to be valuable additional resources.

The empirical results show participation in flood awareness programmes to be more important than the mere existence of such programmes. Victims who have participated in such programmes are better equipped with the necessary knowledge on how to cope with floods. Victims' self-efficacy and social support amongst themselves are important in the event of flood disasters, where individuals with high levels of self-efficacy tend to express higher intentions to evacuate. Flood awareness programmes could therefore pave way for community capacity building. In the first instance of the threat of flood disasters, communities at the grass-root level would be able to take practical and necessary steps without having to wait for evacuation notices from the authorities. Such community capacity building requires availability and distribution of resources. Flood-related authorities should therefore ensure participation of vulnerable communities in flood awareness programmes, rather than merely organising such programmes. In fact, based on

the study's FGD findings, a number of schools in Malaysia's east-coast states have actually initiated flood disaster awareness and preparedness programmes as part of the schools' extracurricular activities, with collaborations from the Malaysian Red Crescent Society. In another finding from the FGD sessions, it is verified that NADMA has already put in place a community capacity building programme known as the "One Family, One Rescuer" programme, as part of NADMA's pre-flood management strategies.

Relevant authorities such as the Malaysian Department of Survey and Mapping and the Department of Irrigation and Drainage could also conduct more frequent re-measurement of high-lying areas. This would help ensure that the geographical locations of designated evacuation centres and food storage depots (also known as forward bases) are logistically strategic and not threatened by a flood of any magnitude or suddenness. Low-lying and flood-prone areas could be reinforced with flood mitigation measures such as flood control embankments/dams, flood diversion canals, river bunds, and flood attenuation retention ponds. Based on the FGD findings, the State Housing Department should coordinate with housing developers to work out ways in order to reduce the number of housing areas in flood-prone areas. This way, relief operations would be minimised in flood-prone areas and therefore the burden on the emergency services would be lessened during flood disasters. The FGD participants also suggested that the siren warning system be revised from just emitting siren blares to actually making announcements on what to do (e.g. "Pack up your essentials and leave the house"). There were also recommendations from the FGDs on the proper upkeep and maintenance of telemetry stations in order to properly capture updated and accurate weather data.

One of the limitations of this study is the relatively low number of respondents. Access to the target group, i.e., victims of the December 2014 flood, was somewhat limited because, during the time of survey, the victims were geographically scattered due to relocations. Eventual access to the sample of respondents was only gained through the assistance and cooperation of district offices.

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Corresponding author
Jan-Jan Soon can be contacted at: soon@uum.edu.my