

# CONSTRUCTION AND EMPIRICAL STUDY OF RISK ENDURANCE MODEL OF RESIDENTS IN RESERVOIR DOWNSTREAM

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**Abstract:** Hazard of dam-break flood has serious social influence. In this study the concept of risk endurance of dam-break flood was proposed which was regarded as a dynamic and open system consisted of five main factors named psychological endurance, risk coping ability, risk attitude, social trust and risk perception. The hypothesized model of risk endurance was supported by the data of 1232 questionnaires which were investigated in three downstream reservoirs of different areas. Results indicate that psychological endurance which has significant positive impact on the other factors is the basis of risk endurance system, risk coping ability is the key of system, risk attitude is the goal of risk endurance system, except for social which has negative impact on risk attitude all the other factors have significant positive impact on it. Social trust and risk perception are mediators and have certain effect on the improving of risk endurance. These results can be applied to develop the education system to improve the risk endurance; also can help to decrease the damage of dam-break flood.

**Key words:** risk endurance, dynamic system, structure model, model test

## 1. Introduction

According to World Commission on Dams (WCD, 2000) there are about 22000 dams in China, three times more than in America and five times more than in India. However the safety condition of dams is worrying as many dams are sick and dangerous. Based on the statistical data, there were 3462 accidents of dam break between 1954~2000 among which there were 2 large-sized reservoirs, 124 middle-sized reservoirs and 3336 small reservoir (LI lei et al, 2006).

Different people have different reaction facing the dam break flood. Some can cope with the flood and manage to survive; some will have psychological fear and shadow. A large number of individual factors influence people's psychological reaction and coping ability which we named risk endurance, such as personal risk attitude, psychological characteristics, personality, risk perception, risk knowledge, ect. The purpose of this study was to determine the influence factors of risk endurance and the way they affect each other in a structure model of risk endurance.

### **1.1 Definition of Risk Endurance**

Risk endurance is psychological acceptance hazard stimulus and ability of successfully avoiding loss in hazard. Risk is objective whereas personal risk endurance is subjective because of different personal characters. Risk endurance is essentially the psychological adjustment and reaction of risk stimulus based on different risk perception. Ability of psychological adjustment is determined by psychological endurance which has great effect on the reaction to hazard. Thus, personal psychological endurance is the base of risk endurance. Psychological endurance, especially for people facing hazard is an important mental quality of individual character. Negative psychology which has bad influence on the people surrounded can lead to poor performance on coping and defeating hazard. Reaction to risk is actually the method choice to cope with hazard. The danger and abruptness of hazard which form great psychological pressure demand immediately response to cope with hazard. Thus, risk coping ability is the key factor of risk endurance. Individuals with different age, gender, experience, knowledge, training level and psychological quality show great difference in risk coping ability. However, risk coping ability also has regularity as a social behavior. Risk perception and social trust also affect how people feel the hazard and how to react to it. Social trust has an influence on risks and benefits perceived (Siegrist, 1999). Risk attitude is another factor of risk endurance. Risk attitude can be adjusted according to individual psychological state and personal ability.

In general, risk endurance is the synthesis of coping ability, adaptability and psychological endurance which is based on the risk perception, risk attitude and social trust. To be specific, it's personal adjust ability to accord with the risk environment knowing the harm,

probability and controllability of risk. Risk endurance can be regarded as a dynamic open system having five main factors named psychological endurance, risk coping ability, risk perception, risk attitude and social trust.

### **1.2 Psychological Endurance**

Psychological endurance is psychological acceptance of outside stimulus. It's personal traits and determined by personal characters. Since individual variability is considerable, characterizing individuals is very complex. Consequently, the personal dimensions considered varied widely from one study to the other, mainly as a function of the authors' preferences and choices. In previous literature, many personal dimensions have been considered, including the following: age (Hermans et al., 1999), gender (Gustafson, 1998; Sjöberg, 2000), educational level (Sjöberg, 2000), income (Flynn et al., 1994; Palmer, 2003), anxiety (Bouyer et al., 2001; Kallmen, 2000), worldviews (Bouyer et al., 2001; Brenot et al., 1998), new age beliefs (Sjöberg & Wahlberg, 2002), environmental beliefs (Sjöberg, 2003), political preferences (Sjöberg, 2000), culture (Mullet et al., 2005), and religious orientation (Sjöberg & Wahlberg, 2002). In this study, seven personal traits were considered to predict psychological endurance which was extroversion/introversion, life satisfaction, stress endurance, emotional stability, personal health, psychological dependency and calmness. Each factor can be considered as the aggregation of numerous categories of items corresponding to aspects of personality that are called facets of personality.

Individuals scoring high on extraversion were particularly inclined to engage in multiple, risky health behaviors (Vollrath and Torgensen, 2002). Thus, extroverts are considered to be more lenient about deviant personal or social behaviors than introverts.

Extroverts are more open to risk-seeking behavior and more likely to accept risk. Life satisfaction is clearly related to the way that each individual behaves with others and view the society. This factor relates to nonviolence, and care for others and the environment. It could be expected individuals with life satisfaction would consider risk more undesirable than the less life satisfied individuals. As shown by Vollrath et al. (1999), more agreeable individuals with life satisfaction tend to engage less often than others in risky health behaviors. Thus, individuals with more life satisfaction will feel more fear facing hazard. Stress endurance and calmness relate to the way individual act in hazard. Endurance on stress and calmness can lead to correct and efficient action to cope with hazard. Strong psychological independence can make sure cope with hazard alone while dependent individuals don't know how to do and need to count on others which decrease the probability of survival. Personal health is the essential factor to defeat the hazard. Emotional stability is related to the idea of fearlessness in many circumstances. Thus, a negative relationship may be expected between emotional stability and all hazard factors (Bruno Chauvin, et al, 2007). Emotional stability is also related to tranquility, moderation, and toughness which have beneficial to cope with hazard.

### **1.3 Risk Coping Ability**

Risk coping ability is stress response and risk avoiding ability when personal life and possession is threatened. Risk coping ability is the result of interaction of hazard, psychological reaction and knowledge of how to cope with hazard. The coping ability not only depends on the characteristic of hazard, such as the type, grade, occurrence time, speed and duration but also related to personal characteristic because the damage of hazard is

reflected through individual cognition, assessment and control ability of hazard. Difference and regularity are two basic traits of risk coping ability.

### **1.4 Risk Attitude**

Attitudes themselves are defined as the rational integration of the expectancies and values put on the outcomes of the behavior (Elke U. Weber, et al, 2002). Risk attitude, a person's standing on the continuum from risk aversion to risk seeking, is commonly considered to be a personality trait, and greater risk taking is sometimes found to be associated with greater personal success (MacCrimmon and Wehrung, 1990). Dyer and Sarin (1982) thought relative risk-attitude was component of risk taking that had cross-situational stability for a particular individual. However Weber (1997) found no evidence of greater cross-situational stability of relative risk attitude in their empirical tests of the model. Bromiley and Curley (1992) thought risk-taking is influenced jointly by the situation and by characteristics of the decision maker. Thus, risk attitude was presented as risk aversion and safety seeking in this study. Risk attitude can be seen as a personal psychological quality and was partially affected by personal experience, knowledge structure, cognitive ability, education and social environment.

### **1.5 Social Trust**

Social trust is also a personal trait (Vicklund, 2003; Siegrist et al., 2000). Social trust is the willingness to rely on those who have the responsibility for making decisions and taking actions related to the management of technology, the environment, medicine, or other realms of public health and safety (Michael Siegrist, et al, 2000). People who trust government and the management department perceived less risk and more

benefits than people who did not. When there is insufficient knowledge or technical background for risk assessments, social trust is needed to reduce the complexity of risk (Earle&Cvetkovich, 1995). Social trust can affect individual opinion, attitude and action in those situations where the individual lacks the interest, time, abilities, knowledge, or other resources. Science and technology are areas where many individuals seem to lack such resources.

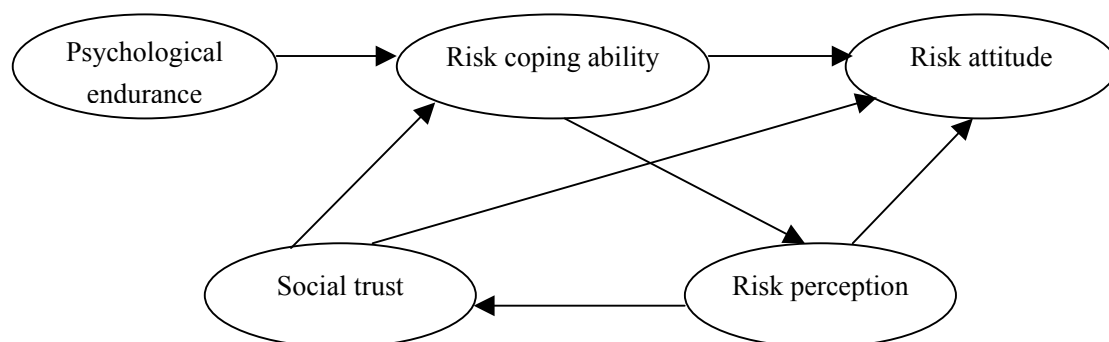
## 1.6 Risk Perception

Risk perception can be defined as the individual judgments of the likelihood that a consequent loss could occur and the seriousness and controllability of its likely consequences. Public has inconsistent knowledge of the absolute frequencies of occurrence of accidents and hazards. Different groups and individuals within society have different perceptions of the risk from the same hazard. This was explained as a natural consequence of personal variables, including an individual's background, prior experience, etc., which influence an individual's judgment or perception concerning risk (Slovic, P, et al.,

1979). It was found that a considerable difference exists among science, business and environmental group members in their perception of risks and in their response to new information (Jenkins-Smith, H. &Bassett Jr., G.W.P, 1994). Different risk perception can lead to different risk attitude.

## 1.7 Hypothesized Model

Psychological endurance is the basis of risk endurance which can influence the effective and efficient of reaction to hazard. Personal ability can lead to different risk attitude. Risk perception and social trust are influence factors of risk coping ability and risk attitude. Public reactions and attitudes toward new technologies are guided by the social trust and confidence people have in companies and government agencies (Siegrist&Cvetkovich, 1999). Risk perception can affect risk attitude. Therefore, we hypothesized that psychological endurance would contribute to risk coping ability and coping ability contribute to risk attitude. Risk perception is the mediator of influence between risk coping ability and risk attitude. Social trust would affect risk coping ability and risk attitude. (See Figure 1).



**Fig.1.**Hypothesized model of risk endurance

## 2. Method

### 2.1 Participants

A total of 3 reservoirs involved in the study and 1400 residents in the reservoir downstream replied to the questionnaire. The

3 reservoirs were located in different areas of China with different economic development level and residents investigated distributed in the dam-break flood submerged area. The method employed to choose the towns and the country in the towns to investigate was

systematic sampling. A random sample of residents in the country was asked to fill in the questionnaire and 1232 valid questionnaires were received. The response rate was 88%.

## 2.2 Measures

A questionnaire named risk endurance of residents survey was developed to examine psychological endurance, risk coping ability, risk perception, risk attitude and social trust.

The demographic section of the survey consisted of five items that requested information related to gender, age, level of education, occupation and income level.

The psychological endurance measures consist of seven scales related to personality variables to be predictors of psychological endurance. These factors included extroversion/introversion, life satisfaction, stress endurance, emotional stability, personal health, psychological dependency and calmness. This part had 13 items.

The risk coping ability measure consisted of five scales which were whether or not rescue disaster, reaction to the hidden danger, whether or not knowing the correct way to survive in flood, risk precaution and the knowledge of avoiding risk. There were 13 items.

Risk attitude measure consisted of five scales named attitude about risk precaution, risk acceptance, attitude about the accidents, risk reduction attitude and personal choice between economic development and safety. This part had 10 items.

Social trust measure related to three scales which were risk expectation level, government trust and personal experience in risk accidents. This part had 6 items.

Risk perception scale measured whether people realized the existing risk and how they think of it. This part had three questions “do you think we live in an unpredictable and uncontrollable risk society”, “do you think

risk can be avoided through technology and management measures” and “how do you think the seriousness of problem of public safety threatened in present society”.

## 2.3 Analysis

First, the data was split randomly into an exploratory and a confirmatory sample. Principal components analysis is applied to determine the dimensions of three elements which were psychological endurance, risk coping ability and risk attitude in the exploratory sample (n=616). One analysis was carried out for each main element. Based on the component loadings of the major principal components, a measurement model is developed to capture the main features of the three elements. The other half of the data then serves as a confirmatory sample to test this model in a confirmatory factor analysis (n=616).

Structural equation modeling was used to analyze the relationships among psychological endurance, risk coping ability, risk perception, risk attitude and social trust (see Figure 1). Analyses were conducted using the item covariance matrix. Model parameters were estimated using the maximum likelihood method because it is robust to violations of multivariate normality and tends to provide reliable estimates under less than optimal data conditions (Hoyle, 1995). As recommended by Anderson and Gerbing (1988), we tested our model fit in a two-step approach, first confirming the measurement model and then testing the full structural model. The measurement model was evaluated through a confirmatory factor analysis of the measures used in the study. Subscale scores on each of factors were used as indicators and specified to load on their respective latent construct (e.g., psychological endurance). The structural model was then tested through AMOS.

Multiple fit statistics were used to evaluate

the overall fit of the measurement and full structural models including the chi-square statistic, Tucher-Lewis Index (TLI), Normed Fit Index (NFI), Comparative Fit Index (CFI), Goodness of Fit Index (GFI), and the Root Mean Square Error of Approximation (RMSEA). Good model fit is indicated by a chi-square to df ratio less than 3 as well as values greater than 0.90 on the NFI, TLI, CFI and GFI. Additionally, a value less than 0.08 on the RMSEA suggests good model fit.

### 3Results

Three factors of psychological endurance, two factors of risk coping ability, two factors of risk attitude were produced through principle component factor analysis. The structure of

the elements is shown in Table 1. Based on the component loadings of the factors of three elements, the factors were labeled. Three factors of psychological endurance were named psychological balance ability, psychological bearing ability and psychological adjusting ability. Two factors of risk coping ability were risk avoiding ability and risk precaution ability. Two factors of risk attitude were risk preference and risk reduction tendency. Then the other half of the sample was used in a confirmatory factor analysis to formally test this factor structure. Results from the confirmatory analysis show that the factor structure was supported and was appropriate for use in the analysis of the full structural model. ( $\chi^2=508.82$ ;  $df=98$ ;  $p<0.001$ ;  $RMSEA=0.05$ ;  $GFI=0.95$ ).

**Table 1** Loading matrix of main factor

Psychological endurance	Factor		
	1	2	3
extroversion/introversion	<b>0.768</b>	-0.037	-0.031
life satisfaction	<b>0.609</b>	0.046	0.231
stress endurance	<b>0.580</b>	0.363	-0.027
emotional stability	-0.029	<b>0.790</b>	0.089
personal health	0.169	<b>0.693</b>	0.057
psychological dependency	0.009	-0.069	<b>0.847</b>
calmness	0.121	0.239	<b>0.671</b>
Risk coping ability	Factor		
	1	2	
whether or not rescue disaster	<b>0.747</b>	0.104	
reaction to the hidden danger	<b>0.681</b>	0.174	
whether or not knowing the correct way to survive in flood	<b>0.632</b>	-0.050	
risk precaution	-0.035	<b>0.929</b>	
knowledge of avoiding risk	0.492	<b>0.528</b>	
Risk attitude	Factor		
	1	2	
attitude about risk precaution	<b>0.732</b>	0.178	
risk acceptance	<b>0.698</b>	-0.067	
attitude about the accidents	<b>0.539</b>	0.343	
risk reduction attitude	-0.056	<b>0.856</b>	
personal choice between economic development and safety	0.319	<b>0.657</b>	

The next step, the hypothesized model was fitted to the data. This model was tested using

Amos 6.0 and the fit statistics for this model indicated that it was not a good fit to the data. So the model was modified by adding five paths between the indicators. The modified model provided an overall good fit to the data. The fit indices suggest that the modified model provided an adequate fit to the data. However, the paths from social trust to risk coping ability was not significant ( $p=0.147$ ). The non-significant paths within the model were dropped and analyses were rerun. The fit statistics of the respecified model were not significantly different from the original model, indicating that dropping the non-significant paths did not reduce the fit of the model. The respecified model provided a good fit to the data (see Table 2). All the parameter estimates

specifying the paths between the elements and the adding path in modified model were statistically significant ( $p<0.05$ , see Figure 2). The adding paths were marked by dashed line in Figure 2.

Inspection of the standardized total effects showed that the indirect effects of psychological endurance on risk attitude were 0.227 which was mediated by the other three factors. The total effects including direct effects of risk coping ability on risk attitude and indirect effects mediated by risk perception and social trust were 0.403. The indirect effects of risk coping ability on risk attitude were 0.012 which is far less than the direct effects and the indirect effects on social trust were 0.024.

**Table 2** Fit Statistics for the Structural Equation Models

Model	$\chi^2$	df	RMSEA	GFI	TLI	NFI	CFI
Hypothesized Model	1101.15	58	0.121	0.890	0.716	0.780	0.789
Modified Model	316.69	54	0.063	0.962	0.923	0.937	0.947

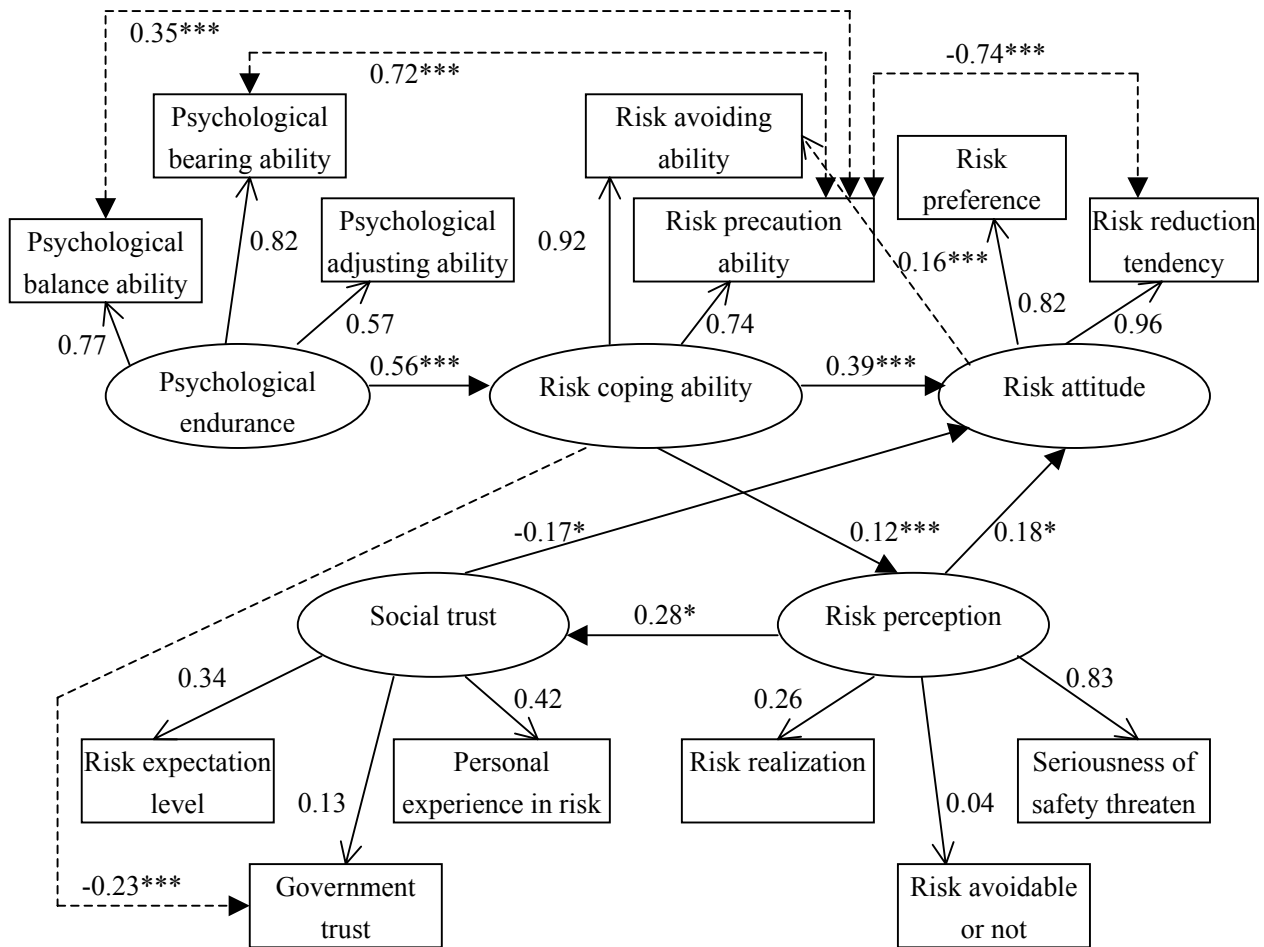
## 4. Discussions

The first aim of the study was to determine the influence factors of risk endurance. The second aim was to examine the interaction relationship between the factors.

Many factors affect risk endurance in which psychological endurance is the base factor, risk coping ability is the key factor, risk attitude is the end result, risk perception and social trust is the influence factors. The confirmatory factor analysis had determined the measurement structure of each factor. The final measurement structure of the factor is that psychological endurance has three indicators, risk coping ability has two indicators, risk attitude has two indicators, social trust has three indicators and risk perception has three indicators. Based on the regression weight of each indicator on the factor, psychological balance ability and

psychological bearing ability was the main predictor of psychological endurance. Risk avoiding ability was the main predictor of risk coping ability. The result that regression weight of both risk preference and risk reduction tendency was high indicated that the two indicators were of equal importance to predict the risk attitude. Seriousness of safety threaten was the main predictor of risk perception and personal experience in risk accidents was the main predictor of social trust.

All the parameter of the path were statistically significant shown that the factors of risk endurance had significant influence between each one. In the structure model, psychological endurance was an exogenous variable which had a direct effect on risk coping ability and had indirect effect on the other factors mediated by risk coping ability. All the effect of psychological endurance on



\*\*\*, significant at 0.001 level; \*\*, significant at 0.01 level; \*, significant at 0.05 level.

**Fig.2.** Modified model of risk endurance with standardized parameter estimates

the other factors were positive shown that the improving of psychological endurance can lead to the improving on risk coping ability and risk attitude. Of all the other factors, psychological endurance had the most influence on risk coping ability and the second influence on risk attitude. Risk coping ability was the core element of all the factors because it's the main influence factor of survival in the flood accident. Risk coping ability affect on risk attitude and risk perception directly and had influence on social trust indirectly. Coping ability had influence on risk perception and risk attitude because the knowledge of risk precaution and risk reduction which was an indicator of risk coping ability indicator can influence the risk cognition and the attitude about the importance of risk prevention. The

effects of risk coping ability on the other factor were all positive indicated that the more attention was paid to the risk precaution and risk avoidance, the stronger risk coping ability was which contributed to more attention on safety and more perception of risk. All the factors had influence on risk attitude directly or indirectly. More risk accidents experience, correct realization of risk probability and higher government trust can result in more psychological support, risk seeking, benefits perceiving and less fear for the risk which lead to more risk acceptance. Therefore the effect of social trust on risk attitude was negative. This was consistent with the finding that social trust had a positive influence on perceived benefits and a negative influence on perceived risks (Michael Siegrist, et al. 2000).



Other influence on risk attitude were all positive in which the most influential factor was risk coping ability then the psychological endurance and risk perception. Higher risk perception which is the predictor of existence, uncontrollability, and seriousness perception of risk can lead to risk aversion. This consistent with the finding that most individuals who reported that they were likely to engage in risky behaviors must have done so with the belief that these behaviors were not very risky, very few indicated willingness to engage in behaviors that they considered to be risky (ELKE U.WEBER,et al.2002). Risk perception and social trust were the mediation variables of the structure model. As the influence of social trust on risk attitude was negative, social trust was also regarded as restrictive factor which prevent the safety from too much attention.

Five path including two loading path and three correlating path were added in the modified model. The loading path shown that risk avoiding ability was also a predictor of risk attitude which means the stronger risk avoiding ability was, the more attention was paid to safety. The non-significant coefficient between social trust and risk coping ability suggested that there was no significant effect of social trust on coping ability. However, government trust, an indicator of social trust, was found to be a predictor of risk coping ability and the regression weight was negative which means less social can lead to more measurement taken to avoid and prevent risk. There was significant positive correlation between risk precaution ability and psychological bearing ability and psychological balance ability. In addition, there was significant negative correlation between risk precaution ability and risk reduction tendency. That is because less preference to risk reduction can lead to more acceptance of risk and more importance put on

the risk precaution.

In general, the results of the model test shown that psychological endurance is the basis of risk endurance which strongly positive effect on risk coping ability and risk attitude, risk coping ability also has influence on risk attitude, risk attitude is the end result of risk endurance and influenced by all the other factors. In addition, risk perception and social acts as mediator of the influence of psychological endurance and risk coping ability on risk attitude. These findings have implications for the improving of risk endurance. Improving of psychological endurance which can focus on the improvement of life satisfaction, stress endurance and emotional stability is the basic and very important measures taken to improve risk endurance. Assessment of risk coping ability can be used as a predictor of risk endurance and can be raised by the education of risk reduction knowledge, risk precaution method, correct way to survival facing the dam-breaking flood. Knowledge about risk including probability, controllability and seriousness of risk can also be included in the education program to help people have right opinion on risk. People must realize the existence of risk, keep necessary vigilance against risk but can not have panic and should treat it calmly and effectively. Risk attitude of public can compose risk culture of the whole society. All the other factors affect risk attitude suggests that personal character, knowledge of risk, opinion on risk and the ability to cope with the risk accidents are all contribute to risk attitude.

## 5. Limitation and summary

Although our results offer important information for understanding the influence factors of risk endurance and the relationship between them, there are a number of limitations that need to be considered. First,

the sample size was not big enough, and this may account for some error in our model. However, the fact that we found significant relationships in our model, despite the small sample, suggests that these effects are quite robust. Still, our use of a small sample may limit the generalization of our findings to all populations. Future studies examining the effects of risk endurance factors should be investigate in more areas and more sample in reservoir downstream. Another limitation involves our measure of risk endurance. As there is no available assessment scale of risk endurance, the scale developed in this study can be further tested and modified more perfect. However the exploratory research of risk endurance in this study can also suggest the relationship of risk endurance factors. Some limitations should also be addressed. Covariances were used to test a causal model. We cannot rule out the possibility that alternative models exist, even with different directions of causality, which also fit data very well. However, based on theoretical considerations we believe that the proposed

causal model is the most meaningful. Future studies can propose models to examine the relationship of the factors of risk endurance.

To summarize, this study determine the influence factors of risk endurance which are psychological endurance, risk coping ability, risk attitude, social trust and risk perception and our model of the relationship of the factors was supported. Results indicate that psychological endurance which has significant positive impact on the other factors is the basis of risk endurance system, risk coping ability is the key of system, risk attitude which is formed based on personal character, opinion and knowledge of risk is the goal of risk endurance system, except for social which has negative impact on risk attitude all the other factors have significant positive impact on it. Social trust and risk perception are mediators and have certain effect on the improving of risk endurance. These results can be applied to develop the education system to improve the risk endurance; also can help to decrease the damage of dam-break flood.

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