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ENVIRONMENTAL RISK PERCEPTIONS OF PORT RESIDENTS: AN EMPIRICAL STUDY ON EAST SIDE OF KEELUNG PORT

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Key words: port environmental pollution, risk perception, Keelung port, multiple linear regression (MLR) model.

ABSTRACT

Environmental risks management and assessment become essential in dealing with environmental pollution events when we pursue green environment and sustainable transportation policies. Hence, this article investigates the environmental risk perceptions of residents living in neighborhood of east Keelung Port in Taiwan. Using surveyed data collected from questionnaires, the multiple linear regression (MLR) model was used to examine the research hypotheses. We obtained several important findings in this empirical study. Firstly, the risk perceptions index of local residents indicates that pollutions produced in port operations become serious threats to health. Secondly, compensation effect, psychological factors, trust, demographic factors and physical environment were found to show influential effects upon risk perceptions of local residents. Local residents showed higher risk perceptions when they believed their daily lives were impacted more serious. Also higher trust toward Taiwan International Ports Corporation (TIPC) heightened risk perceptions. On the opposite, higher trust toward relatives, friends and environmental groups led to low risk perceptions. The people lived farther away from port areas showed lower risk perceptions, too. Besides, groups of 'female,' 'higher educated people,' and 'longer living duration' also showed higher levels of risk perceptions to local pollution risks. Finally, we studied the managerial implications in this article and proposed several recommendations for government to gain supports and trust of local residents.

I. INTRODUCTION

The port of Keelung plays an important role in Taiwan's international trade history since 1863. Among Taiwan's international commercial ports, the port of Keelung is the nearest port to Taipei City which is the economic and political center of Taiwan. It is the major import/export port of northern Taiwan. Along with the newly constructed Taipei Port, the role of Keelung Port has gradually changed to serve container shipping lines sailing the intra-Asia regions.

The port of Keelung is surrounded by mountains and only faces sea in the north. The port area is narrow and near Keelung city. In the port development processes, several kinds of pollution sources were produced, such as the disposal after cargo loading/unloading operations, the waste produced during cargo storage operation, the leakage of oil and liquid goods, the water pollution because of vessel dumping, the air pollution caused by vessels and trucks, the noise induced by cargo handling and vessel repairing (Shao et al., 2009; Tzannatos, 2010; Quynh et al., 2011; Mohee et al., 2012; Valdor et al., 2015). These pollution sources greatly influence the living quality and health of residents in the neighboring areas. Frequent protests had been held because of the inability to control the pollution happenings and to improve the environmental quality.

Since 1980s, the government agencies in Taiwan began to emphasize on the pollution prevention in port areas, and made efforts to improve environmental protection. Still the accumulation of pollution in years cannot be eliminated soon. In addition, the quickly changed port operation environment creates new risks associated with port activities. New types of dangers, emergent events and environmental threats could happen in these activities. For example, more speeding events of container truck, more noise and dust brought by heavier traffic flow, and more traffic accidents occurred because of the newly constructed expressway. Night operations magnified the noise effects and greatly affected the sleeping quality of neighboring areas. To deal with these situations, Taiwanese government introduced administrative risk management and assessment in 2005. Since 2008, risk management was embedded in daily operations and decision making processes in order to enhance the risk handling capabilities of government agencies.

Taiwan International Ports Corporation (TIPC) is a cooperation owned by Ministry of Transportation and Communications (MOTC). TIPC is in charge of operations and management of Taiwan's commercial ports. TIPC is required to perform risk

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assessment and management processes on issues of green environment and sustainable transportation. Recently, Taiwan's ports have to perform the assessment of environmental risks when encountering environmental pollution events. The main themes of TIPC's environmental risk management focus on the technological side of risk prevention and accident aftermath handling. The risk related information is one-way conveyed to the public. The concerns of neighborhood are seldom included in the risk management processes. The public do not have clear environmental safety knowledge due to the uncertainty and complexity of environmental risks (Zhu et al., 2011; Huang et al., 2013; Remoundou et al., 2015). This situation creates barriers to understand the real risks. Furthermore, the benefits of port development are not fairly shared among local residents, yet the environmental risks become a liability of the neighboring areas. The uneven balance between economic benefits and environmental risk burden forms negative attitudes among local residents. Local residents doubt the actions of port's sustainable development and lead to against the development because there is a lack of good risk communication mechanism (Hu et al., 2010).

The port risk assessment and management process in dealing port pollution is a public health issue. The conflicts occur when the risk perceptions of the public disagree with those of the experts of government agencies. A better way to perform the environmental risk management is to include the concerns of local residents. The risk handling processes should be transparent to lessen the public's feeling of threats. Risk perceptions can be considered as individual's interpretations or impressions based on an understanding of a particular threat that may potentially trigger loss of life or property (Bradford et al., 2012). Johnston et al. (1999) documents that risk perceptions are conceptually important in examining how people understand threats and avoid them. Practical importance arises because perceptions can be influenced by emergency managers seeking to protect citizen. Hence, it is vital to introduce the ideas of public risk perceptions and risk communication into port environmental risk management for the improvement of relations between local residents and port operators (Hu et al., 2010).

In summary, this article surveyed the opinions of residents living in areas to the east side of Keelung Port. We analyzed the risk perceptions on port environmental pollution and recognized the ways how local residents judge the environmental risks they faced. From this survey, we obtained the leading factors which can explain how local residents form their risk perceptions. In this study, the multiple linear regression (MLR) model was used to evaluate the risk perceptions of local residents. At the end of this paper, we proposed several suggestions for enhancing environmental risk management in order to heighten the public support and trust level of Taiwan's port operations and sustainable development. The following sections present the literature review and hypotheses, and the third section describes the research methodology. The fourth section contains our empirical study, and the final section presents the study's conclusions and recommendations.

II. LITERATURE REVIEWS AND HYPOTHESES

1. Concepts Related to Risks and Risk Perception

There are a range of risk positions proposed in the literatures falling between the realist approach and the relativist approach (Crawford-Brown, 1999; Janmaimool and Watanabe, 2014). The realist approach (ex-structuralism) treats risks as objective hazards which can be measured independently. Therefore, risks can be estimated based on scientific evidence and knowledge. On the other hand, the relativist approach (post-structuralism) believes nothing is a risk in itself. Risks are thought to be products of historically, socially and politically contingent 'ways of seeing.' Risk varies depending on people's experiences and social interactions.

Recently, risk assessments based on science alone have increasingly been challenged (Ropeik, 2011) because the risks to any social event are exhibiting far more diverse aspects beyond the scope of scientifically estimated risks. Objective data of risk events are collected and analyzed by government agencies, the results are then released to the public. Because it is difficult to illustrate risks fully by collected data alone; therefore, doubts arise among local residents. One of the main characteristic of risks is the uncertainty of future loss. To use past data alone for policy making could easily create biases and hard to be effective. The public attending in the discussions of environmental issues cannot be denied. The public has the right to join the development of policy making. The processes of environment management could be lengthened when the public attends in the discussions. To resolve the concerns raised by the public could delay the progresses and heighten the expenses. However, the quality of environmental policies will be improved due to the presence of public opinions and ideas. Through the interactions between policy makers and the local residents, the potential conflicts could be discovered earlier and then be resolved.

The concept of risk perception is a judgment of the adverse consequences of a particular hazard and can be made by an individual, a group of people, or society (Aven and Renn, 2010). The particular hazard generally refers to natural hazards and threats to the environment or health (Dora, 2006). Risk perceptions of an individual were formed based on both one's belief and self-appraisal (Slovic and Weber, 2002; Aven and Renn, 2010). Four approaches had been used to study risk perceptions. They are sociocultural paradigm, psychometric paradigm, interdisciplinary paradigm, and axiomatic measurement paradigm (Janmaimool and Watanabe, 2014).

Risk perception is influenced by possible catastrophic consequences and likelihood of an occurrence. The forming of risk perception is a dynamic process that takes place in a society. The factors involved in the process are therefore too complicated to be studied by any approach mentioned previously alone. Risk perceptions associated with environmental pollution risks from the process of port development deal not only social adherence and/or emotional factors but also the influences of lay people's comprehension upon the nature of risks which in-

cluding probability and consequence.

Environmental pollution risk is a risk exists between pollution creators and impacted individuals. It is a typical externalized risk. Furthermore, if risks originate from the interactions among the society, the government agencies should fully realize the risk perspectives of local residents in order to develop effective risk management processes. The environment planning decisions of a port involve many value judgement issues. These decisions are subjected to lots of challenges from different stakeholders. Those who promote and regulate health and safety need to understand how people think about and respond to risks. Without such understanding, well-intended policies may be ineffective (Slovic, 1987). Understanding how risk is perceived can potentially improve risk communication (Morrow, 2009; Veland and Aven, 2013). Furthermore, such understanding can also help mitigate underlying impacts (Martin et al., 2009) and support stakeholders' long-term engagement in risk management (Kajenthira et al., 2012).

There are studies about risk perceptions on issues like NIMBY (not in my back yard) and LULU (locally unwanted land uses) (Hung, 2005; Kang and Jang, 2013; Carr-Cornish and Romanach, 2014; Grimes and Esaiasson, 2014), environmental pollution (Stoutenborough et al., 2013; Janmaimool and Watanabe, 2014), climate change (Leiserowitz, 2006; Carlton and Jacobson, 2013), and natural disasters (Leiter, 2011; Zhu et al., 2011). The recent studies about port environment are mainly focused on issues about sustainable development and green port from the government's point of view in Taiwan (Chang and Wang, 2012; Lirn et al., 2013; Chiu et al., 2014; Shiau and Chuang, 2015). Rarely study discussed about risk perceptions of local residents upon environmental pollutions of port development in Taiwan. As of the risk perceptions of port neighborhood pollutions, Hu et al. (2010) proposed a model to establish risk communications upon port environmental risks. In their study, risk perceptions of local residents were not investigated. This study intends to introduce the ideas of risk perceptions and risk communications into the process of risk assessment and management of Keelung Port. We conducted a survey in this study to obtain the influential factors upon risk perceptions of local residents in Keelung Port. The introduction of risk perception in the management process should be able to improve the relationships between local residents and port authority and enhance the ability of local residents to react to pollution events.

2. Factors Determining Risk Perception and Hypotheses

As mentioned above, risk perception can be formed based on both belief and self-appraisal. In other words, risk perception can be processed based on a rational system (Leiserowitz, 2006) or an experimental system, which includes emotion, value, and affect in risk judgments (Slovic et al., 2007). Both psychological and cognitive factors could influence risk perceptions due to the characteristics of risk perception. Laypeople's perceived risks could be constructed based on their analytical way of thinking about the nature of risks (Leiserowitz, 2006), including the perceived probability of environmental contamination, probability of receiving impacts, and perceived severity of catastrophic consequences (Slovic, 1987; Dora, 2006; Leiserowitz, 2006). Both Hung (2005) and Hung and Wang (2011) conducted a risk perception survey about nuclear plants in Taiwan to discuss the forming of risk perceptions among local residents. Through the literature reviews, we concluded that five major factors – compensation effect, psychological factor, trust, demographic factor, and physical environment – may influence risk perceptions of local residents on issues of environmental pollution. The hypotheses on effects of risk perceptions are explained as following:

1) Compensation Effect (COMEF)

Kunreuther et al. (1993) studied the attitudes of people lived nearby port areas about risk facilities (such as hazardous waste repositories, power plants, wind farms, prisons, and many other instances of 'locally unwanted'), local residents were quite negative about these risk facilities because they believed that the benefits they enjoyed were greatly lower than the risks they took. Proper compensation incentives could raise the acceptance level (Pushchak and Rocha, 1998; Mors et al., 2012; Huang et al., 2013). Therefore, it is an effective way to gain supports of setting up risk facilities by establishing suitable compensation mechanism. Mors et al. (2012) also reached the conclusion that compensation could smooth the processes of setting up public facilities. The respondents who accepted compensation had a lower level of risk perception. Upon the 'compensation effects,' we propose the following hypothesis:

H_1: Risk perceptions of local residents are negatively related to the willingness to accept compensation.

2) Psychological Factor (PSY)

Perceived benefit from industrial development is one of the psychological factors which have been widely investigated to determine whether it is associated with perceived risks. Gregory and Mendelsohn (1993) stated that individual risk assessment includes the person's perceived benefits. In general, the theory of conjoint expected risk effects believes that the strength and context of risk perceptions of any individual are majorly related to the possibility of risk happening from the risk source, the probability of beneficial effects, the expected level of damages, the expected level of benefits, and the possibility of remaining in the current status (Slovic, 1987; Palmer et al., 2001; Leiserowitz, 2006; Janmaimool and Watanabe, 2014). Starr (1969) investigated risks in some detail and found that society seemed to accept risks to the extent that they were associated with benefits, which he termed voluntary. The syntheses of the above mentioned possibilities and expected results influence the forming of risk perceptions of the public. The higher expected level of damages leads to higher risk perceptions. The higher expected level of benefits leads to lower risk perceptions. In this study, we propose the following two hypotheses:

H_2: Risk perceptions of local residents are positively related to the expected damage level of risk facilities could bring.

H_3: Risk perceptions of local residents are negatively related to the benefit level of risk facilities could bring.

3) Trust (TRU)

Risk perception is also affected by how much trust the public possesses toward the institution in charge of managing the risks. "Trust" refers to people's willingness to rely on experts and institutions in the management of risks and technologies (Earle and Cvetkovich, 1995). Trust is one of the main influential factors on environmental risk perceptions of local residents (Carlton and Jacobson, 2013; Stoutenborough et al., 2013). Local residents usually do not possess adequate knowledge about risk facilities. They also tend to believe that experts' opinions are biased toward government and industry. The main study issues of social trust are the investigations on trust levels of the public toward different information sources. The public attitudes toward risk information processing are influenced by learning, guessing and uncertainty. Through the processes, the discrepancies in risk information may lead the public to doubt risk information provided by experts. The public easily become panic because of their lack understanding about the management and control capacity of government and industry. The more confidence we have in the professionals responsible for our protection or in government officials or institutions responsible for our exposure to risk or in the people who transmit risk information to us, the less fear we will feel. The less we trust them, the greater will be our level of concern (Dora, 2006). That is, risk perceptions of the public will become higher when trust of experts, government and industry drops (Siegrist and Cvetkovich, 2000). The public could also obtain information through their relatives, friends and community members to acquire their know-hows about risks. This information will influence attitudes and behaviors of the public. Because risks and benefits are common among family members and community members, risk perceptions will drop as trust increased. Base on the above discussions, the public would have lower risk perceptions when they have higher trust level on information provided to them. Thus, we propose the following hypothesis.

H_4: Risk perceptions of local residents are negatively related to trust and credibility of information provided to them.

4) Demographic Factor (DE)

It is essential to understand how individuals perceive the risks of hazardous activities in order to make effective safety and risk control policies (Andersson, 2011; Cummings et al., 2013). Many studies reveal that demographic attributes have significant effected upon risk perceptions (Lindell and Hwang, 2008; Armas and Avram, 2009; Bradford et al., 2012). Demographic attributes include gender, age, educational level, and income level are studied to understand their influences upon risk perceptions of local residents in Keelung Port.

- Gender

Gender was mentioned in many researches about risks in the last few decades. These studies indicated that women and men differ in their perceptions of risks. Women put more concerns upon issues about personal health, well-being of family members and care for family. They are subject to higher stress level and thus they feel more threatened by any forms of hazards (Slovic, 1999; Andersson, 2011; Ainuddin et al., 2014). Thus, we propose the following hypothesis:

H_5: Risk perceptions of local residents are positively related to female.

- Age

Age is another demographic attribute which was mentioned a lot in past studies. The effects of age upon risk perceptions were quite different in each study (Riechard and Peterson, 1988). Some researchers reported positive relationships between risk perceptions and age (Botwinick, 1984; Kellens et al., 2011). Others reported inverse relationships among age and environmental concerns (Buttel, 1979). And some others reported no significant relationships between age and risk perceptions (Riechard and Peterson, 1988; Basha and Maiti, 2013). Generally speaking, the age effect is hazard specific and frequently related to cognitive development. In concern of age, we propose the following hypothesis:

H_6: Risk Perceptions of local residents are related to age.

- Educational level

Some studies reported that higher educated people show lower perceived risk level (Savage, 1993; Rowe and Wright, 2001). But some other studies failed to obtain significant relationships among them (Sjöberg, 2004). Education could increase a person's sense of control which means lower risk concerns (Sundblad et al., 2007). Education could also enhance a person's ability to interpolate scientific evidences associated with hazards which may increase risk perception or decrease risk perception depending on the facts (Sund et al., 2015). Because of the undetermined effects of educational level upon risk perceptions, we only investigated if there was a significant relationship between them. Thus, we proposed the following hypothesis:

H_7: Risk perceptions of local residents are related to educational level.

- Income level

Some studies (Savage, 1993; Lo, 2014) found that lower-income individuals shown more concerns upon potential envi-ronmental consequences due to human activities. Thus, we proposed the following hypothesis:

H_8: Risk Perceptions of local residents are negatively related to annual income level.

- Living duration

This study also investigated the influences from living duration upon risk perceptions of local people. Individuals living in environmentally risky regions would more or less encounter environmental pollution events. The chance of loss happened increases as living duration lengthens. Thus, we proposed the following hypothesis:

H_9: Risk Perceptions of local residents are related to living duration.

5) Physical Environment (PHYEN)

The implementation of port facilities changes the physical environment. The influential effects depend on the spatial distance or the geographic condition (Stone, 2001; Ainuddin et al., 2014). Kellens et al. (2011) observed that the risk perceptions of local residents differ from one another due to their living areas. Lindell and Hwang (2008) concluded that the farther the living distance away hazard sources the lower level of risk perception. Therefore, we propose the following hypothesis.

H_{10}: Risk perceptions of local residents are negatively related to the living distance from Keelung Harbor.

III. METHODOLOGY

Multiple linear regression (MLR) attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data. Every value of the independent variable is associated with a value of the dependent variable. The applications of risk perceptions can be found in a wide range of research fields. The MLR model is frequently used as the tool to explore the important factors upon risk perceptions of the respondents. Many examples applied the MLR model have been used to explore issues in environmental pollution (Huang et al., 2013; Stoutenborough et al., 2013; Janmaimool and Watanabe, 2014), climate change (Carlton and Jacobson, 2013), natural disaster (Leiter, 2011; Zhu et al., 2011), medical risk (Buster et al., 2012; Green et al., 2013) and occupational safety risk (Basha and Maiti, 2013). In this study, we adopted the MLR model to assess the risk perceptions of local residents lived near the port of Keelung.

Individuals perceived risks based on their analytical thinking about the natures of a specific risk (Leiserowitz, 2006), including the perceived probability of environmental contamination, the perceived probability of receiving impacts, and the perceived severity of catastrophic consequences (Slovic, 1987; Dora, 2006; Leiserowitz, 2006). The axiomatic approach can be applied to explore the relationship between the nature of risk and risk perception.

In this study, risk perceptions of port environmental pollutions are defined as the product of the probability of damage received and the severity of damage received. That is, $Risk_x = Risk_p \times Risk_s$, the 'risk perception index ($Risk_x$)' is defined as the product of the 'possibility of damage happening perception ($Risk_p$)' and the 'severity of damage happening perception ($Risk_s$).' The pollution generated from the operations of Keelung Port includes waste, water pollution, air pollution and noise. The pollution risk perception is the synthesis of subjective judgments upon health risk. In this study, 'risk perception index ($Risk_x$)' is composed of 'total risk perception ($Risk_T$),' 'air pollution risk perception ($Risk_A$),' 'noise risk perception ($Risk_N$),' 'water pollution risk perception ($Risk_{WT}$)' and 'waste pollution risk perception ($Risk_{WS}$).'

We adopted the MLR model to assess the relationships between risk perceptions of Keelung port residents and influential factors. These influential factors are independent variables in the MLR model, and the risk perception function is expressed as:

$$Risk_i = f(COMEF_i, PSY_i, TRU_i, DE_i, PHYEN_i) \quad (1)$$

The Eq. (1) is transformed into Eq. (2) to establish the MLR model of risk perception, as follows:

$$Risk_i = \beta_0 + \beta_1 COMEF_i + \beta_2 PSY_i + \beta_3 TRU_i + \beta_4 DE_i + \beta_5 PHYEN_i + \varepsilon_i \quad (2)$$

which $Risk_i$ is the value of the risk perception of one type of environment pollution obtained from the i^{th} respondent, β_0 is the intercept, $\beta_1 \sim \beta_5$ are regression coefficients of the influential factors, and ε_i is the error item.

IV. EMPIRICAL STUDY

In this section, an empirical study to evaluate environmental risk perceptions of port residents is performed as follows.

1. Questionnaire Design and Data Collection

1) Questionnaire Design

This questionnaire consists of three parts. The first part is to assess the perceptions of independent variables used in the MLR model. The second part is for the assessment of risk perception index. The third part is the basic demographic data of respondents. The measurement of variables is presented below.

(i) Risk perception: A Likert scale, a single-select, rating scale question method, was used to collect the data related to respondents' attitudes and perception about port pollution risks. Respondents were asked to rate the probability and severity of port pollutions upon health. Port pollutions were divided into four categories; they were air pollution, noise pollution, water pollution, and waste pollution. The 5-point

Likert scale questions were created. Respondents were asked to rate each question, ranging from 1 ("no possibility/ no severity") to 5 ("high probability/high severity").

(ii) The factors which influenced risk perceptions of local residents included compensation effect, psychological factor, trust, demographic factor, and physical environment. These factors were also measured by the Likert 5-point scale questions. To assess the attitudes of respondents toward compensation for loss due to port pollutions, the acceptance levels were surveyed in this study. Respondents were asked to rate in the range from 1 ("not acceptable") to 5 ("highly acceptable"). To assess the psychologic status of respondents toward effects of port operations on daily life, both the expected health damage probability and expected beneficial probability were surveyed in this study. Respondents were asked to rate in the range from 1 ("no possibility") to 5 ("highly probable"). To assess the trust level toward the information about pollution control and management, the attitudes toward various information sources (government agencies, port operators, environmental groups, relatives and friends, academics, media) were surveyed. Respondents were asked to rate in the range from 1 ("no trust") to 5 ("highly trusted").

2) Data Collection

In-depth interviews with local residents were conducted in July 2013 to February 2014. Then the questionnaire was designed according to the discussions with local residents. We conducted questionnaire surveys in both Ruchuan district and Zhengsha district. These two districts are located on the east side of Keelung Port. These areas are densely populated and close to container yards. The current traffic is very heavy in these areas because new constructed East Connection Highway is near these container yards. The consequences are more air pollution and noise pollution compared to other Keelung districts. Hence, the survey was conducted within these two districts.

In this survey, one household is counted as a sampling unit. Cluster sampling is adopted in this empirical study. We divided the neighboring residential region into several smaller sectors. In each sector, we surveyed a certain amount of units. The number of sampling in each district is proportional to the total households in each district. The number of households is obtained from the department of civic affairs of Keelung city. In the neighboring areas, there were 1608 households. In Ruchuan district, there were 452 households. In Zhengsha district, there were 1156 households. To complete the MLR model, we first identified the effective questionnaires. The number of samples should over 5% of the population (Burns and Bush, 2015). Cohen (1988) suggested that there are four criteria to determine the number of effective samplings. They are (1) the number of independent variables – 12 independent variables were chosen in this study; (2) the α value of type I error – usually set at 0.05; (3) the power of judgement – usually set at 0.8; and (4) the power of explanation $R^2 - R^2$ value for risk perceptions study should be larger than 0.2 (Santos et al., 2011; Carlton and Jacobson, 2013). According to the above-mentioned criteria, the number of effective samplings needed was calculated through the *G*power version 3.1.9*. According to Cohen (1988) and Burns and Bush (2015), at least 81 effective samplings are required to obtain an effective result.

Table 1. Summary of pollution risk perception index.

	Average risk possibility perception	Average risk severity perception	Risk perception index
Air pollution	4.13	4.21	17.39
Noise pollution	3.83	3.81	14.59
Water pollution	4.13	4.13	17.06
Waste pollution	3.94	3.99	15.72
Average	4.01	4.04	16.17

The interviewees were selected through the help of local officials. Researchers conducted the questionnaire survey at the interviewee's house. A random family member was asked to respond the questionnaire. A total of 130 questionnaires were distributed (about 1.5 times of least effective samplings required). Among the questionnaires distributed, 45 questionnaires were distributed in Ruchuan district and 85 questionnaires were distributed in Zhengsha district. In total, 90 sheets (about 70%) were completed. This study recovered 90 effective responses, so the results of this survey are valid under the criteria proposed by Cohen (1988) and Burns and Bush (2015).

The basic features of the returned results obtained from this survey are (1) the majority of respondents were males which occupied 68.9% of total respondents; (2) the age group of 41-50 occupied the largest portion of total respondents with 26.7%; (3) the annual income group of NT$300,000-NT$600,000 occupied the largest portion of total respondents with 35.5%; (4) the educational level of college group occupied the largest portion of total respondents with 55.6%; (5) 32.2% of respondents had been lived in the neighborhood for more than 20 years which is the largest group; and (6) 83.4% of respondents did not possess any port related working experiences. The survey also revealed that estimated 75% of respondents had been lived in neighboring areas for more than 5 years and around 60% of respondents were with living duration more than 10 years. We believed that these residents possessed appropriate living experiences about port pollutions in Keelung Port and they could provide representative opinions.

2. Risk Perception Index

All types of pollution created during the port operation were analyzed and categorized for the evaluations of risk perceptions. Table 1 shows the risk perception index of all types of pollution. The value of risk perception is the product of 'risk possibility perception' and 'risk severity perception.' In

Table 2. Summary of factor analysis.

Questionnaire item	Factor loading	Explained variation (Eigenvalue)	Cumulative explained variation	Factor name
Trust of management and control capability of Keelung Harbor Branch, TIPC	0.890	22.98% (2.987)	22.98%	Trust of TIPC and port operators
Trust of management and control capability of port operators	0.880			
Trust of risk information provided by Keelung Harbor Branch, TIPC	0.874			
Trust of risk information provided by port operators	0.727			
Increased job opportunity	0.766	18.22% (2.369)	41.20%	Economic development benefits
Improved local development	0.878			
Trust of risk information provided by relatives and friends	0.795	15.10% (1.962)	56.30%	Trust of relatives, friends and environmental groups
Trust of risk information provided by environmental groups	0.738			
Accept compensation provided by government or port operators	0.793	10.71% (1.392)	67.01%	Acceptance of pollution and compensation
Accept environmental pollution and damages produced by port operations	0.764			
Impact level of pollution upon daily life	0.881	9.04% (1.175)	76.05%	Impact level of daily life

Table 1, we observe that air pollution and water pollution are the top two risks to health from the views of local residents. The risk perception indexes are 17.39 and 17.06 respectively. The average risk perception index is 16.17 which is a high value. The result indicates that local residents felt serious health threats by pollution produced from port operations.

3. Factor Analysis

The purpose of factor analysis is to construct validity and to simplify the factor structure. The minimal number of common factors obtained to maximally explain the variations is our intention. To perform the risk perception factor analysis, we first conduct factor analysis on all questionnaire items. We use Kaiser-Meyer-Olkin (KMO) value to test the sampling fitness of this survey. When KMO value falls between 0 and 1, the closer the value to 1 the more appropriate for factor analysis. The KMO value of this survey is 0.625, the result indicates factor analysis is an appropriate tool for this study.

Hair et al. (2010) pointed out that basic principle of factor analysis is to use as less number of factors as possible to explain as larger variations as possible. Principal component analysis was used to search for factors. In this article, we adopted VARIMAX to carry out factor rotation. The Cronbach's α is used to estimate the reliability of this survey. The reliability is considered as high when the value of Cronbach's α falls between 0.70 and 0.98; the value between 0.35 and 0.70 is acceptable; the value falls under 0.35 is not acceptable and should be omitted. Finally, this study is of high reliability because of the Cronbach's α of each principal component is above 0.727.

The results of factor analysis are shown in Table 2. The eigenvalues of all factor aspects are larger than 1. The cumulative explained variation is 76.05%. Finally, we named the principal components as "*trust of TIPC and port operators*," "*economic development benefits*," "*trust of relatives, friends and environmental groups*," "*acceptance of pollution and compensation*," and "*impact level of daily life*," respectively.

4. MLR Analysis

The MLR model employs two or more predictors to forecast a criterion. There are five major influential factors used in this study to calibrate the MLR model of risk perceptions. We ran MLR model to test the ten hypotheses proposed in previous sections, the results of which are reported in Table 3. The dependent variables are 'total risk perception ($Risk_T$),' 'air pollution risk perception ($Risk_A$),' 'noise risk perception ($Risk_N$),' 'water pollution risk perception ($Risk_{WT}$)' and 'waste pollution risk perception ($Risk_{WS}$).' The results demonstrate main influential factors upon port pollution risk perceptions of local residents.

Table 3. Summary of MLR model.

Independent variable		$Risk_T$	$Risk_A$	$Risk_N$	$Risk_{WT}$	$Risk_S$
Intercept		10.51***(0.01)$^{\Psi}$	15.42*** (0.00)	8.50 (0.11)	13.78*** (0.00)	5.62 (0.25)
Compensation effect (COMEF)	Acceptance of pollution and compensation	-0.02(0.97)	1.09 (0.23)	0.85 (0.38)	-0.45 (0.61)	-1.30(0.15)
Psychological factor (PSY)	Impact level of daily life	1.06** (0.05)	0.76 (0.26)	1.75**(0.02)	0.44 (0.50)	1.04 (0.12)
	Economic development benefits	0.38(0.50)	0.12 (0.87)	-0.18 (0.81)	1.05 (0.13)	0.81 (0.25)
Trust factor (TRU)	Trust of TIPC and port operators	1.53**(0.03)	0.63 (0.48)	2.17**(0.02)	0.18 (0.83)	2.34*** (0.01)
	Trust of relatives, friends and environmental groups	-1.22*(0.1)	-0.10 (0.92)	-1.83**(0.06)	-1.09 (0.22)	-1.68*(0.06)
Demographic factor (DE)	Gender (male = 0, female = 1)	1.74 (0.12)	1.23 (0.37)	1.84 (0.21)	2.92**(0.03)	1.23 (0.36)
	Age	0.03(0.55)	-0.07(0.18)	0.02(0.69)	0.05(0.30)	0.08(0.14)
	Annual income	-0.003(0.88)	0.01 (0.81)	-0.00(0.94)	-0.02(0.50)	0.01(0.83)
	Educational level (senior high and below = 0, college and above = 1)	1.54 (0.17)	-0.50 (0.72)	0.60 (0.69)	3.21** (0.02)	3.24** (0.02)
	Living duration	-0.02(0.74)	-0.03(0.65)	-0.03 (0.68)	-0.00 (0.93)	0.1* (0.09)
Physical environment factor (PHYEN)	Community (Ruchuan = 0, Zhengsha = 1)	-2.68*** (0.01)	-3.27***(0.01)	-3.35*** (0.01)	-2.68**(0.03)	-1.41(0.25)
R^2 ($Adj\ R^2$)		0.30 (0.20)	0.21(0.10)	0.30 (0.21)	0.24 (0.13)	0.28 (0.18)

Note: Significance level: *** $\alpha = 0.01$; ** $\alpha = 0.05$; * $\alpha = 0.1$; Ψ: p value in parentheses

At first, the investigation into 'total risk perception ($Risk_T$)' reveals that: (1) In the psychological (PSY) aspect, the factor of 'impact level of daily life' shows positive effects. The finding illustrates that the more impacts upon daily life, the higher level of risk perception. (2) In the trust (*TRU*) aspect, the factor of 'trust of relatives, friends and environmental groups' shows negative effects. The finding means that higher trust level upon risk information provided by lay people displays lower risk perceptions; on the other hand, 'trust of TIPC and port operators' shows positively significant effects. (3) In the physical environment (*PHYEN*) aspect, the physical factor shows negative effects. The finding means that residents of Ruchuan community which locates closer to port area show higher risk perceptions.

Secondly, the investigation into 'air pollution risk perception ($Risk_A$)' discovers that only physical factor shows negative significance. Residents of Ruchuan community which locates closer to port area show higher risk perceptions. The results showed that there were obvious different statuses of air pollution in different districts. Other factors showed no significant effects upon risk perceptions of air pollution.

Thirdly, the investigation into 'noise risk perception ($Risk_N$)' discovers: (1) The two variables with positive significance are the factor of 'impact level of daily life' and 'trust of TIPC and port operators.' (2) The two variables with negative significance are the factor of 'trust of relatives, friends and environmental groups' and 'physical environment factor.' The results showed that there were obvious different statuses of noise in different districts. The residents of farther away Zhengsha district revealed lower risk perceptions upon noise. Trust is another important influential factor of risk perceptions upon noise. In the interviews, residents expressed that they were deeply disturbed by noise. They cared about noise prevention measures applied by government agencies or port operators. Trust would influence their risk perceptions.

Fourthly, the investigation into 'water pollution risk perception ($Risk_{WT}$)' discovers that sex and educational attainment within demographic (*DE*) aspect and physical environment (*PHYEN*) one are with significant levels. Female residents with higher level of educational attainment and residents of Ruchuan community which locates closer to port area show higher risk perceptions. The results showed that there were obvious different statuses of water pollution in different districts. Gender and education level are the other important influential factors. Females in Taiwan contact water in more occasions, like cooking and clothes washing. Therefore, they cared more on water quality and showed higher risk perceptions upon water pollution.

Fifthly, the investigation into 'waste pollution risk perception' discovers: (1) The factor of 'trust of TIPC and port operators' shows positive effects; and the factor of 'trust of relatives, friends and environmental groups' shows negative effects. (2) Residents with higher level of educational attainment and with longer living duration show higher risk perceptions. Physical environment factor showed no significant influences for risk perceptions upon waste. That means pollution due to waste is at the same level in different districts. Living duration showed significant relationship to waste might mean that waste pollution was becoming a more serious threat in recent years.

In summary, we concluded the survey results as following:

(1) Only noise showed significant positive relationship on risk positions of daily life quality.
(2) Trust of TIPC and port operators showed significant positive relationships on risk perceptions of noise and waste pollution.
(3) Trust of relatives, friends and environmental groups showed significant negative relationships on risk perceptions of noise and waste pollution.
(4) Females showed higher risk perceptions of water pollution.
(5) People with higher educational attainment showed higher risk perceptions of water pollution and waste pollution.
(6) People lived longer in this area showed higher risk perceptions of waste pollution.

5. Discussions

In summary, the hypotheses 2, 5, 7, 9 and 10 are supported from the survey results. Hypothesis 4 is only partially supported in the test. There are no significant differences in hypothesis 1, 3, 6 and 8.

This study presents further discussions on previous results in the following. Firstly, there is no significant relationship between risk perceptions of local residents and the factor of 'acceptance of pollution and compensation.' The main reason is that Keelung port is not a newly established facility. The local residents have been lived in the neighborhood ever since. They already own a certain level of understanding about the pollution status. Furthermore, the Keelung Harbor Branch of TIPC has not set up any compensation guidelines for neighboring communities. The environmental pollution compensation mechanism was not well designed; therefore, local residents did not feel the benefits of compensation. This situation resulted in no compensation effects on risk perceptions.

Secondly, 'expected damages brought by risk facilities' exhibits positive and significant effects upon 'total risk perception ($Risk_T$)' and 'noise risk perception ($Risk_N$)' of local residents. This finding indicates that the more harmful effects exerted upon daily life, the higher level of risk perception is. This result also reveals that the pollution caused by port operations has created serious negative influence upon daily life of local residents, especially from noise. The adverse effects upon health (damage to hearing ability, sleep disturbance) caused by noise are immediate and observable. Thus, risk perceptions of local residents were highly influenced by noise. Although there are many environmental protection regulations, it still needs to be effectively enforced. To effectively enforce various anti-pollution regulations, especially in noise control, is important to lessen the anxiety among local residents.

Thirdly, 'expected benefits brought by risk facilities' do not show significant effects on the risk perceptions of local residents. Keelung port is already an established facility. Job opportunities and local economy improvement are not expected to be enhanced in foreseeable future. Therefore, risk perceptions are not influenced by 'expected benefits brought by risk facilities.' Furthermore, health risks are hard to be compensated for. So when these kinds of risks are bothering the public, it will be hard to earn support to buy financial compensation. If the compensation strategy is used, it always needs accompanying mitigation measures.

Fourthly, 'trust and credibility of information provided by experts, government and port operators' displays positive and significant effects upon 'total risk perception ($Risk_T$),' 'noise risk perception ($Risk_N$)' and 'waste pollution risk perception ($Risk_{WS}$).' However, 'trust and credibility of information provided by lay people (family members, coworkers and community members)' shows negative and significant effects upon 'total risk perception ($Risk_T$),' 'noise risk perception ($Risk_N$)' and 'waste pollution risk perception ($Risk_{WS}$).'

The survey results about trust on information provided by experts are against hypothesis 4. Two possible reasons could result in this conclusion. Firstly, trust on information source is only one of the factors influence risk perceptions of local residents. Other factors, like whether the public is familiar with the risks, whether the risks can be controlled by individuals themselves, whether the public is voluntarily accept the risks, whether there is an immediate effect, and whether the risks are observable, could all affected risk perceptions of local residents. Ever since these local residents lived in the neighboring areas, the port was already established. It is a voluntary NIMBY and the risks are not immediate or observable. Therefore, people show higher tolerance to these kinds of risks and they show lower risk perceptions. As a result, even though they showed lower trust level toward the information provided by government agencies, the risk perceptions did not increase. And because of the higher tolerance for risks, the risk perceptions were then lowered. Secondly, it could be a two-way causality situation. It could be the situation that local residents recognized the efforts of TIPC on issues of pollution control and management, so they showed higher risk perceptions as well as higher trust level. Especially, the relationships were more obvious in concern with noise and waste pollution.

Government agencies and port operators should pay more attentions to this result. The efforts of government agencies will be appropriated by local residents. Thus, government officials should make more efforts toward good pollution control and suitable policy-making. Under the goal of building a green port, government officials should cooperate with local residents to build a sustainable port.

Fifthly, in the demographic (DE) aspect, higher level of educational attainment shows significant effects upon 'water pollution risk perception ($Risk_W$)' and 'waste pollution risk perception ($Risk_{WS}$).' Females show higher 'water pollution risk perception ($Risk_W$).' Local residents with longer living duration show higher 'waste pollution risk perception ($Risk_{WS}$).' We obtain similar results as in Ainuddin et al. (2014). This finding indicates that further risk communication should be performed among groups of females, higher level of educational attainment and long-time residents. We also recommend that suitable compensation mechanism should be established to deal with negative influences upon living quality of local residents.

Finally, the Ruchuan community locates closer to Keelung Harbor than the Zhengsha community does. This study reveals that every risk perception index is higher among residents of Ruchuan community except 'waste pollution risk perception ($Risk_{WS}$).' Residents with near living distance to risk origin or risk facility show higher risk perception.

V. CONCLUDING REMARKS

Sustainable development and green transportation have become principal government policies. As a result, port operators have to conduct environmental risk assessments when facing environmental pollution events. Nowadays, more emphases have been put on the technical aspects such as risk prevention and aftermath dealing. It is rare to conduct risk communication with local communities. Opinions and concerns of local residents are easily neglected. We conduct an empirical study to investigate risk perceptions of residents living near east Keelung Harbor. The conclusions are listed below:

(1) The risk perception index reveals that the pollutions produced by port operators have already serious influenced health of local residents.
(2) 'Expected damages brought by risk facilities' exhibits positive and significant effects upon 'total risk perception' and 'noise risk perception.' Starr (1969) obtained similar conclusion.
(3) 'Trust and credibility of information provided by experts, government and port operators' displays positive and significant effects upon 'total risk perception,' 'noise risk perception' and 'waste pollution risk perception.'
(4) 'Trust and credibility of information provided by lay people (family members, coworkers and community members)' shows negative and significant effects upon 'total risk perception,' 'noise risk perception' and 'waste pollution risk perception.'
(5) Females show higher 'water pollution risk perception.' As expected, our survey revealed that women rate a wide range of hazards as higher in risk than do men. This result is consistent with gender differences found previously in many studies (for example, Slovic, 1999; Kellens et al., 2011; Ainuddin et al., 2014).
(6) There is no significant relationship between age and risk perceptions of local residents. Riechard and Peterson (1998), Basha and Maiti (2013) obtained same conclusions.
(7) Higher level of educational attainment shows significant effects upon 'water pollution risk perception' and 'waste pollution risk perception.' This conclusion is the same as Sjöberg (2004): higher perceived risk levels among highly educated individuals.
(8) There is no significant relationship between annual income level and risk perceptions of local residents.
(9) Local residents with longer living duration show higher 'waste pollution risk perception.'
(10) Residents living near port areas display higher risk perceptions. We obtained the same conclusion as Lindell and Hwang (2008) did.

According to the goals mentioned above and the conclusions of this study, we propose recommendations for port operators, local communities and future studies, respectively.

- **Recommendations for Keelung Harbor Branch of TIPC and Port Operators**

Risk communication is a well-established tool of risk management. It is implemented to influence risk perceptions and attitudes. It is not the same as risk control and risk financing. The risk response strategies are based on people's welfares. Janmaimool and Watanabe (2014) have argued that risk communication is a deliberate tool to convey health or environmental risk information between stakeholders. It helps people conquer psychological fears, face risks and manage risks.

Government and port operators are the owners of risk information. They are also risk monitors. Therefore, it is important for them to conduct comprehensive risk communication. We believe the implementation of 'risk communication' and 'risk perceptions' in the processes of risk management will improve the environmental pollution knowledge and reactive abilities of local residents. Here, we propose four measures as follows:

(1) ***Establishing the awareness of communication.*** It is vital for Keelung Harbor Branch of TIPC and port operators to recognize that risk communication is a key process in risk management. They should acquire enough understanding on risk communication. Port operators should establish communication channels to listen to opinions and to resolve problems. Before making decisions, they should communicate with stakeholders repetitively to earn their supports.
(2) ***Establishing a dedicated department in charge of communication.*** There is no dedicated department in charge of communication in Keelung Harbor Branch of TIPC. The new department should be responsible for (1) conveying environmental protection efforts done by TIPC; (2) holding public hearing to hear opinions about port planning; and (3) implementing environmental protection measures by considering concerns of environmental groups to reduce risk perceptions of local residents.
(3) ***Strengthening trust and credibility.*** We find that local communities have low trust in risk information provided by government and port operators. To increase trust and credibility, sincere manners is essential in risk communication. Moreover, port operators should run more open-house activities to encourage public visit to port facilities. These activities could increase public understandings on anti-pollution measures taken by port operators.
(4) ***Establishing environmental protection regulations.*** Environmental protection regulations should be vigorously established to standardize the environmental protection measures and processes and therefore decrease human interference upon related issues. Additionally, proper com-

pensation measures, such as more compensation for more serious polluted area, could decrease risk perception of local residents.

- **Recommendations for Local Residents upon Risk Management**

Although many empirical studies investigated the relationships between risk perceptions and personal actions, it is still unclear how risk perceptions relate to preparedness of individual's actions. It is generally assumed that high risk perception will lead to personal protective actions (Wachinger et al., 2013).

Due to the accumulated effects of air pollution, of water pollution, of noise and of waste pollution have influenced health and life of neighboring communities, local residents show high levels of risk perceptions. Besides the environmental protection measures conducted by government, local residents should promote their own awareness of environmental risks and should aggressively participated in port environmental risk decisions. Local communities and local residents should build their own risk management strategies.

Risk management strategies mainly divided into risk control strategy and risk financing strategy. There are two phases in a risk control strategy. The first phase is to adopt appropriate preventive measures to reduce the probability of risk events. The second phase is to adopt loss control measures to reduce the impacts after the happening of risk events. The risk financing strategy puts emphases on financial planning and allocation when risk events happen. Insurance and reserve fund are common means to reduce financial impacts.

From Table 1, we found the risk perceptions index of local residents were very high. Move away from risk regions is the best risk strategy. It is a measure to avoid loss. Loss avoidance is the utter means of risk control. This measure denies any chance of risk events. Because the high house prices, it is not an easy choice for local residents. After assessing housing cost and potential health harm, many people chose not to move. The next option is to reduce and mitigate loss if one could not move away. The following measures can be applied to reduce or mitigate loss due to environmental pollution in Keelung Port neighboring areas.

(1) Plant more trees to reduce dust from port operations and to beautify environment.
(2) Organize community members to form water pollution monitoring teams and report any violations committed by vessels.
(3) Perform better recycling jobs on all port waste.
(4) Install soundproof windows to reduce noise.

Moreover, risk transferring strategy can be applied to those risks cannot be taken care by measures mentioned above. Local residents can buy proper insurances such as whole-life insurance and health insurance for economic and psychological well-being.

- **Recommendations for Future Studies**

There are some causes in this study that limit the effectiveness of the results. Firstly, we could not obtain the name lists of local residents. Thus, we adopted snowball sampling instead of random sampling. The questionnaires were distributed through the help of district head. This result in least number of effective samples was achieved but the minimal number required (135) for MLR was not fulfilled. 135 Statistical biases could be created in this situation. Secondly, some moderators (such as voluntary NIMBY and two-way causality situation) were found to possess the effects that made the hypothesis about trust (H_4) only be partially supported. Future studies could put more emphasis on the influential effects of the moderators. The knowledge about these effects can be used to make more effective and efficient policies. Thirdly, the empirical study was conducted in Keelung Port, Taiwan. There will be differences in risk perceptions when a different port was chosen because of the different port background. Future studies may survey other ports in Taiwan and synthesize the results of different ports to form recommendations for setting up national port environmental risk control regulations and risk communication policies.

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