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A Study of Disaster Risk Communication and Adaptive Behaviour based on Rail Station Protection

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Abstract: Critical infrastructure is an essential element of the operation of the city, such as for rapid transit, high-speed railway, local railways and other mass transit systems that must not only provide adequate service, but focus also on service quality improvement. These transportation station nodes have a single function or multi-target use, offering facilities for accessing transport, waiting, consumption, disaster prevention and other functions. When the city is an important node in disasters, such as floods, earthquakes, fire disasters, terrorist attacks and other disasters, it could seriously affect the city's security, especially through economic losses. In particular, emergency response and disaster recovery require the need to invest a lot in resources and adaptation. Therefore, urban facilities as nodes, space security, risk assessment and adaptation strategies are becoming important issues. This research regards the rail station as critical infrastructure and chooses stations, including railroads, high-speed railroads, and MRT, as nodes and explores the protective measures of stations facing natural disasters or manmade disasters. By collecting domestic and foreign hazard protection literature, this study has established public transport nodes' risk communication and an adaptive behaviour framework. Based on empirical results, the study finds that the station management department in Taipei uses a systematic approach to prevent and respond to disasters, and may not provide information effectively to help passengers to take appropriate autonomous response measures. The study recommends different contingency measures at stations and public-private adaptation strategies. Commercial enterprises do not have business continuity planning for disasters, they still rely on the government and transport management department for information and emergency guidance. Through this research, some principles and strategies for future disaster planning and urban node management policies are provided.

1. INTRODUCTION

Branscomb (2006) published "sustainable city" which introduces three major types of urban disasters, the first is natural disasters, such as earthquakes and floods, the second is a technical disaster, such as the blackout in Canada in 2003, and third, a disaster caused by a terrorist attack, such as the terrorist attack at the World Trade Centre in New York. After the events of 9/11, many countries focused on critical infrastructure protection, including social, economic and transport operations. However, according to Wilson et al. (2007) studying the safety of the US passenger rail system, the study found terrorist attacks affected 80% of the railroads. In addition, Jian (2008) statistics of underground disasters such as earthquakes, criminal acts (such as

arson, bombings, terrorist activities.), flooding, power outages and fires, car accidents, showed a probability of about 60% for fire impacts. Taiwan's transport facilities such as MRT, high-speed rail and Taiwan's Railway Station, provide passengers facilities for accessing transport, interchange, waiting, consumption and other needs. The higher the rate of urbanization and spatial dependence on these facilities, the higher the probability of the occurrence of disasters. Therefore, improving critical facilities' protection planning is increasingly important.

When an underground station or tunnel disaster occurs, because of the special environmental characteristics and structure, which easily lead to disaster relief units being difficult to contact, accessibility is difficult, and the disaster situation is difficult to control (Yang, 2009). Therefore, besides the detailed planning of station safety facilities, disaster information management needs to strengthen emergency response and disaster preparedness.

Managers' adaptability, information communication, passenger awareness of the environment, and physical planning affect station security, so different users have different disaster awareness and disaster communication processes, and finally, produce differing emergency response behaviour. This study reviews the critical infrastructure protection and risk communication literature and deep interviews with Taipei and Banqiao Station managers and operators. Expert forums were also held to discuss security practices. This study establishes the risk communication structure of the station system and explores the relationship of information communication between the different stakeholders.

2. LITERATURE REVIEW

2.1 Critical Infrastructure Protection

Critical infrastructure refers to assets or facilities that have a key role in society or the economy. The National Strategy for the Physical Protection of Critical Infrastructures and Key Assets of the United States (White House, 2003) illustrates the purpose of critical infrastructure protection as to define and protect the assets of critical infrastructure, provide immediate prediction to avoid threats, and nurture the ability to protect and control the safety of facilities. To meet the protection objectives, this requires prioritising five issues, including planning and resource allocation, information sharing, indicators and warnings, human capital and crisis awareness, technology research and development, and simulation and analysis to build infrastructure protection programs. Policymakers should balance four factors in their key infrastructure protection programs, including goals, strategies, the ability to allocate public and private organizations to implement the program, and plan risks (Bartlett, Holman, & Somes, 1995).

Although disaster is difficult to predict, for the transportation critical infrastructures in disaster prevention planning, the risk of communication, countermeasures, and crisis management are rarely discussed. Reviewing Taiwan's station safety literature, this study focuses on the prevention of disaster prevention equipment, such as emergency power facilities, fire facilities, fire and smoke zoning, and materials. There is still a lack of research on risk communication and disaster awareness among different users. This study helps improve the awareness of stakeholders in critical infrastructure

through effective risk communication design, to ensure the safety of personal assets and to maintain the operation of infrastructure.

2.2 Risk Communication Related Literature

The National Institute of Health defined risk communication as "the mutual exchange of information and opinions by the relevant individual, group or agencies to prevent or manage risk" (Yuan, 2007). Risk communication is related to risk cognition, risk attitude and the use of risk management methods. Risk communication among residents, local communities, government agencies, and other stakeholders is indispensable in terms of effective risk management (Tigere, 2013). Risk communication covers a wide range of activities and meanings, including discovering disputes over risk cognition, presenting and explaining risk information, promoting the focus on environmental or health-related issues, and enhancing public risk awareness. The purpose of these activities is to change attitudes toward risk, affecting personal risk behaviour and promoting protective actions, providing strategies for emergency information, improving disaster-warning systems, and developing risk management collaborative decisions and resolving confrontations (Kasperson, 1986; O'Riordan et al., 1989; Covello, Slovic, & von Winterfeldt, 1986)).

Poussin, Botzen, and Aerts (2014) analysed the influence factors of adaptive behaviour based on the Protection Motivation Theory (PMT). The study suggests that the availability of adaptive measure related information would promote the adoption of adaptive behaviour. Lindell and Perry (2003) proposed the information communication process in behavioural protection decision modelling, which serves as a reference for message perceivers in behaviour decisions through proper channels and message content. Rohrmann (2000) proposed a framework of the risk communication process (Figure 1). It suggests an effective assessment of risk information and changes in perceptions of risk for decision-making. Although this model mostly focuses on the correlation between the message and behaviour, it must regard successful risk communication as an interactive process (Leiss, 1996; Renn, 1992). Therefore, it is very important to establish an information mechanism for research, feedback and interaction with risk managers (Rohrmann, 2000).

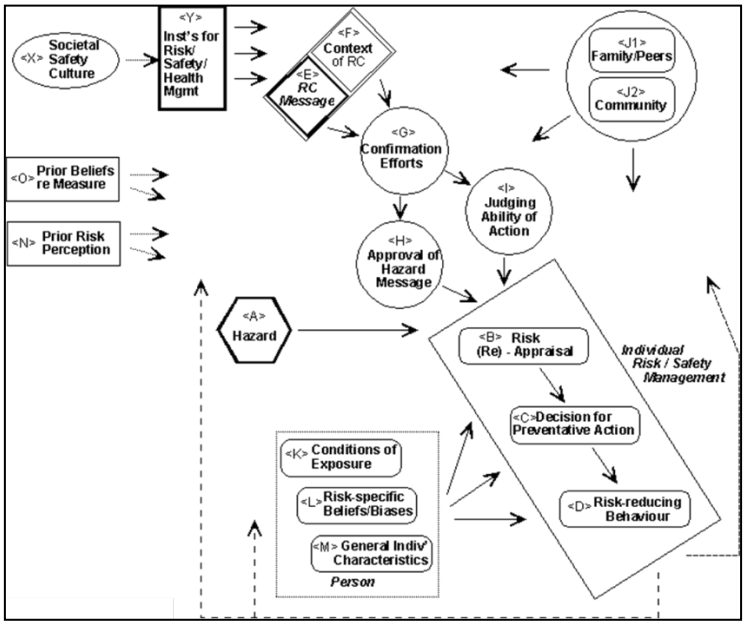

Figure 1. Risk Communication Process Framework

Prior literature regarding the analysis of risk messaging has mostly come from the source of the message, message transmission channels, and the analysis of message content that explores the influence of different message sources, channels and content on the message perceivers. Li (2011) stated in their study that more explicit information content on disasters would help the residents understand disaster information and enhance disaster risk cognition. Valuation on residents' demand for disaster information will affect government intent in the supply of disaster information and increase the intent to take part in prevention campaigns of a community disaster. Kuo (2014) analysed if the availability of risk information would enhance public risk perception, and the results suggest that emergency evacuation maps would help raise the public cognition of threats to life and safety and personal property loss. Meanwhile, there is a significant relationship between flood-risk perception and prior experience and education. A study conducted by Lindell, Lu, and Prater (2005) reveals that although the public most commonly gains typhoon-related information via local news media (particularly the local TV station), the emergency evacuation decisions in times of disaster are mostly subject to the influence of peers and local government. Driscoll and Salwen (1996) discovered from their study that the public differentiates between the professionalism and trust in different communication channels, and that residents consider TV and radio stations to be more professional and trustworthy. Hence, the paper analyses the correlation between risk communication and adaptive behaviour for the source of the message, channel, and content.

2.3 Social-Ecological Systems Theory

The theory of social-ecological systems is based on a combination of ecology and system theory. This theory emphasizes that individual health behaviour interacts with the living space and human behaviour influenced by physical, social and public policy systems, and finally decision-making (Stokols, 1992; Sallis, Bauman, & Pratt, 1998).

Anderies, Janssen, and Ostrom (2004) propose a conceptual model of social-ecological systems that includes resources, resource users, public infrastructure providers and public infrastructure, among which there is an interaction between resource users and public infrastructures. Walker, Tweed, and Whittle (2013) defines social-ecological systems that integrate by "social structures and processes" and "ecological structures and processes". The social structure and process mainly include the population structure, technical level, economy, system, culture and information. The ecological structure and process refer to the ecological elements that affect human society in a specific region, such as due to a natural disaster (Redman, Grove, & Kuby, 2004). Schlüter et al. (2017) also argue that individual decision-making is not only affected by society and the environment but also by its own internal conditions, assessment and set goals, to choose the most optimized program (Figure 2).

Under the analysis of social-ecological systems theory, the governance mechanism of natural disasters is affected by the risk attributes of disaster, but is not controlled by planning, procedure or rule during the communication, implementation or coordination of risk (Quarantelli, 1988). Therefore, this study uses the theory of social-ecological systems and risk communication to integrate the risk communication mechanism and public emergency response of a railway station, which can strengthen the complex urban infrastructure system's disaster response mechanism.

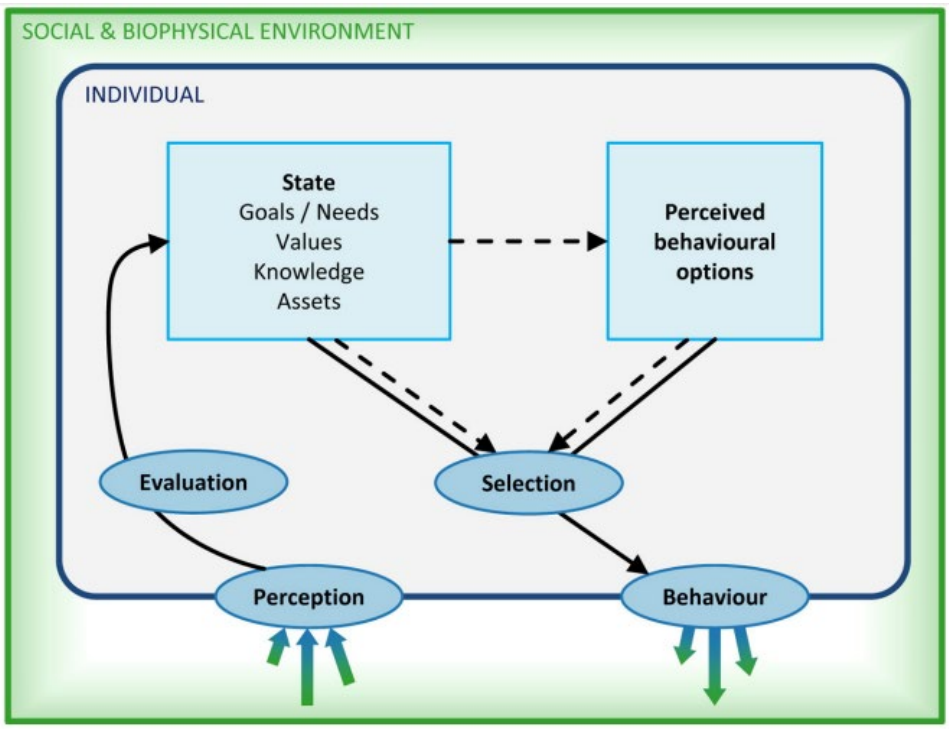

Figure 2. Social-Ecological Systems in the Individual Decision-Making Framework

The compilation of the study found that it could divide the influencing factors into the external environment and internal factors. External environmental factors include the natural environment, social environment and risk communication mechanism. Internal personal factors include risk cognition and adaptive behaviour. Besides external factors, personal characteristics, experience and psychological factors vary and ultimately affect adaptive behaviour. The station manager or operator and the passenger rely on smooth communication channels and enhanced disaster protection awareness, and the provision of a safe space, which should enhance the overall protection of the station.

3. RESEARCH DESIGN

This study is based on the composite Taipei and Banqiao stations, which are organized by the Taiwan Railway, high-speed rail and Taipei MRT facilities. Firus et al. (2011) pointed out that risk communication must be conveyed between interested parties and that the following two points are necessary for the development of a risk communication strategy: 1) Study the existing risk knowledge of inhabitants through interviews or surveys of risk awareness, and 2) Identify ways to influence the risk perception of the target group. Therefore, this study conducted in-depth interviews with Taipei and Banqiao Station managers and operators. The respondents included the security department of the Taiwan Railway Administration, Taiwan Expressway Co., Ltd., Taipei MRT Co., Ltd., and the commercial operators of the two stations, including staff responsible for disaster prevention of Breeze Plaza Industrial Co., Ltd. and Universal Shopping Centre Co., Ltd.

The focus of the interview was to understand the process of disaster awareness and adaptation of station managers and operators, and to compare the emergency response standard operating procedures (SOP) of the Taiwan

Railway, high-speed rail and Taipei MRT. In order to understand the station's contingency planning and risk communication interactions, the interview was based on the risk communication structure, including four facets: communication object and environmental characteristics, communication channels, response and assessment, adaptive behaviour. These four facets consisted of the following:

(1) Communication object and environmental characteristics: Basic data survey and organizational tasks, disaster experience, risk awareness, potential danger or vulnerability of station environment.

(2) Communication channels: Including information sources, delivery methods, and conveying the disaster information.

(3) Response and assessment: How does the manager identify the hazard risk when the station is affected by natural disasters (floods, earthquakes) or manmade disasters (fires, terrorist attacks)? How long does it take to assess and what emergency measures are taken?

(4) Adaptation behaviour: Does the manager have to adjust the emergency response mechanism after the disaster, or improve the station environment and implement disaster prevention education?

This study surveyed 400 passengers at Taipei and Banqiao stations in Taiwan using a questionnaire of the 'state preference' method to survey passengers' perceptions of station disasters, communication methods, response behaviour, satisfaction with station environment, and socio-economic attributes. There were 365 valid samples and the recovery rate was 91%.

4. RISK COMMUNICATION FRAMEWORK

4.1 Interview Summary

The station management organizations have standardized procedures for reporting and emergency response measures for different disasters, and routine disaster prevention exercises and education each year. However, managers think the crisis awareness of passengers is not enough; even if managers provide enough risk information, they are unable to grasp whether the passengers have received the correct information in order to conduct effective evacuation.

4.1.1 Organisation

At the Taipei and Banqiao stations, transport systems such as MRTs, railways and highways are equipped with emergency response organizations and set up with traffic control centres to collect and monitor disaster information. The organization is responsible for regular fire equipment inspection, updating disaster relief plans, handling exercises and other protective activities. When a disaster occurs, the traffic control centre will collect and distribute the disaster information to the police, hospitals, station staff, engineering, electrical and other departments, so that the relevant departments can quickly assume actions.

The commercial operators of the station (Breeze Co., Ltd., Global Mall Co., Ltd.) comply with the safety protection mechanism established by the transport manager. They only have a few staff members responsible for

implementing disaster prevention and protection jobs. They have not established their own independent disaster prevention organizations.

4.1.2 Communication Channel

Respondents think station information transmission has been popular; information communication channels are diverse and smooth and managers broadcast information to the passengers. News release information is also published on the station's official website, Facebook, or software application. They are equipped with a monitoring centre in Taipei Station and Banqiao Station, as the hubs of information transmission and distribution. In addition, the Taipei Station will set up a joint disaster prevention centre, and the respondents believe that this will allow the communication between different departments to be smoother.

Respondents showed that the station had a monitoring and alarm mechanism for different disasters so they could grasp the extent and location of the disaster for the first time. However, managers do not publish disaster information for different users because they consider information consistency to avoid errors, so they issue consistent traffic and disaster prevention information. The two stations have three different transportation systems, so the communication equipment, channels and language are different, resulting in emergency response, scheduling and communication difficulties.

80% of passengers received disaster knowledge, warnings or emergency response measures mainly from the internet, secondly from television or radio (72%), and thirdly from signs or marquees (59%) (Figure 3). 96% of the respondents did not take part in disaster prevention drills at the station. The other 4% of them had taken part in fire escape drills. The survey found that 88% of the passengers would take emergency measures in a disaster, however, 12% of the passengers did not take emergency measures because they did not know how to respond.

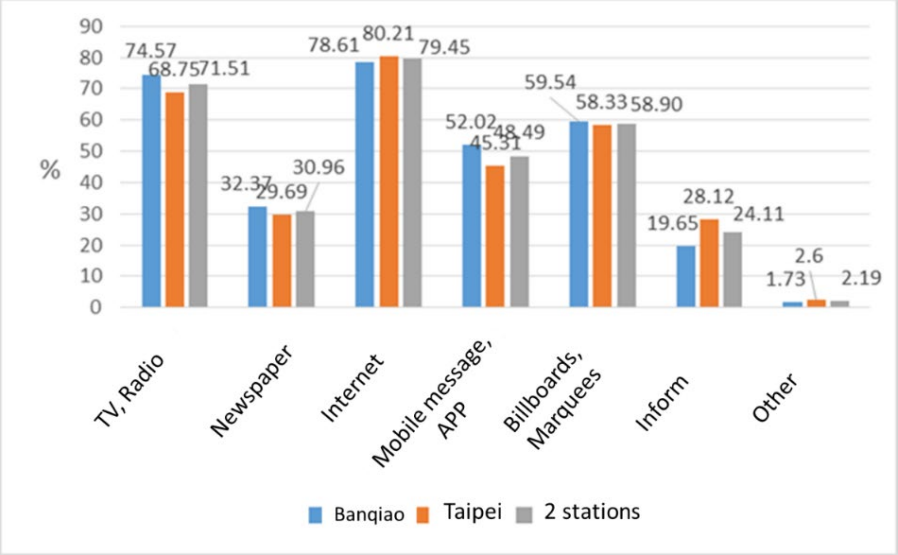

Figure 3. Passengers' risk communication channel ratio

4.1.3 Response and Assessment

Respondents showed that the main function of the station was to maintain traffic. Therefore, when the operator receives disaster information, it should quickly (in about 10 minutes) respond according to the different disasters,

following disaster and emergency SOP. They decide whether to evacuate passengers and control vehicles, and self-defence teams of different station organizations will cooperate with the police and firefighters to help evacuate and relieve passengers. The post-disaster recovery will depend on the degree of injury, but the manager will try to recover traffic operation, schedule vehicles or provide alternative transport programs within about one hour.

4.1.4 Adaptive Behaviours

Respondents have experience in dealing with disaster response, so managers pay great attention to the safety of the station. There are regular disaster prevention exercises and check-up mechanisms under the organization of the managers and also in cooperation with the government to implement protection policies and regularly maintain equipment and update the software. Respondents indicated that routine exercises helped to enhance the awareness and alertness of the organization and the passengers, but when the disaster actually occurred, the managers were not sure whether the passengers were effective in accepting information and adapting.

4.2 Framework of Risk Communication on Managers' Adaptive Behaviour

This study refers to the information communication process in the protection behaviour model (Lindell & Perry, 2003; Rohrmann, 2000), individual decision-making behaviour of a social-ecological nature (Schlüter et al., 2017), and conclusions of the comprehensive interview.

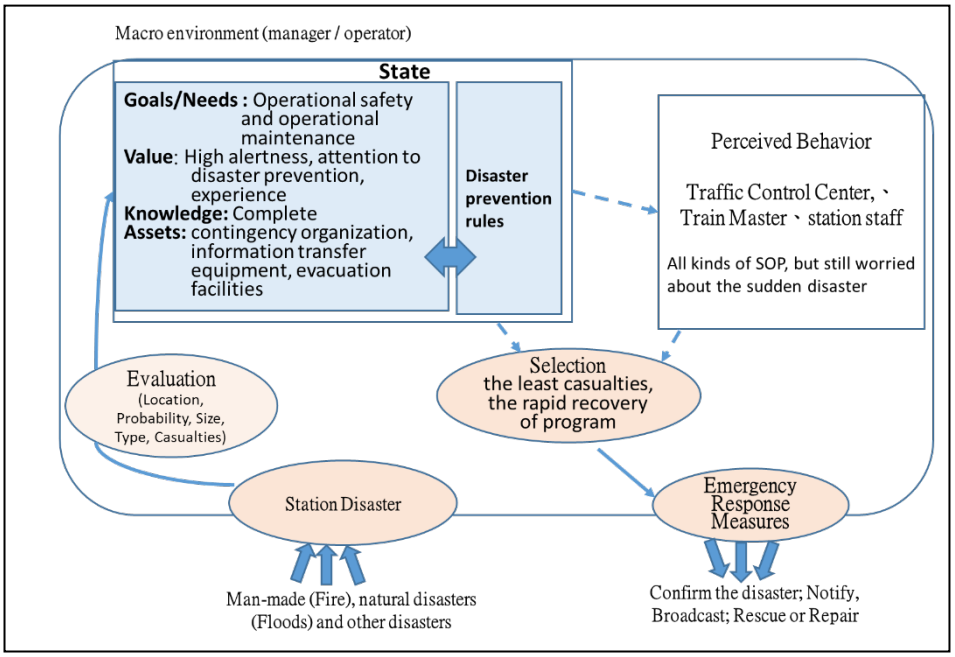

Figure 4. Conceptual Framework of Risk Communication Process for the Manager and Operator under the Station Environment System

A conceptual framework for risk communication for managers and operators in the station environment system is illustrated in Figure 4. First, the risk communication mechanism and environmental factors affect an individual's psychology, and then through the individual, social and economic attributes, disaster experience and psychological factors interact to form a risk

awareness and attitude. In the process of disaster cognition, the managers and operators judge the disaster risk, behaviour effect, cost of and adaptability to the disaster, and follow the organization's emergency standard operating procedure and risk attitude. Finally, the managers and operators will take emergency measures.

4.3 Multiple Logistic Regression Analysis

In this study, 400 passenger questionnaires were distributed, with 365 valid samples retrieved. The recovery rate was 91%. Multiple logistic regression model was used to analyse the variables of risk perception, communication mechanism, facility environment satisfaction, gender, age, occupation, education, average monthly income, the frequency of using stations, and other social and economic variables. How to influence passengers to adopt "negative", "medium positive" and "highly positive" degree of adaptive behaviours was considered.

For the degree of fit of the regression model, the Chi-squared test *P* value is less than 0.01, meaning the final model is significant. The correlation between the dependent variables and the independent variables, Cox & Snell R^2 and Nagelkerke's R^2 reached the standard of 0.15, showing the two variables are related.

4.3.1 Risk Cognition

The cognition of passengers' evacuation abilities significantly affects the positive degree of adaptive behaviour. This variable also significantly affects the level of 0.05 for "moderately positive response". The odds ratio was 1.09, so the score of "evacuation abilities" increased by one unit, and the probability of taking "moderately positive response" was 1.09 times higher than the probability of "negative response".

In addition, the adoption of "highly positive adaptive" also reached a significant level of 0.1. The odds ratio was 1.087. The estimated value of the coefficient is positive, so passengers with better self-cognitive evacuation abilities will have higher chances of selecting active adaptive behaviour. Therefore, the cognition of passengers' evacuation abilities affects their adopting of a response. Managers assisting passengers to strengthen their evacuation abilities can help to improve emergency procedures. The odds ratio of active attention risk information compared to the moderately positive response was 1.91. If a station experiences disaster, passengers who pay more attention to risk information may not only self-rescue but may also take active actions. For example, actively asking for help from the police or station staff.

4.3.2 Risk Communication

Almost every passenger has a portable device, such as a smartphone or tablet. Nearly 80% of passengers receive station information from the internet. However, the trustworthiness of information and the accessibility of information in print or digital media form have not affected passengers' adaptive behaviour. The media and content of the information provided by the stations cannot influence the decision of passengers to take an emergency response action.

4.3.3 Facility Environment

The “entrance-exit design” and “emergency rescue equipment” all reached a significant level of 0.05. The odds ratio of “entrance-exit design” compared to “moderately positive response” and “highly active response” was 1.761 and 1.27. The odds ratio of “emergency rescue equipment” compared to “moderately positive response” and “highly active response” were all 1.317. Therefore, the station’s space and emergency facilities’ planning will help passengers take responsive actions.

4.3.4 Socioeconomic Background

The “average monthly income” of passengers has a significant impact on the positive degree of adaptive behaviour. The average monthly income higher than NT$40,000 was used as a reference group. Passengers that had an average monthly income between NT$20,001-40,000 have a significantly lower chance of taking active response actions than the average monthly income greater than NT$40,000. High-income passengers are more willing to take a response that is more aggressive.

"Different Stations" have a significant influence on the positive change adaptive behaviour. Taipei Station was a reference group used to compare with Banqiao Station. The study found that passengers at Banqiao Station had a higher probability of taking a more moderate response than passengers of Taipei Station. The odds ratios are 1.007 and 1.006. The result may be that the passengers at Banqiao Station are more confident about risk information provided by the station, and they are more confident in the use of space at Banqiao Station in regard to their response. Therefore, the chance of choosing a highly active adaptive behaviour is also higher than at Taipei Station.

In summary, the influencing factors of station management and passengers are shown in Table 1. In the station protection system, the transport management department still adopts top-down emergency communication for planned protection guidance. However, the risk communication mechanism lacks effective communication methods, which leads to the inability of managers to influence passengers to adopt adaptive behaviour.

Table 1 Comparison of Influencing Features between Station Managers and Passengers

Objects / Features	Passenger	Manager
Risk Cognition	1.Lack of emergency knowledge 2. Trust self-cognition and experience	1. High awareness of the crisis 2. Believe that a complete protection system should reduce disaster risk
Risk Communication	1. The internet is the main information source 2. Passively accept information 3. Not affected by risk communication	1. Many types of information sources 2. Provide information for limited participation 3. Actively collect information 4. Failure of risk communication
Response Behaviour	Risk cognition, environmental facilities and social and economic background are the key factors influencing response.	1. Don't understand the user's emergency response needs 2. Professional assessment and decision 3. All stages have operational procedures such as

		preparedness, response and recovery

5. CONCLUSIONS

This study conducted interviews with managers and operators of rail facilities to understand their handling of disaster awareness, assessment factors, information transmission methods and adaptation behaviour for Taipei and Banqiao stations. The Taiwan Railway, high-speed rail and MRT's managers have established standard operating procedures for each emergency response and planned emergency evacuation measures. They all believe that the internet deals with the evacuation needs of passengers in the shortest time. Daft and Lengel (1986) define different information communication mechanisms based on the amount of information and richness of information. They believe that through the communication mechanism information can be exchanged, including through meetings, direct contact, planning, project reports, and formal information systems. This theory explains the relationship between communication mechanisms and information delivery and abundance and suggests that resilient coordination mechanisms can increase the amount of information and the richness of information. Therefore, the internal information transmission mechanism of station managers is closed, large, and singular. This model allows the organization to take emergency response measures, however, managers are not sure that the disaster information is being effectively communicated to the passengers, and through interviews with commercial operators, this study found that passengers are also passive to receiving information and following the manager's command. Operators are also less familiar with the operation of disaster relief equipment. This means that the operators are still not incorporating the concept of corporate disaster prevention to maintain its own business continuity management program. The analysis of this study using the regression model found that passengers taking response measures did not affect the information provided by the station. Passengers still based their behaviour on their own risk perception. This shows that passengers' views on disaster events are inconsistent with the management department.

According to the theory of social-ecological systems, this study finds that the scale of disaster and facilities' design affected the different stakeholders' (government, manager, operator, passenger) planning to take the most suitable adaptive courses of action. There are differences in the amount and richness of information between different stakeholders for risk communication (Daft & Lengel, 1986). This study defines station managers or government departments as using large amounts of data to analyse disaster risk to develop different emergency response strategies. The operator accepts the manager's command to carry out an emergency response plan, however, passengers take a response that did not affect the information provided by the station. Passengers still based their behaviour on their own risk perception. This shows that passengers' views on disaster events are inconsistent with that of the management department.

Finally, the passenger assesses whether to take action through the station's radio, website, signboards or face-to-face contact (Figure 5). The station's protection involves the participation of different stakeholders, so communication mechanisms should plan separately for the needs of different groups. Therefore, all kinds of fire prevention, wind prevention and earthquake prevention station facilities' planning, including escape equipment

(marking, lighting, shelter equipment), safety equipment (emergency call, emergency, escape and temporary refuge space) and other items, are for the suitability of passengers' evacuation needs.

In summary, risk communication mechanisms are part of disaster management and stakeholders exchange information and ideas with each other. Therefore, this study expects that through effective risk communication mechanisms and complete station facility planning, passengers' cognition of station disasters and the probability of taking a response to strengthen their protection capabilities should be improved.

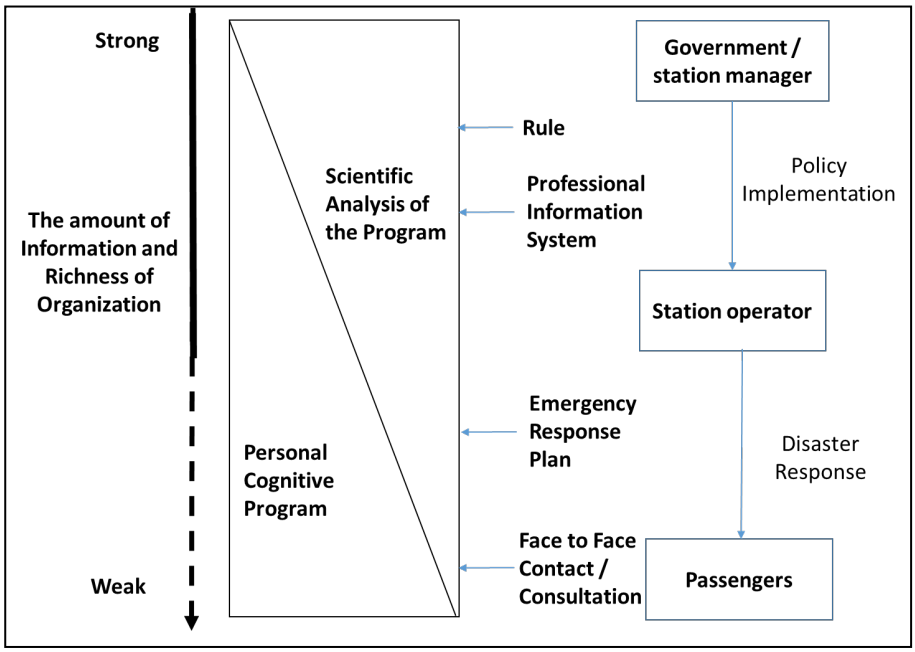

Figure 5. Information Relationships of Different Stakeholders in Station

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