

## **Environmental attitudes and behaviour towards Daya Bay Nuclear Power Plant nearby Hong Kong**

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### **Abstracts**

A survey was conducted to study the environmental attitudes and behaviour of Hong Kong residents towards the Daya Bay nuclear power plant. Only 34.5% of the respondents were confident about the operational safety of the nuclear power plants, whereas 23% stated they would immediately leave Hong Kong when leakage occurs. Multinomial logit analysis indicates that the degree of confidence is significantly related to the perceived ability of the government of Hong Kong Special Administration Region (HKSAR) and the nuclear power plant company, China Light and Power Co. Ltd. (CLP), knowledge of emergency plan and responsibility, gender, and age. However, the degree of confidence is not significantly related to the distance of the residential area from the nuclear power plant. In addition, the higher the perceived ability of the Government and CLP to handle nuclear leakage, the greater the degree of confidence becomes. The knowledge of the parties responsible for payment in nuclear accident is also significantly associated with greater likelihood of residents immediately leaving Hong Kong in case of leakage. Hence, the HKSAR Government and CLP are recommended to improve their perceived ability for safety and social stability.

Keywords: Environment, nuclear energy, sample survey, logit models

### **1. Introduction**

Daya Bay nuclear power plant, which was built in 1994, is approximately 50 km away from the center of the financial hub of Hong Kong. The plant was a 75:25 joint venture between the Guangdong Nuclear Investment Co. Ltd and the Hong Kong Nuclear Investment Co. Ltd (a subsidiary of CLP Holdings Ltd). In this joint venture agreement, 70% of electricity generated is supplied to Hong Kong, while the remaining 30% is sold to Guangdong Province. From 2002 to 2011, four more nuclear reactors were built in Daya Bay. Only 22.5% (1378 MWe) of the overall nuclear power capacity is supplied to Hong Kong, which is approximately 11% of the electricity generation capacity of Hong Kong in 2012. These plants are all under the management of mainland China and follow the regulations set by the Chinese government. CLP Holdings Ltd invests in nuclear reactors in China and buys electricity to address the demand in Hong Kong. The HKSAR government cannot impose any regulations on the operation of these nuclear reactors.

Since 1994, the safety of the Daya Bay Nuclear Power Station has been a constant concern in debates. The risk of nuclear leakage and nuclear accident resurfaced after the occurrence of the Fukushima disaster in Japan on March 11, 2011, arousing public concern toward the safety of the plant (South China Morning Post, March 15, 2011; March 27, 2011). Hence, in this paper, we surveyed the degree of confidence of the Hong Kong residents toward the operation safety of the nuclear power plant and their

reaction to leave Hong Kong in case of leakage, and determine the factors affecting them. The attitudes and behaviour of citizens are traditionally considered important factors in nuclear emergency planning. The succeeding sections of the paper are organized as follows: Section 2 presents the literature review on the factors affecting risk perception of nuclear plant and behavior of people. Section 3 describes the methods. Section 4 presents the results. Section 5 draws the conclusions.

## 2. Literature Review

Choi et al. (2000) used public concern on radiation risk, possibility of accident, possibility of illness, and subjective risk measure to assess the perceived risk of nuclear power. The variables that were hypothesized to affect the public's perception on nuclear risk included (1) trust in the expertise of the government and utility companies (Huang et al. 2010, Tsunoda 2001), (2) knowledge on nuclear related issues (Siegrist and Cvetkovich 2000, Yim and Vagenov 2003), and (3) demographic characteristics such as age, gender, education and the distance of the residence district from the nuclear power plant (Giordano 2005, Horst 2007).

Tateno and Yokoyama (2013) mentioned that "When threatened by a hazard, the public has little need for technical detail; what is needed is the information of how to cope, not information about the hazard but information about hazard management". This is also true to Hong Kong people and so in our study, we asked people knowledge about the emergence plan and responsibility only, which are widely covered by the media after Fukushima accident.

Yim and Vagenov (2003) noted that the governor of Pennsylvania advised pregnant women and preschool children living within 5 miles of the plant to leave after the Three Mile Island accident in USA on March 28, 1979. However, out of fear, a greater number of people (20,000) evacuated approximately 100 miles. Hong Kong is a small place and lies within 85 km (i.e., less than 53 miles) of the Daya Bay nuclear power plant. To flee 100 miles, as what the Americans did, the Hong Kong people should fly away from Hong Kong. The variables that were hypothesized in the literature to affect people's behavior included their attitudes, risk perception (Ajzen and Fishbein, 2000, Ki and Hon 2011, Ulleberg and Rundmo 2003), and demographic characteristics (Chan 1996).

In this paper, the factors affecting the perceived safety of the plant and the reaction of the Hong Kong people to leave Hong Kong in case of leakage were analysed.

## 3. Methods

### *Sampling and data collection*

The survey targeted all Hong Kong residents aged at least 15, who were assumed to have sufficient understanding of the issue regarding the Daya Bay nuclear power plant. In November 2011 (DBCP website), the Nuclear Safety Commission of Japan proposed a Precautionary Action Zone within a radius of 5 km, an Urgent Protective Action Zone within 30 km, and a Plume Protective Zone (i.e., home sheltering) within 50 km. Thus, in this study, the 18 living districts of Hong Kong are classified into three, namely: (1) within 30 km, (2) 30 km–50 km, and (3) above 50 km. Using the database in the Computer-assisted Telephone Interview (CATI) System, which contains the name, phone number, and the living district of the residents in Hong Kong, the stratified sampling method was employed to derive a random sample of 400 respondents from each group.

Telephone interviews were conducted by trained interviewers. To ensure randomness, the person who answered the phone call was requested to find the household member with the nearest birthday to complete the questionnaire. Fieldwork was conducted in February 2012. From the 1209 respondents interviewed, only 1192 questionnaires (98.6%) were used for analysis.

#### ***Measurement and data analysis***

As a first attempt to explore public attitude towards the nuclear power plant and to minimize the non-response rate, the questionnaire contained a few attitudinal and demographic questions.

The degree of confidence of the respondent to the nuclear plant operation was measured by using a 5-point Likert scale (1=very unconfident and 5=very confident). The perception of respondents towards the ability of the HKSAR government and the CLP was also measured using a 5-point Likert scale (1=entirely unable and 5=entirely able). Knowledge or cognition regarding the emergency plan and the parties responsible for payment in nuclear accident was measured in two levels: 1=Yes, and 0=No. The respondents indicated their reactions in case of nuclear leakage based on the given list or other ideas they had. Among the 10 reactions provided in the list, "leave Hong Kong" was most frequently selected (22.9%).

In this study, multinomial logit models were used to examine the statistical significance of seven explanatory variables (perceived ability of the HKSAR government and CLP, knowledge regarding the emergency plan and responsibility, respondents' gender, age, and distance of the living district) on the degree of confidence. In using multinomial logit models, the degree of confidence was recoded to form a categorical variable with three levels (1 = "unconfident" or "very unconfident"; 2 = "neutral"; 3 = "confident" or "very confident"). Binary logit models were used to explore the factors affecting the residents' reaction to leave Hong Kong. The foregoing seven explanatory variables, together with the degree of confidence, were used as independent variables.

## **4. Results**

#### ***Characteristics of the respondents***

The sample consisted of 44.2% males and 55.8% females. The average age of the respondents is 45.7 years. The percentage of respondents (1) within 30 km, (2) 30 km to 50 km, and (3) more than 50 km from the nuclear power plant are almost the same (33%). As the effect size (Cohen 1992) of gender and age of the sample were 0.037 and 0.288, respectively, those of the sample were comparable to the population based on 2011 Population Census (Census and Statistics Department 2012). However, the "distance" of the residence district of the sample was different from that of the population (effect size = 0.546). Although residents living near the nuclear plant (within 30 km) were over-sampled, equal number of residents taken from each residence category enables us to compare the attitudes and behaviour of residents among the three categories.

The mean degree of confidence in the safety of the plant is only 3.08, which is approximately average. The mean perceived ability level of the HKSAR government and CLP are 2.62 and 2.71 respectively, which are below average and below the mean degree of confidence in the safety of the plant. Although the nuclear power plant was built in 1994, 51.4% and 67.8% of Hong Kong residents do not know whether an emergency plan exists and the identity of the person liable for paying for the losses should a nuclear accident occur, respectively. 23% of the respondents indicated that they would leave Hong Kong in case of leakage.

**Factors affecting the degree of confidence**

As the score test of the proportional odds assumption has a p value < 0.0001, multinomial logit models are fitted. The overall model is statistically significant (likelihood-ratio chi-square test statistic = 338.42; p value < 0.0001). The Wald chi-square statistics show that all independent variables except “distance” are significant. Based on the results of the parameter estimation for comparing the “confident” versus “unconfident” cases (columns 2-4 of Table 1), the following observations are drawn:

1. Gender (b = 1.23; odds ratio = 3.42) and Government (b = 1.04; odds ratio = 2.83) have the greatest positive impact on the contrast between the “confident” and “unconfident” attitudes. That is, males are 3.42 times more likely to be confident compared with females. In addition, the odds of being confident increase by a factor of 2.83 per unit increase in the respondents’ perception of the ability of the HKSAR Government.
2. As compared with the perceived ability of the HKSAR Government, the effect of the perceived ability of CLP on confidence is smaller (b = 0.56; odds ratio of 1.76). This result implies that the odds of being confident increases by a factor of 1.76 per unit increase in the respondents’ perception of the ability of the private company CLP.
3. The degree of confidence is significantly related to the knowledge of emergency plans, but not significantly related to the knowledge of the responsibility. The odds of 1.48 suggest that possessing knowledge of emergency plans increases the odds of being confident by 48%.
4. Age has a negative significant effect on confidence (b = -0.014). With a 10-year increase in age, the odds of being confident decreases by a factor of  $\exp(-0.014 \times 10) = 0.87$ . Hence, the older the person is, the lesser the degree of confidence.

Table 1. Parameter estimates, standard errors (SE), and odds ratio for Multinomial logit analysis of the degree of confidence on respondent characteristics (n=1192, of which confident n = 411, neutral n=461, and not confident n=320)

Variable	Confident vs. Unconfident			Neutral vs. Unconfident		
	Estimate	SE	Odds ratio	Estimate	SE	Odds ratio
Intercept	-3.80***	0.45		-1.87***	0.40	
Government	1.04***	0.12	2.83	0.73***	0.11	2.07
CLP	0.56***	0.12	1.76	0.48***	0.11	1.61
Emergency	0.39**	0.17	1.48	-0.23	0.16	0.79
Responsibility	-0.07	0.18	0.94	-0.42**	0.17	0.66
Gender	1.23***	0.18	3.42	0.39**	0.17	1.48
Age+	-0.014***	0.005	0.99	-0.007	0.005	0.99
Distance	-0.03	0.10	0.97	-0.10	0.10	0.90

Notes: \*\*\*, \*\*, and \* denote the significance levels of 1%, 5%, and 10%, respectively.  
+ age is expressed in number of years old.

The parameter estimation results for comparing the “neutral” versus “unconfident” cases (columns 5-7 of Table 1) have almost the same sign as “confident” versus “unconfident” contrast. However, the magnitudes of the estimates are generally smaller because the degree of confidence being compared (“Neutral” vs. “Unconfident”) is less extreme. In the “neutral” versus “unconfident” contrast, the degree of confidence is significantly related to the knowledge about responsibility, but not significantly related to the knowledge about emergency plans. The parameter estimate for the knowledge of the responsibility has a negative sign (b = -0.42; odds

ratio = 0.66), which suggests that a person who possess knowledge of responsibility increases the odds of being unconfident by a factor of  $1/0.66 = 1.52$ . Perhaps a person who possesses certain knowledge on responsibility understands from the media coverage that compensation is very limited or difficult to obtain, and thus, having this knowledge transforms their attitude from being neutral to unconfident.

**Factors affecting the reaction to leave Hong Kong**

The overall model is statistically significant (likelihood-ratio chi-square test statistic = 61.09;  $p$  value < 0.0001). The Wald chi-square statistics showed that only knowledge on responsibility, gender and age are significantly different from zero. The parameter estimation results shown in Table 2 suggest the following:

1. Gender ( $b = 0.44$ ; odds ratio = 1.56) has the greatest positive impact on leaving Hong Kong in case of nuclear leakage. As such, males are 1.56 times more likely to leave Hong Kong as compared with females.
2. The reaction to leave Hong Kong is significantly related to the knowledge of the responsibility. The odds of 1.40 suggest that possessing knowledge of the responsibility increases the odds of leaving Hong Kong by 40%.
3. Age has a negative significant effect on the reaction of leaving Hong Kong ( $b = -0.02$ ). As age increases by 10 years, the odds of leaving Hong Kong decreases by a factor of  $\exp(-0.02*10) = 0.82$ . Therefore, the older a person is, the less likely the person would leave Hong Kong.

Table 2 Binary logit analysis of the reaction to leave Hong Kong (n=1192, of which leave n=274, not leave n=918)

Variable	DF	Estimate	SE	Odds ratio
Intercept	1	0.08	0.39	
Confidence	1	-0.07	0.09	0.93
Government	1	-0.07	0.09	0.93
CLP	1	-0.15	0.10	0.86
Emergency	1	0.19	0.14	1.21
Responsibility	1	0.34**	0.15	1.40
Gender	1	0.44***	0.15	1.56
Age+	1	-0.02***	0.004	0.98
Location	1	0.09	0.09	1.09

Notes: \*\*\*, \*\*, and \* denote the significance levels of 1%, 5%, and 10%, respectively. + age is expressed in number of years old.

**5. Conclusions**

The current paper studied the attitudes and behaviour of the people in Hong Kong in case of any accidents in nuclear power plants. A higher perception of the ability of the HKSAR government and CLP to handle nuclear leakage is associated with greater degree of confidence. Further studies on how the HKSAR government and CLP can improve the perception of its capability are recommended. The government has to understand the scale of the response to leave HK and introduce a number of initiatives to help stabilize the population. To our knowledge, the current study is the only research on the attitudes and behaviour of people in Hong Kong towards the Daya Bay nuclear plant that has combined perceived ability, knowledge, and demographic variables into a single study. In the future, these variables should be studied in detail.

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