RESEARCH ON THE MAIN CRITERIA OF DECISION-MAKING FACTORS THAT AFFECT CONSUMERS' PURCHASE OF RESIDENTIAL FIRE ALARMS

Chih-Yao Lo [1], Hung-Teng Chang[2], Ping-Chang Lin[3] & Lin Yi[4]

[1]Fo Guang University, Taiwan
[2]Yu Da University of Science and Technology, Taiwan
[3]Chung Hua University, Taiwan
[4]Yu Da University of Science and Technology, Taiwan

ABSTRACT

The average number of fires in Taiwan in the past five years was about 1600. Among them, the average number of fires in residential places such as independent houses and collection houses was about 749. The annual loss caused by fires was NTD 700 million. In order to fundamentally prevent the occurrence of fire, the government vigorously promotes the installation of residential fire alarms, but it only subsidizes one residential fire alarm for each household. However, installing only one residential fire alarm is not sufficient to warn all residents to escape in the event of a fire. Therefore, alarms for other living spaces and passages must be purchased by the residents themselves. This study defines the decision-making factors that affect consumers' purchase of residential fire alarms, builds the decision-making hierarchical structure, and discusses the weight of decision-making factors that affect consumers' purchase of residential fire alarms through the Analytic Hierarchy Process (AHP).

This study used the expert questionnaire to gather anonymous expert opinions, and conducted literature review. After integrating expert interview results, this study developed the Delphi questionnaire and conducts surveyed on people of different age, so as to obtain the weight of decision-making factors that affect consumers' purchase of residential fire alarms.

The results showed in the main criteria of decision-making factors that affect consumers' purchase of residential fire alarms, the public places the greatest emphasis on the dimension of the alarm itself, followed by the dimension of the alarm's alert mode. In the secondary criteria, it shows that the price of the alarm itself, detection accuracy and the useful life of the alarm are particularly important for influencing consumers to purchase residential fire alarms. As seen, factors related to the dimension of the alarm itself have a certain influence on consumers' purchase of residential fire alarms (consistency and continuity), which affects consumers' decision-making mode of purchasing residential fire alarms. It is the most important factor affecting the purchase of residential fire alarms.

Keywords: *Residential Fire Alarm, Residential Fire, Delphi Method, Analytic Hierarchy Process (AHP).*

1. INTRODUCTION

The researcher is an active firefighting field service personnel. In multifarious duties of firefighting field service personnel, there are the highest risk levels of fire-related rescue work. The fire site changes rapidly, and various uncertainties affect the success of fire rescue personnel.

British crisis management expert Michael Regester stated: "Prevention is the best way to solve the crisis." The most effective way to reduce the number of fire disasters is to reduce the probability of fire from the beginning, reduce the use of fire sources, use fire-resistant or flame-proof material and set fire alarm devices and automatic fire extinguishing devices. All these measures can reduce the probability of fire and reduce the chance of fire disasters. The most commonly used method in general households or places is installing residential fire alarms. In the early stages of a fire, the alarm can be issued to remind people to escape and perform initial fire extinguishing operations.

2. LITERATURE REVIEW
This section discusses and analyzes the literature. Through analyzing the literature and using related theories as the corroborative evidence, this section examines the decision-making factors that affect consumers' purchase of residential fire alarms.

2.1 INTRODUCTION OF RESIDENTIAL FIRE ALARMS
Residential fire alarms are used in residence under 5 floors that do not have systemic fire alarm equipment. They are also called stand-alone smoke and fire detectors, or residential alarms. Residential fire alarms are equipped with built-in battery, and they can be installed independently on the ceiling or on the wall without wiring. When a residential fire alarm detects smoke or heat, it emits an extremely loud alarm sound so that people can perform fire extinguishing actions or escape as soon as possible. (Taipei City Fire Department website)

2.2 RESIDENTIAL FIRE ALARM REGULATIONS
The Fire Protection Act was revised and announced on May 19, 2010. It stipulated in Item 5, Article 6 that management right holders of residential places who shall install automatic fire alarm equipment but not belong to Item 1, Article 6 (management right holders of places designated by this Law shall install and maintain fire safety equipment for places under their actual management. The classification of the places and the standards for the installation of fire safety equipment shall be determined by the central competent authority) shall install and maintain resident fire alarms.

3. RESEARCH METHOD
The purpose of this study was to explore the decision-making factors that affect consumers' purchase of residential fire alarms, collect relevant domestic statistical data and literature, and collect theoretical models of experts and scholars. The experts invited were senior personnel handling fire prevention related tasks at the Miaoli County Government. This study adopted the revised Delphi method questionnaire analysis and Analytic Hierarchy Process (AHP) method to establish the decision-making hierarchy of the decision-making factors that affect consumers' purchase of residential fire alarms. Finally, it integrated the weights of various decision-making factor indicators, and ranked them in order according to proportions so as to write this paper.

(1)Use the literature analysis method to confirm the research topic.

(2)Establish the evaluation criteria with the revised Delphi method.
According to the research questions of this study, literature review, statistical data, laws and regulations, the criteria obtained were divided into two levels, namely "the dimension of the alarm itself" and "the dimension of the alarm's alert mode", so as to confirm the proposed assessment criteria structure.

(3)Design of the revised Dephi Method questionnaire
First, it conducted the first round of the revised Delphi method questionnaire survey, which uses the semi-open Likert 5-point scale for measurement. The senior fire prevention personnel were selected to fill out the questionnaires, and their opinions were consolidated to verify the effectiveness of the evaluation criteria of decision-making factors that affect consumers' purchase of residential fire alarms. In this phase, repeated questionnaire surveys were conducted to obtain the opinions of various experts, and the results were integrated and analyzed until all expert opinions reach consensus. Only then, the actual measurement process was concluded.

(4)Data analysis of the revised Delphi Method questionnaire
The statistically-screened factors with an importance average value of 3.5 or more were used as the selection items for the final questionnaire. After computing the statistics of expert opinions, items not exceeding the average value of 3.5 were deleted.

(5)Design the hierarchical questionnaire, then send and collect them.

(6)Analyze the survey results with the Analytic Hierarchy Process (AHP) method.
In the selection process, according to the proportion of all element criteria in the obtained reference hierarchy, they were provided to the decision makers for analysis and the optimal plan was selected.

(7)A comprehensive analysis of decision-making factors that affect consumers' purchase of residential fire alarm.
After the hierarchical questionnaires were collected, the data were analyzed with the AHP method, which is divided into 3 parts: Part 1 is the target layer, which is the target that this study is expected to accomplish, namely "decision-

making factors that affect consumers' purchase of residential fire alarms". Part 2 is the main criteria for the evaluation of decision-making factors that affect consumers' purchase of residential fire alarms: including two dimensions, namely "the dimension of the alarm itself" and "the dimension of the alarm's alert mode". Part 3 is the secondary criteria: The dimension of the alarm itself includes the price of the alarm itself, the useful life of the alarm, detection accuracy, the installation method of the alarm, and the convenience of alarm maintenance. The dimension of the alarm's alert mode contains 10 items, including alarm volume, pure alarm sound, systematic linkage alarm, smoke detection, and heat detection, etc.

 (8)Use the decision analysis software to obtain the weight of various indicators and build the influencing factor selection table.
Saaty (1990) indicated that when the C.R. value is closer to 1, it means that the rating is generated randomly in greater degree. When the C.R. value is closer to 0, it means that the consistency is higher. Therefore, in principle, C.R. ≦ 0.1, then the consistency degree of the matrix is acceptable. If C.R. > 0.1, it means that the evaluation results are not consistent and it needs to be re-evaluated.

(9)According to the results of the study, conclusions and recommendations were made.

4. RESULTS ANALYSIS AND DISCUSSION
This study treated the local residents of Miaoli County as the subjects, in order to explore decision-making factors that affect consumers' purchase of residential fire alarms. Questionnaires were used to collect, analyze, and discuss the data. The importance and influence of "the dimension of the alarm itself" and "the dimension of the alarm's alert mode" on the public's purchase of residential fire alarms were determined:

4.1 ANALYSIS OF THE RESULTS OF THE FIRST ROUND OF DELPHI METHOD QUESTIONNAIRE

(1) "Discussion by experts of the dimension of the alarm itself"
Under the selection dimension of "the dimension of the alarm itself", the concept of "alarm appearance" is too subjective because it is the personal subjective perception of the consumer for residential fire alarms, which is inconsistent with the overall practicality or functionality. After discussion by experts, this factor is deleted.

(2) "Discussion by experts of the dimension of the alarm's alert mode "
Under the selection dimension of "the dimension of the alarm's alert mode", "alarm sound in recorded voice" may make the public unable to make instinctive reaction when the fire occurs due to its voice being too complicated. Therefore, after discussion by experts, it is deleted. In addition, "direction guidance" is not an important factor because people are very familiar with their residence, and they can escape through the familiar route in the event of the fire alarm when there is still a chance to escape before the fire expands. Therefore, it is deleted. In addition, some experts regard "warning light" as "not important", because when the smoke is thick, people tend to adopt a low position and cover their mouths and noses with their hands and head down to escape. Therefore, it is deleted according to the statistical results.

(3) "Summarizing the overall agreement degree of the experts"
Summarizing the overall agreement degree of the experts and scholars, it limits the rating results to "3.5" (between ordinary and agreeing) or above, and it is considered that all experts and scholars reach a consensus, whose agreement degree are all over 70%. In the first questionnaire results evaluation criteria, 4 out of 14 items have a mean number of 3.5 or more, so they are allowed to be deleted.

4.2 ANALYSIS OF THE RESULTS OF THE SECOND ROUND OF DELPHI METHOD QUESTIONNAIRE
In the second round of Delphi method questionnaire, the mean number of the 10 evaluation criteria is above 3.5, and the agreement degree is over 70%, which represents the convergence of expert opinions.

4.3 ESTABLISH SELECTION INDICATOR HIERARCHY FOR DECISION-MAKING FACTORS THAT AFFECT CONSUMERS' PURCHASE OF RESIDENTIAL FIRE ALARMS

(1) "Level 1 is the main criteria"
They include two dimensions, namely "the dimension of the alarm itself" and "the dimension of the alarm's alert mode" respectively.

(2) "Level 2 is the secondary criteria"
Under the selection dimension of "the dimension of the alarm's alert mode", "alarm sound in recorded voice" may make the public unable to make instinctive reaction when the fire occurs due to its voice being too complicated. Therefore, after discussion by experts, it is deleted. In addition, "direction guidance" is not an important factor because people are very familiar with their residence, and they can escape through the familiar route in the event of the fire alarm when there is still a chance to escape before the fire expands. Therefore, it is deleted. In addition, some experts regard "warning light" as "not important", because when the smoke is thick, people tend to adopt a low position and cover their mouths and noses with their hands and head down to escape. Therefore, it is deleted according to the statistical results.

4.4 ANALYSIS OF THE MAIN CRITERIA
Since the number of main criteria n=2, the number of comparisons of 2(2-1)/2=1 can be regarded as the convergence effect, so it meets the consistency requirement. The results of comparison matrix of the main criteria are shown in Table 1:

Table 1: Paired Comparison Matrix of the Main Criteria of Decision-making Factors that Affect Consumers' Purchase of Residential Fire Alarms

Paired Comparison Matrix of the Main Criteria of Decision-making Factors that Affect Consumers' Purchase of Residential Fire Alarms				
	The dimension of the alarm itself	The dimension of the alarm's alert mode	Weight	Ranking
The dimension of the alarm itself	1	2.704	0.730	1
The dimension of the alarm's alert mode	0.370	1	0.270	2

4.5 ANALYSIS OF THE SECONDARY CRITERIA
(1) "Importance analysis of the secondary criteria of the dimension of the alarm itself"
"The price of the alarm itself" has the greatest impact, which reaches 0.365, followed by "detection accuracy", which is 0.279. Next is "the useful life of the alarm", which is 0.169, followed by "the installation method of the alarm", which is 0.098, and the last is "the convenience of alarm maintenance," which is 0.089.

(2) "Importance analysis of the secondary criteria of "the dimension of the alarm's alert mode"
The 5 secondary criteria are analyzed by the Analytic Hierarchy Process (AHP), and the results show that, among the influencing factor items of "the dimension of the alarm's alert mode", "alarm volume" is most important, which is 0.351, followed by the "systematic linkage alarm", which is 0.260. Next is "heat detection", which is 0.183, the fourth is "pure alarm sound", which is 0.122, and the last is "smoke detection", which is 0.084.

4.6 WEIGHT ANALYSIS OF THE MAIN (SECONDARY) CRITERIA PAIRWISE COMPARISON MATRIX
After the comprehensive scoring, the weights are ranked, which can be used to further understand the relative importance of each influencing factor. The results of the weight analysis of paired comparison matrix are shown in Table 2:

Table 2: Weight Analysis of Paired Comparison Matrix

Weight Analysis of Paired Comparison Matrix						
Main Norm level			Secondary Norm level		Multiplication level	
Main Norm	Weight of Main Norm	Ranking	Secondary Norm	Weight of Secondary Norm	Weight multiplication	Ranking
The dimension of the alarm itself	0.730	1	The price of the alarm itself	0.365	0.267	1
			The useful life of the alarm	0.169	0.123	3
			Detection accuracy	0.279	0.203	2
			The installation method of the alarm	0.098	0072	5
			The convenience of alarm maintenance	0.089	0.065	7
The dimension of the alarm's alert mode	0.270	2	Alarm volume	0.351	0.095	4
			Pure alarm sound	0.122	0.033	9
			Systematic linkage alarm	0.260	0.070	6
			Smoke detection	0.084	0.023	10
			Heat detection	0.183	0.049	8

Overall, the combination of 2 main criteria and 10 secondary criteria evaluation factors shows that "the price of the alarm itself" (0.267)", "detection accuracy" (0.203), "the useful life of the alarm" (0.123) take the first to third places in the overall weight ranking. These three evaluation criteria also account for 59.3% of the total weights. This study classifies these three evaluation criteria as [highly valued] influencing factors of the county residents of Miaoli County. "Alarm volume" (0.095)", "the installation method of the alarm" (0.072) and "systematic linkage alarm" (0.260) take the 4th to 6th places in the weight ranking. These three evaluation criteria also account for 23.7% of the total weights. This study classifies these three evaluation criteria as [moderately valued] influencing factors of the county residents of Miaoli County. The remaining evaluation criteria are regarded as [lowly valued] influencing factors by Miaoli County's firefighting field service personnel and procurement specialists.

5. CONCLUSION
"The price of the alarm itself" is the most important weight: When purchasing goods, the general public will consider their prices with reference to their possible use values. They want to obtain the best application performance with reasonable cost, and it is the factor that they will give priority to.
"Detection accuracy" is the second most important weight: If the alarm can detect the particles contained in the smoke generated by the fire, it can perform the alarm action more effectively in the early stage of the fire and remind the occupants to escape.
"The useful life of the alarm" is the third most important weight: The length of useful life includes the useful life of residential fire alarm detectors, battery life, etc. If an alarm with a long useful life can be purchased at the same price, it will also become an important factor for consumers to consider when purchasing.

Residential fire alarms are indispensable tools to effectively remind residents to perform initial fire extinguishing when the fire has not yet occurred or in the early stages of the fire, or successfully escape after failed firefighting. Successful alarms can effectively reduce human casualties and property losses. There are many cases at all county and municipal fire departments that residential fire alarms successfully raise the alarm for residential fire, which indicates the importance of the alarm. Therefore, if the results of this study can be successfully promoted to all county and municipal fire departments as the reference for fire protection advocacy, or be provided to residential fire alarm manufacturers as the direction for the research and development of residential fire alarms, they can produce alarms with attractive price, high detection accuracy and long useful life, which are most probably to win the favor of the public.

6. REFERENCES

[1]. Chen H.Y. ,Fire Science (2010)**.**

[2]. Laws & Regulations Database of The Republic of China, Fire Services Act(2017).

[3]. Saaty, Thomas L. The Analytic Hierarchy Process in Conflict Management, The International Journal of Conflict Management(1990).

[4]. Dalkcy, N., The Delphi Method: An Experimental Study of Group Opinion（1969）.

[5]. National Fire Agency, Ministry of The Interior Website,National Fire Times, Fire Causes and Fire Loss Statistics of 2012-2016,http://www.nfa.gov.tw/cht/index.php?code=list&ids=220(2015).

[6]. National Fire Agency, Ministry of The Interior Website, National Fire Statistics Analysis of 2016, http://www.nfa.gov.tw/cht/index.php?code=list&ids=220 (2015).

[7]. Taipei City Fire Department Website, Residential Fire Alarm Reference FAQ, http://www.119.gov.taipei/faq_detail.php?id=12342(2017).

[8]. NFPA edition. Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile or Expanded Vinyl Wall Coverings on Full Height Panels and Walls, 265-4 (2007).

[9]. Linstone, H.A., Turoff, M. *The Delphi method : techniques and applications*. (3rd ed).Ma：Addison-Wesley(1975).

[10]. Fu W.S, Liao H.F, Residential fire alarm and home fireproof the effectiveness of research - in Miaoli County(2015).

[11]. Federal Emergency Management Agency, FEMA. State-by-State Residential Smoke Alarm Requiremen*t*(2010).

[12]. Gene Rowe＆George Wright.The Delphi Technique as a Forecasting Tool: issues and analysis(1999).