

Customer-Recognition-based-Quality Attributes in Developing Fire-Fighting Garment using Kano Model

Jinhee Choi*

Department of Fashion Business, Jeonju University, Korea – 55069; jhchoi@jj.ac.kr

Abstract

Objectives: This study looks at quality attributes of fire - fighting garment based on customer recognition using Kano Model and provides basic research materials to help develop better fire. **Methods/Statistical Analysis:** Data was collected using a survey by the self - administered method, and the survey was conducted for fire fighters stationed in Jellabukdo from 08.01.2015 to 01.31.2016. Convenient sampling was used to collect data from the total of 175 fire fighters, and the collected data was analyzed by IBM SPSS 22. **Findings:** The results of this study were followed: First, only 'color' and 'design' was classified into an attractive quality attribute among 20 quality attributes of fire - fighting garment, and the all the rest was classified into a unitary quality attribute. Second, some quality attributes showed a significant difference in the results of statistical analysis, but overall, no significant differences were found in the categories of service periods and age groups. Thirds, no significant statistical differences were found in service periods and age groups in the category of satisfaction in work, and 67% of the total respondent answered more than satisfied, showing relatively high work satisfaction of fire fighters. **Improvements/Applications:** A further study is necessary to reduce dissatisfaction on the rest of quality attributes except for color and design through improvements, while increasing the satisfaction level.

Keywords: Client, Fire-fighting Garment, Quality Attributes Kano Model, Statistical Analysis

1. Introduction

Fire-fighting officers extinguish fires and work under an urgent situation such as disasters and calamities for the preferential protection of lives and property of the people. Due to such a poor working environment, for the last 5 years (2010~2014), among the annual average of 362 cases including 163 rescue cases and 376 emergency relief cases, 6.6 officers died on the job on average and 319.25 were hurt on the job. The highest casualties came from the emergency relief and fire suppression jobs, taking 23.1% and 22.3%, respectively¹. To strengthen safety of fire-fighting officers exposed to such a risk, wearing protective garment is a requirement since 2003² to deal with physical/chemical/biological risks as well as ergonomic risks that may occur during fulfillment of the job, but casualties of fire-fighting officers are not decreasing currently.

Clothing is a medium between exterior environment and our body and its basic function is protecting the body. Protective clothing is the clothing designed to protect our body from one or more risks and replaced by ordinary clothes with a special emphasis on its protective function of the body. Protective clothing is largely classified into protection from heat and flame, protection from chemical and organic substances and protection from mechanical movements, and among them, fire fighter's protective clothing is included into the category of protection from heat and flame³. A partial revision in Fire-Fighting Equipment Management Regulations modified in September 2013¹ classifies fire-fighter's protective clothing into uniform and protective equipment. The uniform includes formal suits, ceremonial suits, duty suits, maneuver suits, activity suits, jackets, duty suits for pregnant women, snowsuits, and special suits (training suits, flying suits, suits for rainy day activity, physical

*Author for correspondence

training suits) and the protective equipment is classified into fire-fighting garment used for fire extinguishment, special fire suits, heat-proof suits, electricity-resistant suits and chemical fire extinguishment suits. A special fire suit generally known as a fire-fighter's suit is garment designed for fire fighters to wear conveniently and swiftly in the scene for fire extinguishment and its major purpose is to protect the body with excellent heat-resistant and water-proof functions⁴. To achieve such a purpose, protective garment should be made of new materials from the perspectives of ergonomic clothes design, while reflecting functional requirements requested by customers to products, as well as ensuring safety and comfort. Ergonomic design, the most important factor in clothes, comes from an accurate measurement to enhance body compatibility and is completed in the course of measuring clothes movement ranges that may give harmful influences for the operator to fulfill their duty, and reflecting the measurement results to clothes pattern and design in advance⁵. In addition, protective function of fire - fighting garment is another very important factor, as a lot of diverse harmful environments exist in the scene of a fire. As such, fire-fighting garment requires complex functions for fulfillment of special duties and therefore, it should be developed from the ergonomic perspectives to ensure comfortable and pleasant feeling as well as safety, in consideration of working environment and body.

Prior studies were conducted to provide basic materials to develop such fire-fighting garment^{6,7}. In addition, ^{8,9} evaluated functional flame-resistant garment from the ergonomic perspectives and¹⁰ studied durability changes in fire - fighting garment from the engineering perspectives. However, these studies mostly focused on satisfaction in wearing and enhancement methods, as well as on evaluation of the degree of discomfort in wearing, and almost no basic research was conducted from the perspectives of fire fighters, the customers and clients of fire - fighting garment, although from the perspectives of quality in business administration, customer satisfaction should be put on the front line.

In this regards, this study looks at quality attributes of fire - fighting garment based on customer recognition using Kano Model¹¹ and provides basic research materials to help develop better fire - fighting garment by means of statistical analyses including, independent sample t-test and analysis of variance. Furthermore, this study is intended to make a contribution to developing the fire-fighting garment that fire fighter hope for.

2. Research Methods

2.1 Data Collection and Analysis Tools

Data was collected using a survey by the self - administered method, and the survey was conducted for fire fighters stationed in Jellabukdo from 08.01.2015 to 01.31.2016. Convenient sampling was used to collect data from the total of 175 fire fighters, and the collected data was analyzed by IBM SPSS 22.

2.2 Survey Composition

The survey was composed of 4 sections in large to identify quality attributes for developing fire-fighting garment and the detailed contents are described in Table 1.

Table 1. Questionnaire Contents

Classification	Contents
Design & Control	Color, Design, Washing, Elasticity, Activity, Hygiene, Air Permeability, Wear Convenience, Size Segmentation, Ease, Kind of Diversity, Convenience when using the toilet
Fit for field Activities	Thermal Sensation, Tightness, Wet Sensation, Comfortable Sensation, Hard and Soft sensation, Weight Sensation,
Motional Flexibility	Part of body, Clothing Shape
Demographic factors	Gender, Work Periods, Age, Level of Education, Job Satisfaction

2.3 Kano Model

Kano Model, a theory of quality based on customer satisfaction, has been used in developing clothing products to unfold customer-oriented quality¹². Kano Model, introduced by Professor Kano, is a model developed to analyze product or service quality identifications in dual dimensions: Subjective perspectives such as satisfaction or dissatisfaction and objective perspectives such as physical fulfilling or unfulfilling. Most of customers feel unsatisfied with inadequate products and services, but they tend to be not satisfied when fulfilled, simply taking them for granted. Kano Model is a theory that explains such differences systematically¹³. As described in Figure 1, the horizontal axis indicates satisfaction degree of quality attributes and the vertical axis indicates customer

satisfaction. Five quality attributes described by ¹⁴ are the followings.

1. Attractive quality attributes provide satisfaction when achieved fully but do not cause dissatisfaction when not fulfilled. These attributes become the source of customer delight.
 2. One-dimensional quality attributes result in satisfaction when fulfilled and dissatisfaction when not fulfilled. These attributes are the same as linear quality recognition in the concept of the more, the better, which has been recognized in the conventional quality management.
 3. Must-be quality attributes are the basic attributes taken for granted in product or service composition and cause dissatisfaction when not fulfilled. These attributes can be regarded as dissatisfaction prevention factors.
 4. Indifferent quality attributes do not result in either customer satisfaction or dissatisfaction whether or not fulfilled or not fulfilled. These attributes are not related to essential desire felt by customers.
- Reverse quality attributes because dissatisfaction when fulfilled and satisfaction when not fulfilled. These attributes do not occur generally but they may occur once in a while in the case of de-marketing.

To conduct a two-way analysis of quality using Kano Model, all questions in the survey are composed of a pair of positive and negative questions. To determine quality attributes using Kano Model after collecting responses from the survey, two-way table shown in Table 2 is used.

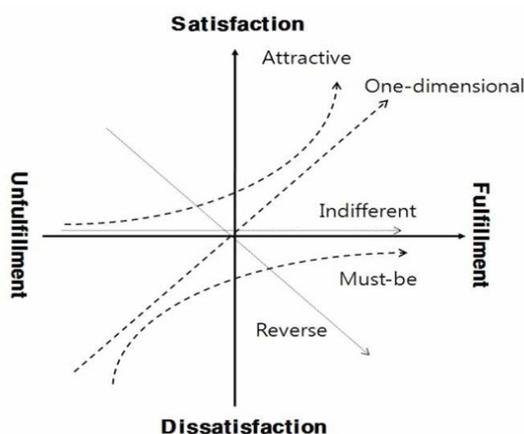


Figure 1. Kano model.

3. Analysis Result

3.1 Descriptive Statistics of Respondents

The Table 3 indicates the descriptive statistic results for demographics of respondents answered the survey. Due to characteristics of such job as fire fighters, there were more male respondents than female respondents, and more than 80% were college graduates.

For service period, 50% responded less than 10 years and more than 10 years, respectively. 40.2% and 38.5% of respondents were their 30s and 40s respectively, while 10% of respondents were their 20s and 50s respectively. For satisfaction with the current job, 66.9% answered 'More than satisfied,' while 5% answered dissatisfied, showing that fire fighters have relatively high satisfaction with their job.

3.2 Classification by Quality Attributes

In¹⁵ defined the category strength and classified quality attributes using the category. However, in this study, quality attributes were classified by using the mode alone which had the most responses among 5 sections, as suggested by¹¹. As a result, as shown in Table 4, quality attributes of fire - fighting garment are classified into attractive quality attributes (A) only for 'color' and 'design' in the design management section, and the all the rest was classified into one-dimensional quality attributes (O). What should be paid attention is that color and design, which was classified into attractive quality attributes, were also classified into reverse quality by many respondents, which indicates that the respondents have tendency of not wanting to change color and design quality attributes.

Among 20 quality attributes, 18 categories of fire - fighting garment quality attributes are classified into one-dimensional quality attributes, which indicates that satisfaction increases when fulfilled but dissatisfaction is caused when not fulfilled. That is, these attributes showed the same aspects as the linear quality recognition in the concept of the more, the better, which has been recognized in the conventional quality management. Therefore, for the quality attribute except for color and design, enhancement efforts are required to reduce dissatisfaction while increasing satisfaction by means of improving material performances, functional patterns and size segmentation.

Table 2. Two – way analysis of quality using Kano model

		Response to Negative Question				
		①Like	②Be natural	③Feel nothing	④Be obliged to	⑤Don't like
Response to Positive Question	①Like	Q	A	A	A	O
	②Be natural	R	I	I	I	M
	③Feel nothing	R	I	I	I	M
	④Be obliged to	R	I	I	I	M
	⑤Don't like	R	R	R	R	Q

A: Attractive quality attribute, O: One-dimensional quality attribute, M: Must-be quality attribute, R: Reverse quality attribute, I: Indifferent quality attribute

Table 3. Descriptive statistic of respondents unit (person,(%))

Gender	Male		Female		
		1 54(91.7%)		1 4(8.3%)	
Work Periods	Under 5 years	5~10 years	10~20 years	Over 20 years	
	40(23.7%)	45(26.6%)	46(27.2%)	38(22.5%)	
Age	20's	30's	40's	Over 50's	
	9(11.2%)	68(40.2%)	65(38.5%)	17(10.1%)	
Level of Education	High School		University		Graduate School
	35(20.7%)		132(78.1%)		2(1.2%)
Satisfaction	Completely dissatisfied	Dissatisfied	Normal	Satisfied	Very Satisfied
	1(0.6%)	8(4.7%)	47(27.8%)	76(45%)	37(21.9%)

Table 4. Results of quality attributes by Kano model

Quality attributes	A	O	M	I	R	Q	SI	DI	Classify
Color(QA1)	62	36	2	46	23	2	.6712	-.2603	A
Design(QA2)	58	44	7	52	9	1	.6335	-.3168	A
Washing(QA3)	33	116	8	12	2	1	.8817	-.7337	O
Elasticity(QA4)	54	99	5	12	0	1	.9000	-.6118	O
Activity(QA5)	40	111	6	12	0	2	.8935	-.6923	O
Sanitation(QA6)	67	77	5	18	0	1	.8623	-.4910	O
Air Permeability(QA7)	43	97	6	21	0	2	.8383	-.6168	O
Fit Convenience(QA8)	49	90	9	20	0	1	.8274	-.5893	O
Size Segmentation(QA9)	53	70	5	40	0	1	.7321	-.4464	O

Ease(QA10)	54	69	9	33	3	1	.7455	-.4727	O
Kind of Diversity(QA11)	43	80	11	40	1	1	.7069	-.5230	O
Convenience when using Toilet(QA12)	48	80	11	28	1	1	.7665	-.5449	O
Thermal Sensation(QA13)	53	71	6	22	0	1	.8158	-.5066	O
Tightness(QA14)	40	72	4	32	4	1	.7568	-.5135	O
Wet Sensation(QA15)	47	72	4	30	0	0	.7778	-.4967	O
Comfortable Sensation (QA16)	43	85	2	22	0	1	.8421	-.5724	O
Hard and Softness(QA17)	44	70	1	38	0	0	.7451	-.4641	O
Weight Sensation(QA18)	42	74	3	34	0	0	.7582	-.5033	O
Part of body(QA19)	46	95	2	18	0	0	.8758	-.6025	O
Clothing Shape(QA20)	56	68	3	33	1	0	.7750	-.4438	O

SI and DI in Table 4 indicate satisfaction coefficient and dissatisfaction coefficient respectively, as shown in equation (1) and equation (2). Customer satisfaction coefficients identify how much customer satisfaction can increase when customers meet product or service, and how much customer satisfaction can drop when they are not satisfied with products. A negative value appears when calculating the dissatisfaction coefficient because dissatisfaction has an opposite responding value against satisfaction. When all respondents choose attractive quality attributes in the survey, SI has +1 and DI has 0. On the other hand, when all respondents choose must-be quality, SI has 0 and DI has -1. Furthermore, when all respondents choose one-dimensional quality, SI becomes +1 and DI becomes -1¹⁶.

$$SI = \frac{A + O}{A + O + M + I} \quad (1)$$

$$DI = \frac{A + O}{A + O + M + I} * (-1) \quad (2)$$

The Figure 2 shows SI-DI diagram. Quadrant 1 represents 'attractive quality attributes'; quadrant 2 represents 'one-dimensional quality attributes'; quadrant 3 represents 'must-be quality attributes'; and quadrant

4 represents 'indifferent quality attributes', respectively. Fire - fighting garment quality recognition by fire fighters mainly shows one-dimensional quality attributes, while some attractive quality attributes also appear. Such results are similar to the results described in Table 4 in which quality attributes are determined by using the mode only. In general, one-dimensional quality attributes are the attributes that customers always want. These attributes increase along with product satisfaction when fulfillment of required quality is raised¹². The fact that most of quality attributes on fire - fighting garment are classified into one-dimensional quality attributes indicates that fire fighters hope for enhancement of current fire - fighting garment in various aspects.

3.3 Statistical Analysis

In¹⁷ assigned 5,4,3,2 and 1 point respectively for A, O, M, I, Q and R, the Kano's classification results, converting measured data into quantitative data available for statistical analysis. For 20 categories of quality attributes of fire - fighting garment, analysis of variance was performed for service years that frequency in demographic categories is appropriate for statistical analysis and its results are described in Table 5. At 5% significance level, a significant

statistical difference appears in color, design and shape of clothes, and post-hoc analysis by Duncan resulted in classification of groups as shown in Table 5.

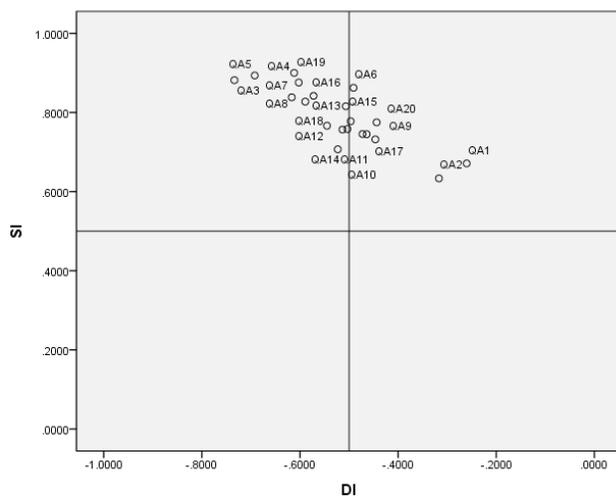


Figure 2. SI-DI diagram about quality attributes of fire – fighting garment.

Meanwhile, an independent sample t-test was performed by categorizing age into less than 30 years old and more than 40 years old. In this test also, a significant statistical difference ($t=2.20$, $p=0.029$) only appeared for shape of clothes, while no significant differences were found for the rest of quality attributes by different age groups. Furthermore, no significant statistical differences appeared for service periods ($F=0.848$, $p=0.469$) and age groups ($t=-0.376$, $p=0.707$) in terms of job satisfaction.

4. Conclusion

Working clothes should be basically equipped with safety, workability, functionality and economic efficiency. Working clothes exposed to various working conditions should also protect workers' body from external impacts.

In the case of producing or treating high-temperature products during a work process, high heat is radiated to workers and may lead to high possibility of causing heat congestion, burns or vocational diseases, which stresses importance of working clothes¹⁸. One of the most representative working clothes in the previous mentioned case is fire-fighting garment worn by fire fighters. Fire - fighting garment is a cloth made for fire fighters to wear conveniently and swiftly in the scene of a fire for efficient fire extinguishing work. Its purpose is to protect fire fighters' body with excellent heat-resistant and waterproof performances⁴. Therefore, fire-fighting garment should be designed to improve safety and comfort of fire fighters. If not, it may give negative impacts to fire fighters' ability of fulfilling duty because of various reasons including heat stress, deterioration of work efficiency and decrease in range of motion³. As such, fire-fighting garment requires complex functions for fulfillment of special duty and therefore, it should be designed and developed from the ergonomic perspectives to ensure comfort and pleasantness as well as safety in consideration of working environment and characteristics of motion range.

A lot of prior studies have been conducted to provide basic research materials for developing such fire-fighting garment. However, until now most of prior studies mostly focused on satisfaction in wearing, enhancements and evaluation of discomfort, and almost no basic research was made to help develop fire - fighting garment from the quality perspectives of business administration. In this regard, this study reviewed quality attributes of fire-fighting garment based on customer recognition using Kano Model¹¹, and analyzed the results in a statistical method to find the following results.

First, among 20 categories of quality attributes in fire - fighting garment, 'color' and 'design' in design and management sections were only classified into attractive quality attributes (A), and all the rest was classified into

Table 5. Quality attributes appeared significant statistical difference by service periods

	Under 5 years(a)	5~ 10 years (b)	10~20 years (c)	Over 20years (d)	F-value	p-value
Color (a,c<b,d)	2.88	3.69	3.09	4.03	5.186	0.002
Design (a<c,d,b)	3.00	3.59	3.78	3.71	2.813	0.041
Clothing shape (c<d,b,a)	4.18	4.02	3.50	3.92	2,906	0.037

one-dimensional quality attributes (O). That is, among the total of 20 quality attributes in fire-fighting garment, 18 categories were classified into one-dimensional quality attributes, which indicates that it is necessary to perform a study to reduce dissatisfaction while increasing satisfaction by improvements for the quality attributes except for color and design.

Second, some quality attributes showed a significant difference in the results of statistical analysis, but overall, no significant differences were found in the categories of service periods and age groups. This means that no meaningful differences appeared in quality attributes in terms of demographic variables.

Third, no significant statistical differences were found in service periods and age groups in the category of satisfaction in work, and 67% of the total respondent answered more than satisfied, showing relatively high work satisfaction of fire fighters.

5. References

1. Fire statistics and administrative data. Date Accessed: 30 August 2016. Available from: <https://www.usfa.fema.gov/data/statistics/>.
2. Bang CH. A Study on wearing practice of personal protective equipment of fire - fighter: focusing on Gyeongnam province. *Journal of Korean Society Hazard Mitigation*. 2010; 10(6):65-71.
3. Han SA, Nam YJ, Choi YL. A survey of Korean firefighters regarding their satisfaction with protective clothing. *Journal of the Korean Society of Costume*. 2008; 58(9):166-75.
4. Bang CH, Lee JK, Huh YS, Park EJ, Kwon JS. A survey of firefighters regarding their satisfaction with fire-protect clothing in field activities of fire-fighting. *Journal of Basic Sciences*. 2014; 31:107-15.
5. Brown P. Ready-to wears apparel analysis. Macmillan Publishing Co; 1992.
6. Kim DS. A study on the durability of protective cloth of fire fighter. [Ph. D. Thesis]. Seoul, Soongsil University; 2006.
7. Woo SK. A study on the maintenance system for maintaining heat resistance of protective clothing for structural fire - fighting and proximity fire - fighting, [Master Degree Thesis]. Gyeonggi-do, Kyungwon University; 2011.
8. Yoon KJ, Hong KA. Effect of spacer in multilayer thermal barrier of firefighting clothing on thermal property and comfort. *Textile Science and Engineering*. 2010; 47(6):420-25.
9. Kim HE, Yeon SM, Jeong JR, Lee MJ, Chang JH, You HC. Ergonomic evaluation of functional working-clothes-Focused on flame-proof clothing. *Fashion and Textile Research Journal*. 2006; 8(5):597-603.
10. Kim D, Shim H. Study on the durability change of fire fighter's protective cloth (I)-Protective cloth worn in the domestic fire extinguishing field. *Textile Science and Engineering*. 2008; 45(6):395-400.
11. Kano N, Seraku N, Takahashi F, Tsuji S. Attractive quality and must-be quality. *Journal of Japanese Society for Quality Control*. 1984; 14(2):39-48.
12. Ahn MY. Quality characteristics based on customer satisfaction in apparel product development-Focused on Kano's theory. [Ph. D. Thesis]. Seoul, Hanyang University; 2006.
13. Yoon S. A study on the customer perception of socially responsible management via Kano model for food and electronics industries. [Master Degree Thesis]. Seoul, Sangmyung University; 2012.
14. Jang HY. Determination of the relative importance of quality attributes in the Kano model. [Ph. D. Thesis]. Seoul, Sungkyunkwan University; 2012.
15. Kim HG. Customer perceptions of vehicle seats using the Kano model. [Master Degree Thesis]. Seoul, Sungkyunkwan University; 2012.
16. Shin AR, Lee S. A study on the development of total customer satisfaction coefficient based Kano model. *IE Interfaces*. 2007; 20(4):479-87.
17. Park MH. Service plan of national R&D report system using Kano model. *Journal of the Korea Contents Association*. 2014; 4(1):364-73.
18. Bang CH, Lee JH, Yea YT. An experimental study on the thermal characteristics of the working uniform exposed to the radiation heat. *Journal of the Korean Society of Safety*. 2002; 17(3):56-60.