A Motorist's Perception on How Fast Should the Police Respond to and Serve for a Traffic Accident

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Abstract: Using the police command center hotline "110" as a channel, this study performed a call back interview to ask the accident reporting motorists about their perceptions on the quality of police service. A concept of fuzzy logic was introduced to measure the qualitative questions characterized with fuzziness. A total of 254 accident reporting motorists in Taipei City were interviewed. The results revealed that no less than 80% of the respondents would be satisfied and no more than 20% of them would be dissatisfied if the police response time could stay within 5 to 10 minutes and service time within 20 to 35 minutes. Both satisfaction and dissatisfaction to the police service time for A2-type accident (injury) were significantly longer than that for A3-type accident (property damage). According to our findings, the current practices of police deployment and accident investigation in Taipei City should be reexamined.

Key words: police service; traffic accident; motorist satisfaction; fuzzy logic

1. INTRODUCTION

When a traffic accident occurs, the involved motorists normally look forward to the police arriving at the spot as quickly as possible, recording the accident scenes as professionally as possible, and treating the implicated parties as impartially as possible. Complaints and criticism, however, may sometimes come about as a consequence of unhurried response, unprofessional investigation, or underprivileged service. Some immediate questions arise as how quickly, how professionally, and how impartially the police should respond to and serve for an accident in order to make the majority satisfied. Answering these questions is never easy as it depends on the location of an accident, the deployment of the police, the social values of the race and ethnicity, and more importantly, the perceptions of the motorists. In rural areas, for example, the police deployment is sparsely distributed; the police response time should be reasonably longer than that in urbanized areas where the police are much more densely deployed. Exploring a little further into the accident involved motorist expectations, nonetheless, can throw new light on the above issues in hope of improving the police service for traffic accidents. As a result, it may greatly level up the police overall image.

In Taiwan, the insurance companies require a police investigation report for the liabilities to reimburse the accident involved parties' claims for vehicle damage and/or personal injuries. Therefore, most accident involved motorists will dial the hotline "110" to ask for police service. Upon receiving a call, the police staff in the command center will record the caller's information and assign the jurisdictional precinct to dispatch police manpower to the accident spot at once. The command center will automatically record the detailed times of each reporting case, including the motorist call-in (on-line) time and hang-up (off-line) time, as well as the police departure time, arrival time, and end-of-service time. After the event, the staff in the command center may call back to ask the reporting motorists if they are satisfied with the police service in terms of response time—an interval from hang-up time to police arrival time, service time—an interval from police arrival time to end-of-service time, and quality of service regarding police attitude, professionalism, neutrality, and others. It is believed that the 110 hotline should be able to serve as a useful channel for exploring a little further on the issue as how fast the police should respond to and serve for a traffic accident to meet the majorities' expectations. This motivates our study.

In the past, a considerable number of researchers have endeavored to assess both citizen attitudes toward the police or quality of police service mainly on crimes, thefts, lost things, and others (Bellman, 1935; Decker, 1981; Parasuraman *et al*., 1988; Zeithaml, *et al*., 1990; Dietz and Watson, 1994; Lanier and Davidson, 1994; Morgan and Murgatroyd, 1994; Watson, 1994; Dietz, 1997; Beck *et al*., 1999; Ashcroft *et al*., 2003). Most of the above literature adopted both quantitative and qualitative measures, which contained counting events (e.g., arrest in a given area, calls for service, number of abandoned cars) and perceptual measures (e.g., degrees of satisfaction). Of them, the perceptual measures were mainly collected via a questionnaire survey on either stratified sampling citizens or some selected experts (Yang, 2002; Weitzer and Tuch, 2005; Donnelly *et al*., 2006; Sun *et al*., 2013). What seems to be lacking, however, is to assess accident reporting motorist attitudes toward the police or quality of police service. It is particularly rare to make use of the police hotline as a data collection channel.

Most studies agreed that the police should be quick, professional, objective, and compassionate in response to any reporting event. However, disagreement might exist among citizens in view of the police service because different citizens may have different perceptual values, personal attitudes, and cultural backgrounds. Dietz and Watson (1994) indicated that citizen attitudes toward the police can encompass citizen perceptions of police performance, beliefs about police demeanor, assessments of police characteristics, and preferences for police duties and practices. Dietz (1997) further pointed out that quality of police service can be very global referring to general referents to the police; it can also be very particular referring to specific incident and experience in police-citizen encounters. In the latter case, researchers might ask citizens to respond to specific questions such as "How satisfied were you with the way the officer treated you when you were stopped or called for service?" Most citizens would be satisfied with the enforcement or service if the officer arrived in no time, treated them with professionalism and impartiality, and provided sympathy and consolation after the event (Tyler, 1990; Tyler and Darley, 2000; Donnelly *et al*., 2006; Horowitz, 2007; Chu and Hung, 2010; Chiu, 2011). Fast response and professional service are the two key factors influencing citizen satisfaction to the police service; however, personal perception can be another key. Many researchers indicated that residents from different cultural backgrounds have different values, attitudes, and beliefs in regards to appropriateness of police practices (e.g., Skogan, 1990; Frank *et al*., 1996; Maxson *et al*., 2002; Schafer *et al*., 2003; Nofziger and Williams, 2005; Skogan, 2005, 2006; Chiu, 2011). Webb and Marshall (1995) identified three domains of individual characteristics that would significantly influence citizen

satisfaction to the police service: socioeconomic status, age, and gender. However, their conclusion remains arguable because some studies have shown a relationship of these three factors with the citizen satisfaction, while others have failed to produce evidence demonstrating a relationship between them (Zamble and Annesley, 1987; Davis, 1990; Brown and Benedict, 2002).

Importantly, the results of questionnaire survey would not be convincing or reliable if the questions were not well designed to reflect the respondent's desires, or if the interviewees were not the implicated parties of an event. More importantly, when answering questions about the police service, people were easily inclined to respond negatively or badly if they had been stopped or ticketed by the police, or they might show an attitude of indifference if they did not have personal experience of calling for police help. Most importantly, the perceptual attitudes or satisfaction items were generally measured in linguistic form, which can mean differently to different people. It is never easy to precisely measure the qualitative attitudes or satisfaction items due to the ambiguity or vagueness. The fuzzy logic, coined by Zadeh (1965), has been proven powerful for mimicking the human reasoning. It evolved from the need to model the type of vague or ill-defined systems that are difficult to handle with crisp binary-valued logic. In light of this, the objective of this study is to employ the fuzzy logic to investigate on the accident involved motorists' attitudes toward the police service. It is hoped to explicitly disclose the motorists' expectations so that the police can derive more effectual service in response to traffic accidents. The remaining parts are organized as follows. Section 2 briefly reviews the concept of fuzzy logic and membership functions. Section 3 illustrates a case study in Taipei City. Based on the findings, some policy implications are discussed in Section 4.

2. THE FUZZY LOGIC

Elucidating a real world problem or a social system may be roughly categorized into deterministic, probabilistic and linguistic models. When human perceptions were involved, conventional logic mainly constructed inventories of satisfaction and interviewed respondents on a dichotomous or binary-valued scale (0 or 1) or on a Likert scale (e.g., 5-point) to obtain crisp values. Opposing to the conventional logic, the fuzzy logic uses a small number of rules to produce a smooth output via a process of interpolation. It forms rules that are based on multi-valued logic. By fuzzy logic, an element could partially belong to a set and at the same time partially belong to another set, and this can be represented by the set membership. The output of a fuzzy reasoning system would produce similar results for similar inputs (Zadeh, 1965). Fuzzy logic is simply the extension of conventional logic to the case where partial set membership can exist, rule conditions can be satisfied partially, and system outputs are calculated by interpolation and thus have output smoothness over the equivalent binary-valued rule base. This property is particularly relevant to depiction of human perceptions, such as degrees of satisfaction or importance measured on a scale base. With fuzzy logic, linguistic variables with uncertainty and fuzziness can be successfully described and depicted by membership functions.

In literature, the membership functions can be categorized in different ways. For instance, (1) heuristically-based membership functions (e.g., Zadeh, 1965; Zadeh, 1971; Zadeh, 1972; Zadeh, 1975, 1976; Schwartz, 1987; Krusinska and Liebhart, 1986; Dimitru and Luban, 1986; Svarovski, 1987); (2) membership functions based on reliability concerns with respect to the particular problem (e.g., Zimmermann, 1978; Sakawa, 1983; Heshmaty and Kandel, 1985; Tanaka and Asai, 1982; Hannan, 1981; Sakawa and Yano, 1986); (3)

membership functions based on more theoretical demand such as decision making—Schwab (1983) axiomatically justified membership functions on the basis of spline functions, whereas Civanlar and Trussel (1986) based the membership function on probability density functions; (4) membership functions and control—Sugeno *et al*. (1985; 1986) defined the functions and identified the system parameters, whereas Kiszka *et al*. (1985a; 1985b) worked with a given system and identified the membership function under the control process; (5) membership function as a model for human concepts—Zadeh (1976) introduced fuzzy sets to build a model of human concepts, whereas Hersh *et al*. (1979) presented a context effecting upon the interpretation of a set of natural language terms.

The type of representation of a membership function depends on the base set. If the base set consists of many values or is a continuum, then a parametric representation is appropriate. A piecewise linear membership function is preferred because of its simplicity and efficiency with respect to computability. Mathematically, a membership function, denoted as $\mu_A(x)$, describes the membership of the element x of the base set X in the fuzzy set A, whereby for $\mu_A(x)$ a large class of functions can be taken. The membership grade $\mu_A(x_0)$ of a membership function $\mu_A(x)$ describes for the special element $x = x_0$ to which the membership grade is characterized in the fuzzy set A. This value is in the unit interval [0,1]. Of course, x_0 can simultaneously belong to another fuzzy set B, such that $\mu_B(x_0)$ characterizes the membership grade of x_0 to B. As an illustration, Figure 1(a) shows a trapezoidal function expressed by Equation (1)

$$\mu(x, x_1, x_2, x_3, x_4) = \begin{cases} 0 & , \quad x < x_1,\ x > x_4 \\ \frac{x - x_1}{x_2 - x_1} & , \quad x_1 \le x \le x_2 \\ 1 & , \quad x_2 < x < x_3 \\ \frac{x_4 - x}{x_4 - x_3} & , \quad x_3 \le x \le x_4 \end{cases} \tag{1}$$

which migrates for the case x_2=x_3 into a triangular membership function. In our case study, other three patterns of membership function can properly refer to motorists' perception on police services (satisfactory, acceptable, and dissatisfactory), which can be transformed from a trapezoidal function into a right-descending trapezoidal membership function (Figure 1(b)), a triangular membership function (Figure 1(c)), and a left-rising trapezoidal membership function (Figure 1(d)), respectively. The piecewise red lines in Figure 1(b) depict that the membership grade equals 1 when x is less than x_1 and it goes down to 0 when x is larger than x_2. Likewise, we can use the piecewise red lines in Figure 1(c) and Figure 1(d) to describe the degrees of human perception (e.g., satisfaction or importance) in accordance with the value of x.

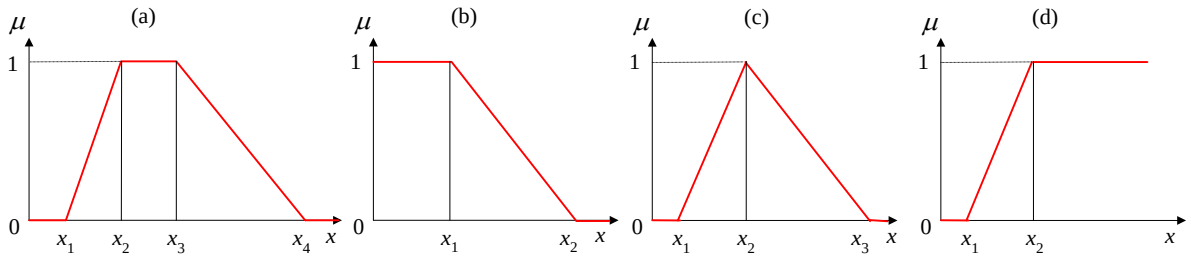

Figure 1. Trapezoidal membership functions

3. CASE STUDY

3.1 The data

A case study is undertaken in the jurisdiction of Taipei City, where a call-back interview was performed by the staff using the hotline 110 in the Taipei police command center. The questionnaire items contained four parts: (1) a basic description of the previous call (accident case numbered, call-in time, hang-up time, police arrival time, and end-of-service time), (2) degrees of importance toward police service (response and service time, police attitude, police professionalism, quality of services, and effects of overall satisfaction of police service on the trust to the police), (3) degrees of satisfaction toward police response time and service time (satisfactory, acceptable and dissatisfactory), and (4) motorist's socioeconomic status (gender, age, and education).

For ease of recording a motorist's perception on the police response time and service time, a table with time intervals 3 or less, 5, 10, 15, 20, 25, 30, 35, 40 minutes or more was designed for use to record the response time. Similar table was also designed for recording a motorist's perception on service time; however, the service time intervals are larger and broader: 10 or less, 20, 30, 60, 90, 120, 150, 180, 210, 240 minutes or more. Table 1 demonstrates the way to record the call-back interview on an individual motorist. This motorist felt "satisfactory" providing that the police arrival time was within 15 minutes upon reporting the accident case to the 110 hotline; hence, the staff checked marks on the blanks of 3 through 15 minutes. Likewise, marks were checked on the corresponding blanks of 15 through 25 minutes as the motorist also expressed "acceptable" if the police arrival time was between 15 and 25 minutes. The motorist expressed "dissatisfactory" that the police arrival time exceeded 25 minutes, thus the blanks of 25 and afterwards were checked. It should be mentioned, however, that each motorist has been informed of the traffic conditions and the distance between accident spot and jurisdictional police precinct prior to answering the questions.

Table 1. Example of call-back interview recording a motorist perception on response time

Time interval (minutes)	Satisfactory	Acceptable	Dissatisfactory
3 or less	√		
5	√		
10	√		
15	√	√	
20		√	
25		√	√
30			√
35			√
40 or more			√

The call-back interview lasted for three weeks from August 10 to August 31 in 2012 with a total of 254 accident reporting motorists: 49 (19.3%) females and 205 (80.7%) males. The call-back interview just asked the motorists about their personal perceptions on the police response time and service time for the reporting accident cases, nothing to do with the investigation of accident liabilities. Hence, the respondent's opinions would not be affected by the accident factors. Regarding the age and education, those who aged thirties with university degrees made up of the majority. In terms of the types of accident, the number of A1 (fatal) accident was 0, A2 (injured) accident was 36 (14.2%), and A3 (property-damaged only) accident was 218 (85.8%). We further categorized the twelve administrative districts of Taipei

City into four regions: residential district, suburban area, business district, and traditional community. The number of respondents in each of the four regions was greater than 30, indicating sufficient samples for analysis and comparison. The samples of the respondents were summarized in Table 2.

Table 2. Samples of the respondents

Item	Number of respondents	%	Item	Number of respondents	%
Gender			Education		
Male	205	80.7	Junior high school	13	5.1
Female	49	19.3	Senior high school	85	33.5
Total	254	100	University	142	55.9
Age			Graduate school	14	5.5
Under 20	4	1.6	Total	254	100
21-30	47	18.5	Education*		
31-40	118	46.5	Secondary school	98	38.6
41-50	69	27.2	University	142	55.9
Over 51	16	6.3	Graduate school	14	5.5
Total	254	100	Total	254	100
Age*			Region		
Under 30	51	20.1	Residential district	43	16.9
31-40	118	46.5	Suburban area	51	20.1
Over 41	85	33.5	Business district	75	29.5
Total	254	100	Traditional community	85	33.5
			Total	254	100
Types of accident					
A1	0	0			
A2	36	14.2			
A3	218	85.8			
Total	254	100			

Note: * denotes that some data in age and education groups were combined for analysis of variance (ANOVA) test due to insufficient samples.

Besides, we also asked the motorists about their opinions on importance of the following five items:

1) Response and service time: “How soon the police have provided and accomplished the task upon your reporting the accident.”
2) Police attitude: “How satisfied you were with the ways the police treated and served you.”
3) Police professionalism: “How well the police possessed skills and knowledge in recording the accident scenes.”
4) Quality of services: “How impartial or neutral the police were in investigating the accident.”
5) Effects of overall satisfaction of police service on the trust to the police: “How your overall satisfaction of police services would affect your trust in police.”

These five items were measured on a five-point scale (very important, moderately important, important, less important, and not important). The results were presented in Table 3, which shows that the majority of respondents have expressed very important to moderately important for all items, suggesting a consensus of most motorists using these items to measure

the police service in response to traffic accidents.

Table 3. Degrees of importance for measured items

Item		VI	MI	I	LI	NI	Total
Response and service time	Number of respondents	95	143	15	1	0	254
	%	37.4	56.3	5.9	0.4	0	100
Police attitude	Number of respondents	95	142	14	3	0	254
	%	37.4	55.9	5.5	1.2	0	100
Police professionalism	Number of respondents	122	115	16	1	0	254
	%	48	45.3	6.3	0.4	0	100
Quality of services	Number of respondents	139	101	13	1	0	254
	%	54.7	39.8	5.1	0.4	0	100
Effects of satisfaction on trust	Number of respondents	67	122	34	31	0	254
	%	26.4	48	13.4	12.2	0	100

Note: VI: Very important; MI: Moderately important; I: Important; LI: Less important; NI: Not important

3.2 The membership functions

After inquiring the motorists' opinions, we constructed the membership functions of response time and service time, respectively. As interpreted in Section 2, the membership grade $\mu_A(x_0)$ of a membership function $\mu_A(x)$ describes for the special element $x = x_0$ to which the membership grade is characterized in the fuzzy set *A*. The respondent's answers can be transformed into the membership grade to construct the membership function of the fuzzy set *A*, expressed by Equation (2):

$$\mu_A(x_i, f_j) = \frac{N_{ij}(f_j \in x_i)}{N_i} \tag{2}$$

where,

f_j denotes the number of times in the j^{th} time interval (from less than 3 minutes to 40 minutes or more), N_{ij} is the number of times in the j^{th} time interval at the i^{th} degree of satisfaction (satisfactory, acceptable, or dissatisfactory), and N_i is the sum of N_{ij}**.** From Equation (2), the membership frequency with i^{th} degree of satisfaction, denoted as N_{ij}/N_i, can be obtained.

Taking response time in the traditional community as an example, Table 4 shows the membership frequencies of response time with various degrees of satisfaction. By calculating membership frequencies, the membership functions with satisfactory level $\mu_S(x)$, acceptable level $\mu_A(x)$ and dissatisfactory level $\mu_D(x)$ could be respectively formulated in Equation (3), Equation (4) and Equation (5). By further plotting membership frequencies, the diagram of three membership functions of response time for the 85 respondents in traditional community region could be constructed in Figure 2.

Following the same vein, the membership functions of service time with various degrees of satisfaction could be created and formulated in Equation (6), Equation (7) and Equation (8), respectively. The diagram of three membership functions of service time for the 85 respondents in traditional community region could be constructed in Figure 3.

Table 4. An exemplified membership frequency (response time in traditional community)

Degree of satisfaction	Membership	Response time (minutes)								
		≤3	5	10	15	20	25	30	35	≥40
Satisfactory	Number of respondents	85	81	44	12	2	0	0	0	0
	Frequency	1	0.95	0.52	0.14	0.02	0	0	0	0
Acceptable	Number of respondents	3	40	70	72	54	28	10	0	0
	Frequency	0.04	0.47	0.82	0.85	0.64	0.33	0.12	0	0
Dissatisfactory	Number of respondents	0	2	10	30	56	74	84	85	85
	Frequency	0	0.02	0.12	0.35	0.66	0.87	0.99	1	1

$$\mu_S(x) = \begin{cases} 1 & , \quad x \le 2 \\ 1.1 - 0.05x & , \ 2 < x \le 22, \ R^2 = 0.91 \\ 0 & , \quad 22 < x \end{cases} \tag{3}$$

$$\mu_A(x) = \begin{cases} 0 & , \quad x \le 0 \\ 0.026 + 0.063x & , \ 0 < x \le 14 \ , \ R^2 = 0.83 \\ 1.49 - 0.044x & , \ 14 < x \le 34, \ R^2 = 0.98 \\ 0 & , \quad 34 < x \end{cases} \tag{4}$$

$$\mu_D(x) = \begin{cases} 0 & , \quad x \le 4 \\ -0.145 + 0.036x & , \ 4 < x \le 32, \ R^2 = 0.96 \\ 1 & , \quad 32 < x \end{cases} \tag{5}$$

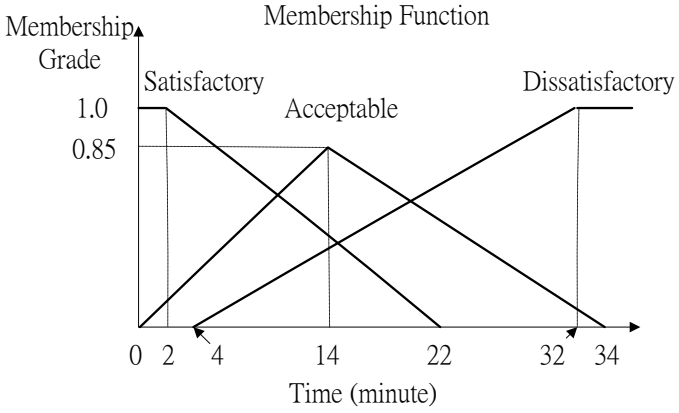

Figure 2. An exemplified diagram of membership functions (response time in traditional community)

$$\mu_S(x) = \begin{cases} 1 & , \quad x \le 4 \\ 1.04 - 0.01x & , \ 4 < x \le 104, \ R^2 = 0.87 \\ 0 & , \quad 104 < x \end{cases} \tag{6}$$

$$\mu_A(x) = \begin{cases} 0 & , \quad x \le 8 \\ -0.33 + 0.04x & , \ 8 < x \le 30 \ , \ R^2 = 0.99 \\ 1.11 - 0.007x & , \ 30 < x \le 158, \ R^2 = 0.96 \\ 0 & , \quad 158 < x \end{cases} \tag{7}$$

$$\mu_D(x) = \begin{cases} 0 & , \quad x \le 6 \\ -0.05 + 0.008x & , \ 6 < x \le 131, \ R^2 = 0.96 \\ 1 & , \quad 131 < x \end{cases} \tag{8}$$

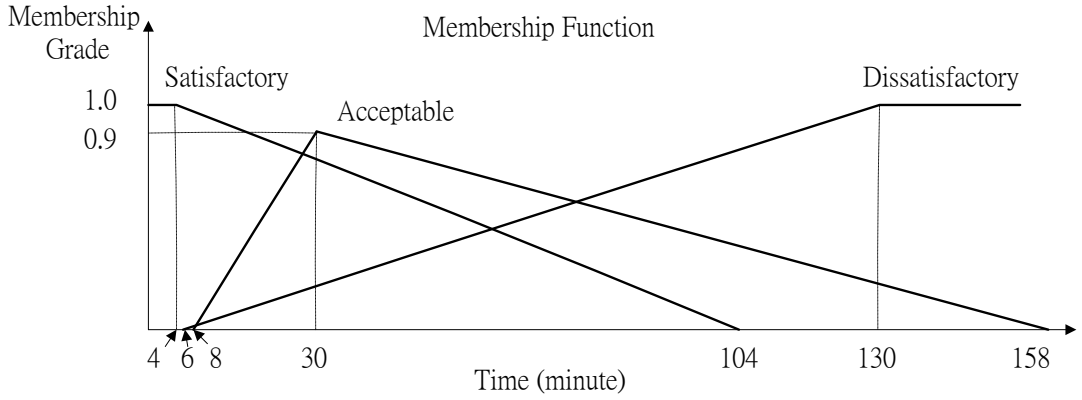

Figure 3. An exemplified diagram of membership functions (service time in traditional community)

3.3 Acquiring the motorist perceptions

Once the diagrams of membership functions for both response time and service time are plotted, the motorist perceptions on police service would no longer be vague. In theory, the membership grade essentially indicated the percentages of respondents who felt satisfactory, acceptable, or dissatisfactory to the police service. In practice, however, the information of membership grade and membership functions did not tell the specific time intervals that the majority (say, 80% of motorists) was satisfied with or the minority (say, 20% of motorists) was dissatisfied with the specific item. Therefore, we need to introduce appropriate techniques, such as the fuzzy α-cut in this study, to acquire the motorist crisp perceptions.

Let A_a denote the set of elements which degree of membership in a fuzzy set A is no less than a fixed value $\alpha \in (0, 1)$. Then, a crisp set A_a can be identified by the α-cut of a fuzzy set A, called α-cut set, expressed as follows:

$$A_\alpha = \{x \in X | \mu_A(x) \ge \alpha\}, \forall \alpha \in (0, 1) \tag{9}$$

where,

α represents a threshold value. In the process of translation, we use a specific α-cut to obtain two values, b and c, in the fuzzy set A (see Figure 4). For those membership grades between b and c, i.e., $\mu_A(x) \ge \alpha$, we regard them as totally equaling one; otherwise, they are zero. As such, a crisp set A_a can be acquired from a fuzzy set A, as depicted in Figure 4.

In the following, we regard 80% of the total respondents as the majority group and 20% as the minority group. Hence, we introduce two threshold values (0.8 and 0.2) to acquire the time intervals from the satisfactory and dissatisfactory membership functions in Figure 2 and Figure 3, respectively. In the satisfactory aspect, we use $\alpha = 0.8$ to assure that no less than 80% of the motorists would be satisfied—from Figure 2 and Figure 3, they are 6.0 minutes for response time and 24.0 minutes for service time. In the dissatisfactory aspect, we use $\alpha = 0.2$ to assure that no greater than 20% of the motorists would be dissatisfied—from Figure 2 and Figure 3, they are 9.6 minutes for response time and 31.3 minutes for service time. Accordingly, the police response time for a traffic accident in traditional community should be within an interval from 6.0 to 9.6 minutes to meet the majority expectations. Likewise, the police service time for a traffic accident in traditional community should be within an interval from 24.0 to 31.3 minutes. Following the same procedure, the majority expectations on police response time and service time in another three regions can also be determined. It was found that the majority of motorist's anticipated response times were within an interval from 5 to 10.2 minutes in residential district, from 6.6 to 13.3 minutes in suburban area, and from 7 to 13.4 minutes in business district. And the majority of motorist's anticipated service times were within an interval from 17 to 21.6 minutes in residential district, from 17.2 to 44.5 minutes in suburban area, and from 20.3 to 34 minutes in business district. All in all, the majority expectations of the 254 respondents on police response time were within an interval from 5.5 to 11 minutes and service time from 18.8 to 32 minutes, regardless of the distinction of regions. For ease of practices, we suggest rounding the above figures to multiples of five. As such, the motorists' anticipated response time to a traffic accident in Taipei City should be from 5 to 10 minutes and service time from 20 to 35 minutes.

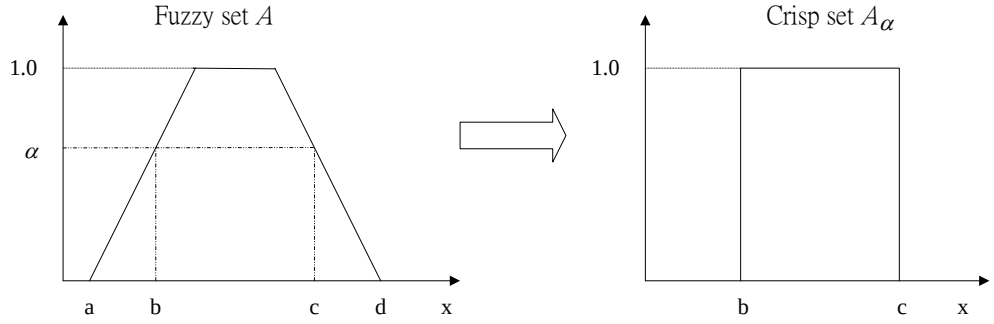

Figure 4. The α-cut—translating a fuzzy set A to a crisp set A_a

3.4 Comparisons

We employ analysis of variance (ANOVA) techniques to test if motorist perceptions on the police response or service times are significantly different among regions and socioeconomic backgrounds (gender, age, education), or a combination of both. Table 5 presents the motorist perceptions on police response and service times among four regions, in which the number of respondents in each region were randomly divided into three equal-sample-size groups. We then used one-factor ANOVA to test the differences at a significance level of 5%. The result showed that the threshold of 80% satisfaction toward the police response time or service time is not significantly different among distinct regions. Same result was also found for the threshold of 20% dissatisfaction toward the response time but not toward the service time; namely, motorist dissatisfaction showed significantly different among the four regions.

Table 5. Motorist perceptions on police response and service times among four regions (Unit: minute)

Threshold values	Time	Group	Traditional community	Business district	Suburban area	Residential district
80% satisfaction	Response time	1	6.4	7.6	8.2	5.7
		2	5.8	7.6	6.0	5.1
		3	6.2	7.4	5.1	6.8
	Service time	1	17.7	23.6	11.4	14.3
		2	19.2	15.8	14.3	13.5
		3	17.5	25.4	20.0	14.6
20% dissatisfaction	Response time	1	11.1	13.0	15.0	9.7
		2	10.8	14.4	13.3	11.0
		3	8.5	16.3	12.3	14.0
	Service time	1	33.8	31.5	52.2	14.0
		2	33.0	22.8	38.8	18.8
		3	28.4	39.8	36.0	23.6

We wondered if the motorist perceptions were influenced by more than one factor, thus the technique of two-factor ANOVA was used to test the differences at a significance level of 5% for Table 6 (the motorist perceptions on police response and service times at a threshold of 80% satisfaction) and Table 7 (similar perceptions at a threshold of 20% dissatisfaction). The results showed that the motorist dissatisfaction toward the police service time is significantly different when combining the influence of region and gender altogether; namely, the dissatisfaction toward the police service time would be affected by two factors—region and gender. The same test was also performed on another two factors—age and education, but it revealed that motorist perceptions would neither be affected by age nor by education with respect to either the police response time or service time.

Table 6. Motorist perceptions on police response and service times at 80% satisfaction (Unit: minute)

Time	Factor	Traditional community	Business district	Suburban area	Residential district	Factor	Age under 30	Age 31-40	Age over 40
Response time	Male	6.2	7.8	7.0	6.9	Secondary school	3.1	5.4	7.5
	Female	5.9	7.4	5.0	5.6	University	6.8	6.4	7.0
						Graduate school	7.9	5.2	8.6
Service time	Male	20.0	22.0	20.7	18.5	Secondary school	9.4	17.3	14.9
	Female	18.5	25.0	16.9	20.0	University	20.8	16.7	21.5
						Graduate school	27.1	19.0	27.1

Table 7. Motorist perceptions on police response and service times at 20% dissatisfaction (Unit: minute)

Time	Factor	Traditional community	Business district	Suburban area	Residential district	Factor	Age under 30	Age 31-40	Age over 40
Response time	Male	9.7	13.1	14.1	13.7	Secondary school	9.8	9.3	12.2
	Female	9.6	16.8	15.0	14.4	University	11.5	11.4	12.5
						Graduate school	17.6	9.8	16.2
Service time	Male	31.3	29.6	44.8	27.3	Secondary school	15.0	19.5	27.4
	Female	32.7	32.0	48.5	28.1	University	36.6	26.8	36.4
						Graduate school	53.0	23.3	48.5

Finally, we also wondered if the motorist perceptions were influenced by different types of accident: A2 (injured) and A3 (property-damaged only). Table 8 presented the motorist perceptions toward the police response time and service time with different types of accident, where the total 254 respondents have been randomly and equally divided into three groups. It is reasonable to postulate that the service time in investigating an A2 case should be longer than the time in investigating an A3 case. A *t*-test was used to examine the difference between A2 and A3. The result showed that, as what anticipated, motorist satisfaction and dissatisfaction perceptions on the police service time for A2 case are significantly longer than that for A3 case at a significance level of 5%. However, no significant difference between these two types of accident was found on the police response time.

Table 8. Motorist perceptions on police response and service times for different types of accident

Item	Group	80% satisfaction threshold		20% dissatisfaction threshold	
		A2	A3	A2	A3
Response time	1	7.0	5.7	12.8	11.7
	2	7.2	6.1	9.5	11.7
	3	6.0	6.4	10.8	11.2
Service time	1	29.5	9.3	45.3	23.0
	2	26.9	13.3	41.1	25.0
	3	24.7	16.7	37.5	20.0

Note: A2 refers to injured accident; A3 refers to property-damaged only accident

4. DISCUSSION AND CONCLUSIONS

In Taiwan, a motorist involved with a road traffic accident will normally call the 110 hotline for police service. Upon receiving a call, the police staff in the command center will record the motorist's information and assign the jurisdictional precinct to dispatch police manpower to the accident spot as quickly as possible. The police administrators in Taipei City used to ask their subordinated police to quickly respond to and serve for the road traffic accidents, but no rigorous methods have been attempted to determine the response time and service time. Our study provided a pragmatic approach for this purpose.

This study made use of the 110 hotline in the police command center to call back the

accident reporting motorists to interview their perceptions on the police service. It contributed to the policing literature in several ways. It is the first of its kind to utilize the 110 police hotline as a channel to inquire the previous accident reporting motorists about their opinions, rather than via a questionnaire survey on the general citizens commonly used by most literature. Because the perceptual measures typically exhibited with vagueness, we employed the fuzzy logic, in lieu of conventional crisp binary-valued logic, to measure the motorist perceptions on police services. The case study in Taipei City has explicitly disclosed the majority of motorists' expectations, which can facilitate the police to derive more effectual service and to reexamine the current practices in response to traffic accidents. According to the findings, some policy implications and directions for future studies are discussed below.

Most of the motorists who involved in an accident in Taipei City were satisfied with the police response time—the percentages of satisfaction varied from 66% to 83% depending on the administrative region. The current standards practiced by the Taipei City Police Department (TCPD) are as follows: a response time within 4 minutes is very satisfactory, 4 to 6 minutes is satisfactory, 6 to 10 minutes is acceptable, 10 to 15 minutes is dissatisfactory, and over 15 minutes is very dissatisfactory. Those arriving at the accident spot within 4 minutes will be rewarded and more than 15 minutes will be punished. The standards together with the rewarded/punished system have been practiced for years but no one could accurately explain the rationale. Our findings that "no less than 80% of the motorists would be satisfied and no greater than 20% of the motorists would be dissatisfied providing that police response time could stay within 5 to 10 minutes" may throw new light to refine the standards of response time practiced by TCPD and to review the appropriateness of police deployment.

Most motorists have not reached a consensus about how long the police should take to investigate a traffic accident. With respect to the A2 and A3 accident types, the motorists have perceived that the time needed to investigate an injured case is different from a property-damaged case. The significant difference between A2 and A3 for both motorist's satisfaction and dissatisfaction toward the police service time might explain why TCPD had no standards for the service times. Nonetheless, our findings that "no less than 80% of the motorists would be satisfied and no greater than 20% of the motorists would be dissatisfied providing that police service time could stay within 20 to 35 minutes" may add new evidence to launching standards of service times or providing ideal norms to accomplish the preliminary investigation corresponding to different types of accident for TCPD.

The accident involved motorist's satisfaction/dissatisfaction toward police not only depends on response time and service time, but also on other service quality factors such as police attitude, professionalism, impartiality, and compassion to the involved parties. The present study focused on response time and service time, which allowed the motorists to feel the efficiency in response to a traffic accident. Although this study has also touched a little upon the degrees of importance for these service quality factors, it requires further elaboration on the service quality issues relating to police attitude, professionalism, impartiality, and compassion to the involved parties so as to greatly enhance the motorist satisfaction level. Furthermore, the present study used two threshold values (80% and 20%) to define the majorities and the minorities. In fact, these thresholds should be determined by the highest decision maker such as the Mayor. Changing the threshold values would certainly lead to different outcomes, thus it would change the standards of response time and service time. If the Mayor wishes to shorten the police's response time and service time, the two threshold values must be altered (e.g., 90% and 10%); accordingly, our membership functions can easily produce a different set of standards. Future study can also develop education or on-job training programs to cultivate the police skills and knowledge in recording the accident scenes and investigating the accident cases. Of course, the cutting-edge devices with

cloud-computing technologies can also be introduced to accident scenes and investigation to greatly ameliorate the efficiency and effectiveness of police service quality.

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