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Decision Aiding

Using fuzzy measures and habitual domains to analyze the public attitude and apply to the gas taxi policy

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Abstract

Public acceptance and support are the crucial keys for implementing public policies successfully. Thus, the understanding of public acceptance or rejection towards the policy, as well as the important attributes of concern, could be very helpful to implementing the policy. However, most conventional attitude models could not approximate people's subjective evaluation process exactly by virtue of the additivity and independence assumptions. Additionally, people's decision behavior is deeply affected by their existing habits. Since habitual domains exist in the decision process, if the government can change or extend people's habitual thinking in favor of the public policy, the policy will receive satisfactory acceptance. Therefore, this study uses the habitual domain theory to analyze the public's attitude towards public policies. Furthermore, general fuzzy measures and fuzzy integrals, which require only boundary conditions and monotonicity, are also applied to develop a public attitude analysis model. An empirical study on the compress natural gas (CNG) taxi policy in Taipei City is conducted to show the applicability of the proposed model. The empirical results indicate that there are significant differences between the public's concern and governmental publicity, and some valuable strategies are suggested to the government. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

The determination of public attitude is an essential issue for implementing public policies. It is difficult and troublesome for the government to promote and conduct a policy if this policy cannot be fully supported by the public. Additionally, the

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policy will hardly receive the expected outcome for lack of desirable communication with the public. Thus, the public attitude, that is the public acceptance or rejection towards a policy, is the crucial key to public policies. Furthermore, specifying important attributes of public concern can be most helpful to the implementation of relevant policies.

A classical and common way to capture public attitude is to use the method of a weighted mean. This method is based on the implicit assumption that attributes are independent of one another; that is, their effects are viewed as additive. However, these attributes are interactive in most real situations. Thus, we need another method that can describe the interaction involved. If we adopt a nonadditive set function, such as a fuzzy measure (Sugeno, 1974, 1977), to characterize the importance of attributes and use a fuzzy integral as a synthetic evaluator, then a reasonable and appropriate result can be obtained.

On the other hand, from a behavioral perspective, people's decisions are deeply affected by their habits. Their existing thought, thinking, judgment, and reaction will influence the attitude-formation process tremendously. If the government hopes the public policy will be supported by the public, it is necessary to figure out their habitual thinking regarding the policy. When a negative attitude is found, the government should adopt a strategy that can help to change or extend people's habitual domains in favor of the policy. Since habitual thinking exists in human minds, we will apply the theory of habitual domains (Yu, 1980, 1990) to analyze the public attitude.

Summing up, based on the habitual domain theory, this study intends to apply fuzzy measures and fuzzy integrals to approximate people's subjective evaluation process and establish a public attitude analysis model. In order to show the applicability of the proposed method, we will conduct an empirical study about the compress natural gas (CNG) taxi policy in Taipei City. The empirical results can provide much valuable information for drawing CNG taxi policies.

The rest of this paper is organized as follows: Section 2 introduces the concept of habitual domains. Section 3 presents the public attitude analysis model using fuzzy measures and fuzzy integrals. Then, an empirical study of the CNG taxi policy is undertaken to implement this model. Section 4 illustrates the problem background with respect to natural gas taxies. We conducted a survey of the public and taxi drivers in Taipei City and draw some useful suggestions for the policy implementation. We end this paper with concluding remarks in Section 5.

2. Habitual domain theory

Habitual domain is the central idea of this study. In brief, people's thought, thinking, judgment, and reaction often become stable over time and stay within a domain. This domain is called the habitual domain. Such a domain will significantly affect human behavior and decision processes.

The theory of habitual domains was proposed by Yu (1980). Generally, if there are no significant stimuli or arrival of new information, the knowledge, experience, thought and skills encoded and stored in the human brain will become comparatively stabilized after a rather long time. Then, human responses (such as cognition, understanding, or judgment) will tend to be habitual and form a comparatively stable pattern (Yu, 1987, 1990, 1995). Furthermore, such thought, judgment, and behavior are the expressions of habitual domains. In other words, habitual domains will be reflected in the individual's personality, character, behavior, work attitude, principle, viewpoint and so on.

The thoughts or memory encoded and stored in the human brain can be differentiated into ideas and operators. The former is a concept or viewpoint, while the latter is a procedure or method. The new ideas can be generated from previous ideas through operators. Habitual domains have four primary elements (Yu, 1985, 1991): (i) potential domain, which is the collection of all ideas or operators that can be potentially activated with respect to a specific event or problem; (ii) actual domain, which is the collection of ideas or operators that are actually activated; (iii) activation propensity, which represents the possibility that ideas or operators in the potential domain have been actually activated; and (iv) reachable domain, which is the collection of ideas or operators that can be generated from the original idea set and the original operator set.

Finally, for a decision problem, the collection of ideas or operators whose activation propensities are equivalent to or larger than a specific threshold value will become the core of a decision maker's habitual domains (Yu, 1990). Such a core of habitual domains will control people's behaviors since the ideas or operators in the core would almost surely be activated with respect to the decision problem.

3. Establishment of public attitude analysis model

Central to the public attitude analysis is the model structure. Traditional approaches are primarily based on the Lebesgue measure and apply linear combination models. However, the practical cases of public attitude analysis may be devoid of additivity and independence. Moreover, people's subjective evaluation process does not always exhibit linearity. Thus, it is more reasonable and appropriate to use a nonadditive measure to approximate people's evaluation processes. Consequently, we will apply fuzzy measures and fuzzy integrals to analyze the public attitude towards public policies.

3.1. Preliminaries

Generally, the structure of attitudes is fundamentally defined by the essential attributes and their interrelation. In such a structural analysis, a suitable model is required to decompose the attitude into meaningful attributes. Conventionally, the study of public attitudes used to be based on the Lebesgue measure (Onisawa et al., 1986), that is to apply a linear combination model, and its general indication is as follows (Fishbein, 1963; Fishbein and Ajzen, 1975):

$$Y_k = \sum_{i=1}^{n} b_i \times e_{ik}, \tag{1}$$

where Y_k is the public attitude towards an object or an event k (e.g., public acceptance or rejection of the policy), e_{ik} stands for the public's evaluation of the object k in the attribute x_i, b_i is the degree of belief of attribute x_i about the object, and n is the number of attributes which have prominent representation. This model has been applied in many areas, such as risk assessment and public acceptance on nuclear power (Niehaus and Swaton, 1981; Swaton and Renn, 1984).

The problems of the aforementioned model result from the assumptions of additivity and independence. First, the linear combination form is obviously inadequate because people's subjective evaluation does not always exhibit linearity. Conventionally, Lebesgue measures assume additivity of the interaction among attributes. This assumption is too strong to match human behaviors in the real world. On the other hand, fuzzy measures only make a monotonicity assumption and thus are more general than Lebesgue measures. Hence, more and more studies have applied fuzzy measures to determine grades of importance for multiple attributes. Second, the attributes considered in people's evaluation process are not always independent of each other. Additionally, it is difficult to specify their interrelation by conventional methods. Therefore, it would be more appropriate to use a fuzzy integral model, which is not necessary to assume additivity and independence, to approximate people's subjective evaluation processes. In the following, we will review the concept of general fuzzy measures.

3.2. Fuzzy measure analysis

Fuzzy measure is a measure for representing the membership degree of an object to candidate sets (Sugeno, 1974, 1977). Let X be a universal set and $\mathscr{P}(X)$ be the power set of X. Then a fuzzy measure, g, is defined by the following function:

$$g : \mathscr{P}(X) \to [0, 1], \tag{2}$$

which assigns each crisp subset of X a number in the unit interval $[0, 1]$. The axioms of fuzzy measures include boundary conditions ($g(\phi) = 0$ and

$g(X) = 1$) and monotonicity (for every $A, B \in \mathscr{P}(X)$, if $A \subseteq B$, then $g(A) \leqslant g(B)$). If the universal set is infinite, we must add an extra axiom of continuity (Klir and Folger, 1988). In actual practice, it is enough to consider a finite universal set. Let $X = \{x_1, x_2, \ldots, x_n\}$ and $i = 1, 2, \ldots, n$. The fuzzy measure, $g(\{x_i\})$, of a single element set, $\{x_i\}$, is called a fuzzy density, and we denote $g_i = g(\{x_i\})$.

In order to differentiate from other fuzzy measure patterns (such as λ-fuzzy measure, F-additive measure, classical probability measure), we use the term "general fuzzy measure" to designate a fuzzy measure that only requires the satisfaction of boundary conditions and monotonicity. A general fuzzy measure is the most general type of fuzzy measures because of the fewest constraints and full degrees of freedom.

Compared with other types of fuzzy measures, general fuzzy measures can provide more valuable information. Let X be a finite set. Consider a fuzzy measure g of $(X, \mathscr{P}(X))$, $A \in \mathscr{P}(X)$, $B \in \mathscr{P}(X)$, $A \cap B = \phi$, and $A, B \neq \phi$. The coupling coefficient μ_{AB} is defined as follows (Ishii and Sugeno, 1985):

$$\mu_{AB} = \frac{g(A \cup B) - [g(A) + g(B)]}{g(A) \wedge g(B)}. \tag{3}$$

Coupling coefficient μ_{AB} demonstrates the degree of additivity that the fuzzy measure holds between subsets A and B. Suppose that subsets A and B are the single element sets $\{x_i\}, \{x_j\}$, respectively, where $x_i, x_j \in X$ and $i \neq j$. Let $\mu_{ij} = \mu_{\{x_i\}\{x_j\}}$, then

$$\mu_{ij} = \frac{g(\{x_i, x_j\}) - (g_i + g_j)}{g_i \wedge g_j}. \tag{4}$$

The degree of additivity that the fuzzy measure holds between attributes x_i and x_j ($x_i, x_j \in X$ and $i \neq j$) is termed as the overlap coefficient m_{ij}, where $m_{ij} \in [-1, 1)$. We define m_{ij} as follows:

$$m_{ij} = \begin{cases} \mu_{ij}, & \mu_{ij} \leqslant 0, \\ \mu_{ij}/(\mu_{ij} + 1), & \mu_{ij} > 0. \end{cases} \tag{5}$$

Note that the normalized μ_{ij} is m_{ij} (Onisawa et al., 1986).

Assume that $n > 1$. The degree of overlap shows the average overlap between a specific attribute and other attributes. We define the degree of overlap η_j of attribute x_j as follows:

$$\eta_j = \frac{\sum_{i=1,\ i \neq j}^{n} m_{ij}^3}{n - 1}, \quad j = 1, 2, \ldots, n. \tag{6}$$

Coefficient $\eta_j \in [-1, 1)$ indicates the mean degree of overlapping between x_j and other attributes. When $\eta_j \geqslant 0$, this denotes that there exists no overlap between x_j and other attributes on average. Thus, attribute x_j should be withheld as it does have some kind of influence on the evaluation process. As for the situation $\eta_j < 0$, both the importance (g_j) and overlapping (η_j) should be used to decide whether attribute x_j is included in the model or not. Then, the necessity coefficient $\xi_j (\in [0, 1])$ of attribute x_j can be used to express the degree of necessity of x_j in the model structure (Onisawa et al., 1986):

$$\begin{aligned} \xi_j &= 1 + \eta_j [1 - g(\{x_j\})] \\ &= 1 + \eta_j (1 - g_j), \quad -1 \leqslant \eta_j < 0. \end{aligned} \tag{7}$$

The above-mentioned properties of general fuzzy measures are summarized in Table 1, which includes the object that is described, theme of discussion, range of values, and the meaning of the specific value.

3.3. Fuzzy integrals

Consider a fuzzy measure g of $(X, \mathscr{P}(X))$ and X is a finite set. Let f be a measurable function from X to $[0, 1]$, that is $f : X \to [0, 1]$. Then, without loss of generality, assume that fx_j) is monotonically decreasing with respect to j, i.e., $f(x_1) \geqslant f(x_2) \geqslant \cdots \geqslant f(x_n)$. If it does not hold initially, the elements in X will be renumbered. The fuzzy integral of f with respect to g is

$$\int f(x)\,\mathrm{d}g = \bigvee_{i=1}^{n} [f(x_i) \wedge g(X_i)], \tag{8}$$

where $X_i := \{x_1, x_2, \ldots, x_i\}$, $i = 1, 2, \ldots, n$.

In practice, f can be considered the performance of an alternative on a specific attribute. In addition, the fuzzy measure, g, can be used to express the grade of subjective importance for each

Table 1
Properties of general fuzzy measures

Property	Object	Theme	Range	Special meaning
Coupling coefficient μ_{AB}	Subsets A and B, $A, B \in \mathscr{P}(X)$	Degree of additivity of fuzzy measure between A and B	R	$\mu = 0$: additive; $\mu > 0$: superadditive; $\mu < 0$: subadditive; $\mu = -1$: F-additive
Overlap coefficient m_{ij}	Attributes x_i and x_j, $x_i, x_j \in X$	Degree of additivity of fuzzy measure between x_i and x_j	$[-1, 1)$	$m = 0$: additive
Degree of overlap η_j	Attribute x_j $x_j \in X$	Average overlap between x_j and other elements	$[-1, 1)$	$\eta > 0$: relevant information; $\eta < 0$: redundant information; $\eta = 1$: complete unoverlapping; $\eta = -1$: complete overlapping
Necessity coefficient ξ_j	Attribute x_j $x_j \in X$	Degree of necessity of x_j in the structure of the model	$[0, 1]$	$\xi = 0$: absolutely unnecessary; $\xi = 1$: absolutely necessary

attribute (Sugeno, 1974; Ishii and Sugeno, 1985; Murofushi and Sugeno, 1989; Wang and Klir, 1992; Sugeno and Kwon, 1995). The fuzzy integral of f with respect to g gives the overall evaluation of the alternative.

Since fuzzy integrals need not assume the independence of one attribute from another, they can be used in nonlinear situations. Even if two attributes are objectively independent, people may not recognize this independence subjectively. This is why fuzzy integrals with synthetic evaluations would be desirable in practice. Furthermore, people's subjective evaluations always occur according to the differences between the ideal and actual evaluation values of all attributes. Because each person's ideal values could be different and extremely difficult to be measured, it is appropriate to use subjective evaluations even if one attribute is physically independent of another. Thus, we apply fuzzy integrals to establish the analysis model of the public attitude towards public policies.

We can use the same fuzzy measure, but the Choquet integral is used instead of the max–min integral (Murofushi and Sugeno, 1989; Wang and Klir, 1992; Denneberg, 1994; Pap, 1995). Even if there is complete information regarding $(2^n - 2)$ subsets, the max–min integral calculation only determines some interval at which the measure values are possibly located. On the contrary, the unique solution will be obtained if the Choquet integral is used. In addition, using the Choquet integral can obtain more reasonable results than using the fuzzy integral in many cases (Wang and Wang, 1997). Furthermore, the usage of Choquet integrals offers more aid for facilitating fuzzy measure identification because of the provision of extra constraints. Therefore, Choquet integrals are used in this study.

3.4. Specification of public attitude analysis model

For the public, there exists a set of goal functions to be achieved for their satisfaction level regarding the public policy. Goal functions can be measured by a collection of elementary evaluation attributes, $\{x_1, x_2, \ldots, x_n\}$ (n is the number of attributes). This collection is finite and denoted by X. Consider the elementary attribute set, $\{x_1, x_2, \ldots, x_n\}$, to be the discussion universe for the public acceptance or rejection problem. In the following, the assumptions for this study are first elaborated, followed by the modeling of the public attitude towards the government policy.

3.4.1. Establishment of hypotheses

For applications in the management field, we denote the element of power set, $\mathscr{P}(X)$, on $(X, \mathscr{P}(X))$ by "attribute aspect". The collection of all aspects that have i elements is called the ith aspect set, where $i = 1, 2, \ldots, n$. The degree of importance of each attribute aspect can be derived from the questionnaire investigation. The following problem is encountered in practice when general fuzzy measures are used to demonstrate grades of importance for attribute aspects.

First, when excluding the boundary conditions, respondents have to make judgments on the grades of importance regarding $(2^n - 2)$ attribute aspects and this is highly infeasible in practice. Moreover, if we directly ask respondents the grades of importance for each attribute aspect, it is difficult to obtain their responses as the question is quite abstract. Since people's perceived grades of attribute importance are deeply affected by the alternatives (or object), requesting respondents to evaluate the overall performance of the concrete alternative in attribute aspects would be easier. Furthermore, if the respondents cannot indicate the performance of the alternative adequately, we can use the degree of belief for the evaluation value to express the uncertainty. Lastly, if more attributes are contained in the aspect, there would be a stronger possibility of conflict and more intertwined complexity.

In view of the aforementioned difficulties, the following assumptions are established in this study:

1. Researchers can list all of the relevant attributes regarding the evaluation of ups and downs for the alternative or object.
2. At the point of evaluating an alternative in a specific attribute aspect, people have already considered the overall importance of all attributes contained in this aspect.
3. The accuracy of people's evaluation for an alternative in an attribute aspect will diminish as the number of attributes for this aspect increases.

For the second assumption, an alternative must be related to a set of goal functions in every evaluator's mind. Goal functions can be measured by finite elementary attributes. When there is an unfavorable deviation in the perceived attribute value from the ideal one, this attribute will produce a corresponding level of charge (i.e., pressure). The totality of the charge by all attributes is called the charge structure. Our attention will focus on the attribute aspect that has the greatest influence on the charge structure, and of course, this aspect enjoys a relatively higher grade of importance (Tzeng et al., 1998). Thus, the evaluators' perceived grade of importance for each attribute aspect is, in fact, greatly affected by the alternative. Next, we will identify the overall importance of each attribute aspect according to fuzzy densities and the evaluation values of the alternative in each attribute aspect.

3.4.2. Public attitude analysis process

In the attitude analysis problem, the basic investigation items include evaluation value e_{ij}, degree of belief b_{ij}, and the grade of importance $\hat{g}_{ij}$. We denote e_{ij} as the evaluation of the alternative in attribute x_i by subject j, b_{ij} as the belief in the evaluation of the alternative in attribute x_i by subject j, and $\hat{g}_{ij}$ as the perceived importance of attribute x_i by subject j. In applications, e_{ij}, b_{ij}, and $\hat{g}_{ij}$ can be judged on a 7-possibility bipolar scale from −3 to 3. Evaluation values are labeled as "extremely bad", "very bad", "bad", "fair", "good", "very good", and "extremely good", whereas their scores are, in order, −3, −2, −1, 0, 1, 2, and 3. Likewise, the belief is labeled "unlikely" to "likely", and the grade of importance is labeled as "unimportant" to "important". The score endowment is the same as that indicated in the evaluation values.

The effective evaluation e^*_{ij} of the ith attribute for the alternative by subject j can be defined by e_{ij} and b_{ij}; according to the definition by Onisawa et al. (1986):

$$e^*_{ij} = \frac{e_{ij}\left(b_{ij} + 0.75\right) + 11.25}{22.5}. \tag{9}$$

The above definition implies the following meaning. If $e_{ij} = 3$ (extremely good) and $b_{ij} = 3$ (quite certain), then $e^*_{ij} = 1$ (best evaluation). If $e_{ij} = -3$ (extremely bad) and $b_{ij} = 3$ (quite certain), then $e^*_{ij} = 0$ (worst evaluation). If $e_{ij} = 0$ (neutral), then $e^*_{ij} = 0.5$ (neutral) in spite of b_{ij}. From Eq. (9), we know that $0 \leqslant e^*_{ij} \leqslant 1$. Next, $\hat{g}_{ij}$ is normalized in $[0, 1]$ as follows:

$$\hat{g}^*_{ij} = \frac{\hat{g}_{ij} + 3}{6}. \tag{10}$$

In order to reduce the influence of subjective biases caused by the individual respondents and get a more reasonable evaluation, we use an arithmetical average of the evaluation values by a number of respondents. Then, we obtain the synthetic evaluation of the alternative as follows:

(a) *First aspect set*. Let N_1 denote the total number of people interviewed for the first aspect set. Let $\hat{f}(x_i)$ and $f(x_i)$, respectively, represent the actual value (obtained by investigation) and the predicted value of the effective evaluation regarding attribute x_i. Because the first aspect set contains the essential data from which one would infer the grades of importance for other aspects, let $f(x_i) = \hat{f}(x_i)$.

Then

$$f(x_i) = \hat{f}(x_i) = \frac{1}{N_1}\sum_{j=1}^{N_1} e^*_{ij} \quad \text{for } i \in [1, n]. \tag{11}$$

The fuzzy density g_i of each attribute can be derived from the investigation data:

$$g_i = \hat{g}_i = \frac{1}{N_1}\sum_{j=1}^{N_1} \hat{g}^*_{ij} \quad \text{for } i \in [1, n]. \tag{12}$$

(b) kth aspect set, $k = 2, 3, \ldots, n$.

Let an element of the kth aspect set be $\{x_{i_1}, x_{i_2}, \ldots, x_{i_k}\}$. Let N_k denote the total number of people interviewed regarding the kth aspect set. If there are investigation data about $e_{i_1 i_2 \cdots i_k j}$ and $b_{i_1 i_2 \cdots i_k j}$, $e^*_{i_1 i_2 \cdots i_k j}$ can be obtained in a similar way as Eq. (9). Let $E(\{x_{i_1}, x_{i_2}, \ldots, x_{i_k}\})$ denote the predicted value of the effective evaluation for aspect $\{x_{i_1}, x_{i_2}, \ldots, x_{i_k}\}$, and let $\hat{E}(\{x_{i_1}, x_{i_2}, \ldots, x_{i_k}\})$ denote the actual effective evaluation obtained from the investigation. Then, for $i_1, i_2, \ldots, i_k \in [1, n]$ and $i_1 < i_2 < \cdots < i_k$,

$$\hat{E}(\{x_{i_1}, x_{i_2}, \ldots, x_{i_k}\}) = \frac{1}{N_k}\sum_{j=1}^{N_k} e^*_{i_1 i_2 \cdots i_k j}. \tag{13}$$

The evaluation of each attribute aspect and the grade of importance of each single-attribute aspect can be used to estimate the measure values of unknown aspects. However, if the grades of importance of all aspects are to be solved, the evaluation of the alternative in each aspect must be given. The data amount reaches as much as $(2^n - 2)$ and it is highly infeasible in practice. Therefore, the authors proposed a concept of partial information (Chen, 1998; Chen and Tzeng, 2000). Through an experimental design approach, they designed a sampling procedure of attribute aspects to capture the most useful information and thus reduce the original data requirement in solving general fuzzy measures.

To facilitate the experimental design, f must be monotonically non-decreasing in Choquet integrals. Consider a fuzzy measure g of $(X, \mathscr{P}(X))$, where X is a finite attribute set. Let $f(x_i)$ stand for the public's evaluation of the policy in the attribute x_i and $f(x_i)$ is monotonically increasing with respect to i, that is, $f(x_1) \leqslant f(x_2) \leqslant \cdots \leqslant f(x_n)$. Fuzzy measure g_i represents the degree of importance of attribute x_i. Let $X_i = \{x_i, x_{i+1}, \ldots, x_n\}$, $i = 1, 2, \ldots, n$, the public attitude towards a public policy is defined as follows:

$$\begin{aligned} E(\{x_1, x_2, \ldots, x_n\}) &= (c)\int f(x)\,\mathrm{d}g \\ &= f(x_1)g(X_1) + [f(x_2) - f(x_1)]g(X_2) + \cdots \\ &\quad + [f(x_n) - f(x_{n-1})]g(X_n). \end{aligned} \tag{14}$$

Chen (1998) and Chen and Tzeng (2000) proposed the concept of "sufficient information", which contains all information concerning grades of importance, serving as the foundation for data collection. They showed that if the evaluation values of the aspects with attribute x_1 are already known, the importance information of all aspects will be covered. The design of sufficient information can contain all importance information and eliminate half of the data requirement for evaluations, but it is still difficult to collect the information with complexity $O(2^{n-1})$.Consequently, based on sufficient information, the authors further proposed a method to simplify the information demand and termed such information as "partial information". A sampling procedure of attribute aspects was developed to reduce the data requirement of fuzzy measure identification. Under partial information, the complexity of data requirement is $O(2^n/n)$.

From the comparison among complete, sufficient, and partial information, we know that the sampling procedure under partial information can significantly reduce the information demand of evaluation values and the investigation procedure is actually feasible in practice. Therefore, partial information will be most desirable if the solution exactness is only required to reach a satisfactory level.

Based on the partial information acquired by the sampling procedure, the authors further developed an identification procedure to determine the values of general fuzzy measures (Chen et al., 2000). Fuzzy integrals are not differentiable with respect to fuzzy measures. In addition, the problem size is extremely large and the interactions among attributes are very complicated. Thus, solving general fuzzy measures is cumbersome and strenuous. Therefore, based on partial information, Chen et al. (2000) applied genetic algorithms to develop a solution procedure as well as the detailed design for identifying general fuzzy measures.

According to the identification procedure, we use the effective evaluation of each sample aspect and the importance of each attribute to estimate the grades of importance for other attribute aspects. The public attitude towards a public policy can then be derived. Thus, we can realize the public attitude towards the public policy through attribute importance and fuzzy measure analysis. To show the applicability of our attitude analysis model, we applied the proposed method to the following empirical case: the promotion of the CNG taxi policy in Taipei City.

4. Empirical study

In order to realize the attitudes of the public in Taipei City towards the CNG taxi policy as well as their support for such policy, a questionnaire survey was conducted in Taipei City. The empirical results can be used to review and criticize the policy implementation. Next, we will illustrate the background of the gas taxi policy.

4.1. Problem background

In Taipei City, the average daily traveling mileage for each private vehicle is about 20–30 km, while for each taxi it is about 250–300 km, and for each bus it is about 138 km. Thus, the environment is more polluted by taxies than by other modes. If all of the 38 000 taxies in Taipei City replace gasoline with CNG in their combustion system, the reduction of pollution emission will be nearly equal to the emission of 0.4 million private vehicles (Bureau of Transportation, 1997). This will significantly improve the air quality of Taipei City.

In view of this, the municipal government of Taipei City has implemented subsidies for installing the gas combustion system since 1996. However, the explosion of a gas vehicle in Kaoshiung City brought fear to the public and seriously affected taxi drivers' willingness to conduct the replacement. From the viewpoint of the government, the issues of how to change the public's habitual thoughts and how to overcome the public's intense fears are important for implementing the CNG taxi policy. Therefore, the following empirical study will investigate the acceptance or rejection of the general public and taxi drivers in Taipei City towards the gas taxi policy. The results can be employed as references for policy administration.

4.2. Questionnaire design and investigation methods

In our questionnaire survey, respondents' socioeconomic and demographic characteristics included gender, age, marital status, education level, occupation, and average monthly income. The major questionnaire contents are elaborated as follows:

(A) *To the general public*:

(i) Investigate respondents' alternative transportation modes and the mode-used frequency.

(ii) Conduct a survey on the respondents about their habits for taking taxies, including their frequency of taking taxies, their experience of taking natural gas taxies, and their attitudes towards the CNG taxi policy.

(B) *To taxi drivers*:

(i) Ask the drivers whether their taxies are gas vehicles or not. If the answer is positive, they are asked further about the reason they have decided to change to the gas combustion system and their overall evaluation of gas vehicles.

(ii) If the taxies are not gas vehicles, then ask the respondents their reason for not employing the gas-powered system, and try to determine whether they reject gas vehicles or not.

(C) *To the general public and taxi drivers*:

(i) Investigate the subjective importance of each influential factor in the CNG taxi policy considered by the general public. The grade of importance is judged on a 7-possibility bipolar scale from −3 to 3, and the scores are labeled as unimportant to important. We determined seven influential factors related to the CNG taxi policy according to the relevant studies. These attributes include:

(a) welfare (x_1), referring to the improvement of air quality in the city;
(b) economy (x_2), referring to the gas-recharging cost of gas taxies;
(c) safety (x_3), referring to the degree of safety of gas taxies;
(d) prevalence (x_4), referring to the perception that the location of natural gas stations is widespread or not;
(e) operation (x_5), referring to the operation and maintenance costs of gas taxies;
(f) sustenance (x_6), referring to the sustaining distance of continuity (that is, the distance the vehicle can run between every gas-recharge) or the frequency of gas-recharging;
(g) efficiency (x_7), referring to the efficiency improvement of energy usage.

Let X be the discourse universe and $X = \{x_1, x_2, x_3, x_4, x_5, x_6, x_7\}$. Welfare and efficiency are the attributes concerning the fitness of the environment. Safety, operation, and sustenance are the attributes concerning the vehicle functions. Prevalence is to measure the auxiliary extent of relevant policies towards gas taxi promotion. The cost-related attributes are economy and operation.

(ii) Ask respondents to evaluate the performance of gas taxies with respect to each attribute. Furthermore, since it is likely that the respondents will not understand the performance of gas taxies towards a particular attribute, the respondents are requested to mark out their degrees of belief in order to demonstrate their certainty for their own evaluation values. The evaluation and degree of belief are also judged on a 7-possibility bipolar scale from −3 to 3, and the scores are labeled as bad to good and unlikely to likely, respectively. Then, we can derive the effective evaluation of each attribute aspect in the first aspect set.

(iii) Conduct the sampling procedure of attribute aspects under partial information. Then 17 sample aspects from the second to sixth aspect sets can be obtained, including $\{x_1, x_3\}$, $\{x_2, x_3\}$, $\{x_3, x_4\}$, $\{x_3, x_5\}$, $\{x_3, x_6\}$, $\{x_3, x_7\}$, $\{x_2, x_3, x_4\}$, $\{x_1, x_3, x_5\}$, $\{x_3, x_6, x_7\}$, $\{x_3, x_4, x_5, x_7\}$, $\{x_3, x_4, x_6, x_7\}$, $\{x_2, x_3, x_5, x_6\}$, $\{x_1, x_2, x_3, x_7\}$, $\{x_1, x_3, x_4, x_5, x_6\}$, $\{x_2, x_3, x_4, x_6, x_7\}$, $\{x_1, x_2, x_3, x_5, x_7\}$, and $\{x_1, x_2, x_3, x_4, x_5, x_7\}$. The sampling procedure of attribute aspects in detail can be found in the study of Chen and Tzeng (2000). Since we intend to use the effective evaluation to derive the grade of importance, we make an investigation on the evaluation of these 17 sample aspects.

(iv) Ask the respondents their opinion regarding the integral performance of gas taxies towards all attributes so as to appreciate their overall evaluation of gas taxies.

After collecting the required data, we can compute the following items, including the grades of importance for each attribute ($\hat{g}_i = g_i$ for $i \in [1,7]$), the effective evaluation of each single attribute aspect ($\hat{f}(x_i) = f(x_i)$ for $i \in [1,7]$), the effective evaluations of 17 sample aspects ($\hat{E}(\{x_1, x_3\})$, $\hat{E}(\{x_2, x_3\})$, $\hat{E}(\{x_3, x_4\})$, $\hat{E}(\{x_3, x_5\})$, $\hat{E}(\{x_3, x_6\})$, $\hat{E}(\{x_3, x_7\})$, $\hat{E}(\{x_2, x_3, x_4\})$, $\hat{E}(\{x_1, x_3, x_5\})$, $\hat{E}(\{x_3, x_6, x_7\})$, $\hat{E}(\{x_3, x_4, x_5, x_7\})$, $\hat{E}(\{x_3, x_4, x_6, x_7\})$, $\hat{E}(\{x_2, x_3, x_5, x_6\})$, $\hat{E}(\{x_1, x_2, x_3, x_7\})$, $\hat{E}(\{x_1, x_3, x_4, x_5, x_6\})$, $\hat{E}(\{x_2, x_3, x_4, x_6, x_7\})$, $\hat{E}(\{x_1, x_2, x_3, x_5, x_7\})$, and $\hat{E}(\{x_1, x_2, x_3, x_4, x_5, x_7\})$), and the overall evaluation ($\hat{E}(\{x_1, x_2, x_3, x_4, x_5, x_6, x_7\})$). Next, the grades of importance for other unknown aspects can be derived according to the abovementioned data (the identification procedure of general fuzzy measures in detail can be found in Chen et al.'s study). Then, we can compute overlap coefficients, degrees of overlap, and necessity coefficients to conduct the fuzzy measure analysis.

The investigation population in this study was the general public and taxi drivers of Taipei City. We employed choice-based stratified sampling to the general public, and the criterion of proportion allocation was based on the proportion of each alternative mode. The alternative modes included bus, mass rapid transit (MRT), train, taxi, private vehicle, motorcycle, and other modes. A total of 200 questionnaires were sent out and the retrieval rate was 100% since the interviews were conducted face-to-face. After removing incomplete questionnaires, we obtain 189 valid copies amounting to 94.5% of the total questionnaires retrieved.

Since taxi drivers are the primary group influenced by the CNG taxi policy, we decided to take an enriched sampling in order to grasp their response towards the policy. There was no definite rule in determining the sample size generally; thus, we tried to send out 200 questionnaires as well. However, it was very difficult to collect data during the pre-investigation period because of the poor cooperation by taxi drivers. Hence, we decided to cut down the sample size in order to reduce the difficulty in practice. A total of 100 copies of questionnaires were sent out and 91 valid copies were collected after the incomplete ones were eliminated, amounting to 91.0% of the total. Thus, a total of 280 valid questionnaires were acquired.

4.3. Empirical results

As for the general public, respondents' socioeconomic background statistics were as follows: male respondents amounted to 52% of the samples, while females were 48% of the samples. The highest age group proportion was 41%, 30–39 year old, seconded by 20–29 year old (38%). The unmarried rate is 58%. Most respondents received a college education. The occupations were mainly found to be public servants, students, or in the service and commercial industry. Their monthly incomes were NT$15,000–30,000 (35%) and NT$45,000–60,000 (27%).

In terms of taxi drivers, all samples in the investigation were male. The age distributions were 40–49 year old (37%), seconded by 30–39 year old (33%). The unmarried rate is 22%. Most interviewed taxi drivers had obtained a secondary education. Income distribution was NT$30,000–45,000. In addition, 91% of the drivers owned their vehicles, thus, most taxi drivers can make the decision to replace the gas combustion system by themselves.

The feasibility proportion of each alternative transportation mode for the general public is shown in Table 2. Ninety percent of the respondents consider bus as their ordinarily available mode, and 89% of the respondents take taxies as the available mode. In addition, motorcycle (63%) and private vehicle (45%) are the other feasible modes. Since the network of the MRT in Taipei City has not been completely finished, most respondents did not place MRT as their available transportation mode.

The ranking of mode-used frequency for the general public is listed in Table 2. We ask respondents to rank available modes according to the frequency, and the most frequent use is registered as 1, then the second one as 2, and so on. As indicated by the percentage, 43% of the respondents consider bus as the most frequented mode, seconded by motorcycle (36%), next private vehicle (11%), and then taxi (9%). As for the second most frequented mode reckoned by the respondents, the percentage of taxi ranks the highest (34%), followed by private vehicle (25%), bus (19%), and motorcycle (13%). With regard to the third most frequented mode, taxi tops with 31%, trailed by train (12%) and motorcycle (10%). As learned from the summarized results of the statistics, the respondents would most often take the bus and motorcycle as their modes. Furthermore, the respondents will most often resort to taxi as their alternative mode when their habitual mode is not available.

The proportion of respondents who have taken a ride with taxies more than six times a week amounts to 10%, while 38% for three to six times, and 52% for less than three times. It was learned that nearly half of the respondents were riding taxies with a frequency of three or more times per week. By virtue of the undistinguished external appearance between gas vehicles and gasoline vehicles, most respondents did not have any idea that they had taken a ride in gas vehicles. This explains why no respondents reported that they had experience riding in gas vehicles. However, when asked if they are ready to take such a ride with gas taxies, 43% of them replied negatively, 46% replied with

Table 2
Statistics of mode-used frequency for the general public

Type of transportation mode		Private vehicle (%)	Motorcycle (%)	Bus (%)	Mass rapid transit (%)	Taxi (%)	Train (%)
Available mode		45	63	90	5	89	32
Ranking of	1	11	36	43	1	9	0
mode-used	2	25	13	19	0	34	9
frequency	3	8	10	6	2	31	12

yes, while 11% did not show any preference. This indicates that half of the people remain reluctant to ride in natural gas vehicles.

About 20% of the taxi drivers interviewed had replaced their petroleum engines with gas combustion systems. The primary reason for replacement was to reduce their operating costs since the gas-recharging cost is lower than the refueling cost. Moreover, there are also government subsidies to taxi owners for the replacement. These gas taxi drivers have no experience with passengers' rejection of their vehicles as passengers may not know that these taxies are natural gas-powered. Most taxi drivers are not satisfied with the convenience of recharging since natural gas stations have not been widely established. On the other hand, half of the remaining taxi drivers who still drive gasoline vehicles express a lack of interest in gas vehicles because of the danger of a gas explosion, the limited number of natural gas stations, and the intrinsic advantages of gasoline vehicles. Nevertheless, among the taxi drivers with gasoline vehicles (80% of total), about 29% of those drivers are considering replacement in the future.

The investigated data about grades of importance and effective evaluation of the single attribute aspects are listed in Table 3. Here we have three sample types: the general public, taxi drivers, and the total sample. We observed that safety (x_3) is the most important attribute for all respondents from the table. of aspects in the first aspect set.

In order to compare the three sample types, we further represented their difference graphically in Figs. 1 and 2. Fig. 1 shows the investigated importance of the aspects in the first aspect set for the general public, taxi drivers, and the total sample. On the other hand, Fig. 2 indicates the effective evaluation of single attribute aspects for the distinct samples.

The most important attribute is safety (x_3), and its grade of importance reaches as high as 0.93 for the total sample (0.94 for the general public; 0.91 for taxi drivers). In general, the objectives related to survival and safety are essential for human beings, and these objectives are inborn drives of people's behavior. On the contrary, the objectives left outside of the survival and safety class belong

Table 3
Grades of importance and effective evaluations of aspects in the first aspect set

Aspect	Grade of importance			Effective evaluation		
	General public	Taxi drivers	Total sample	General public	Taxi drivers	Total sample
$\{x_1\}$: welfare	0.69	0.63	0.67	0.60	0.57	0.59
$\{x_2\}$: economy	0.40	0.81	0.53	0.53	0.54	0.53
$\{x_3\}$: *safety*	*0.94*	*0.91*	*0.93*	*0.38*	*0.42*	*0.39*
$\{x_4\}$: prevalence	0.70	0.74	0.71	0.49	0.43	0.47
$\{x_5\}$: operation	0.72	0.75	0.73	0.52	0.45	0.50
$\{x_6\}$: sustenance	0.60	0.69	0.63	0.53	0.47	0.51
$\{x_7\}$: efficiency	0.65	0.65	0.65	0.55	0.59	0.56

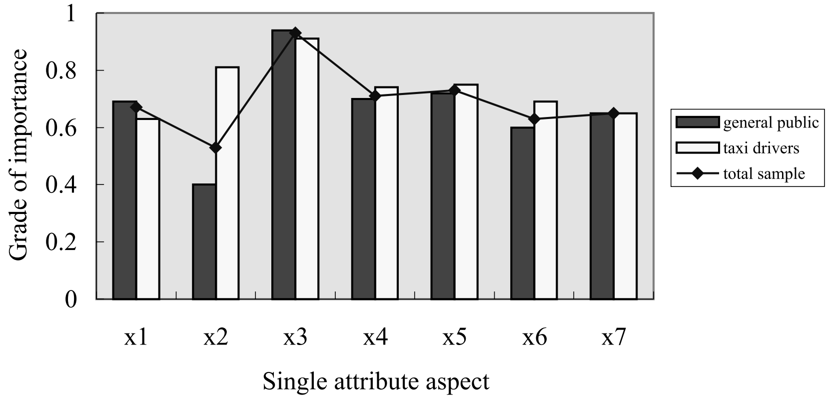

Fig. 1. Grades of importance of aspects in the first aspect set.

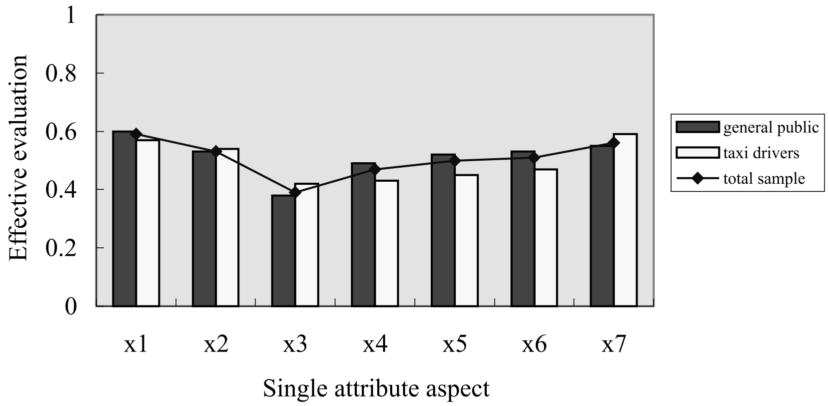

Fig. 2. Effective evaluations of aspects in the first aspect set.

to the category of self-suggestion, which is associated with post education learning, training, and experience (Yu, 1990). Unlike the objectives of self-suggestion that can tolerate large bias, the objectives of survival and safety exert severe and sensitive demands on the ideal or equilibrium condition. Thus, their acceptable bias is quite slim. Once any bias of objectives exceeds the tolerance value, people will make a rapid and obvious response. From the investigated result we know that the effective evaluation of gas vehicles in safety is lowest (only 0.39 for the total sample) among all attributes. Since the ideal condition of physiological objectives remains almost constant, the large difference of the ideal and actual values in safety creates tremendous pressure. Thus, it is clear that safety has aroused adequate attention and its importance is highest correspondingly.

Economy (x_2) is the least of the concerns of the general public and its importance is only 0.40. Since it provides no extra taxi rate benefit to the public, the incentive of lower gas-recharging cost does not encourage passengers. However, the reduction in recharging cost is a tremendous motivation to taxi drivers for the replacement. Economy is the second most important attribute for taxi drivers and its importance is 0.81. For the total sample, economy is least important because the valid questionnaires of the general public amount to 67.5% of the totality of questionnaires.

From Figs. 1 and 2, the ranking of importance and evaluation for different attribute aspects is similar among the general public, taxi drivers, and the total sample, except in the case of the "economy" aspect. The municipal government of Taipei City can hardly make a change to the gas-recharging price since the fare is always restricted and determined by the city parliament. Hence, the economy aspect has little influence on the formulation of promotional policies. In view of this situation, in the following we will combine the results of the 280 valid questionnaires for simplicity.

Most respondents consider that the operation and maintenance cost of vehicles are closely related to the function of the vehicle. Furthermore, vehicle function has a close relationship with safety. Consequently, operation (x_5) is the second most important attribute and its grade of importance is 0.73 for the total sample (0.72 for the general public; 0.75 for taxi drivers). In addition, many respondents show concern as to whether the location of natural gas stations is widespread or not: the importance of prevalence (x_4) is 0.71 for the total sample (0.70 for the general public; 0.74 for taxi drivers).

As for the objectives of public welfare, welfare (x_1) and efficiency (x_7) are ordinarily important and the grades of importance are, respectively, 0.67 and 0.65. Although most people nowadays have come to realize the importance of environmental protection, such an issue, somehow, does not receive special attention as it is only remotely related to individual interests. In addition, people do not seem to care about the improvement of energy usage because they believe that it is primarily a public issue for the government. It does not exert any discernible negative impact on them directly, even in the case of bad energy efficiency. Thus, welfare and efficiency remain short of being widely recognized by the respondents. This further indicates that the emphatic advantages of the reduction of air pollution and the improvement of energy usage with gas vehicles have not gathered common approval from the public. Therefore, we suggest that the notions of welfare and efficiency as they pertain to gas taxies can be excluded from focus of government publicity, while more focus should be made on safety, operation, and prevalence with which the public has indicated greater concern.

On the other hand, if the government insists that the public be educated to realize the reduction of social costs from the employment of gas vehicles, the government should take another approach. For example, the authorities can inform the public about the danger of increased likelihood of respiratory illness or other diseases if air pollution worsens continuously. Moreover, efficient usage of energy resources can largely reduce reliance on petroleum and even indirectly bring down the price of gasoline. In other words, if the authorities can publicize that welfare and efficiency are closely related to the objectives belonging to the categories of "survival and safety" and "sensuous gratification" (Yu, 1990), the public will positively support the CNG taxi policy.

Fig. 3 shows the contrast of grades of importance and effective evaluations for single attribute aspects. From this figure, it can be observed that the three most important attributes, safety, operation, and prevalence, received the worst evaluation values. In view of the fact that these highly regarded attributes performed unsatisfactorily, it is no wonder that half of the respondents are not willing to accept gas taxies. If the authorities cannot improve people's stereotypical image of gas vehicles in these three attributes, it will be difficult to induce the public to endorse gas vehicles prevalently. Therefore, we suggest that the government should focus its promotion on how to relieve the fear of the public rather than focus on the contributions of gas vehicles to welfare and efficiency. Furthermore, the authorities should further instruct taxi drivers on the proper operation and maintenance procedures for gas vehicles as well as

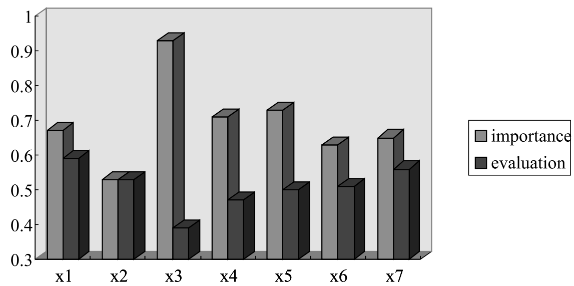

Fig. 3. Contrast of grades of importance and effective evaluations.

provide more locations to establish natural gas stations.

Based on the effective evaluations, the importance and overlap coefficient for each aspect in the second aspect set are derived as shown in Table 4. The overlap coefficient, m_{ij}, represents the degree of additivity of fuzzy measures between attributes x_i and x_j $(x_i, x_j \in X)$. It indicates the interactive relationship between attributes.

As can be seen from Table 4, the importance of x_3 and x_5 only reaches as high as 0.98, indicating that both safety and operation are absolutely important in the respondents' minds. It further indicates that people care about the attributes directly related to their survival and safety, and these attributes form the core of human habitual domains. The public attitude and actual decision behavior are thoroughly influenced by this core, and the core can be considered the actual domain at the decision time. If the government could capture the decision core of the public, it would not be difficult to induce people to accept and support the CNG taxi policy.

Furthermore, even if the other attributes are not found in the respondents' actual domains, they are still contained in the potential domains since their grades of importance are all positive. Hence, the government can turn to another approach: to transfer or extend the actual domain of the public. If the public can bring welfare and efficiency into their decision core, it will help establish the reachable domain beneficial for gas vehicles since the public gives the highest evaluation in welfare and efficiency. Under the reachable domain, it would be easy to bring down people's negative attitude towards gas taxies. However, since the degree of rigidity for habitual domains varies from person to person, it remains in controversy whether the actual domains of humans can be transferred or extended successfully.

Since the overlap coefficient only exhibits the interaction between two attributes, we further compute the average degree of overlap for each attribute to demonstrate the average overlap between an attribute and all other attributes. As shown in Table 5, the degree of overlap, η_i, of attribute x_i indicates the mean degree of overlap with regard to the information effect between x_i and the other six attributes. From Table 5, we know that the degrees of overlap for all attributes are smaller than zero, indicating that the effects provided by each attribute more or less overlap. In addition, there are higher degrees of overlap in welfare ($\eta_1 = -0.935$) and safety ($\eta_3 = -0.900$). In contrast, there are lower degrees of overlap in operation ($\eta_5 = -0.730$) and sustenance ($\eta_6 = -0.796$).

We can use the degrees of overlap and grades of importance to identify the degree of necessity, ξ_i, of attribute x_i, which expresses the necessity of x_i in the model structure. For example, if $\eta_j = -1$ (i.e., complete overlapping) and $g_j = 0$ (i.e., no impor-

Table 4
Grades of importance and overlap coefficients of aspects in the second aspect set

Aspect	Grade of importance, $g(\{x_i, x_j\})$	Overlap coefficient, m_{ij}	Aspect	Grade of importance, $g(\{x_i, x_j\})$	Overlap coefficient, m_{ij}
$\{x_1, x_2\}$	0.71	−0.925	$\{x_3, x_4\}$	0.95	−0.972
$\{x_1, x_3\}$	0.95	−0.970	$\{x_3, x_5\}$	0.98	−0.932
$\{x_1, x_4\}$	0.72	−0.985	$\{x_3, x_6\}$	0.96	−0.952
$\{x_1, x_5\}$	0.73	−1.000	$\{x_3, x_7\}$	0.94	−0.985
$\{x_1, x_6\}$	0.68	−0.984	$\{x_4, x_5\}$	0.87	−0.803
$\{x_1, x_7\}$	0.67	−1.000	$\{x_4, x_6\}$	0.72	−0.984
$\{x_2, x_3\}$	0.94	−0.981	$\{x_4, x_7\}$	0.73	−0.969
$\{x_2, x_4\}$	0.75	−0.925	$\{x_5, x_6\}$	0.85	−0.810
$\{x_2, x_5\}$	0.79	−0.887	$\{x_5, x_7\}$	0.77	−0.939
$\{x_2, x_6\}$	0.69	−0.887	$\{x_6, x_7\}$	0.70	−0.921
$\{x_2, x_7\}$	0.66	−0.981			

Table 5
Degree of overlap and necessity coefficient of each attribute

Attribute	x_1: welfare	x_2: economy	x_3: safety	x_4: prevalence	x_5: operation	x_6: sustenance	x_7: efficiency
Degree of overlap, η_i	−0.935	−0.831	−0.900	−0.841	−0.730	−0.796	−0.903
Necessity coefficient, ξ_i (comparative value)	0.691 (0.738)	0.609 (0.650)	0.937 (1.000)	0.756 (0.807)	0.803 (0.857)	0.705 (0.753)	0.684 (0.730)

tance), then $\xi_j = 0$, indicating that x_j provides redundant information. If $\xi_j = 1$, x_j is an absolutely necessary attribute. Thus, we can use the ξ value as a criterion for eliminating attributes. The maximal value of necessity coefficients can be selected from the attributes whose η values are negative. If ξ_j of attribute x_j is comparatively smaller than the maximal value, the degree of necessity of x_j is comparatively lower than all other redundant attributes. Let β be a threshold value. When the proportion of ξ_j to the maximal value is smaller than β, x_j can be eliminated. In other words, where $\eta_j < 0$, attribute x_j can be dropped if ξ_j satisfies the following inequality:

$$\frac{\xi_j}{\max\limits_{k;\eta_k<0} \xi_k} < \beta. \tag{15}$$

The value of the threshold, β, is obtained by the subjective judgment of researchers and the needs of various problem patterns. A threshold value of 0.7 was proposed by Onisawa et al. (1986), and the value can be cited in this study. From Table 5, we know that the comparative necessity value of x_2 is 0.650 (<0.7); thus, the economy attribute can be dropped.

From Table 5, safety, operation, and prevalence have the highest necessity coefficients. Because the three attributes enjoy not only the highest importance but also the greatest necessity in the model structure, the government should place more focus on them during publicity for the CNG taxi policy. For instance, the public should be informed that the natural gas vehicles have the same functions as gasoline vehicles. It also should be emphasized that qualified gas vehicles can be free from gas explosions, and the government will establish more natural gas stations as soon as possible.

In the seventh aspect set, the importance $g(\{x_1,x_2,x_3,x_4,x_5,x_6,x_7\}) = 1$ from the boundary conditions. In addition, the respondents' overall evaluation regarding gas taxies is 0.54 ($\hat{E}(\{x_1,x_2,x_3,x_4,x_5,x_6,x_7\}) = 0.54$) in average from the investigation results.

Summing up, in order to obtain the support of the general public and taxi drivers towards the CNG taxi policy, it is necessary for the government to change or to extend their decision core. In other words, the authorities should improve people's stereotype about gas vehicles to extend their habitual domains in favor of the gas taxi policy. Concerning the attributes with higher importance, if the public and taxi drivers can appreciate the safety of gas vehicles, it would be helpful to enhance their understanding and confidence regarding gas taxies. This can further facilitate taxi owners to adopt the gas combustion system. In addition, the authorities should educate gas taxi drivers about the operation and maintenance of gas vehicles so as to ensure safety. Moreover, the administration ought to search for more suitable locations to establish natural gas stations for gas recharging. Lastly, multimedia can be used to conduct the policy marketing to the public to ensure the expected outcome of related strategies. Once the public has established confidence in gas vehicles, the government can promote gas taxies smoothly to reduce the emission of air pollution, improve air quality, and enhance the efficiency of energy usage.

5. Conclusions

Public attitude is the core for implementing public policies, but so far, the conventional attitude models cannot clarify people's evaluation processes clearly because of the additivity and independence assumptions. Additionally, human decision behavior is deeply affected by their existing habits. Since habitual domains exist in human behavior, how to break (even extend) people's habitual thinking and induce the public to favor a policy becomes very important for the government. Therefore, this study used the theory of habitual domains to analyze the public's attitude towards public policies, and applied general fuzzy measures and fuzzy integrals to establish a public attitude analysis model. An empirical study for the CNG taxi policy in Taipei City was conducted to show the applicability of the proposed model.

The empirical results indicate that most respondents use buses and motorcycles as their habitual transportation modes. When the habitual modes are not available, the taxi is the major alternative mode for respondents. In addition, 43% of the respondents express that gas taxies are unacceptable, indicating that most people would be reluctant to ride in natural gas vehicles. Only a small proportion of the interviewed taxi drivers have already equipped their vehicles with the gas combustion system, while half of the rest adhere to their disapproval for gas vehicles.

From the analysis results, we know that safety, operation and prevalence of charging stations are the most important attributes. However, respondents deliver the lowest evaluation values for those attributes, so that half of the respondents do not support the CNG taxi policy. On the other hand, welfare and efficiency, though beneficial to the environment and society, do not receive as much attention as they deserve. Thus, the focus of the subsequent promotion activity should be placed on safety, operation, and prevalence rather than on welfare and efficiency. Furthermore, the authorities should also take action to eliminate people's fear of gas vehicles, instruct gas taxi drivers with proper operation and maintenance procedures, and provide more natural gas stations, so that the CNG taxi policy could be more widely accepted by the public.

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