Combining Importance-Performance Analysis with Analytic Hierarchy Process for Enhancing Satisfaction

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Abstract—**This paper aims to explain how to combine the importance-performance analysis (IPA) and the analytic hierarchy process (AHP) to make a better decision. We investigate the relevant relationships among the attributes for enhancing satisfactions on online education services by combining the methodologies of both IPA and AHP. In the course of estimating pair-wise comparisons among attributes, the back-propagation neural network is employed. As an empirical study, we consider how to manage the important attributes (or factors) for enhancing satisfactions on online education services. A questionnaire survey on satisfactions of online courses for Korean Scholastic Aptitude Test was conducted. IPA is a simple but useful technique to determine the status of attributes, but it does not indicate how each attribute should be treated to enhance a managerial goal. However, combination of IPA & AHP can answer the question of what to do with attributes to achieve a goal, which is satisfying customers in this paper. IPA and AHP are very powerful methods, respectively, but when combined, the effect is more than doubled. It is attempted to combine the two very useful methods, IPA & AHP, and the results indicate not only the current status of the attributes, but also the direction of them to achieve a goal.**

Index Terms—**Customer satisfaction, Decision making, Online education, Priority rating**

I. Introduction

Martilla and James (1977) first used market strategy developed and organized by IPA. IPA has since been widely used by various organizations over the years. The IPA technique is widely applied in general marketing research areas, such as tourism, hospitality, hotel, automobiles and environmental protection (Almanza, Jaffe, Lin, 1994; Chu, Choi, 2000; Duke, Persia, 1996; Evans, Chon, 1989; Hsu, Byun, Yang, 1997; Lee, Lee, 2009; Martin, 1995; Matzler, Fuchs, Schubert, 2004; Tonge, Moore, 2007). AHP is a simple yet powerful tool that was first developed within the management science field over 20 years ago (Saaty, 1980). It was studied to help managers make decisions that are more effective by structuring and evaluating the relative attractiveness or the priority ratings of competing attributes. The goal of this paper is to demonstrate how to combine IPA and AHP to figure out the priority ratings of competing attributes. To do this, we need pair-wise comparisons among attributes and the four quadrants to apply AHP. However, we assume that pair-wise comparisons are unavailable. This assumption is rather realistic, since no one knows how attributes will be located on four quadrants before IPA is actually done. Instead of direct pair-wise comparisons, back propagation neural network (BPNN) is used to estimate them. In this paper, we consider how to enhance customers' satisfaction with online education as an example to test the usefulness of the proposed method. We present some strategies based on IPA and AHP concerning this example. For instances, the *cost* of taking an on-line class is considered to belong in the *low priority* quadrant after IPA, but *cost* turns out to be a highly ranked attribute concerning customers' satisfaction. We could discover the various facts which could not have been discovered if only IPA had been performed.

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II. Proposed Method for Ordering Attributes after IPA

Once IPA is performed (Fig. 1), we consider the decision hierarchy. Like the one in Fig. 2, there are four criteria (quadrants) and five alternatives (attributes). We need pair-wise comparisons among (1) criteria (quadrants) and (2) alternatives (attributes) to carry out AHP. However, the conditions of this study require us to assume that pair-wise comparisons are unavailable. As an alternative to the explicit pair-wise comparisons, the following statistically inferred comparisons are proposed.

A. Local Priorities (Relative Weights) for Attributes

As previously stated, the information about pair-wise comparisons among the attributes is assumed unavailable. After IPA, fortunately we have the averages of the importance of each attribute belonging to each quadrant. We propose using the ratio of the averages of the importance of a pair of attributes in a quadrant, as the measure of the pair-wise comparison among the attributes.

B. Relative Weights among the Quadrants (Alternatives)

In addition to the priority ratings of attributes, we also need the relative importance or priorities of the criteria (i.e. the quadrant in this case) to calculate overall scores (rankings). However, we do not have a pair-wise

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comparison among the quadrants, so one may put weights on Q_I, IV, II and III in order, as IPA usually implicates. Of course, depending on the decision maker, a larger weight may be put on Q_IV than on Q_I. Without pair-wise comparisons from respondents, those weights are very subjective. We propose the methods for pair-comparisons that are more objective, as follows. We borrow the idea of the relative importance of input variables for the BPNN. We then define a multilayer perceptron with an input layer of four nodes and an output layer of one node. The input patterns for the input layer are (1, 0, 0, 0), if the attribute belongs to Q_I, (0, 1, 0, 0) for Q_II, (0, 0, 1, 0) for Q_III and (0, 0, 0, 1) for Q_IV and the corresponding output indicates the value of overall satisfaction. By performing a sensitivity analysis that computes the importance of each input variable in determining the neural network, we can obtain the importance of each quadrant in predicting overall customer satisfaction.

III. Example

Customer satisfaction with online learning for the Korean Scholastic Aptitude Test is considered. Evans and Haase (2001), Vincent and Ross (2001), and Wild et al. (2002) discussed the many needs associated with online learning, such as just-in-time training, economic and time benefits, readiness and availability.

A structured questionnaire was designed to measure attribute's importance and performance and the overall satisfaction. The attributes are (1) *accessibility*: you can study any time and any place; (2) *cost*: tuition and fees are affordable; (3) *text* : the text is readable; (4) *instructor* : the instructor is able; (5) *interaction*: interaction between instructors and students is possible. Students were asked to indicate both the importance and the performance for each attribute and their overall satisfaction using a five-point Likert scale with 1 (extreme low) to 5 (extreme high). Answers from 246 college students were collected by a self administered survey.

A. Attribute Positioning by IPA

Table I presents the descriptive statistics of importance and performance. The students consider instructor as the most important attribute and interaction as the attribute with the least performance. The gaps between importance and performance are all statistically significant with the exception of accessibility. The overall averages of importance and performance are 3.91 and 2.99, respectively. Based on IPA (Fig. 1), one has to concentrate on *text*, and to keep up the good work on instructor, but to put low priority on *cost* and *interaction*, and finally to consider accessibility being possibly over killed.

B. Attribute Positioning by AHP

- Step 1: Establishing a decision-making hierarchy

We consider the following hierarchy to optimize the goal, that is to satisfy customers (Fig. 3). We have four criteria (or strategies which are classified as four quadrants in our case) for satisfying customers. For each criteria (or quadrant), we have five alternatives to be rated (or prioritized).

- Step 2: Determining the relative ratings of alternatives (attributes)

The alternative (attributes) of the bottom of the hierarchy should be compared pair-wise with respect to the quadrants (criteria) in the upper level. Unfortunately, we do not have such information, but we do have the averages of the responses on importance. For example, in Q_I the averages of importance rating of *accessibility* and *cost* are 4.395 and 4.390, respectively. We define 1.001 (=4.395/4.390) as a pair-wise comparison of *accessibility* over *cost* with respect to importance. All other comparisons based on the averages for Q_I are listed in Table I and AHP gives us the relative weights (local priorities) among the attributes in Q_I (Table II). Similar calculations for Q_II ~ Q_IV were conducted. Table II lists the local priorities of the five attributes under the four quadrants.

We can notice that the relative weights (local priorities) are actually the relative averages of the attributes. In fact, .195 is the average of the importance of *accessibility* divided by the sum of the averages which is the relative average for *accessibility* in Q_I.

- Step 3: Determining relative weights (local priorities) for the quadrants (criteria)

We proposed three methods to obtain the relative weights for the quadrants: weighting by BPNN. Input patterns, such as (1, 0, 0, 0), (0, 1, 0, 0), (0, 0, 1, 0) and (0, 0, 0, 1), represent Q_I~Q_IV and the outputs correspond to overall satisfaction. With the help of SPSS 17, a network with four nodes in the input layer, four nodes in the hidden layer and one node in the output layer turns out the best result. It turns out that the relative weights (local priorities) for Q_1, Q_II, Q_III, and Q_IV are .322, .103, .326, and .249, respectively.

- Step 4: Determining the overall scores of the alternatives

The overall score are with respect to the attribute pair-comparison based on the averages (Table III).

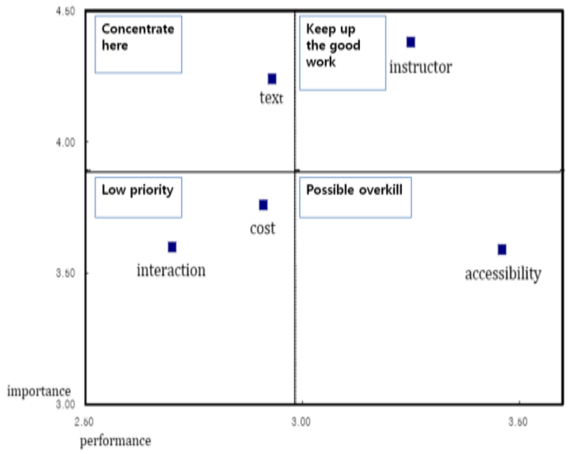

Figure 1. Five attributes of the importance-performance matrix

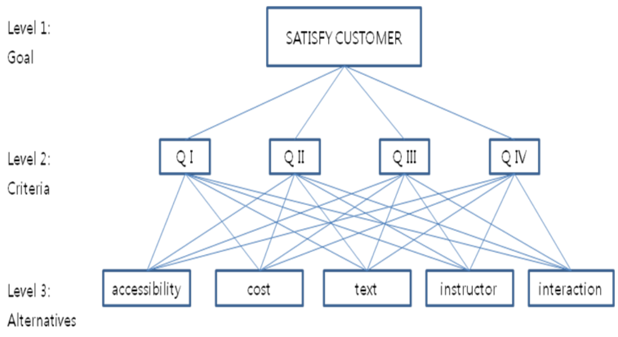

Figure 2. Decision hierarchy

TABLE I. JUDGMENTAL MATRIX BASED ON AVERAGES IN THE FIRST QUADRANT

	accessibility	cost	text	instructor	interaction
accessibility	1.000	1.001	.958	.949	.981
cost	.999	1.000	.957	.948	.980
text	1.043	1.045	1.000	.990	1.024
instructor	1.054	1.055	1.010	1.000	1.034
interaction	1.019	1.020	.976	.967	1.000

TABLE II. RELATIVE WEIGHTS (LOCAL PRIORITIES) OF THE ATTRIBUTES IN EACH QUADRANT

	accessibility	cost	text	instructor	interaction
Q_I	.195	.195	.204	.206	.199
Q_II	.195	.195	.201	.209	.199
Q_III	.173	.224	.231	.173	.198
Q_IV	.198	.197	.205	.210	.190

TABLE III. SUMMARY OF THE RELATIVE WEIGHTS (LOCAL PRIORITIES) AND RANKING

	accessibility	cost	text	instructor	interaction
BPNN Relative weights	.189	.205	.213	.197	.196
AHP ranking	5 (Q_IV)	2 (Q_III)	1 (Q_II)	3 (Q_I)	4 (Q_III)

IV. CONCLUSION

The five attributes related with satisfaction are ranked as *text* -> *cost* -> *instructor* -> *interaction* -> *accessibility* in order, based on the results of IPA and AHP. IPA is a simple but useful technique to determine the status of attributes, but it does not indicate in which way an attribute should be treated to attain the goals. IPA & AHP can be combined to remedy such drawback. In this article, the goal is to enhance customer satisfaction and the proposed method can answer the question of how to do deal with attributes to satisfy customers.

Rather than simply locating attributes on a two-dimensional grid, investigating the example of on-line instruction in Korea allowed us to understand how to address the attributes to best satisfy customers, as follows. (1) *Text* and *cost* are the most highly ranked and *accessibility* is ranked as the least important attribute in terms of enhancing customer satisfaction. *Text* is in Q_II by IPA and it is ranked as the first important attribute for customer satisfaction. It means that if a service provider concentrates on it, customer satisfaction may continue to follow. Text should be the primary focus of investment and improvement to enhance overall satisfaction. (2) *Cost* is the second most important attribute, although it is considered a low priority attribute according to IPA. It seems that *cost* is the key attribute related to dissatisfaction, in fact, the overall satisfactions in Q_III are relatively lower. The students, who desire a better grade on the aptitude test, are willing to pay a specified amount of money to register for an on-line class, even though it is expensive, but *cost* is a key attribute influencing dissatisfaction, when they are dissatisfied with service. *Cost* is low priority from the supplier's viewpoint but it may be a very important aspect in terms of a customer's viewpoint. (3) It is surprising to know that *instructor* is ranked third even though it is the one for which we should keep up the good work by IPA. A service provider should maintain good quality of instructors, however, the impact on satisfaction. is not as great as both *text* and *cost*.. *Instructor* is the primary attribute for which to keep up the good work, but it is not the primary attribute influencing satisfaction. (4) *Interaction* is in Q_III (low priority) and it is not that important attribute for satisfaction. *Interaction* is difficult to address due to the intrinsic nature of the internet or cyber system. It is better to admit that there should be a limit to communication with students through a computer system or cyber system. So, it is probably alright to put *interaction* attribute aside. (5) Korea is known as one of the top countries in the world in terms of having a high level internet infrastructure. A*ccessibility* has already been over-invested, and it contributes the least to enhancing satisfaction.

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