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A Dual Importance Diagram Approach to Evaluate Service Quality

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Abstract: Kano's model is a very useful tool to classify customer needs into different categories. It completely uses self-stated evaluations to classify the service quality. The disadvantages of self-stated evaluation are respondents often find it difficult to differentiate and respondents' answers may be influenced by social norms or political correctness. The derived evaluation approach uses a less direct way of uncovering the evaluations that are most reliable to reflect the respondents' view from the survey. The major drawback of the derived importance computed by multiple regression, structural equation modeling, or partial correlation is all based on linear assumption between each item and overall satisfaction. However, a non-linear effect between each item and overall satisfaction is often incurred in practice. To overcome this major drawback, a dual importance diagram based on generalized correlation is proposed to classify items into appropriate satisfaction factors by considering both linear and non-linear effects between items and overall satisfaction. A case of evaluating the service quality of a particular hospital is illustrated to show how this proposed dual importance diagram works to classify the service items into different types of Kano's categories. The result shows that using the generalized correction-based dual importance diagram is more practical in our case study.

Key words: Kano's model, dual importance diagram, mutual information, generalized correlation

INTRODUCTION

Kano's model which was proposed based on the two-factor theory of job satisfaction by Herzberg is a very useful tool to classify customer needs into different categories (Tontini, 2007; Wu and Pan, 2009). The traditional view of quality for a particular product or service is one-dimensional (linear), but in reality a product or service might induce a variety of distinct types of satisfaction or dissatisfaction depending upon whether customer needs are fulfilled completely, are met partially, or go unserved (Martensen and Gronholdt, 2001; Wang and Wu, 2009). According to Kano's model, customer requirements as shown in Fig. 1 can be classified into five categories (Gitlow, 1998; Kuo, 2004):

- **Must-be quality element:** Customers consider these requirements as prerequisites if present since these requirements are considered as the basic functions of a product or service. If these requirements, however, are not present, customers will be extremely dissatisfied
- **One-dimensional quality element:** Customer satisfaction is linearly proportional to one-dimensional quality element. Customers typically demand one-dimensional requirements explicitly

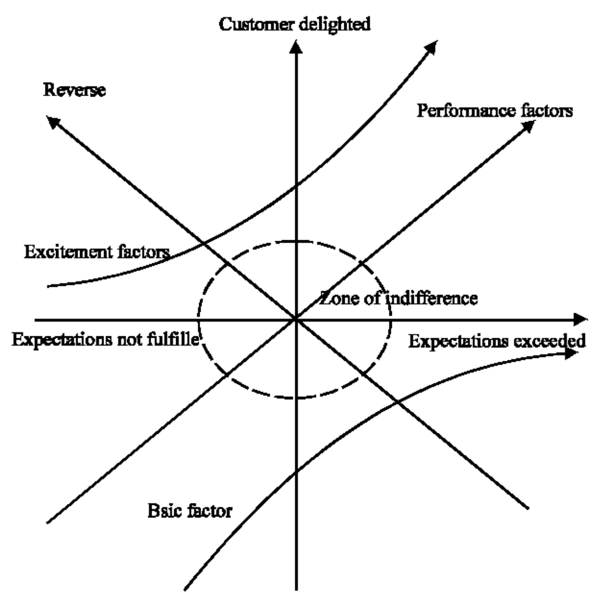

Fig. 1: Five major categories of customer requirements in Kano's model

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- **Attractive quality element:** Attractive quality elements are not demanded nor expected by customers. Thus, high level of attractive quality performance creates feelings of delight for a customer. In contrast, low level of performance creates feelings of indifference to the requirement since customers do not expect the element
- **Indifferent quality:** Customers will be indifferent if the quality element is present
- **Reverse quality:** Customers will be dissatisfied when the quality element is present and vice versa

Unlike the traditional survey approach, Kano's model uses a pair of questions to classify a product or service feature into an appropriate category by collecting the voice of the customer (Wu and Pan, 2009). A pair of question of Kano's model is as follows:

- How would you feel if this product or service feature were present?
- How would you feel if this product or service feature were not present?

For each question, there are six answers to choose from, namely (1) delight, (2) expect it and like it, (3) no feeling, (4) live with it, (5) do not like it and (6) other (Gitlow, 1998).

Kano's model completely uses self-stated evaluations to classify the service quality. The disadvantages of self-stated evaluation are respondents often find it difficult to differentiate and respondents' answers may be influenced by social norms or political correctness. The derived evaluation approach, by contrast, uses a less direct way of uncovering the evaluations that are most reliable to reflect the respondents' view from the survey. Vavra (1997) proposed a partial derived method, used self-stated importance and implicitly derived importance to form a two-dimensional importance grid, as shown in Fig. 2, to identify three satisfaction factors, including basic attributes, one-dimensional performance attributes with either high importance or low importance and exciting attributes (Matzler and Sauerwein, 2002). Thus, customer needs can be classified into three satisfaction factors, where the explanations of these three satisfaction factors are equivalent to those of Kano's model.

The self-stated importance is to ask each respondent to evaluate the importance of a particular item (feature) based on a Likert scale with five levels, while the derived importance is to derive the importance value based on performance evaluation for each item and overall satisfaction by such as multiple regression, structural equation modeling, or partial correlation (Deng *et al*., 2008). Two grids are required in order to classify each item into one of the three satisfaction factors. Compared with the traditional Kano's questionnaire, Vavra's (1997) approach only used one question for each item.

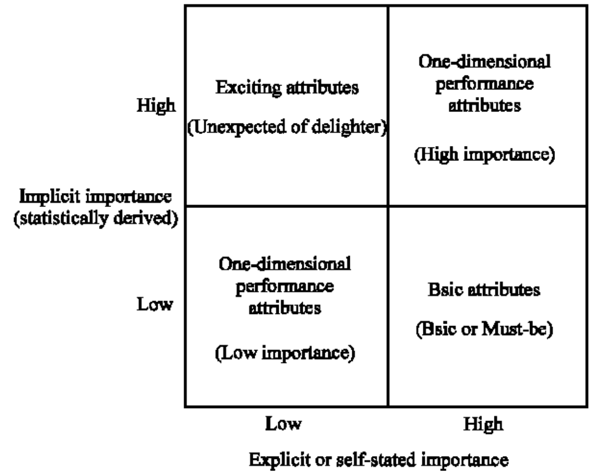

Fig. 2: Three satisfaction factors by explicit and implicit importance

The major drawback of the derived importance which computed by multiple regression, structural equation modeling, or partial correlation is all based on linear assumption between each item and overall satisfaction. However, a non-linear effect between each item and overall satisfaction is often incurred in practice. To overcome this major drawback, a dual importance diagram based on generalized correlation is proposed to classify items into appropriate satisfaction factors by considering both linear and non-linear effects between items and overall satisfaction. Specifically, when the performance questions were performed, the derived importance for each item can be calculated by generalized correlation between each item and overall satisfaction. A dual importance diagram can be constructed by self-stated importance and derived importance computed by generalized correlation.

PEARSON CORRELATION COEFFICIENT, MUTUAL INFORMATION AND GENERALIZED CORRELATION

Correlation is a statistical measure referring to the relationship between two random variables. It is a positive correlation when each variable tends to increase or decrease as the other does and a negative or inverse correlation if one tends to increase as the other decreases (Keller, 2005). Correlations are useful because they can indicate a predictive relationship that can be exploited in practice. Pearson correlation coefficient was introduced to measure the strength of the linear relationship between two variables. Other correlation coefficients have been developed to be more robust than Pearson correlation coefficient, or more sensitive to non-linear relationships (Croxton *et al*., 1973; Dietrich, 1973).

Shannon (1948) has introduced the concept of entropy to measure the uncertainty of a random variable, where a random variable with large entropy in its ratings is more important in a user's interest than a random variable with small entropy is depicted below (Yu *et al*., 2003). Given a discrete random variable X, let P^X be the probability of X, then define entropy of X to be h (x) = $-\Sigma P^x \log_2 P^x$, where, $P^x>0$. Entropy is computed for those states with the positive probabilities. For convenience, $-0^*\log_2 (0)$ is set to zero. Let Y be the overall satisfaction and the other items be X_i's in the questionnaire and assume the overall satisfaction is affected by random variable X_i's. When the relationship between overall satisfaction Y and random variable X_i's is known and to be non-linear, the philosophy of mutual information is introduced.

Mutual information is an ideal measure of stochastic dependence. A higher mutual information value shows a result of strong correlation, whereas a mutual information value of zero indicates uncorrelated variables (May *et al*., 2006; Shieh and Wu, 2008). Specifically, the mutual information MI (X, Y) between random variables X and Y measures the amount of information in X that can be predicted when Y is known. If X and Y are discrete, MI (X, Y) = h (X) + h (Y)-h (X,Y), where, h (X) is the entropy of X, h (Y) is the entropy of Y and h (X,Y) is the joint entropy of X and Y (Cover and Thomas, 2006).The joint entropy of X and Y is defined by the following equations (Cover and Thomas, 2006; Shieh and Wu, 2008):

$$h(X,Y) = -\sum_{x,y} P(x,y)\log_2 P(x,y), \quad (1)$$

where, P (x, y) is joint probability of each pair of possible outcomes (x, y). When we use the base 2 the units of entropy and joint entropy are in bits. When we use the base of the natural logarithms, e, the units of entropy and joint entropy are in nats. In this study, we use the base of the natural logarithms, e, to compute entropy and joint entropy.

Mutual information provides a well-defined and complete measure of correlation yielding the values in the range of [0, ∞), which is unfamiliar and has no obvious interpretation.

An interpretation in terms of a coefficient of non-determination, r_{MI}, which quantifies how well the best non-linear model can describe the data is developed below. r_{MI} is defined as $\sqrt{1-\exp^{-2\bullet MI(X_i,Y)}}$, where, MI (X, Y) is the mutual information between X and Y. To this aim, we generalize the above one-dimensional linear case for which the Pearson coefficient r directly allows this interpretation.

A DUAL IMPORTANCE DIAGRAM BASED ON GENERALIZED CORRELATION

A dual importance diagram based on generalized correlation is proposed below:

Step 1: Compute the importance value for each item. First, the importance value for each item is calculated by the average value from all respondents. In this study, a sample of size is 296. Thus, the average importance value for item i becomes $\Sigma x_{ij}/296$ where, x_{ij} is the importance value from 1 to 5 for j-th respondent in i-th item and i = 1, 2, ..., 25 and j = 1, 2, ..., 296

Step 2: Compute the derived importance value for each item based on its respective performance value. To calculate the mutual information MI (X, Y) between the performance value for each item X_i and overall satisfaction Y from the survey data where a Likert scale with five levels is applied to X_i and Y, first calculate P (X_i = a) for each item X_i with a = 1, 2, 3, 4 and 5. Let n_a be the number of the level a for X_i, then P (X_i = a) = n_a/296. Second, compute P (Y = c) with c = 1, 2, 3, 4 and 5. Let n_c be the number of the level c for the overall satisfaction Y, then P (y = c) =n_c (X_i)/296. Third, calculate P (X_i =a, Y = c) for each item. Let n_{ac} (X_i) be the number of the level a for item X_i and the level c for the overall satisfaction Y, then P (X_i =a, Y = c) =n_{ac} (X_i)/296. Repeat the process to compute P (X_i =a, Y = c) for the other items. Fourth, calculate MI (X_i, Y) by the formula of h (X_i) +h (Y)-h (X_i, Y) = (-ΣP (X_i = a) $\log_e$ P (X_i = a) + (-ΣP (Y = c) $\log_e$ P(Y = c)- (-ΣΣP (X_i = a, Y = c) $\log_e$ P (X_i =a Y = c)). Finally, compute the derived importance for each item X_i by the following formula $\sqrt{1-\exp^{-2\bullet MI(X_i,Y)}}$ and set the derived importance for each item X_i = derived_$impo_i$

Step 3: Assign a two-dimensional vector for each item. In this study, a set of 25 two-dimensional vectors is presented as ($impo_1$, derived_$impo_1$), ($impo_2$, derived_$impo_2$), ... and ($impo_{25}$, derived_$impo_{25}$)

Step 4: Plot dual importance diagram, where the vertical reference line L1 is drawn by the formula of x = (1/25) ($impo_1$ + $impo_2$ + ...+ $impo_{25}$) and the horizontal reference line M1 is depicted by the formula of y = (1/25) (derived_impo$_1$ + derived_impo$_2$ + ... + derived_impo$_{25}$). Plot these 25 vectors in dual importance diagram

A CASE STUDY

A case study of applying a dual importance diagram based on generalized correlation in Chang-Hwa Hospital, Department of Health is demonstrated in this section. The derived importance for each item was computed by generalized correlation between performance value for each item and overall satisfaction. The questionnaire was designed based on SERVQUAL model proposed by Parasuraman *et al.* (1988). There are 25 items, as shown in Table 1, in this study. Each respondent was asked to fill out both importance and performance for each item as well as the overall satisfaction of this hospital. For performance evaluation, the selections for each item include very dissatisfactory, dissatisfactory, neutral, satisfactory and very satisfactory which can be transformed into 1, 2, 3, 4 and 5, respectively, for numerical analyses. For importance evaluation, the selections also include very less important, less important, neutral, important and very important which can be transformed into 1, 2, 3, 4 and 5, respectively, for numerical analyses. The survey was taken among 310 patients or their families at Chang-Hwa Hospital, Department of Health from July 23, 2009 to August 7, 2009. A total of 296 valid questionnaires were received and the valid return rate was 95.5%.

The reliabilities of the survey measured by Cronbach's α were well above 0.89, which indicate the scales of the formal questionnaire have considerable reliability (Nunnally, 1978). The construct validity was supported by factor loading. The structure for performance questions in factor analysis went well with the structure of the questionnaire with the Kaiser-Meyer-Olkin statistic of 0.9576 and Bartlett's test of sphericity with χ^2 = 4631.9697 (p-value = 0.000). The structure for importance questions in factor analysis went well with the structure of the questionnaire with the Kaiser-Meyer-Olkin statistic of 0.9290 and Bartlett's test of sphericity with χ^2 = 4422.3223 (p-value = 0.000).Therefore, the construct validity of the questionnaire was good (Kaiser, 1974). In addition, Table 2 provides some demographic information such as gender, age, occupation, income and education in this survey.

To follow the proposed framework, the first step is to compute the average importance value by the formula of impo$_1$ = Σx_{ij}/296 for each item i. The average importance value for each item is summarized in Table 3. In step 2,

Table 1: Twenty-five questions in the survey

No.	Item
1	Image of social public service
2	Clear entrance signs
3	Convenience of parking
4	Warm and comfortable environment in the hospital
5	Tidy appearance of service personnel
6	Well-equipped medical equipment
7	Clear marked signs in the hospital
8	Feeling comfortable when services are provided
9	Trusted medical staff with professional competence of health care
10	Exact outpatient locations guided by service persounel
11	Medical staff with good communication skills
12	Outpatient waiting time for drug-picking
13	Nursing staff with immediate problem-solving abilities
14	Ease of use of the hospital reservation system
15	Outpatient waiting time for medical treatment
16	Processes of hospitalized services
17	Cordial attitude of service personnel
18	Caring attitude of medical staff
19	Medical staff with professional abilities
20	Detailed description of the patient's condition by the medical doctor
21	Feeling a sense of security when medical services are provided
22	Pharmacist's advices on taking medicine
23	Medicine preservation advices by pharmacists
24	Concern for individual needs by medical staff
25	Follow the trail of care regularly after being discharged from hospital

Table 2: The demographical information from the survey

Item	Classification	No. of times	Percentage
Age group	20 and below	54	18.20
	21-30	82	27.70
	31-40	58	19.6
	41-50	55	18.60
	51-60	34	11.50
	61 and above	13	4.40
Education	High school below	92	31.10
	High school	138	46.60
	Technological School	26	8.80
	University	37	12.50
	Graduate	3	1.00
Occupation	Service industry	91	0.31
	Physical labor	35	0.12
	Agricultural industry	20	0.07
	Business industry	14	0.05
	Government employee	72	0.24
	Student	64	0.22
	Other	91	0.31
Living location	Changhua City	122	50.20
	Changhua County	107	36.10
	Taichung City and Taichung County	57	19.30
	Yunlin City and Yunlin County	4	1.40
	Other	6	2.00
Gender	Man	152	51.40
	Female	144	48.60

first calculate P (X_i = a) for each item X_i with a = 1, 2, 3, 4 and 5, namely P (X_i = 1) = 27/296,P (X_i = 2) = 98/296,P (X_i = 3) = 162/296,P (X_i = 4) = 6/296 and P (X_i = 5) = 3/296. Second, compute P (Y = c) with c = 1, 2, 3, 4 and 5, i.e., P (Y = 1) = 21/296, P (Y = 2) = 103/296, P (Y = 3) =164/296, P (Y = 4) = 8/296 and P (Y = 5) = 0/296. Third, calculate P (X_1 = a, Y = c) for each a = 1, 2, 3, 4, 5 and c = 1, 2, 3, 4, 5. For example, P (X_1 = 1, Y = 1) = 11/296 = 0.0372. By the same method, we can compute joint probability of X_1 and

Table 3: Self-stated importance for 25 items

Item	Self-stated importance
1	1.7365
2	1.5507
3	1.4662
4	1.6723
5	1.6284
6	1.2804
7	1.5000
8	1.4561
9	1.4189
10	1.6723
11	1.4764
12	1.7095
13	1.4966
14	1.6622
15	1.5676
16	1.5946
17	1.5743
18	1.4088
19	1.3919
20	1.3041
21	1.4696
22	1.2838
23	1.3750
24	1.5642
25	1.6318

Table 4: Joint probabilities for item 1 and overall satisfaction at different levels

	Y = c				
X_1 = a	c = 1	c = 2	c = 3	c = 4	c = 5
a = 1	0.0372	0.0439	0.0068	0.0034	0
a = 2	0.0304	0.1723	0.1250	0.0034	0
a = 3	0.0034	0.1250	0.4088	0.0101	0
a = 4	0	0.0068	0.0101	0.0034	0
a = 5	0	0	0.0034	0.0068	0

Y at different levels. The results are summarized in Table 4. Repeat the process to compute P (X_1 = a, Y = c) for the other items. The value of h (X_1, Y) is 1.8453. The details of calculation are shown in Appendix 1. Fourth, calculate MI (X_1, Y) by the formula of

$$h(X_1) + h(Y) - h(X_1, Y) = \left(-\sum_{a=1}^{5} P(X_1 = a) \log_e P(X_1 = a)\right) + \left(-\sum_{c=1}^{5} P(Y = c) \log_e P(Y = c)\right) - \left(-\sum_{a=1}^{5} \sum_{c=1}^{5} P(X_1 = a, Y = c) \log_e P(X_1 = a, Y = c)\right)$$

= (-0.0912. Log_e(0.0912) -0.3311. $\log_e$(0.3311)-0.5473. $\log_e$ (0.5473) -0.0203. $\log_e$ (0.0203)-0.0101. $\log_e$ (0.0101) + (-0.0709. $\log_e$ (0.0709)-0.3480. $\log_e$ (0.3480)-0.5541. $\log_e$ (0.5541)-0.0270. $\log_e$ (0.0270)-0. $\log_e$ (0))-1.8453 = 0.1741. Repeat the process to compute MI (X_i, Y) for the other items. Finally, compute the derived importance for item X_1 by the following formula $\sqrt{1 - \exp^{-2 \bullet MI(X_1, Y)}}$. That is, X_1 = $\sqrt{1 - e^{-2 \bullet 0.1741}}$ = 0.5423. Set the derived importance for item X_1 equal to derived_impo$_1$. Repeat the process to compute the derived importance for the other items.

Table 5: Self-stated importance and derived importance for each item

Item	Self-stated importance	Mutual information	Derived importance
1	1.7365	0.1741	0.5423
2	1.5507	0.1722	0.5397
3	1.4662	0.1108	0.4458
4	1.6723	0.1298	0.4781
5	1.6284	0.1606	0.5241
6	1.2804	0.1792	0.5488
7	1.5000	0.1891	0.5612
8	1.4561	0.2164	0.5927
9	1.4189	0.1878	0.5596
10	1.6723	0.1921	0.5648
11	1.4764	0.1937	0.5667
12	1.7095	0.1552	0.5165
13	1.4966	0.2133	0.5893
14	1.6622	0.1618	0.5259
15	1.5676	0.2125	0.5884
16	1.5946	0.1772	0.5462
17	1.5743	0.1368	0.4893
18	1.4088	0.1614	0.5253
19	1.3919	0.1909	0.5634
20	1.3041	0.2469	0.6243
21	1.4696	0.1957	0.5691
22	1.2838	0.2017	0.5762
23	1.3750	0.1281	0.4754
24	1.5642	0.2218	0.5986
25	1.6318	0.2337	0.6110

Table 6: Classifications of 25 items

Item	Classification
1	Must-be
2	Must-be
3	One-dimensional
4	Must-be
5	Must-be
6	One-dimensional
7	Exciting
8	Exciting
9	Exciting
10	One-dimensional
11	Exciting
12	Must-be
13	Exciting
14	Must-be
15	One-dimensional
16	Must-be
17	Must-be
18	One-dimensional
19	Exciting
20	Exciting
21	Exciting
22	Exciting
23	One-dimensional
24	One-dimensional
25	One-dimensional

In step 3, this study has a set of 25 two-dimensional vectors, namely (1.7365 0.5423), (1.5507, 0.5397), … and (1.6318, 0.6110), where the first figure in the bracket is the self-stated importance and the second figure represents the derived importance for each item. Please refer to Table 5 for complete 25 two-dimensional vectors information. Step 4 is to plot dual importance diagram as shown in Fig. 3, where L1 is drawn by x = (1/25) (1.7365+ 1.5507+ … +1.6318) = 1.5157 and M1 is depicted by y = (1/25)(0.5423+ 0.5397+ … + 0.6110) = 0.5489. The results

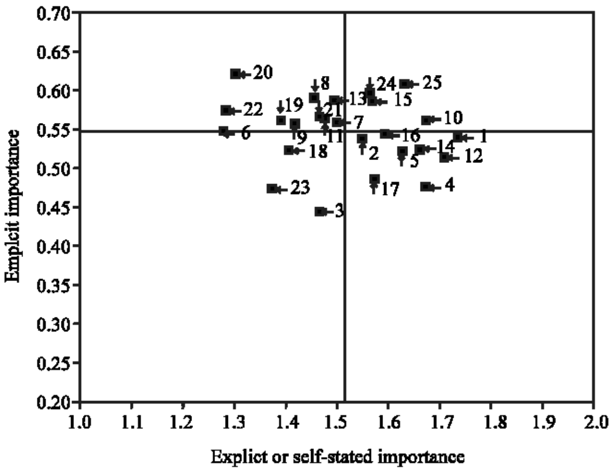

Fig. 3: The results generated by the dual importance diagram

Table 7: Comparing correlation and generalized correlation for each item

Item	Generalized correlation	Correlation
1	0.5423	0.5150
2	0.5397	0.4953
3	0.4458	0.2458
4	0.4781	0.4115
5	0.5241	0.4957
6	0.5488	0.5417
7	0.5612	0.5430
8	0.5927	0.5544
9	0.5596	0.5340
10	0.5648	0.5588
11	0.5667	0.5542
12	0.5165	0.4977
13	0.5893	0.5730
14	0.5259	0.5001
15	0.5884	0.5771
16	0.5462	0.5256
17	0.4893	0.4591
18	0.5253	0.4522
19	0.5634	0.5124
20	0.6243	0.6048
21	0.5691	0.5597
22	0.5762	0.5292
23	0.4754	0.4524
24	0.5986	0.5754
25	0.6110	0.5535

generated by this proposed generalized correlation-based dual importance diagram are summarized in Table 6. Specifically, items can be first classified into one of the four quadrants. Moreover, items can be further described into appropriate Kano's categories. In this study, items 7, 8, 9, 11, 13, 19, 20, 21 and 22 belong to exciting quality attributes; items 3, 6, 10, 15, 18, 23, 24 and 25 are one-dimensional quality attributes and items 1, 2, 4, 5, 12, 14, 16 and 17 are must-be quality attributes.

We also compute the correlation between each item and overall satisfaction. Table 7 summarizes and compare, the results computed by generalized correlation and correlation, where the non-linear effect between each item and overall satisfaction exists, particularly on item 3. This suggests there is a non-linear effect between item 3 and overall satisfaction. Therefore, the generalized correction-based dual importance diagram is more practical in this case study.

CONCLUSIONS

This study proposes the dual importance diagram with self-stated importance and derived importance to form a two-dimensional matrix by using generalized correlation-based derived importance to deal with the non-linear effect instead of only considering or assuming linear effects. Later, a case of evaluating the service quality of a particular hospital is illustrated to show how this proposed dual importance diagram works to classify the service items into different types of Kano's categories. Specifically, twenty-five items are classified into appropriate Kano's categories, including nine items in exciting quality attributes, eight items in one-dimensional quality attributes and eight items in must-be quality attributes. Moreover, comparing the generalized correlation and correlation, item 3 (convenience of parking) has significantly different results because there is a non-linear effect between item 3 and overall satisfaction. In fact, using the generalized correction-based dual importance diagram is more practical in our case study.

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APPENDIX

From Table 4, we can calculate h (X_1, Y) by the formula:

$$(-\sum_{a=1}^{5}\sum_{c=1}^{5} P(X_1 = a, Y = c)$$

$\log_e P(X_1 = a, Y = c) = -0.0372.\ \log_e(0.0372)-0.0439.\ \log_e(0.0439)-0.0068.\ \log_e(0.0068)-0.0034.\ \log_e(0.0034)-0.\ \log_e(0)-0.0304.\ \log_e(0.0304)-0.1723.\ \log_e(0.1723)-0.1250.\ \log_e(0.1250)-0.0034.\ \log_e(0.0034)-0.\ \log_e(0)-0.034.\ \log_e(0.034)-0.1250.\ \log_e(0.1250)-0.4088.\ \log_e(0.4088)-0.0101.\ \log_e(0.0101)-0.\ \log_e(0)-0.\ \log_e(0)-0.0068.\ \log_e(0.0068)-0.0101.\ \log_e(0.0101)-0.0034.\ \log_e(0.0034)-0.\ \log_e(0)-0.\ \log_e(0)-0.\ \log_e(0)-0.0034.\ \log_e(0.0034)-0.0068.\ \log_e(0.0068)-0.\ \log_e(0) = 0.1224+0.1372+0.0339+0.0193+0$

+ 0.1062 + 0.3030 + 0.2599 + 0.0193 + 0 + 0.0193 + 0.2599 + 0.3657 + 0.0464 + 0 + 0 + 0.0339 + 0.0464 + 0.0193 + 0 + 0 + 0 + 0.0193 + 0.0339 + 0 = 1.8453.

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