A Novel Social Media App Performance Evaluation Model

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Abstract

The performance evaluation matrix (PEM) is an effective method that uses data from customer feedback to evaluate a system's operations and to identify critical-to-quality items that need improvement in areas including e-commerce, social media sites, digital learning systems, and applications (Apps). Many studies show how PEM is able to improve an entire system's operating performance. Herein, we use a simple user-friendly questionnaire with a seven-point Likert scale to collect data, aligning the PEM evaluation standard with the idea that total quality management requires continuous improvement. In order to resolve this issue of sampling error in the questionnaire used to gauge customer satisfaction and importance, we introduce the confidence interval of the evaluation indices to perform statistical hypothesis testing. First, the study divides PEM into four evaluation zones according to the evaluation criteria. Second, based on the intersection formed by the confidence interval of the two indices, we use the locations where the points fall on the matrix to evaluate whether a service item needs improvement. Third, to make the best use of limited resources, we rank items that require improvement by level of priority. Fourth, to increase the convenience of utilizing PEM, this study designs an evaluation table and proposes rules for construction of the evaluation matrix diagram. Finally, as Instagram is one of the two largest social media applications with the most significant growth in users, we take it as a case study to demonstrate implementation of the proposed approach.

Keywords: Evaluation index; Confidence interval; Statistical test; Performance Evaluation Matrix; Social media App

JEL Classifications: C12, M11

1. Introduction

Lambert and Sharma (1990) use customer feedback data to establish a performance evaluation matrix (PEM) with the degree of satisfaction taken as the horizontal axis and the degree of importance taken as the vertical axis. Consequently, other studies have employed

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PEM as a tool to evaluate the performances of many industries (Ghosh et al., 2017; Chen and Chen, 2014; Hung et al., 2003; Wong, and Szeto, 2018). By observing where the points of satisfaction and importance of each key service-related criterion fall on the PEM diagram, managers can easily and quickly determine critical-to-quality (CTQ) items. However, conventional PEM approaches require a large amount of data on satisfaction and importance (Chen, 2009; Chiou et al., 2011; Hsia et al., 2009; and Feng, 2014), which may affect the willingness of customers to provide feedback and thus reduce evaluation accuracy. Therefore, Chen et al. (2012) suggest taking the correlation coefficient between customer satisfaction and total satisfaction as an influence index indicating the degree of importance to customers. Chen et al. (2012) establish a revised PEM by replacing the value for the degree of importance to a customer with the coefficients of the multiple regression model between satisfaction with individual items (independent variable) and total satisfaction (dependent variable). This revision reduces the required amount of data by 50% and also conforms to the concept of satisfaction, as Cronin and Taylor (1992) and Luo et al. (2012) note.

Aczel (2012) and Chen and Chen (2014) point out that other independent variables with high correlations impact the regression coefficients of multiple regression models, which clouds the impact of satisfaction with individual items on total satisfaction. Therefore, some studies have proposed using partial correlation coefficients instead of multiple regression coefficients to deal with the issue of collinearity (Deng, 2007; Deng et al., 2008; and Matzler et al. 2003). However, Chen and Chen (2014) believe that a high correlation between independent variables may influence the partial correlation coefficient, resulting in a smaller coefficient value. One solution is to apply a simple regression to avoid such interference between the independent variables.

The simple regression coefficient is in fact the ratio of the standard deviation of the dependent variable to the standard deviation of the independent variable multiplied by the correlation coefficient. A standardized simple regression coefficient therefore represents the correlation between a dependent variable and an independent variable. It is clear that the simple regression coefficient has a one-to-one mathematical relationship with the correlation coefficient. Therefore, this paper uses the correlation coefficient to replace the standardized simple regression coefficient as the influence index. Following the concept of standardization from Hung et al. (2003), this paper also defines the satisfaction index with a value between 0 and 1, representing complete dissatisfaction (0%) to complete satisfaction (100%).

Since the index contains unknown parameters, there is a probability of misjudgment due to sampling errors if only the sample points are estimated (Chen et al. 2017; Wang et al. 2015). In order to deal with this issue, we construct the confidence intervals between the influence index and the satisfaction index and unite them to form an intersection to replace sample points of PEM. According to Yu et al. (2018), this concurrently establishes the evaluation criteria and the concept of continuous enhancement in total quality management (TQM). To simplify the task of constructing the evaluation matrix diagram, we utilize an evaluation table and propose evaluation rules.

A wide range of service systems has applied PEM. Recently, the maturation of network technology and the sudden emergence of intelligent communication equipment have greatly increased the utilization rate of Internet technology. According to consulting firm InsightXplorer's (2018 and 2019) survey on the Internet's penetration rate among the population in Taiwan, its overall rate of usage increased from 81.7% in 2016 to 86.1% in 2018. In fact, the rate of Internet usage on smartphones hit as high as 82.8% in 2018. Among the more popular social networking applications (apps), Facebook has highest penetration rate among users, while Instagram has the most significant user growth rate (Smith and Anderson, 2018). Social media apps can be operated easily, relieve fatigue and stress, act as an integral channel of communication to connect people, and serve as important marketing tools. Therefore, this paper leverages an evaluation table based on PEM and the evaluation criteria mentioned above to evaluate the system operation performance of social media apps, identify the CTQ items that need improvement, and propose improvement strategies, all of which should help improve customer satisfaction with the system as well as usage efficiency.

The remainder of this paper runs as follows. Section 2 expounds on the applications of the theoretical foundations of Yu et al. (2018) and Chen et al. (2018) in guiding performance evaluation indices and interval estimation. Section 3 applies the performance evaluation indices and interval estimation in Section 2 to construct PEM to find CTQ items. Section 4 presents a case study of Instagram to illustrate the methodologies presented herein while providing analyses and conclusions. Section 5 summarizes the final conclusions.

2. Performance Evaluation Indices and Interval Estimation

Similar to Yu *et al.* (2018) and Chen *et al.* (2018) and in order to proceed without loss of the general principle, this paper assumes there are q numbers of items under investigation in a satisfaction survey. The number q+1 denotes the total satisfaction. This study uses random variables X_i to represent the degree of satisfaction with item *i* and random variable Y to indicate total satisfaction. We assume that the expected value of random variables X_i to be μ_i - that is, $E\left(X_i\right) = \mu_i$. Thus, we define the satisfaction index as follows.

Satisfaction Index:

$$\theta_i = \frac{\mu_i - 1}{R}. \tag{1}$$

When the survey applies a k-level scale, then R = k – 1. Obviously, $0 \le \theta_i \le 1$, i = 1,…, q. Based on Chen et al. (2018) and Yu et al. (2018), we define the influence index as follows.

Influence Index:

$$\rho_i = \frac{cov_i}{\sigma_i \sigma_Y}, \ i = 1,2,\ldots,q, \tag{2}$$

where σ_i is the standard deviation of satisfaction with item *i*; σ_Y is the standard deviation of total satisfaction; and $cov_i = E\left[\left(X_i - \mu_i\right)\left(Y - \mu_Y\right)\right]$.

Based on Chen (2019) and due to unknown parameters of the index, the estimate must be supported by sample data. We assume that $\left(X_{i1},...,X_{ij},...,X_{in}\right)$ is a set of sample data of random variables X_i with sample size *n*, and we then let $\bar{X}_i$ and S_i denote the sample mean and sample variance, respectively, as follows:

$$\bar{X}_i = \frac{1}{n} \times \sum_{j=1}^{n} X_{ij}, \tag{3}$$

and

$$S_i^2 = \frac{1}{n} \times \sum_{j=1}^{n} \left(X_{ij} - \bar{X}_i\right)^2. \tag{4}$$

If we let $\left(X_{i1},...,X_{ij},...,X_{in}\right) = \left(x_{i,1}, \mathrm{L}, x_{i,j}, \mathrm{L}, x_{i,n}\right)$ for $i = 1,2,...,q$ where x_{ij} is the observed value of random variables X_{ij}, then:

$$\theta_i^* = \frac{\bar{x}_i - 1}{R}. \tag{5}$$

Based on Yu *et al.* (2018) and according to the concept of continuous improvement in TQM, we let θ_0 be the mean value for all satisfaction indices, and therefore:

$$\theta_0 = \frac{1}{m} \sum_{i=1}^{m} \theta_i^*. \tag{6}$$

We now determine whether the satisfaction index of item *i* is less than the mean ($\theta_i < \theta_0$), equal to the mean ($\theta_i = \theta_0$), or greater than the mean ($\theta_i > \theta_0$). As such, we conduct the following hypothesis test.

$H_0 : \theta_i = \theta_0$ (null hypothesis)

$H_1 : \theta_i \neq \theta_0$ (alternative hypothesis)

Based on the set of sample data, we calculate the test statistic θ_i^* and let:

$$Z_i = \frac{\left(\theta_i^* - \theta_0\right)}{S_i / \sqrt{n} R}. \tag{7}$$

Here, Z_i is distributed as $N(0,1)$ for $n \to \infty$. Thus, we have:

$$1 - \alpha = P\left\{-z_{\alpha/2} \le Z_i \le z_{\alpha/2}\right\}, \quad = P\left\{-z_{\alpha/2} \le \frac{\left(\theta_i^* - \theta_0\right)}{s_i / \sqrt{n} R} \le z_{\alpha/2}\right\} = P\left\{L\theta_i \le \theta_i \le U\theta_i\right\}.$$

Here, $z_{\alpha/2}$ is the upper $\alpha/2$ quintile of $N(0,1)$, and:

$$U\theta_i = \theta_i^* + z_{\alpha/2} \times \frac{s_i}{\sqrt{n} R}, \tag{8}$$

and

$$L\theta_i = \theta_i^* - z_{\alpha/2} \times \frac{s_i}{\sqrt{nR}}, \tag{9}$$

where $U\theta_i$ and $L\theta_i$ are the upper and lower confidence limits of θ_i respectively. The test rule hence goes as follows.

(1) If $L\theta_i > \theta_0$, then reject H_0 and conclude that $\theta_i > \theta_0$.

(2) If $L\theta_i < \theta_0 < U\theta_i$, then do not reject H_0 and conclude that $\theta_i = \theta_0$.

(3) If $U\theta_i < \theta_0$, then reject H_0 and conclude that $\theta_i < \theta_0$ (improvement needed).

We similarly let $(Y_1,...,Y_j,...,Y_n) = (y_1,...,y_j,...,y_n)$, where y_j is the observed value of random variables Y_j. Next, we present the observed values of sample mean, sample standard deviation, and correlation coefficient as:

$$\bar{Y} = \frac{1}{n} \times \sum_{j=1}^{n} Y_j, \tag{10}$$

$$S_Y = \sqrt{\frac{1}{n-1} \times \sum_{j=1}^{n} \left(Y_j - \bar{Y}\right)^2}, \tag{11}$$

and

$$r_i = \frac{\sum_{j=1}^{n} x_{ij} y_j - n\bar{x}_i \bar{y}}{(n-1) s_i s_Y}. \tag{12}$$

As recommended by Chen et al. (2018) and Yu et al. (2016), when resources are limited and overall improvement is not possible, priority should be given to items according to their degree of influence. We therefore let r_0 be the mean of all influence indices and set up:

$$r_0 = \frac{1}{q} \sum_{i=1}^{q} r_i. \tag{13}$$

Suppose there are *m* items in need of improvement. According to the above-mentioned satisfaction test rule, set *NI* represents the set of all items in need of improvement. To determine whether the influence index of the item that needs improvement is less than the mean ($\rho_i < r_0$), equal to the mean ($\rho_i = r_0$), or greater than the mean ($\rho_i > r_0$), we conduct the following hypothesis test:

$H_0: \rho_i = r_0$ (null hypothesis)

$H_1: \rho_i \neq r_0$ (alternative hypothesis)

Based on Chen *et al.* (2018), we use the Fisher transform to let:

$$W_i = \tan^{-1}(r_i), \tag{14}$$

for $i \in NI$. Therefore, test statistical Z_i is distributed as $N(0,1)$ for $n \to \infty$, where:

$$Z_i = \sqrt{n-3}\left(\tan^{-1}(\rho_i) - \tan^{-1}(r_0)\right), \tag{15}$$

while W_i is distributed as $N\left(\tan^{-1}(\rho_i), \frac{1}{n-3}\right)$ when the null hypothesis is true. Thus, we have:

$$1-\alpha = P\{-z_{\alpha/2} \le Z_i \le z_{\alpha/2}\} = P\left\{-z_{\alpha/2} \le \sqrt{n-3}\left(\tan^{-1}(\rho_i) - \tan^{-1}(r_0)\right) \le z_{\alpha/2}\right\}$$
$$= P\{L\rho_i \le \rho_i \le U\rho_i\}.$$

Here, $z_{\alpha/2}$ is the upper $\alpha/2$ quintile of $N(0,1)$, and:

$$L\rho_i = \tan\left(\tan^{-1}(r_i) - \frac{z_{\alpha/2}}{\sqrt{n-3}}\right), \tag{16}$$

and

$$U\rho_i = \tan\left(\tan^{-1}(r_i) + \frac{z_{\alpha/2}}{\sqrt{n-3}}\right). \tag{17}$$

Obviously, the 100($1-\alpha$)% confidence interval of ρ_i is:

$$[L\rho_i, U\rho_i] = \left[\tan\left(\tan^{-1}(r_i) - \frac{z_{\alpha/2}}{\sqrt{n-3}}\right), \tan\left(\tan^{-1}(r_i) + \frac{z_{\alpha/2}}{\sqrt{n-3}}\right)\right].$$

The test rule thus runs as follows.

(1) If $L\rho_i > r_0$, then reject H_0 and conclude that $\rho_i > r_0$ (improvement priority).

(2) If $L\rho_i < r_0 < U\rho_i$, then do not reject H_0 and conclude that $\rho_i = r_0$.

(3) If $U\rho_i < r_0$, then reject H_0 and conclude that $\rho_i < r_0$.

3. Performance Evaluation Matrix

As noted by Yu et al. (2018), index θ_i falls between 0 and 1. On the other hand, based on a theoretical perspective, $-1 \le \rho_i \le 1$ (Wang et al., 2015; Chen et al., 2019), but in fact, $0 \le \rho_i \le 1$. Yu et al. (2018) use satisfaction index θ_i as the horizontal axis and influence index ρ_i as the vertical axis to establish a PEM and the evaluation criteria by which to evaluate the degree of satisfaction with items. Figure 1 illustrates this approach.

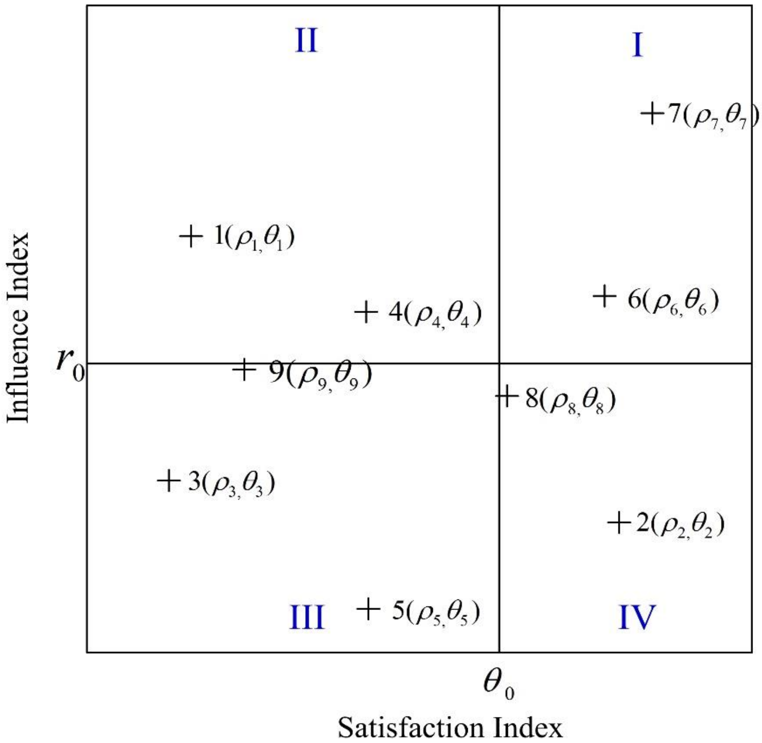

Figure 1: Performance Evaluation Matrix (PEM)

Before constructing the evaluation criteria for PEM, we first let events:

$$E_{ix} = \left\{ \left(x, r_i \right) \middle| L\theta_i \le x \le U\theta_i \right\}, \tag{18}$$

and

$$E_{iy} = \left\{ \left(\theta_i^*, y \right) \middle| L\rho_i \le y \le U\rho_i \right\}. \tag{19}$$

Furthermore, we let event $E_i = E_{ix} \cup E_{ix}$ represent an evaluation event, L_θ represent the vertical line $x = \theta_0$, and L_ρ represent the horizontal line $y = r_0$. Based on the test rule of satisfaction index θ_i and influence index ρ_i, the PEM's evaluation rule is as follows.

(1) If $E_i \cap L_\theta \ne \phi$ or $L\theta_i > \theta_0$, then item *i* does not need improvement and the priority of item *i* is 0.

(2) If $E_i \cap L_\theta = \phi$ and $U\theta_i < \theta_0$, then item *i* needs improvement and its priority level is as follows.

a. If $L\rho_i > r_0$, then the priority of item *i* is 1.

b. If $L\rho_i \leq r_0 \leq U\rho_i$, then the priority of item *i* is 2.

c. If $U\rho_i < r_0$, then the priority of item *i* is 3.

4. Case Study

This paper utilizes the modified Instagram service quality questionnaire (IG-S-Qual), which is based on the ES-QUAL questionnaire proposed by Parasuraman et al. (2005), to collect user satisfaction data from this well-known social media app. IG-S-Qual measures the following four dimensions: efficiency, reliability, privacy, and responsiveness. For questionnaire details, see Table 1.

The questionnaire employs a seven-point Likert scale to investigate users' satisfaction with Instagram's service items, ranging from (1) very dissatisfied to (7) satisfied. The questionnaire was administered to online users without restrictions. In total, 1,802 questionnaires were received, of which 167 were considered non-viable, because over half of their data were missing. The 1,635 viable questionnaires make up an effective response rate of 90.7%. Among the viable samples, 38.6% are male. Participants between the ages of 10-19 years represent 21.7% of the sample; 46.2% are between 20-29 years; and 14.5% are between 30-29 years. The age group of 40-49 years old is 12.4%, and the age groups of 50-59 and over 60 years old are the smallest at only 3.6% and 1.7%, respectively.

In terms of reliability, the overall Cronbach's value of the satisfaction questionnaire is 0.897, which we obtain through SPSS statistical software. This indicates that the scale has good reliability (DeVellis, 2003). In terms of validity, we conduct confirmatory factor analysis (CFA) with LISREL statistical software. For the degree of satisfaction questionnaire, CFI = 0.96, GFI = 0.91, and SRMR = 0.05. These and all other indicators are above the acceptable level. In summary, the sample data show good reliability and validity.

This study analyzes 535 viable questionnaires, calculates the satisfaction indices θ_i and influence indices ρ_i of each item, and then obtains the confidence intervals of satisfaction indices θ_i and influence indices ρ_i of each item. The lower limit of confidence $L\theta_i$ and the upper limit of confidence $U\theta_i$ of the satisfaction index and the lower limit $L\rho_i$ and upper limit $U\rho_i$ of the influence index represent the confidence intervals. To perform the analysis, we take the aforementioned evaluation rules and the intersection drawn out according to the confidence intervals of the two indices for each question item as well as the position at which points fall on PEM. Table 1 present the relevant data.

Table 1A: PEM for the Instagram Case Study

Dimension	Item	$L\theta_i$	θ_i	$U\theta_i$	$L\rho_i$	ρ_i	$U\rho_i$	Priority
Efficiency	1. The search function provides card categorization.	0.734	0.742	0.750	0.357	0.413	0.471	0
	2. The post has “My Collection”.	0.790	0.798	0.807	0.352	0.408	0.465	0
	3. The social media app distinguishes between “Friends” and “Acquaintances”.	0.732	0.742	0.752	0.305	0.359	0.415	0
	4. The social media app meets the needs of users.	0.748	0.757	0.766	0.418	0.477	0.538	0
Reliability	5. The social media app allows for reorganization to see the latest posts from followers.	0.770	0.780	0.790	0.265	0.318	0.372	0
	6. The social media app provides event log information.	0.651	0.661	0.671	0.353	0.409	0.467	2
	7. The social media app provides post reminders for followers.	0.707	0.717	0.727	0.338	0.393	0.450	0
	8. The social media app’s search function allows users to find desired pictures and videos.	0.753	0.762	0.771	0.388	0.445	0.504	0
Privacy	9. The social media app provides dynamic content for a limited time and disappears automatically after 24 hours.	0.734	0.743	0.752	0.358	0.414	0.472	0
	10. The social media app provides the last time online.	0.677	0.689	0.701	0.254	0.306	0.360	3
	11. Each time the social media app posts content, it allows the user to select privacy settings.	0.628	0.641	0.654	0.187	0.237	0.289	3

Table 1B: PEM for the Instagram Case Study

Dimension	**Item**	$L\theta_i$	θ_i	$U\theta_i$	$L\rho_i$	ρ_i	$U\rho_i$	**Priority**
Privacy (cont')	12. The social media app provides a private account that restricts the viewability of posts to a user's followers.	0.744	0.755	0.766	0.365	0.421	0.479	0
Responsiv-eness	13. The social media app developers can receive and review user comments.	0.750	0.759	0.768	0.308	0.362	0.418	0
	14. The social media app protects user accounts.	0.813	0.822	0.831	0.380	0.436	0.495	0
	15. The social media app continuously updates its software.	0.734	0.744	0.753	0.369	0.426	0.484	0
	16. The social media app allows users to report usage problems.	0.679	0.689	0.699	0.410	0.468	0.529	1
	17. The social media app developers respond to user questions in a timely manner.	0.617	0.628	0.638	0.340	0.395	0.452	2
	18. The social media app developers provide multiple channels for users to give feedback on system problems.	0.648	0.659	0.669	0.411	0.469	0.530	1

From Eq. (6), we calculate $\theta_0 = 0.727$. As shown in the table above, if $U\theta_i < \theta_0$ (0.727), then we reject H_0 and conclude that $\theta_i < \theta_0$ (improvement needed). Therefore, $U\theta_i$ values for items 6, 10, 11, 16, 17, and 18 are below the satisfaction index mean value, and hence these items should be improved. Owing to limited resources, we use the evaluation criteria of influence index ρ_i to prioritize the items. From Eq. (13), we calculate $r_0 = 0.398$; because $L\rho_i > r_o$, we mark the first priority of items 16 and 18 by "1"; if $L\rho_i \le r_o \le U\rho_i$, then we mark the second priority of items 6 and 17 by "2" ; when $U\rho_i \le r_o$, we mark the third priority of items 10 and 11 by "3".

5. Conclusion

This study sets up the satisfaction index as the horizontal coordinate and the influence index as the vertical coordinate to establish a performance evaluation matrix (PEM). Following the concept of the continuous improvement of total quality management and using the mean estimated values of these two indices as the evaluation criteria, we determine about 50% of the items below the mean satisfaction index need improvement. Next, to maximize the use of limited resources, we rank the items in need of improvement based on the evaluation criteria. As drawing an evaluation matrix can be a complex task, this paper designs a performance evaluation table to replace point estimation by joining the confidence intervals of two indices and then proposes evaluation rules based on the concept of the above evaluation matrix in order to deal with the risk of misjudgment caused by sampling error. In addition, we present the ranking of items in the "priority" column and apply the proposed approach to a case study of Instagram, one of the two major social media applications worldwide.

Our designed survey has a total of 19 question items, including a question on overall satisfaction (therefore, q = 18). Based on the evaluation rules proposed in this paper, we identify items 6, 10, 11, 16, 17, and 18 as in need of improvement. Lastly, we rank items 16 and 18 as first priority, items 6 and 17 as second priority, and items 10 and 11 as third priority.

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