MULTIATTRIBUTE CONTROL CHART FOR CUSTOMER SATISFACTION MEASUREMENT

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Abstract

This article deals with the problem of measuring and controlling customer satisfaction. In literature most of the proposed methods are carried on the basis of questionnaires focused on the gap between the Perceived and the Expected Quality. This paper introduces the use of multiattribute control chart for the measurement of customer satisfaction. This approach allows a simultaneous evaluation of the different characters of the service and the overall quality dimension. The advantage of this procedure is to avoid the synthesis of the charts for each quality dimension, using a multiattribute chart.

Keywords: service quality control, perceived quality, expected quality, multiattribute control chart.

1. INTRODUCTION

Customer satisfaction may be studied in order to supply two kinds of services (Gori & Vittadini, 1991; 1999). On one hand there are services like education, attendance, culture, health, etc., where the definition of quality is not verifiable before the supply of the service, because of personal characteristics which interfere with the results of the process.

On the other hand there are services like transportation, telecommunication, etc., where the quality is verifiable before the supply of services. In this case the nature of the service is the same for all the customers because it doesn’t depend on their personal features.

Concerning the specific competences and activities, there are three kinds of aspects which are interesting to deal with the quality assessment of the service as follows: a) the users of the services, b) the units that provide the service, c) the corporations or organizations that are institutionally competent about the evaluation of the productivity of the units.
In particular the units b) and the subjects c) may be interested in the extend of the relative efficiency therefore the assessment of the same process should be supplied by different units. The relative efficiency of the service can be obtained by means of comparison between the units or with an *a-priori* standard.

The quality control is carried on the total process. It starts from the “input” evaluation and finishes with the “outcome” evaluation. The service efficiency is the result of the evaluation of several factors linked to: 1) the resources and the managerial abilities employed by the units; 2) the characteristics of the context where the units operate; 3) the users personal abilities, their economic status, etc, because of the interaction with the process in some kind of services.

The evaluation of the performance of units that produce services may be analysed by means of statistical multivariate methods that highlight dependency among variables or by means of descriptive methods. Indexes are simple indications of actions or situations to estimate.

They estimate all the aspects of the activity (Stiefel, 1997), and they are codified in order to attribute objectivity, or to reduce subjectivity (Wilson, 1992).

The indexes represent the synthesis of the productivity process and they have to possess some well-known fundamental requirements. The results, which are produced by the units that supply services, can be defined through a variety of indexes that consider the following elements: a) the characteristics of the customers that receive the service; b) the characteristics may affect the productivity process; c) the entity of the resources employed by the units.

Methods of customer satisfaction are generally based on the use of questionnaires where the definition of services quality is connected to the measurement of the gap between Expected Quality and Perceived Quality.

The most important methods are: “Servqual”, “Normed Quality”, “Servperf”, “Two-way” and “Qualitometro” (Cronin & Taylor S.A. 1994, Franceschini & Rossetto S., 1998 a,b).

More recently methods based on control chart have been proposed. As it is well known, control charts have their main use in the evaluation of industrial production quality.

In this paper we analyze a way to control service quality using a particular control chart. We propose the use of a multiattribute scheme approximation in order to evaluate the quality service attributes.

This approach allows a simultaneous evaluation of the different characters of the service and the overall quality dimension.

The method is characterized by the synthesis of the final dimensions of the quality service.
In the second paragraph the features of customer satisfaction models are analysed, in the third paragraph we recall the control chart applications in service quality and customer satisfaction domain.

In the fourth paragraph we introduce the multiattribute control chart and the related control limits.

Finally, in the last section some conclusive remarks are discussed.

2. CUSTOMER SATISFACTION FEATURES

The theme of services quality evaluation is more and more perceived from the units that operate in this field (Oliver, 1981; Teas, 1993). There are many problems to face related to the customer satisfaction assessment. The service characters to measure are immaterial and their aggregation imposes the respect of the hypothesis of homogeneity concerning the reference systems. The quality measurements have multidimensional characters and their attributes are not equally important, so, usually, it is necessary to assign some weights to each variable. Moreover, every customer has his own reference system, and this creates some conceptual problems in the aggregation of the data coming from several customers.

The assessment of the service performance is expressed in measure scale that is necessarily of ordinal type, this involves problem of comparability. Such aspect is often neglected in the application of the techniques of multidimensional data analysis, as a matter of fact, they deal these scale like a quantitative scale.

A generalized way to carry out customer satisfaction implies the measurement of some service parameters. To measure these parameters the consumers express ex ante an ideal or expectations score of the service and, after the service, they express ex post an experienced or perceptions score. Customer’s satisfaction is measured through the gap between perceptions and expectations; the importance of attributes is established by weighting the service dimensions. In order to complete the analysis, the respondent is often asked to specify its own personal characteristics, like the social-professional position, age, and gender.

The aggregation of subjective evaluations creates some problems linked to the global “trend” estimation of the investigated system and to the introduction of some criteria of judgement. The main problems are:
1) To deal with subjective evaluations and, accordingly, with ordinal scale of measures;
2) To include the weights expressed by the customers on the importance of attributes.

In literature there are several customer satisfaction models, each of them has
some particular characteristics. “Servqual”, “Normed Quality”, “Servperf”, “Two-way” and “Qualitometro” have been proposed for the study and the evaluation of customer satisfaction. They are connected to the gap theory between Expected Quality and Perceived Quality, the information is drawn from the questionnaires. It is crucial to take into account the different scale of variables measurement and their weights when the discrepancy between the evaluation of Expected Quality and Perceived Quality has to be evaluated. These models submit to evaluation the determinants of the service quality introduced by the Parasuraman, Zeithaml and Berry model (1988, 1991). The determinants to be examined are: “Tangibles”, “Reliability”, “Responsiveness”, “Assurance” and “Empathy”.

They represent five dimensions considered both for expectation and perception evaluations and for the expectation and perception weights.

The step of aggregation of data that refer to the single respondent imposes that the homogeneity of the system of reference is respected. Further problem derive from the improper use of the judgments expressed on the questionnaires, as the measure scale is necessarily of ordinal type; this excludes comparability, even if elaborations often consider them like quantitative scale.

Several studies show that, from the psychometric point of view, it is not exhaustive to concentrate attention on the discrepancy between the ex-ante and ex-post evaluations only, since it is not related to different item/dimensions importance. It is necessary to improve the analysis by weighting the items of the questionnaire. Further improvements of the analysis and of its interpretation are obtained with additional information on the interviewed individuals.

The real application of every customer satisfaction model based exclusively on the difference between scores is object of a wide debate. This occurs mainly for psychometrics reasons; particularly, when such discrepancies are elaborated through multivariate analysis. In order to catch up an high explicative ability, it would be necessary to consider the discrepancies, the common characteristics and the relations between the two evaluation scores of the Expected and of the Perceived Quality. An important goal is to observe how the evaluations expressed in the former score may influence the latter and the contrary. The scales of score used in “Servqual” model are of differential semantic type and, however, they are treated as interval scales. (Zanella, Cerri, 1999).

3. CUSTOMER SATISFACTION AND CONTROL CHARTS

Customer satisfaction methods based on questionnaire accordingly to the “disconfirmation paradigm” scheme by Parasuraman, Zeithaml and Berry are
discussed in this section.

Some of these procedures allow the evaluation “on line” of the gap between Expected Quality and Perceived Quality. The instruments proposed to measure the variables of the questionnaires are the multi-item scale “Servqual” and “Servperf”. Their common characters are linked to the problem of quantifying the qualitative data, for that, it is necessary to assume that the customer preferences possess the linear interval properties. If this assumption is not accepted, the measure meaning is modified. The assessment depends on the manner in which the customer takes into account the scale that collects information and it is related to its conceptual reference. Some methods, like “Qualitometro”, as it is known, allow to remove the problems linked to the use of the nominal scale measurement, as they are able to deal with the item responses in some oral or linguistics scales (Zadeh, 1976; Yager, 1993; Franceschini & Rossetto, 1998b). The most important aspect of this procedure is that it allows to elaborate data according to the traditional scheme, recognizing linear interval proprieties to assessment. It is actually possible to estimate the centrality and variability indexes on the basis of the ordinal properties of information only.

Some relevant aspects linked to the quantification of qualitative data are due to the introduction of an arbitrary metric and to the assumption that all the customers possess the same way to signify the scale order.

All the customer satisfaction methods introduced define, for each customer assessment, the dominance of Expected Quality ($Q_e$) or Perceived Quality ($Q_p$). We can have:

1-Expected Quality ($Q_e$) greater than Perceived Quality ($Q_p$);
2-Expected Quality ($Q_e$) less than Perceived Quality ($Q_p$).

Such dominance is expressed taking in account the different importance of each dimension.

By the use of these procedures it is possible to analyse, to model and to aggregate the preferences expressed by customers.

From the analysis of the global gap, related to the specific dimensions, it is possible to control the process and to find the point out of control.

The “Qualitometro” method has been introduced for the evaluation “on line” of the gap between Expected Quality and Perceived Quality, and its use is proper when the evaluation quality characters are expressed under the form of attributes. It is the first procedure that allows to control the quality “on line” by using control charts.

Also this method, follows the “disconfirmation paradigm” scheme, and submits to an attribute p-control chart the evaluations drawn from questionnaires.

Many organizations collect frequently customer satisfaction data from time to time through customer surveys. In order to make a continuative quality control,
parametric and distribution free control charts have been recently proposed.

Control chart process has its main utilization in the industrial production quality control. It is an approach infrequently used for monitoring service quality data, but it can represent a good way to control the external and internal conditions of changes in customer satisfaction levels. However traditional Shewhart charts has been modified to monitor categorical or ordinal customer survey data.

When we use data drawn from the questionnaire, the blind application of the traditional variable charts to ordinal survey data can lead to false conclusions about the level of customer satisfaction.

Most of the papers (Jackson, 1959), (Montgomery, Woodall W.H., 1997), (Lauro et al, 2002) in multivariate context suppose that the variables to control could be under the hypothesis of multinormality, so the ellipsoidal shape of the control regions has been assumed.

In literature, parametric and distribution free Control Charts were suggested in order to obtain on-line quality control related to customer satisfaction data.

Scepi, Lauro, Balbi (1997) made up a procedure for the construction of nonparametric control regions that does not consider any distributional hypothesis, and they use some resampling techniques. Such approach is more appropriated to solve the problem of service quality evaluation. In this case, the value of the target regarding the presence of situations out of the control derives from the complex evaluations of the consumer satisfaction degree. The characteristics to control, therefore, are not described by a parametric distribution like the multinormal one.

These characteristics, expressed under the form of attributes, are not quantifiable on continuous scales. In this case a statistical model for the design of multiattribute control chart (MACC’S) has been proposed.

4. MULTIATTRIBUTE CONTROL CHART APPROACH

To design an approach that permits to control together all the quality service dimensions we suggest to use the Multiattribute Control Charts (MACC).

The Multiattribute Control Chart procedure in the univariate case assumes that we have k possible responses. If we assume known the proportion $p_x$ of the x customers who have given response, X is a discrete random variable with probability mass function, $f(x) = Pr(X=x) = p_x$, $x = 1, 2, ..., k$.

The expected value, $\mu_x$, and the variance, $\sigma_x^2$, are:

$$\mu_x = \sum_{x=1}^{k} x p_x ;$$
The expected value and variance of a sample mean calculated from a sample of \( n_j \) customers are \( \mu_x = \mu_x \) and \( \sigma_x^2 = \sigma_x^2 / n_j \). The control limits are then given by:

\[
\sum_{x=1}^{k} x^2 p_x \pm \frac{3}{\sqrt{n_j}} \sqrt{\sum_{x=1}^{k} x^2 p_x - \left( \sum_{x=1}^{k} x p_x \right)^2}.
\]

When we are interested in estimating the expected fraction of “defective”, it is to say a bad evaluation, the control limits concerning the quality service indicators are the following:

\[
UCL = np_0 + k \left[ np_0 \left( 1 - p_0 \right) \right]^{1/2},
\]
\[
LCL = np_0 - k \left[ np_0 \left( 1 - p_0 \right) \right]^{1/2},
\]

where \( p_0 \) is the expected fraction of defective produced when the process is in-control (EFDPIC), and \( k \) is the factor determining the spread of the control limits.

The probability that the shift in fraction defective is detected on a single sample, when the process goes out of control is given by:

\[
P = 1 - \sum_{i=0}^{c} \binom{n}{i} p_0 \left( 1 - p_1 \right)^{n-i},
\]

where \( p_1 \) is the expected fraction defective perceived when the process is out of control (EFDPOC); and, \( P \) is the power of the chart.

When the service is in-control, the probability of a bad assessment (or first type error) is given by:

\[
\alpha = 1 - \sum_{i=0}^{c} \binom{n}{i} p_0 \left( 1 - p_1 \right)^{n-i},
\]

If we consider \( m \) attributes, the development of the model will be based on the approximation of the independent binomial variables, with reference to all \( m \) attributes considered (Landenna, Marasini, Ferrari 1997), by means of the convolution (Jolayemi, 1999), and of the extension of np-Control Charts.
This proposal permits to monitor the process through the use of approximation of the multiattribute Control Chart instead of \( m \) different np-Charts for all the “\( m \)” attributes.

The upper and lower control limits of the new Chart are:

\[
UCL = nm\bar{p}_0 + k \left[ mn\bar{p}_0 (1 - \bar{p}_0) \right]^{1/2},
\]

\[
LCL = nm\bar{p}_0 - k \left[ mn\bar{p}_0 (1 - \bar{p}_0) \right]^{1/2},
\]

where \( k \) is the factor that determines the spread of the control limits, \( \bar{p}_0 \) is the mean of \( p_{0i} \), it is to say, the expected unsatisfied customer fraction with reference to attribute \( x_i (i = 1,2,\ldots,m) \), when the process is in-control.

The lower limit will be equal to zero as it happens for a single attribute. Therefore, a corrective action is to be undertaken whenever the sum of the numbers of unsatisfied customers found in the sample, with reference to the “\( m \)” attributes, exceeds an acceptance number “\( c_m \)”, where “\( c_m \)” is the largest integer equal or less than the upper control limit (UCL).

Consequently, the probability that a shift in the service supply is detected in a single sample when the service evaluation goes out of control is the following:

\[
P = 1 - \sum_{i=0}^{c_m} \left( \begin{array}{c} nm \\ i \end{array} \right) \bar{p}_i^i \left( 1 - \bar{p}_i \right)^{nm-i},
\]

where \( \bar{p}_i \) is the mean of \( p_{1i} \), \( (i = 1,2,\ldots,m) \).

Consequently \( p_{1i} \) is the expected fraction of unsatisfied customer with respect to attribute \( x_i (i = 1,2,\ldots,m) \), when the evaluation of service is out of control (EFOUC) and P is the power of the Chart.

It is often written as \( P = 1 - \beta \), where \( \beta \) is the customer’s risk.

If \( 1 - \beta \) is substituted for \( P \) in (1) and then simplified, we have:

\[
\sum_{i=0}^{c_m} \left( \begin{array}{c} nm \\ i \end{array} \right) \bar{p}_i^i \left( 1 - \bar{p}_\lambda \right)^{nm-i} = \beta
\]

Therefore the probability of a false alarm, when the service is in control, is given by:

\[
\alpha = 1 - \sum_{i=0}^{m} \left( \begin{array}{c} nm \\ i \end{array} \right) \bar{p}_i^i \left( 1 - \bar{p}_1 \right)^{nm-i} = \beta,
\]

where \( \alpha \) is the producer’s risk. Finally we obtain:
We can design the Multiattribute Chart solving equations (4) and (6). We simultaneously obtain values for \( n \) and for \( c_m \) for specified \( \alpha \) and \( \beta \) levels. The values of UCL can be obtained if the values of \( n, m \) and \( k \) are inserted into (1) to obtain the value of the upper control limit UCL.

It can be noted that as the lower control limit is zero and the producer’s risk is \( \alpha \), the value of \( k \) is the normalised deviate, \( z_{1-\alpha} \), corresponding to \( (1 - \alpha) \) level. Equation (4) and (6) are implicit in \( c_m \) and can be solved by means of an approximation method.

A direct search method may solve the two equations simultaneously assuming \( n' = nm \):

\[
n' = \frac{a^2 z_\beta^2 \bar{p}_1 \bar{q}_1}{(b - a\bar{p}_1)^2}
\]

\[
c = n' \frac{b}{a}
\]

where \( a = z_\beta \sqrt{\frac{\bar{p}_1 \bar{q}_1}{\bar{p}_0 \bar{q}_0}} - z_1 - \alpha \); \( b = \bar{p}_0 z_\beta \sqrt{\frac{\bar{p}_1 \bar{q}_1}{\bar{p}_0 \bar{q}_0}} - z_1 - \alpha \bar{p}_1 \);

\[
\bar{q}_0 = 1 - \bar{p}_0, \bar{q}_1 = 1 - \bar{p}_1, \ z_\beta < 0 .
\]

Using the above relations the values of \( c_m \) and \( n' \) to insert in the (4) and (6) are obtained. They permit to check whether the rate of convergence is satisfied. If it is so, the required values of \( c_m \) and \( n' \) can be regarded as good estimates. Otherwise, we obtain only some intervals around the values that satisfy the two equations as closely as possible.

5. FINAL REMARKS

The methods of customer satisfaction that apply the questionnaires method are useful to elaborate and to quantify main aspects of the service quality. However they create some problems with reference to the scale measures and to the
conceptual assessment system which have to be solved. The first problem starts with the practice to assign the properties of an interval scale to the qualitative measures that express assessments. The second problem is linked to the different conceptual reference of the customer assessments.

Concluding we can state that the customer satisfaction methods reduce the first inconvenience as it considers the questionnaire data as ordered measurement data.

This paper proposes an approach which allows an analysis and a control of the service quality. In the particular case the variables to be checked are two or more, we introduce the Multiattribute Control Chart. This approach provides a simultaneous evaluation of the different characters of the service. It permits to obtain results using only one multiattribute chart. This is an advantage as regards to the use of “m” different Charts, one for each quality dimension.

This method allows the immediate comparison between Perceived and Expected evaluation of all dimensions. A further advantage is to avoid the synthesis of the “m” charts, as it is well known that this step could influence the final assessment of the quality control.

BIBLIOGRAPHY


Multiattribute control chart for customer satisfaction measurement


L’IMPIEGO DELLA CARTA DI CONTROLLO MULTIATTRIBUTO PER LA MISURA DELLA SODDISFAZIONE DEI CLIENTI

Riassunto

Questo lavoro si inserisce nella problematica della misura e del controllo della soddisfazione dei clienti. La maggior parte dei metodi proposti in letteratura analizza il problema della misurazione con l’ausilio di tecniche dirette ed indirette, basate sull’analisi di questionari somministrati agli utilizzatori dei servizi. Queste procedure focalizzano la loro attenzione sul confronto tra qualità attesa e qualità percepita ed i risultati ottenuti sono espressi prevalentemente su scale nominali e/o ordinali.

Recentemente sono stati proposti metodi per la misura della soddisfazione del cliente fondati sull’apparato metodologico delle Carte di Controllo.

In questa nota viene proposto uno strumento di misura “ad hoc” in grado di valutare e controllare simultaneamente le differenti caratteristiche del servizio. L’approccio proposto si riferisce all’analisi di due o più dimensioni valutate simultaneamente attraverso l’uso della Carta di Controllo multiattributo. Il vantaggio di questa procedura è costituito dall’eliminazione del problema della sintesi delle valutazioni delle singole caratteristiche della qualità, il quale, com’è ben noto, spesso conduce ad approssimazioni nei risultati.