MUSA: a Decision Support System for Evaluating and Analyzing Customer Satisfaction

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Abstract. The MUSA (MUlticriteria Satisfaction Analysis) system is a customer-based tool for service/product quality evaluation. The system analyzes customer satisfaction using survey-based data, while the analysis of collected information is based on an original preference disaggregation methodology. The MUSA methodology follows the principles of multicriteria analysis using mainly ordinal regression techniques. The provided results are mainly focused on the determination of the critical service dimensions in order to prioritize improvement actions. Furthermore, these results are sufficient enough to analyze customers' needs and expectations and to aid service quality decision process. The paper briefly presents an overview of service management tools and customer relationship management technologies. The presented technologies related with customer satisfaction surveys are mainly focused on internet-based surveys or specialized survey management information systems, aiming to questionnaire design and advanced data management. Moreover, an illustrative application is presented in order to demonstrate the MUSA system's basic features and capabilities. Finally, future research and several extensions of the presented system are discussed.

1 Introduction

Modern technology of information systems offers numerous alternatives for managing relations/transactions between companies and customers. Most of these systems are focused on customer service, while their satisfaction evaluation capabilities are rather limited. This is mainly explained by the lack of methods and techniques purely oriented to customer satisfaction measurement, and the availability of several statistical packages and data analysis applications that solve this particular problem.

The aim of customer service information systems is mainly to satisfy customer requirements or manage customer complaints. In general, the primary requirements expressed by the customers during their transaction with business organizations are [1]:

- direct resolution of technical or other problems related to particular product/service,
- on line access to technical or other information provided by the company, and
- ability to provide interactive support.

The type and content of the interaction offered by these information systems depend heavily on the extent and level of the access provided by the business organization. As Fig. 1 shows, the interaction levels may be as follows [2]:

1. *Product information*: It is the most elementary form of access provided by a business organization with no interaction capabilities.
2. *Problem resolution*: In this particular non continuous form of communication, the customer is able to submit specific questions/requests mainly for technical problems.
3. *Access to people*: This access level refers to the communication ability with specific departments or company employees. However, still no interaction can take place.
4. *Access to process*: This is the most complex form of communication. It supports interaction and provides the customers with the ability to be involved and get information about the service processes of the company (placement and search of orders, monitoring of transactions, etc.).

This progression of giving the customer more and more access to product information, problem resolution information, people, and processes may be characterized as customer integration

Another important feature of modern customer service information systems is their integration/cooperation abilities with other software applications installed in business organizations. The aim of this approach is to integrate the customer-related information, in order to achieve an optimal coordination of the company's departments and processes.

Furthermore, modern customer service information systems are characterized by the automation of communication procedures to the maximum possible extent. This automation feature is able to reduce operating costs and increase company's productivity level. Finally, it should be noted that these particular systems ensure, at a satisfactory level, the independency between the communication process with the customers and the medium used.

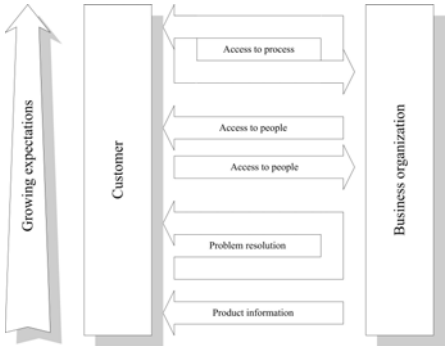

Fig. 1. Different levels of customer integration [2].

The main aim of this paper is to show that the management of customer-related information requires the existence of sophisticated information systems. Moreover, the paper presents an overview of the information systems that may be used in the customer satisfaction evaluation problem, focusing in the presentation of the MUSA (MUltictiteria Satisfaction Analysis) system. The latter is based on a multicriteria preference disaggregation model and its main advantages are:

- The model respects the qualitative form of customers' satisfaction data.
- Input data can be easily collected using a very simple and short questionnaire.
- The results of the model are not only focused on descriptive analysis of customer satisfaction data, but they are also able to assess an integrated benchmarking system.
- The model does not require strong assumptions regarding customer satisfaction or consumer behavior generally.

The MUSA system is a survey-based software, which is able to provide complete and effective results to the user, through the evaluation of concrete and understandable indices of customer satisfaction.

The paper is organized into 5 sections. Section 2 analytically presents the various categories of customer service systems as well as the most characteristic specialized cases such as the helpline/helpdesk systems, the automated response systems, and the electronic data interchange systems. Technologies related with customer satisfaction surveys are examined in section 3, which are mainly focused on Internet-based surveys or specialized survey management information systems. An analytical presentation of the MUSA system is given in section 4, while section 5 summarizes some concluding remarks, as well as several extensions of MUSA's features and capabilities.

2 Customer Service Systems

2.1 Helpline Systems

The majority of these systems refers to the customer service centers (helpdesk/helpline systems, call centers). Typical examples of this case are the call centers with free of charge phone lines to the customers, various systems for complaints recording and management, and helpline systems offering forms of continuous communication with customers.

These systems have been significantly developed within the few last years and are broadly used in business organizations, especially in the service sector [3]. It should be noted that it is rather difficult to categorize these systems, since they are based on different platforms, they apply different technologies and they focus on different problems of business organizations.

Helpline systems are combined with other commercial software applications usually installed in organizations such as office automation systems, accounting applications, electronic document filing, and communications software in order to create an

integrated communication environment for the management and the analysis of customer-related information [4]. In many cases, this integration process is particularly difficult because there are no widely accepted communications standards, although a large number of such standards are available, like TSAPI, TAPI, JTAPI, CSTA, etc.

Advanced helpdesk information systems make use of technologies that are based on the combination of telephone and computer systems. The process of Computer Telephony Integration (CTI) is presented in Fig. 2 [4, 5, 6].

2.2 Automated Response Systems

Automated Response Systems (ARS) refer to technologies that allow partial or fully automatic provision of services, or satisfaction of customers' requests. According to [7], the term is used as a general reference for technologies like Automated Response Unit (ARU), Voice Response Unit (VRU), and Interactive Voice Response (IVR).

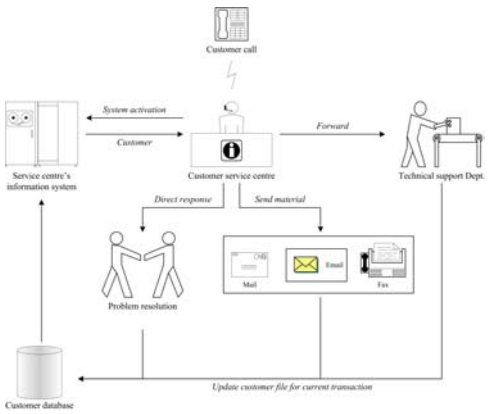

Fig. 2. Computer Telephony Integration.

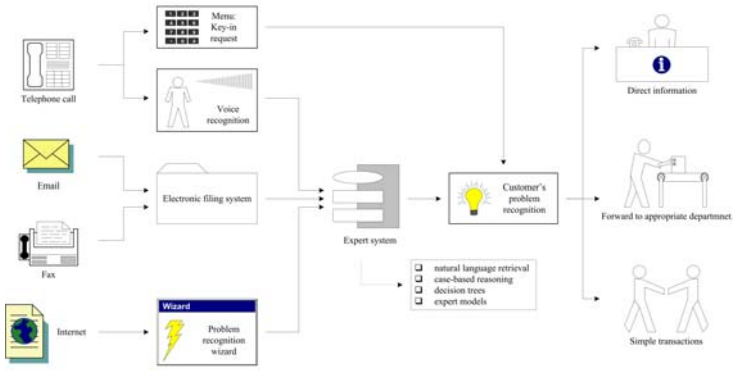

Fig. 3. Automated Response Systems.

ARS automate customer service process, by giving the ability of self-service. According to [1], this may result to the decrease of the service cost, the establishment of a continuous interactive communication with the customers, the depletion of helpline centre from simple repeated calls, the development of personalized new products or the cross-selling actions of the business organization, and broadly to the customer relationship strategies.

In general, as shown in Fig. 3, the operation process of these systems includes the following steps: (1) Contact with the customer, (2) Identification of customer's problem, and (3) Customer's problem resolution.

Finally, it should be noted that criticism referring to ARS is mainly focused on the loss of personal contact with the customer and the feeling of "abandonment" that may be created [7]. For this reason, using ARS, customers have also the ability to pass over the automated procedures and have a direct communication with the employees.

2.3 Electronic Data Interchange

Electronic Data Interchange (EDI) is a business process that allows business organizations to improve their performance by minimizing the bureaucratic procedures. EDI allows the electronic exchange of structured business information among computer systems located in different organizations. Data are handled through internationally accepted standards, so that the messages between the trading sides can be easily sent, received and processed by different computer systems [8, 9].

As already stated in the previous sections, customer service information systems allow the handling of simple business transactions. This possibility can be further extended to integrated and automated business actions (order, order tracking, dispatch, payment, etc.) through the installation and cooperation of an EDI system with the company's customer service centre. In addition, this leads to the integration of the interaction process between the customers and the company.

The most important advantage of EDI systems is the improvement of customer satisfaction, based on the following points [10, 11]:

- Decreasing necessary time to complete an order.
- Improving the accuracy in the processing of the orders.
- Satisfying customer demands for installation of an EDI system.

3 Internet and Survey-Based Systems

Internet consists one of the most important available media for the interaction between business organizations and customers. Its main feature is the ability to exchange complex information through a user-friendly environment. In addition, its growth and expansion during the last years offers a uniform communication standard. In general, business organizations use the Internet to provide special services to their customers (products' information, orders, orders' information, bills' tracking, etc.) as well as to conduct satisfaction surveys [2].

Web-based systems have the ability to record the entire interaction between customers and organizations, in order to perform potential complementary analyses. Also, World Wide Web is widely used in conducting customer satisfaction surveys. In fact, several satisfaction survey questionnaires are placed permanently in the web site of business organizations. The advantages of this approach compared to other classical types of survey conduction are summarized in the following [12]:

- The participation in web-based satisfaction surveys does not consider time or space restrictions.
- This type of satisfaction surveys reduces human interviewer bias.
- Available tools (menus, icons, combo boxes, etc.) are able to provide a user-friendly environment for filling-in the questionnaire.
- Usually, questionnaire information is automatically stored in a database, and this may result to reducing the overall cost of satisfaction survey conduction, and directly accessing survey results, even in real-time.
- Internet provides the ability to automatically validate available collected data.

The previous advantages may increase customer participation rate in satisfaction surveys. However, conducting a web-based satisfaction survey should be justified by important conditions, such as Internet access for the total set of customers and a large clientele in order to benefit from the reduction of the related cost [2, 12, 13].

Another major software category related to customer satisfaction measurement refers to survey-based information systems. The major functions of these systems include the design of the questionnaire, the printing and/or electronic filling of questionnaires, the development of the relevant database, and the statistical analysis and reporting.

An important attribute of these systems is the high level of user-friendliness characterizing the design process of the satisfaction survey questionnaire, which is achieved by a set of ready-to-use tools (predefined types of questions, satisfaction scales, etc.) and the implementation of complex information (sounds, images, graphics, etc.). An additional attractive feature of these systems is their ability to validate collected information, which is ensured during the design and development of the structure and the contents of the questionnaire. Another important feature of these systems refers to the process type of distributing the questionnaire and collecting customer responses.

The development of the database containing customer responses is to a great extent an automated procedure, which is able to reduce the overall cost of survey conduction. Survey-based software packages also provide the ability to perform simple statistical analyses of the collected data, and in addition, the user is able to choose predefined templates in order to generate reports with the results of the satisfaction survey.

4 The MUSA System

4.1 The MUSA Method

Extensive research has defined several alternative approaches for the customer satisfaction evaluation problem. All these proposed models and techniques, so far, adopt the following main principles [14]:

- The data of the problem are based on the customers' judgments and should be directly collected from them.
- Customer satisfaction measurement is a multivariate evaluation problem given that customer's global satisfaction depends on a set of variables representing service characteristic dimensions.
- Usually, an additive formula is used in order to aggregate partial evaluations in a global satisfaction measure.

The most important measurement approaches include quantitative methods and data analysis techniques, quality approach models, and consumer behavioral analysis [14].

The MUSA method is a multicriteria preference disaggregation approach, which provides quantitative measures of customer satisfaction considering the qualitative form of customers' judgments [15, 16]. The main objective of the MUSA method is the aggregation of individual judgments into a collective value function, assuming that client's global satisfaction depends on a set of n criteria or variables representing service characteristic dimensions. This set of criteria is denoted as $\mathbf{X}=(X_1, X_2, ..., X_n)$, where a particular criterion i is represented as a monotonic variable X_i.

The required information is collected via a simple questionnaire in which the customers evaluate provided service, i.e. they are asked to express their judgments, namely their global satisfaction and their satisfaction with regard to the set of discrete criteria. A predefined ordinal satisfaction scale is used for these customers' judgments.

The MUSA method assesses global and partial satisfaction functions Y^* and X_i^* respectively, given customers' judgments Y and X_i. It should be noted that the method follows the principles of ordinal regression analysis under constraints using linear programming techniques [17, 18, 19]. The ordinal regression analysis equation has the following form:

$$\begin{cases} Y^* = \sum_{i=1}^{n} b_i X_i^* \\ \sum_{i=1}^{n} b_i = 1 \end{cases} \quad (1)$$

where the value functions Y^* and X_i^* are normalized in the interval [0, 100], n is the number of criteria, and b_i is the weight of the i-th criterion.

Based on the above modeling approach and introducing a double-error variable (see Fig. 4), the ordinal regression equation becomes as follows:

$$\tilde{Y}^* = \sum_{i=1}^{n} b_i X_i^* - \sigma^+ + \sigma^- \tag{2}$$

where $\tilde{Y}^*$ is the estimation of the global value function Y^*, and σ^+ and σ^- are the overestimation and the underestimation errors, respectively.

The global and partial satisfaction Y^* and X_i^* are monotone functions normalized in the interval [0,100]. Thus, in order to reduce the size of the mathematical program, removing the monotonicity constraints for Y^* and X_i^*, the following transformation equations are used:

$$\begin{cases} z_m = y^{*m+1} - y^{*m} & \text{for } m = 1,2,...,\alpha - 1 \\ w_{ik} = b_i x_i^{*k+1} - b_i x_i^{*k} & \text{for } k = 1,2,...,\alpha_i - 1 \text{ and } i = 1,2,...,n \end{cases} \tag{3}$$

where y^{*m} is the value of the y^m satisfaction level, x_i^{*k} is the value of the x_i^k satisfaction level, and α and α_i are the number of global and partial satisfaction levels, respectively.

According to the aforementioned definitions and assumptions, the basic estimation model can be written in a linear program formulation, as follows:

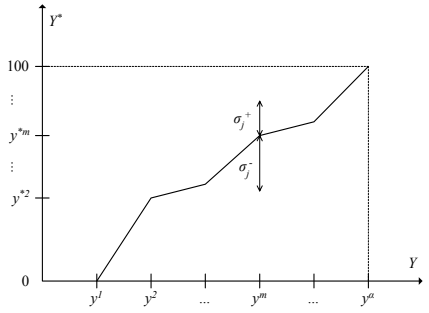

Fig. 4. Added value function and error variables for the *j*-th customer.

$$\begin{cases} [\min] F = \sum_{j=1}^{M} \sigma_j^+ + \sigma_j^- \\ \text{subject to} \\ \sum_{i=1}^{n} \sum_{k=1}^{x_i^j - 1} w_{ik} - \sum_{m=1}^{y^j - 1} z_m - \sigma_j^+ + \sigma_j^- = 0 \quad \text{for } j = 1,2,\ldots,M \\ \sum_{m=1}^{\alpha - 1} z_m = 100 \\ \sum_{i=1}^{n} \sum_{k=1}^{\alpha_i - 1} w_{ik} = 100 \\ z_m,\ w_{ik},\ \sigma_j^+,\ \sigma_j^- \quad \forall\, m,i,j,k \end{cases} \tag{4}$$

where M is the size of the customer sample, and y^j, x_i^j are the j-th level on which variables Y and X_i are estimated.

The preference disaggregation methodology includes also a post optimality analysis stage in order to overcome the problem of model stability. The final solution is obtained by exploring the polyhedron of multiple or near optimal solutions, which is generated by the constraints of the previous linear program. This solution is calculated by n linear programs (equal to the number of criteria) of the following form:

$$\begin{cases} [\max] F' = \sum_{k=1}^{\alpha_i - 1} w_{ik} \quad \text{for} \quad i = 1, 2, ..., n \\ \text{under the constraints} \\ F \le F^* + \varepsilon \\ \text{all the constraints of LP (4)} \end{cases} \tag{5}$$

where ε is a small percentage of F^*. The average of the solutions given by the n LPs (5) may be taken as the final solution. In case of non-stability, this average solution is less representative.

The principles of the mathematical development of the MUSA method can be found in [14, 15, 16]. The applications of the MUSA method refer mostly to customers or employees of business organizations [15, 20, 21, 22, 23], or any human activity in the social field like evaluation of educational systems [24, 25].

4.2 Overview of the MUSA System

The system implements the MUSA methodology in order to assess customer satisfaction. The main features of the system include:

- Simplicity, which is achieved through the use of efficient data management methods.
- Friendliness through the implementation of a graphical user interface.
- Effectiveness, based on the provided analytical results for customer behavior, organization performance, potential improving actions.

Input and output data files have a very simple form because they are basically text files (ASCII files), and as a result, they are fully compatible with almost all application programs (spreadsheets, DBMS, etc.). This way, MUSA data may be read from an external text file or they may be entered directly to the program. The result data file is also saved in a text format so that the user may use it to perform any kind of complementary analysis with other software packages.

The information required to create data files refers basically to the definition of the variables of the MUSA model. It is very important to mention that the type of information handled by the MUSA system can be either quantitative (price, time, etc.) or qualitative (company's image, personnel's behavior, etc.). Generally, in order to collect input data for the customer satisfaction problem, a predefined qualitative satisfaction scale for the set of criteria/subcriteria should be used. There is no restriction in

the number and specification of satisfaction levels in MUSA, which may be different from one criterion/subcriterion to another.

4.3 Presentation of Results

The MUSA system provides basic descriptive analysis based on the calculated frequencies. Available results consist of global criteria and subcriteria satisfaction frequencies, giving a general view of the customer satisfaction data.

The main results of the method are focused on global and partial explanatory analysis. Global explanatory analysis lays emphasis on customers' global satisfaction and its primary dimensions, while partial explanatory analysis focuses on each criterion and its relevant parameters separately. Satisfaction analysis results, in more detail, consist of:

1. *Global satisfaction index*: this average index shows, in the range 0-100%, the level of global satisfaction of the customers (see Fig. 5); it may be considered as the basic average performance indicator for the business organization, and it is assessed through the following equation:

$$S = \frac{1}{100} \sum_{m=1}^{\alpha} p^m y^{*m} \tag{6}$$

   where S is the average global satisfaction index, and p^m are the frequencies of customers belonging to the y^m satisfaction levels.
2. *Added value curve*: this curve shows the real value (0-100) that customers give for each level of the global ordinal satisfaction scale; it refers to the Y^* model variable and the form of the curve indicates if customers are demanding (Fig. 5).
3. *Criteria satisfaction indices*: these indices show, in the range 0-100%, the level of partial satisfaction of the customers according to the specific criterion, similarly to the global satisfaction index; these indices are calculated through the following formula:

$$S_i = \frac{1}{100} \sum_{k=1}^{\alpha_i} p_i^k x_i^{*k} \quad \text{for } i = 1, 2, \ldots, n \tag{7}$$

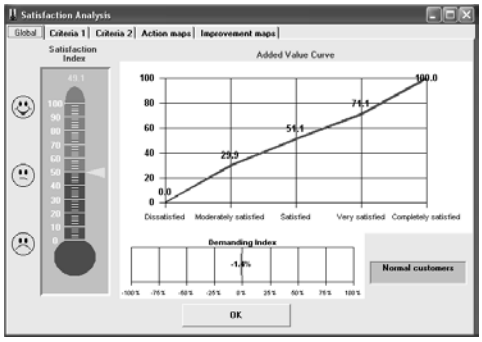

Fig. 5. Global explanatory analysis.

where S_i are the average partial satisfaction indices, and p_i^k are the frequencies of customers belonging to the x_i^k satisfaction levels.

4. *Weights of criteria*: they refer to the b_i model variables and they show the relative importance within a set of criteria.

Other advanced results include the average demanding indices, which are based on the shape of global and partial satisfaction functions. The average global and partial demanding indices, D and D_i respectively, are assessed through the following equations:

$$\begin{cases} D = \dfrac{\sum_{m=1}^{\alpha-1}\left(\dfrac{100(m-1)}{\alpha-1} - y^{*m}\right)}{100\sum_{m=1}^{\alpha-1}\dfrac{m-1}{\alpha-1}} \quad \text{for } \alpha > 2 \\ D_i = \dfrac{\sum_{k=1}^{\alpha_i-1}\left(\dfrac{100(k-1)}{\alpha_i-1} - x_i^{*k}\right)}{100\sum_{k=1}^{\alpha_i-1}\dfrac{k-1}{\alpha_i-1}} \quad \text{for } \alpha_i > 2 \text{ and } i = 1,2,\ldots,n \end{cases} \tag{8}$$

These indices are normalized in the interval [-1, 1] and they represent the average deviation of the estimated value functions from a "normal" (linear) function. The average demanding indices can be used for customer behavior analysis, and they can also indicate the extent of company's improvement efforts: the higher the value of the demanding index, the more the satisfaction level should be improved in order to fulfill customers' expectations.

Finally, combining weights and average satisfaction indices, a series of action diagrams can be developed (Fig. 6). These diagrams indicate the strong and the weak points of customer satisfaction, and define the required improvement efforts. Each of these maps is divided into quadrants, according to performance (high/low) and importance (high/low) that may be used to classify actions:

- *Status quo* (low performance and low importance): Generally, no action is required.
- *Leverage opportunity* (high performance/high importance): These areas can be used as advantage against competition.
- *Transfer resources* (high performance/low importance): Company's resources may be better used elsewhere.
- *Action opportunity* (low performance/high importance): These are the criteria that need attention.

4.4 Evaluation of Results

The reliability evaluation of the results is mainly related to the fitting level to the customer satisfaction data, and the stability of the post-optimality analysis results. The MUSA system incorporates the following stability analysis results:

1. *Average fitting index*: The optimal values of the error variables indicate the reliability of the value system that is evaluated. The Average Fitting Index (AFI) depends on the optimum error level and the number of customers:

$$AFI = 1 - \frac{F^*}{100 \cdot M} \tag{9}$$

where F^* is the minimum sum of errors of the initial LP. The *AFI* is normalized in the interval [0, 1], and it is equal to 1 if $F^* = 0$, i.e. when the method is able to evaluate a preference value system with zero errors.

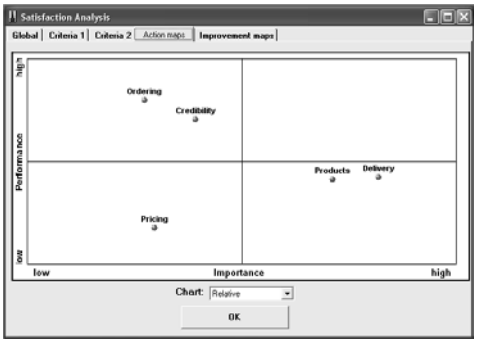

Fig. 6. Action diagram.

2. *Global added curve variance*: This diagram depends upon the estimated satisfaction values and the optimal values of the error variables as well (Fig. 7). It shows the value range that the customers' set gives for each level of the ordinal satisfaction scale. Thus, it can be considered as a confidence interval for the estimated additive value function.
3. *Average stability index*: The stability of the results provided by the post-optimality analysis is not related to the degree of fitness of the MUSA method. More specifically, during the post-optimality stage, n LPs are formulated and solved, which maximize repeatedly the weight of each criterion. The mean value of the weights of these LPs is taken as the final solution, and the observed variance in the post-optimality matrix indicates the degree of instability of the results. Thus, an Average Stability Index (*ASI*) may be assessed as the mean value of the normalized standard deviation of the estimated weights (Fig. 7):

$$ASI = 1 - \frac{1}{n}\sum_{i=1}^{n} \frac{\sqrt{n\sum_{j=1}^{n}\left(b_i^j\right)^2 - \left(\sum_{j=1}^{n} b_i^j\right)^2}}{100\sqrt{n-1}} \tag{10}$$

where b_i^j is the estimated weight of the i-th criterion in the j-th post-optimality analysis LP; the *ASI* is normalized in the interval [0, 1].
4. *Weights variance*: The variance table of the weights is also able to provide valuable information for the stability analysis of the results provided by the MUSA method. This table can give a confidence interval for the estimated weights, and

can identify possible competitiveness in the criteria set, i.e. the existence of certain customer groups with different importance levels for the satisfaction criteria

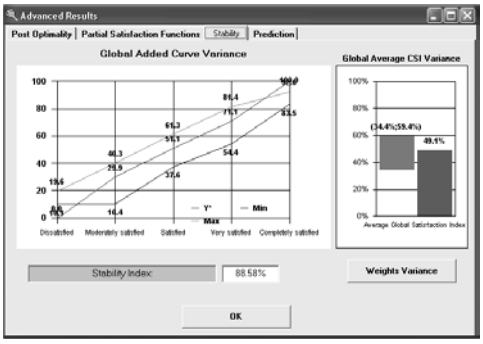

Fig. 7. Stability analysis.

5 Concluding Results

The MUSA system may be characterized as a consumer-based tool for measuring and analyzing customer satisfaction. The software package is based on a collective preference disaggregation methodology, as described in section 5.1. Thus, the main advantage is that MUSA fully respects the qualitative form of customers' judgments and preferences. Other important features of the proposed software include simplicity, friendliness, and effectiveness. As described in the previous section, a customer satisfaction problem may be easily constructed, solved, and analyzed using MUSA. Furthermore, obtained results are sufficient to give a clear understanding, and analyze in depth customer satisfaction.

Several extensions of the MUSA system may be proposed in order to develop an integrated Customer Satisfaction Decision Support System including:

- Incorporation of other statistical methods in order to develop an integrated model base subsystem. The system could provide an alternatively and/or complementary implementation of these methods. For example, the MUSA method requires completely and correctly answered questionnaires as input data. In case of missing data, data mining techniques could be used in order to fill in the empty cells in the data table.
- Addition of an expert system in order to fully explain provided results and recommend the best decision to be taken. Additionally, the expert system may guide users in the value hierarchy development process.
- Development of a database management system, which could assist in the establishment of a permanent customer satisfaction barometer. For example, a history database could record the evolution of customer satisfaction for a particular time period. This way, the effectiveness of business organization's strategies could be evaluated through customer satisfaction measurement.

– Addition of network support in order to perform comparative analysis for a number of different departments/stores within a company. This way, an interior benchmarking system may be established. This system can relate customer satisfaction and company's performance and it may motivate departments and/or employees to perform and achieve higher levels of productivity.

Finally, it should be emphasized that the MUSA system is more than a decision aid software because it serves for the development of a truly customer-focused management and culture.

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