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Research paper

Model End-To-End Integrated Quality Management

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Abstract

In this work, a model of end-to-end integrated quality management is developed, based on a set of existing models of enterprise operation, performance assessment and customer satisfaction ratings. The developed model integrates quality assessments by key parameters with the help of fuzzy regulators, which allow specifying estimates described in natural language.

Keywords: *model, end-to-end integrated quality management, fuzzy sets, quality assessment, quality characteristics.*

1.Introduction

In modern scientific discussion, integrated quality management is considered in the following main aspects:

- Integration of quality management into the overall management system [13], which involves considering quality management itself as another element of the management system, but does not allow analyzing and managing individual elements of the production activity or service rendering process;
- Integration of quality management into separate controls [11], which does not provide integrated process management;
- Integration of information at different stages of the product life cycle [4], which is not a complete integration of quality management into the organizational structure;
- An integrated quality management system as an additional structure in the network organizational model [12], while preserving the simultaneous rigid hierarchy of the main control structure, which makes the proposal poorly organized, since for qualitative QMS integration by the network principle, it is necessary to abandon the rigid hierarchical structure;
- Integration of various quality management to achieve maximum results [7];
- Integrated quality management as a multi-stage assessment of a single business process [10].

None of the above interpretations of integrated quality management is exhaustive [5, 8]. Moreover, all the cited works are more likely to consider integrated quality management as something given, nevertheless, without using definitions and without introducing them. As a result, they consider either a separate aspect of integration, or have significant logical and structural errors, or consider quality management as an additional element of the existing management, without going into particular technical content of this approach. That is why it is necessary to introduce an intrinsic definition of end-to-end integrated quality management to further elaborate the topic of improving the efficiency of an enterprise's activity based on the principle of end-to-end integrated quality management.

2.Research method

It can be argued that end-to-end integrated quality management is a quality management system, within which data on quality integrated into a single indicator are collected from each element of the production system and compared with a similar indicator generated for consumers, taking into account their requirements and satisfaction, there is a control of the quality of production element by element.

At the conceptual level, the key innovations of this principle are:

- Comparison of the integrated indicator of the quality of the products produced with the integrated indicator of the estimated quality on the part of consumers;
- Adjustment of the internal level of quality to the estimates and expectations of consumers while taking into account the change in both ratings in the actual change in the quality of a product or service.

At the stage of comparison, the following indicator is calculated:

$$F = \frac{Ii}{Ic} \to 1$$

Where F is the ratio of internal quality to external assessment, Ii is an integrated indicator of internal quality, Ic is an integrated quality indicator based on consumer assessment. Note that this indicator should strive for unity, since both integrated estimates imply a corresponding rationing, as well as due to the fact that the internal and external quality must be balanced.

3.Analysis of the results

We can distinguish the following levels of variables of the developed model, reflecting the principle of end-to-end integrated quality management:

- Quality indicators for individual elements of the inner and outer parts of the model;
- A set of indicators reflecting a set of indicators of the first level combined on the basis of well-known mathematical methods used in the framework of quality management;

- Integrated quality indicators for the internal and external parts of the model.

A distinctive feature of end-to-end integrated quality management is that when moving from the first level to the second level, mathematical methods are used in classical quality management, including those based on the principles of mathematical statistics. While in the transition from the second stage to the third, fuzzy logic methods are applied. The use of fuzzy logic will allow modeling the expert's assessment in the field of quality management, which will allow abandoning the "slogans" and the poorly specified characteristics, and at the same time, taking into account complex assessments that are poorly amenable to formalization and comparison within the framework of classical logic.

Thus, the general scheme of increasing the efficiency of the enterprise's activity through the application of the principle of end-to-end integrated quality management can be presented as follows (Fig. 1).

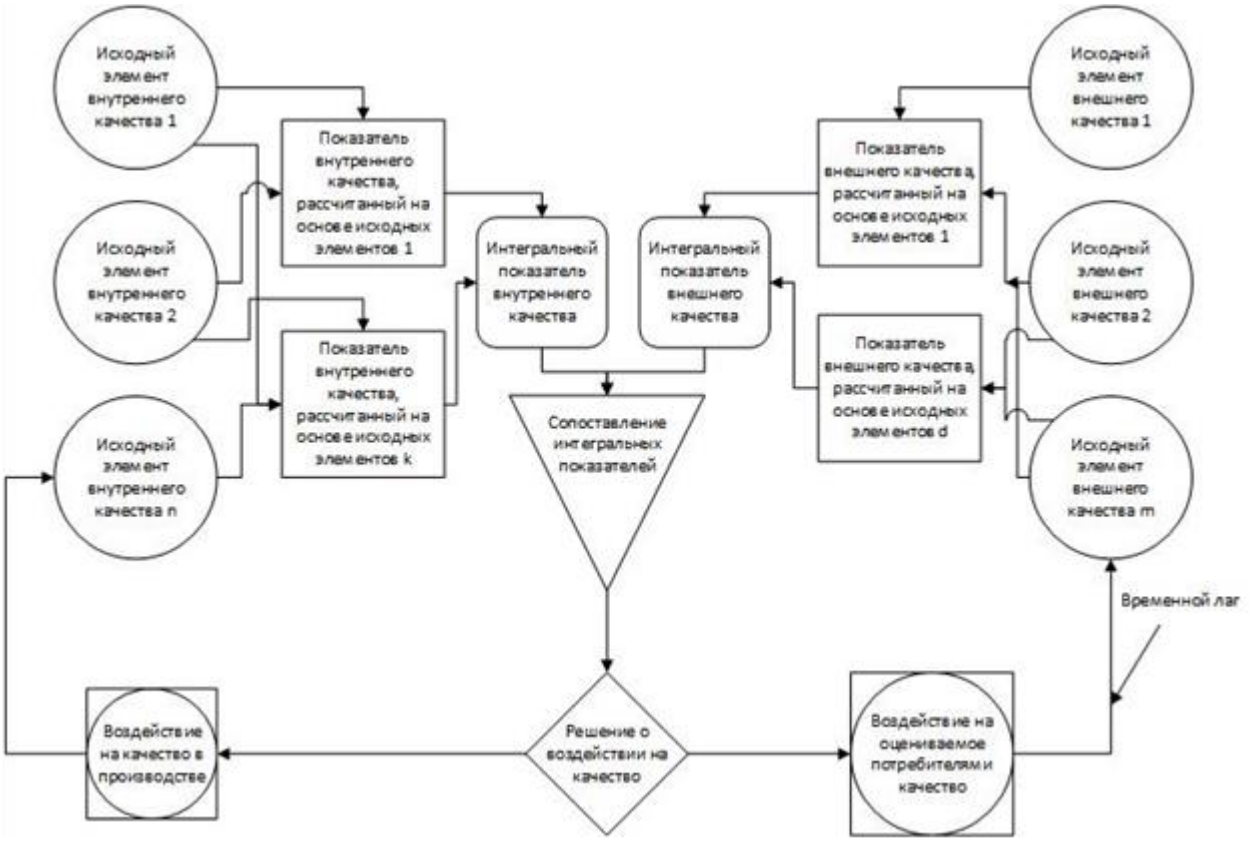

Fig.1. Block diagram of the principle of end-to-end integrated quality management.

Note that in the case of an increase in the economic efficiency of the enterprise, elements of business models are considered as elements of internal quality.

Describing the end-to-end integrated assessment of the quality of the enterprise's activity, one of the existing business models should be taken as a basis in order to formalize internal processes. One of the most common models of the company's operation is the Osterwalder model [9], the key elements of which are key activities; key partners and resources; sales channels. The basic mathematical models for assessing the quality of business model elements can be written as follows:

• for key activities [3]

$$K = \frac{1}{2} * \left(\frac{L_j^o}{\sum_{j=1}^{n} L_j^o / j} + \frac{L_j^v}{\sum_{j=1}^{n} L_j^v / j} + \frac{L_j^p}{\sum_{j=1}^{n} L_j^p / j} \right) : \frac{W}{\sum_{j=1}^{n} W_j / j}, \quad (2)$$

Where K is the quality assessment of key activities; Lo - the quality of the main activity; Lv - the quality of the auxiliary activity; Lp is the quality of the secondary activity; W is the cost of ensuring the quality of activities; j - period number; n is the number of periods.

• for key partners and resources [6]

$$R = \frac{N}{B} * \sum_{i=1}^{n} \frac{\frac{H_i}{H}}{\sum_{j=1}^{n} \frac{H_j}{H}}, \quad (3)$$

Where R is the functional assessment of the quality of key partners and resources; N is the number of parameters included in the quality assessment of key partners and resources; B - the number of parameters included in the assessment of the quality of key partners and non-zero resources; Hi is the actual quality level of the parameter included in the quality assessment of key partners and resources; H is the basic quality level of the parameter included in the quality assessment of key partners and resources; j is the parameter number; n is the number of parameters.

• for sales channels

$$\begin{cases} \xi \in \{o, \upsilon, p\}; \\ S = C + \sum_{\xi} C_{\xi} * K_{\xi}; \\ K_{\xi} = \dfrac{\sum_{i=1}^{n} A_i^{\xi}}{\sum_{j=1}^{n} D_j^{\xi}}. \end{cases} , \quad (4)$$

Where o is the main activity; - ancillary activities; p - side activities; S - functional assessment of the quality of distribution channels; C - the basic level of quality of distribution channels; C - coefficient of influence; K - assessment of the quality of distribution channels; A - the actual quality level of distribution channels; D - the basic level of quality of distribution channels; n is the number of elements; i is the sequence number for the actual elements; j - the sequence number for the basic elements.
Since all assessments of the quality of key elements have a uniform functional structure, to create a fuzzy regulator, it is possible to enter 5 linguistic variables, allowing assessing the quality level of each individual element: very low; low; normal; tall; very tall. Similarly, linguistic variables are introduced for end-to-end integrated assessment of enterprise performance. As a result, control planes similar to fig. 2

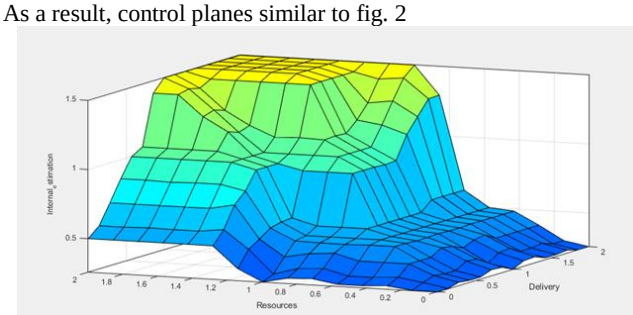

Fig.2. The model of management planes for internal assessment of the quality of an enterprise activity depending on the quality level of key partners and resources and the quality level of distribution channels

Given the specifics of calculations within the framework of the theory of fuzzy sets, in the first approximation, it is possible to formulate the following list of key indicators that reflect customer satisfaction and are included in the end-to-end integrated assessment of external quality: accessibility; terms of purchase of goods (provision of services), pre-sale preparation and after-sale service; time consuming.
Note that for all groups the recommended calculation formula is:

$$I = \sum_{i=1}^{n} (B_i * I_i) ,$$

Where I is the value of the group quality parameter assessed by consumers; Ii is the value of the quality parameter assessed by consumers for a particular characteristic of a product or service; Bi is the weight of an individual characteristic of a product or service in a group indicator.

Having formed the general structure of the end-to-end integrated quality management model, as well as specifying the elements included in it and their membership functions, it is possible to reflect them in a mathematical and structural form. Returning to the diffusion of innovations, it should be noted that the basic diffusion function of innovations is written as follows [14]:

$$P(t) = p + \frac{q}{F(t)} ,$$

Where p is the innovation coefficient, which expresses the "advertising effect" under the assumption that innovators learn about new products from the media, or by chance; q is the coefficient of imitation, expressing the effect of "word of mouth", or the ability of consumers to learn about innovations from people who have acquired it; F (t) is the share of completed consumers by the time t.

At the same time, within the framework of the principle of end-to-end integrated quality management, the initial impact is carried out directly on internal processes, in order to adjust their quality, and then on external ones. In addition, it is important to note that the impact on internal processes is carried out with a lag relative to the moment of decision-making, expressed using the classical oscillatory component of the theory of automatic control [2], namely

$$V = \frac{1 + F(t)}{T + 1} ,$$ где

V is the output signal, taking into account the time delay to influence the basic quality indicators; F is the ratio of internal and external quality in the end-to-end integrated quality management model; T is the system response time (delay or time lag from the moment of the decision to its implementation).
As a result, the cumulative impact (for example, distribution channels) is written as follows:

$$B = \int_0^t \left(\frac{1 + F(t)}{T + 1} * Ao2 \right) dt ,$$

Where B is the cumulative impact on the quality assessment (in this case, the quality of the second indicator of the main distribution channel); F is the ratio of internal and external quality in the end-to-end integrated quality management model; T is the system response time (delay or time lag from the moment of the decision to its implementation); Ao2 is the basic quality level of the second indicator of the main distribution channel.

This formula can be implemented for any of the indicators, by replacing variables, at the same time, if for the overall quality indicator for the estimated parameter, values of previous periods are also taken into account in the denominator, and then the cumulative impact is added to the indicator in the denominator. Thus, formula 7 can be converted to the following

$$P(t) = p + \frac{q}{B(t)} ,$$

Where P (t) is the level of penetration of quality in the assessment of consumers; p is the coefficient of innovation; q is the simulation coefficient; B is the cumulative effect on the quality assessment.
Note that this indicator can be normalized for use in calculations in assessing the impact on the perceived consumer level of quality. Considering that initially P (t) in this case varies in the range [0; 1], it is necessary to multiply this value by the basic quality estimates given by consumers initially.
The full assessment of the impact on the consumer is described by the formula [1]:

$$In = P(t) * Ii + Ii ,$$

Where P (t) is the level of penetration of quality in the assessment of consumers; In - a new level of consumer assessment; Ii is the base level of consumer assessment.

4.Conclusion

The proposed model of end-to-end integrated quality management is a complex model based on the totality of existing models of the enterprise, assessing the quality of activities and assessing customer satisfaction. At the same time, it integrates quality assessments by key parameters with the help of a fuzzy regulator, which allows specification of estimates described by natural language.

The model proposed in this paper assumes a comparison of external and internal estimates, and a complex feedback system that allows one to influence selected or predetermined parameters. At the same time, the model takes into account the internal time lag between the decision to improve the quality and its implementation, as well as the external time lag of consumer assessment, implemented on the principle of diffusion of innovations. The model also reflects the limited possibilities of improving internal and external quality assessment by controlling only one parameter, reflecting the principle of comprehensiveness of quality assessment.

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