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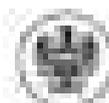
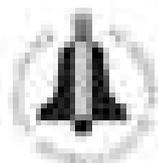
## INTELLECTUAL ECONOMICS

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## ASSESSMENT OF QUALITY MANAGEMENT SYSTEMS OF SERVICE COMPANIES

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**Abstract:** *Decision-making in the formation of quality management systems for compliance with the requirements of the international standard ISO 9001:2015 should be a strategically important area of activity for enterprises in the service sector, and should be based on the use of effective methods, measures, methodology, and other quality management tools. The aim of this article is to study the existing methodological approaches to the evaluation of the quality management systems of enterprises and to develop effective practical tools for their application in the field of engineering services. The existing methodological approaches to the evaluation of the quality management systems of enterprises are considered, and attention is focused on the advantages and disadvantages of each of them. Directions for the estimation of the quality management systems of enterprises in the sphere of engineering services on the basis of requirements of the international stan-*

*standard ISO 9001:2015 are offered. An algorithm for the expert evaluation of the processes of quality management systems of an enterprise in the field of engineering services is developed, and recommendations for its application are provided. The expediency of applying the methodology of the balanced scorecard (BSC) for the evaluation of quality management systems of enterprises in the field of engineering services is also substantiated. A strategic map of an enterprise in the field of engineering services is formed on the basis of a balanced system of indicators for the assessment of quality management systems. A comparative analysis of the costs of the business processes of an enterprise in the field of engineering services before and after the implementation of the quality management system is conducted, alongside the calculation of the economic effect of this implementation.*

**Keywords:** *quality management system, sphere of engineering services, ISO 9001:2015 standard, algorithm of expert evaluation of processes, economic effect.*

**JEL Classification codes:** *L15, L21, L84, M21*

## **1. Introduction**

In the context of Ukraine's integration into the European and world space, the formation, implementation, and certification of quality management systems (QMS) in the context of the requirements of international standards ISO 9000 series is relevant for domestic enterprises. In particular in the field of engineering services, ISO 9001:2015 stimulates their competitiveness and the development of their innovation potential. It is obvious that the formation of effective QMS can provide a guarantee for improving the quality of services (works) which meet the requirements of all stakeholders in the field of engineering services, and ensure the achievement of key business goals and high economic performance. Decision-making by senior management on the formation of QMS in accordance with the requirements of ISO 9001:2015 should be a strategically important area of activity of an enterprise which is based on the use of effective methods, measures, methodology, and other tools of quality management.

## **2. Literature review**

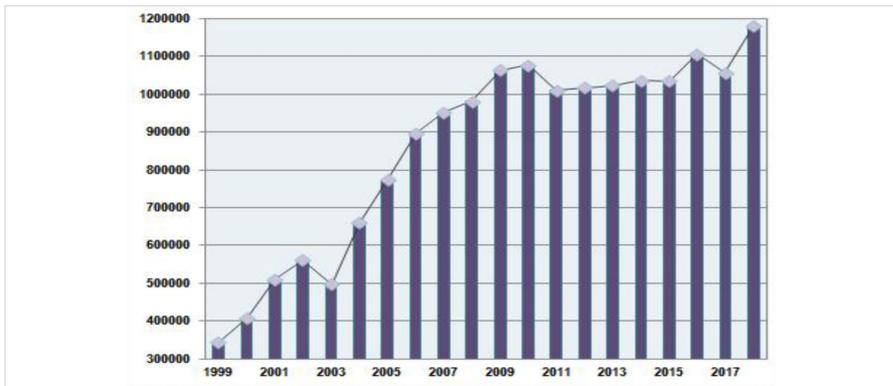
The work of a number of Ukrainian and international scientists – including: Stolyarchuk [1]; Yankovyi, Goncharov, Koval, and Lositska [2]; and Shulyar [4] – is devoted to the study of QMS assessment of enterprises in various fields of activity. This list also includes the work of: Levkulich [5]; Chekmasova [6]; Ravichandran and Rai [7]; Kaplan and Norton [8]; Manz and Stewart [10]; Androsyuk [11]; Bednall, Sanders, and Runhaar [13]; Fok, Fok, and Hartman [14]; Kumar, Van Der Aalst, and Verbeek [14]; Trachenko [16]; Lokhanova [18]; Levine and Toffel [19], and others. Stolyarchuk [1] emphasizes the use of the absolute and comparative forms of the rating method. Levkulich [5] developed 12 indicators of cost estimation in QMS of an enterprise manufacturing clothes which apply to its estimation. Chekmasova [6] emphasizes that when assessing the effective-

ness and adaptability of QMS today it is advisable to take into account the fact that they require the integrated application of existing mathematical, technical, organizational, managerial, and other special methods. Others [7–9] have analyzed the advantages and disadvantages of introducing a balanced system of indicators in the restaurant industry. Despite significant research, today there are no effective methodological tools for specifically assessing the QMS of enterprises in the field of engineering services.

The aim of this article is to study the existing methodological approaches to the assessment of QMS of enterprises, and to develop practical tools for their application in the field of engineering services.

### 3. Results and discussion

Recently, Ukrainian enterprises have been actively involved in the implementation and certification of quality management systems (QMS) in accordance with the international standards of the ISO 9000 series. The main motive is to improve the quality of enterprise management and ensure its more efficient development in domestic and international markets. After receiving its certificate, a company must maintain QMS in working order. Various inspections, evaluations, and analyses are needed to ensure its proper functioning and continuous improvement [1]. According to the ISO survey (The ISO Survey of Certifications – 2018) at the end of 2018, there were 878,664 certificates and 1,180,965 ISO 9001 certified production sites in the world. Figure 1 shows the survey data on the number of ISO 9001 certificates issued in the world from 1999 to 2018. According to the chart, there is an obvious tendency to increase the number of certified enterprises in different countries of the world. For the period of 2011–2015, their number remains almost at a constant level. However, in 2017 there is was decrease in certificates by approximately 3%, and this then increased again in 2018. The reason for this drop is related to the involvement of certification bodies and changes in the data provided by the same organizations, which led to a significant reduction in registered certificates [3].



**Figure 1.** Number of ISO 9001 certificates issued in the world from 1999 to 2018  
Source: compiled according to “The ISO Survey of Certifications – 2018”

It is advisable to focus on countries and industries with more certificates according to ISO 9001:2015. Table 1 shows the Top 10 countries that are certified according to ISO 9001:2015 in 2018.

**Table 1.** Top 10 countries that are certified according to ISO 9001:2015 in 2018

<b>№</b>	<b>Name of the country</b>	<b>Number of certificates</b>
1	China	295,703
2	Italy	87,794
3	Germany	47,482
4	Japan	34,335
5	India	31,795
6	Spain	29,562
7	Great Britain	26,434
8	United States of America	21,848
9	France	21,095
10	South Korea	14,123

*Source: compiled according to "The ISO Survey of Certifications – 2018"*

Unfortunately, Ukraine is not included in the top 10 certified countries according to the ISO 9001:2015 standard, which indicates a large number of problems. In the opinions of the authors, prime among these are: firstly, the decline of the country's economy (destruction of industry, oppression of small and medium-sized businesses); secondly, the low level of capacity and competence among existing enterprises to form and implement effective and efficient QMS.

It is important that, according to "The ISO Survey of Certifications – 2018," the top 5 most certified industries (by type of activity) for compliance with ISO 9001:2015 are the following: metallurgy; construction; automotive; electronics; and engineering.

Analysis of certified countries according to other ISO standards (Table 1) shows that Ukraine is not included in any top 10. However, "engineering" as a certified industry is, by all standards (Table 1), included in the top 5. The importance of certification of QMS in the field of engineering (engineering services) is obvious and indisputable, as legal requirements and participation in the World Trade Organization force this industry to carry out activities in the presence of certificates of compliance with ISO standards, the most important of which is ISO 9001:2015. At the same time, successful certification is possible due to the formation and implementation of adequate QMS in enterprises. At the same time, one of the most important principles of QMS is its constant improvement, which is only possible due to its evaluation.

Evaluating the effectiveness and efficiency of QMS is one of the most complex and important issues in enterprise quality management, in particular in the field of engineer-

ing services. Today there are various methods and recommendations for assessing the QMS of enterprises in various fields.

Existing methods for assessing the effectiveness of QMS allow for assessment in three ways: the level of economic efficiency achieved as a result of the application of the quality management system; according to the criterion of compliance of the QMS level with the established requirements; the degree of influence of individual elements of QMS on the functioning of the organization as a whole and the level of quality of its products. It should be noted that the third method of evaluating the effectiveness does not differ fundamentally from the second, and is therefore its variant. Thus, the effectiveness of QMS can be assessed on the basis of two basic methods: assessment of economic efficiency; and determination of compliance [2]. In other words, the author suggests two approaches to the assessment of QMS of economic efficiency and effectiveness, with which we agree.

Investigating methodological approaches to QMS assessment, Stolyarchuk proves the effectiveness of the absolute and comparative forms of the rating method and emphasizes that the following methods are used in the absolute form: total, arithmetic mean, sum-differential, arithmetic-differential, and weighted average. In the comparative form, one can use the basic principles of the same methods as used in determining the level of product quality [1]. According to the Stolyarchuk, it is advisable to develop a universal approach to QMS assessment which should be based on a process approach, the main purpose of which is to eliminate inconsistencies, inefficiencies, and internal conflicts in companies.

In our opinion, such an approach to the assessment of QMS of engineering services enterprises, given the fierce competition, is not rational for the following reasons: firstly, it aims to assess only the effectiveness of QMS; and secondly, it does not contain questions relating to all of the important QMS processes regulated by the requirements of the international standard ISO 9001:2015.

On the other hand, some [4] argue that the method involving theory of extreme characteristics and double exponential distributions can be used to estimate the QMS of enterprises. This method is based on applying the desirable function of E. Harrington, which allows for the identification of deviations between the distribution of smallest, largest, and average estimates. Indicators are divided, by the method of T. Saati, into hierarchies via pairwise comparisons, and the optimality of indicators is tied to the logic of their content load.

There are ways to estimate the QMS based on the costs incurred by the company in the operation of such systems, and the costs of their improper operation. In one study [5], 12 indicators were developed for assessing cost in the QMS that are used for the evaluation of a clothing production company.

Studies of quality problems in recent years contain a method based on the principles of VI Romanovsky's criterion for the formation of a generalized indicator of the quality system, criteria for nonparametric statistics, "series criterion," and ordinal statistics, with the construction of a median series of inversions to confirm the stability of processes' influences. In other words, this approach can identify and analyze the QMS which leads to the fewest failures and deviations [4].

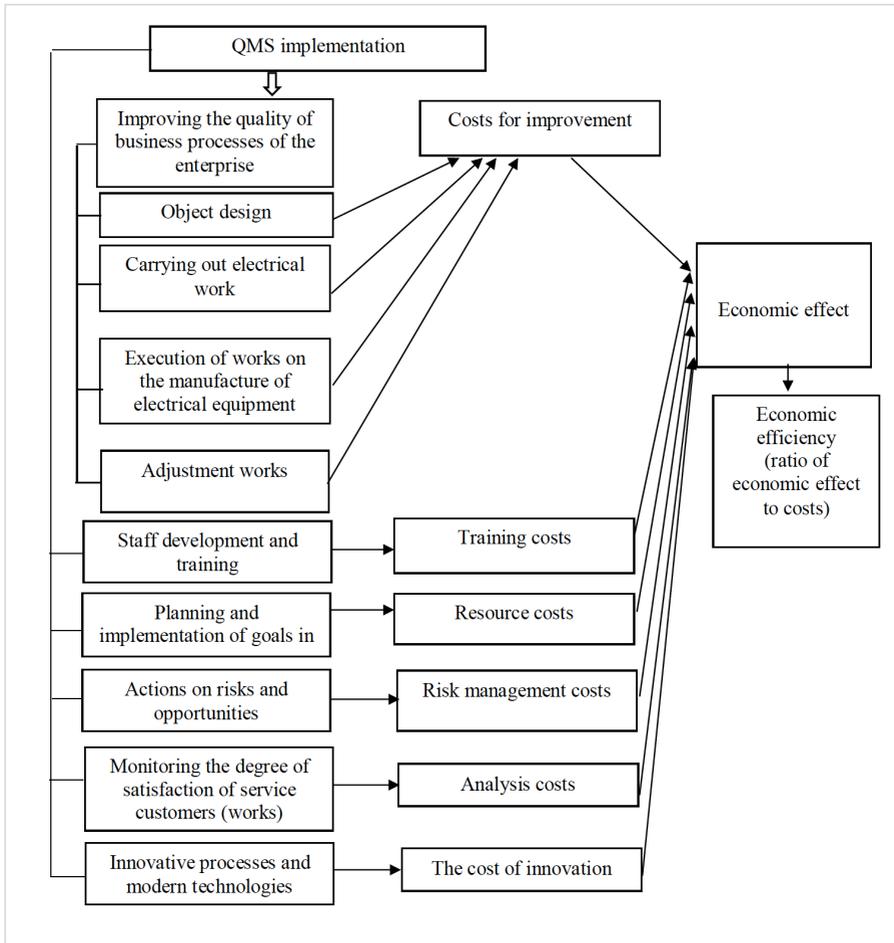
When evaluating the effectiveness and adaptability of QMS today, it is advisable to take into account the fact that they require the integrated application of existing mathematical, technical, organizational, managerial, and other special methods [6].

The effect of the introduction or improvement of QMS can have both external and internal origins. These effects can be expressed in the following areas: an increase in enterprises' guarantees of quality of production for clients; saving money by increasing productivity; an increase in sales of the company's products on the market due to improved quality characteristics; a simplification of the procedure for checking product quality upon receipt of orders; or an opportunity to participate in national and international tenders [7].

In the latest developments and scientific works, one can identify several basic integrated approaches to QMS assessment, which should be grouped into four categories.

1. Evaluation of QMS efficiency on the basis of the technical, economic, and social effect (effects) of its formation, implementation, application, and certification according to the international standards of the ISO 9000 series.
2. Study of cause and correlation between the introduction of QMS and other indicators of the enterprise (economic, social), determining the economic effect and economic efficiency of QMS based on the ratio of results from its operation and the cost of its implementation.
3. QMS, which can be measured on the basis of consumer satisfaction indices, are more effective from their point of view. Indices are calculated in many countries, some of which are international.
4. For the management system of the enterprise (general management) it is advisable to apply the method of a balanced scorecard of Norton and Kaplan (BSC) [8]. Taking into account the interests of groups of influences and the principle of continuous development of the enterprise allows for a more objective identification of the impact of QMS on the activities of the enterprise (general management) [9].

One might consider in more detail the above approaches to QMS assessment in order to develop effective tools for companies in the field of engineering services. The first two approaches, in our opinion, are appropriate for use by enterprises in the field of engineering services for the assessment of QMS, as they indicate a synergistic effect associated with the improvement of business processes such as: design of facilities, electrical work, electrical work equipment (ETO), and commissioning. On the other hand, the synergistic effect is associated with the management processes of the enterprise, which are important for improving its QMS: staff development and training, planning and implementation of quality objectives, actions on risks and opportunities, monitoring customer satisfaction (works), and innovation processes. In our opinion, this approach to QMS assessment indicates its integration into the overall management of the enterprise in the field of engineering services, which is an essential requirement of the ISO 9001:2015 standard. Directions for assessing the implemented QMS at the enterprise in the field of engineering services are shown in Figure 2.



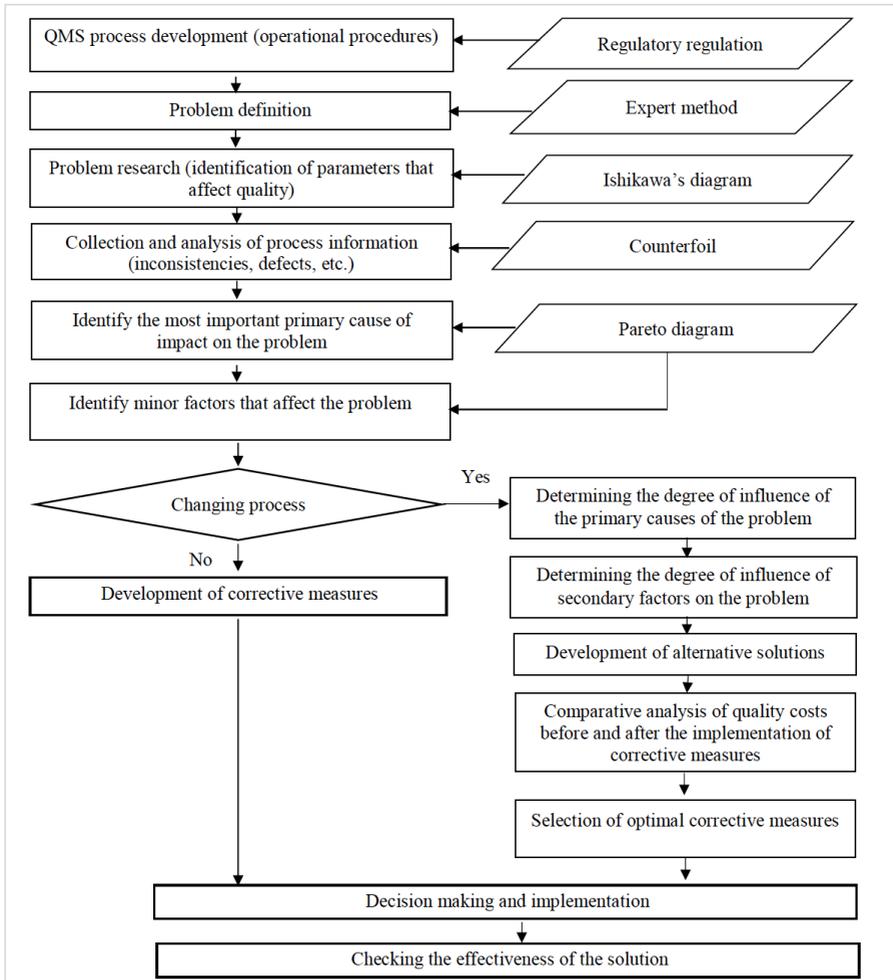
**Figure 2.** Directions of QMS assessment for an enterprise in the sphere of engineering services  
 Source: author's own development

Areas of assessment of the QMS of enterprises in the field of engineering services are determined taking into account the requirements of the international standard of ISO 9001:2015. The assessment of QMS in relation to this approach requires taking into account the level of development of the financial and economic condition of the enterprise in the field of engineering services at the initial stage of assessment. More objective evaluation results can be obtained by taking into account the time period of occurrence of the relevant changes and the impact of QMS on certain indicators.

QMS assessment can be internal and external, for example by being carried out independently or by independent organizations, associates, consumers, or customers,

and may include audit, analysis, or self-assessment [10]. Undoubtedly, the audit (internal or independent) allows for the assessment of the QMS for compliance with the requirements of the international standard ISO 9001:2015, to determine its adequacy and compliance with the requirements of the standard. One of the key processes of QMS is the planning and conducting of internal audits with a periodicity determined by the company, during which non-compliance of QMS with the requirements of the above standard allows the auditor to identify conclusions about its effectiveness and opportunities for improvement. One unconditional advantage of audits is systematization, or independence. The company's internal QMS audits can be attributed to the company's self-assessment. However, they provide for the mostly selective nature of inspections of the QMS processes of the enterprise, which does not ensure the completeness and objectivity of the assessment. On the other hand, the results of audits significantly depend on the competence, experience, and qualifications of auditors. Regarding third party audits (through an independent certification body), i.e., a certification audit, the shortcomings are almost the same as with internal audits, but companies receive the coveted QMS certificate for compliance with ISO 9001:2015. This provides them with a number of positives, such as: a guarantee for consumers of proper quality of products, services, and works; the opportunity to enter international markets; increasing competitiveness, etc. Certification is an external assessment of the QMS of the enterprise. In general, audits allow us to assess the effectiveness of the QMS processes of the enterprise, and there is no question of efficiency.

Regarding the analysis of the QMS of the enterprise, this approach includes, in particular, the issue of adjusting the policy and the quality objectives in the event of changing needs and expectations of stakeholders. This makes sense, however, given the fact that the purpose of assessing and analyzing the QMS of the enterprise is to improve it, and, in our opinion, they should be considered in terms of identifying problems with the functioning of system processes using certain methods. Today, enterprises in the field of engineering services do not have the methodological tools to solve these problems, so we propose to use an algorithm for the expert evaluation of QMS processes, which was developed as part of research on the adaptation of the integrated enterprise management system to international standards ISO 9001:2015, ISO 14001:2015, and ISO 45001:2018. The algorithm was developed on the basis of QMS research on 12 companies in the field of engineering services in Ukraine (Fig. 3).



**Figure 3.** Algorithm for the expert evaluation of the QMS processes of the enterprise in the field of engineering services

Source: author's own development

The algorithm developed is an effective tool for analyzing the problems of companies, and has a wide range of applications. Its use is advisable during internal audits to assess the QMS processes in the context of ISO 9001:2015, including risk assessment and taking into account the areas shown in Fig. 2. For the effective application of the developed algorithm in the work of an enterprise in the field of engineering services, it is advisable to create a quality management department as the main body to clarify the problems

associated with the functioning and improvement of QMS processes. The responsibility of such a unit should be the collection, systematization, and processing of data on the functioning of the QMS, along with the external and internal influences on both its processes and the activities of the enterprise as a whole. An important aspect in the formation of QMS is the definition and clear regulation of its processes in accordance with the requirements of regulations. No corrective action is required if the requirements are met. If deviations from the requirements are found, their reasons should be formulated as issues that require appropriate management decisions. The functions of the quality management department are also the development of a schedule that determines the frequency of data collection, document management, and the development of forms of relevant documents.

To develop solutions to address the identified deviations, it is necessary to unite and coordinate actions, which forms part of the function of the quality management department. This body is responsible for the transfer and systematization of non-compliance (deviations) with the requirements for the operation of QMS in the enterprise, their routing, scheduling solutions, the appointment of executors, clarification of the state of problem solving, and their synchronization.

As the company's resources are limited, a chain of tools is needed to select the problems of QMS operation, the solutions to which give the company significant potential benefits. On the basis of a complete set of situations and corresponding solutions, problems are selected to which solutions already exist. If the necessary solution has already been formulated, the quality management department will find it and determine the period of its previous use in a similar situation and notify the person who raised the problem.

If such a solution does not exist, it is proposed to use the causal diagram of Ishikawa to prepare it. This method allows one to identify deviations and their causes. The outcome of the process depends on many components, between which there are cause-effect relationships. The Ishikawa diagram is a tool that allows one to display these relationships in a simple and accessible form. When creating a cause-and-effect diagram, it is necessary to select the maximum number of factors related to the characteristic that went beyond the allowable values. The most effective is a group method of analyzing the causes – brainstorming.

It was noted above that the collection and analysis of information is an important step in quality management. The guide to action is the data from which we learn the facts. Any data that is collected has a purpose and must be worked with once it has been collected. To do this, we used one of the Japanese quality management tools – a checklist.

Based on the collected and analyzed information for each primary and secondary cause affecting the problem, the most important of them are identified. The Pareto diagram is used for this purpose. It allows one to distribute efforts to solve the problems that have arisen and identify the main reasons for which to act, and also provides an opportunity to quantify the causes that affect the problem.

To find optimal solutions, it is desirable for the company to have a library equipped with the necessary literature. Leaders (not exclusively) should get acquainted with the

latest achievements in the areas that interest them. In addition, managers should be given the opportunity to attend conferences, seminars, refresher courses, and special university lectures. Managers must not only know the solutions that have been tested in practice, but also create new ones. Therefore, their desire to experiment and develop in this direction should be encouraged. Finding the optimal solution requires from the person responsible for solving the problem a huge creative return, and a degree of determination.

The effective search for and selection of optimal solutions should be carried out by changing the process conditions. This allows one to objectively determine the root causes and secondary factors that cause the problem. Having received the data under different conditions of the process, by ranking them you can determine the most important root cause of the problem and approve its priority. In this way, we get objective information on how to solve the problem.

Having identified the most important primary cause of the problem, we determine the most important secondary factor that affects it. It is for this that we make the optimal management decision. The choice of optimal solutions is always based on a set of indicators of the state of the object or phenomenon, taken from both subject and system knowledge.

Once the best of the possible solutions has been chosen, one must make a plan to implement corrective action and check on its implementation.

The reasoned decision is registered and sent to the quality management department to determine which departments of the enterprise will be affected by the proposal and what their reaction will be. Once it has been decided which departments are affected, the quality management department selects the managers with whom the proposal needs to be agreed, schedules their work, and sets a deadline by which they must communicate their views on the proposal.

Each division of the enterprise should calculate the effect that is planned to be obtained from the implementation of the proposal. It is also advisable to conduct a comparative analysis of quality costs before and after the implementation of corrective measures. If the decision is prepared and approved, the person responsible for its implementation is appointed.

There are eight principles of quality management in accordance with the international standards of the ISO series: customer focus; management; employee involvement; process approach to management; system approach to management; continuous improvement; evidence-based approach to decision-making; and a mutually beneficial relationships with suppliers. The use of a balanced scorecard can be integrated into quality strategy, thus influencing its formation and implementation in the short and long term [11].

The system of performance and efficiency evaluation indicators, built on the basis of BSC, provides an opportunity to combine the evaluation of QMS efficiency in general with the calculation of efficiency and effectiveness of business processes that are aimed at making a profit. Noting this provision, it should be highlighted that the QMS effect is by nature synergistic (i.e., the effect of enhancing interaction and coordination between the elements of this system). The objective basis for the emergence of the synergistic effect of

QMS is the real interaction and integration of its constituent processes. Hence, respectively, we can draw two methodological conclusions:

1. the effect of QMS is always greater than the algebraic sum of the effects of business processes;
2. the efficiency of QMS is directly related to determining the increase in the magnitude of the overall effect of the system in comparison with the total effect of the functioning of its individual business processes. The latter can be assessed on the basis of indicators of customer satisfaction and staff. Meanwhile, BSC allows you to see business activities in four main projections: financial prospects; prospects of customer satisfaction; prospects for the development of the organization; and prospects for innovation, learning, and growth [12].

Today, the BSC is the most successful attempt to integrate the use of financial and non-financial indicators. As practice shows, a company needs 15–20 indicators, a division approximately 7–10, and for one employee no more than 5 are required. BSC focuses evaluation on four closely related perspectives: financial results; consumers; internal organization; and training and staff development. In a typical BSC, each will contain key success factors and relative indicators that will stimulate performance in certain directions [13].

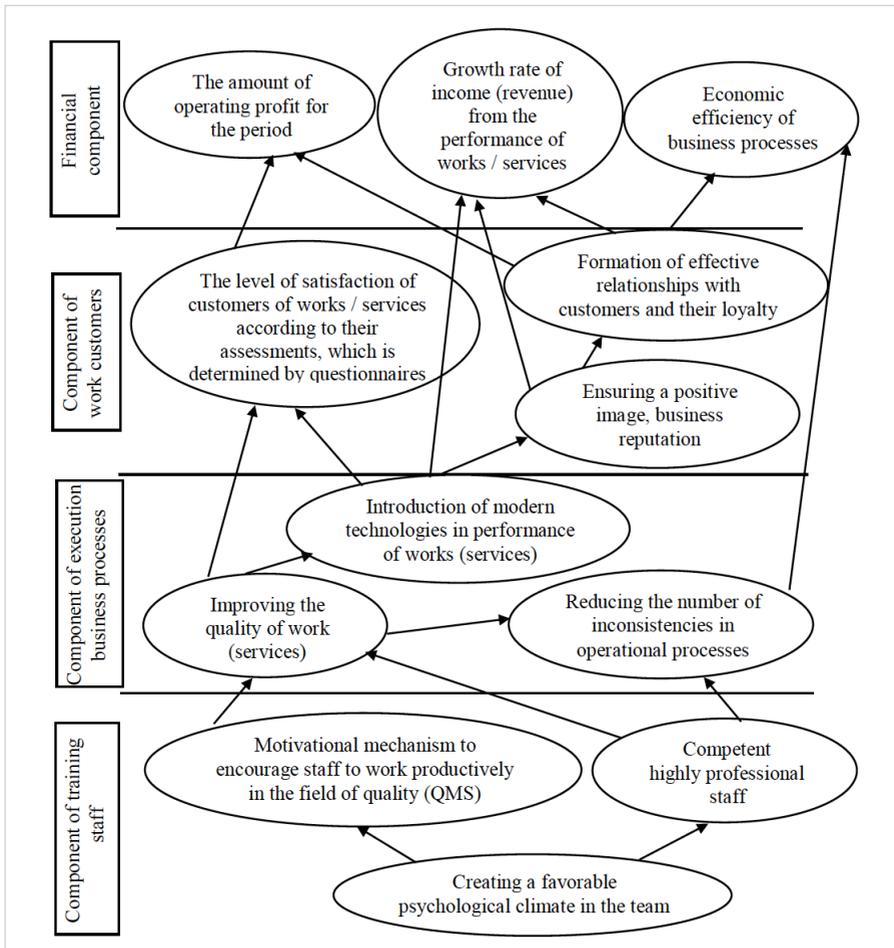
It is necessary to introduce a balanced system of indicators in stages: the first stage is preparatory; the second is a continuous cyclic process of system deployment and refinement. First, it is necessary to identify key strategic goals that will form the basis of the entire analysis, such as “finance,” “clients,” “processes,” or “development.” Breaking these concepts into narrower ones, it is possible to compile a decision tree on the problem of improving the efficiency of enterprise management [14].

The stages of analysis with the help of BSC are: SWOT analysis and the determination of success factors; the definition of strategic goals and their reflection on the basis of the construction of a strategic map; the determination of indicators for each component of a balanced system of indicators and target values, and the calculation of these indicators; and a strategic action plan and the support, updating, and development of a balanced scorecard [15].

The construction of a balanced system of indicators was carried out on the basis of data obtained during the study of the 12 largest enterprises in the field of engineering services in Ukraine, in the field of energy. According to the stages defined, the analysis of a condition of internal and external environments of the enterprises by means of SWOT analysis was carried out. The SWOT analysis showed a significant number of strengths of the company’s internal environment. The excess of threats over opportunities in the external environment is mainly associated with political instability, an imperfect legal framework, the wear and tear of equipment, the constant improvement of competitors’ skills, and high inflation [16].

It is the assessment of its internal capabilities that allows us to identify the mechanism of causal links between the strategic goals of an engineering enterprise. All of this is clearly reflected in the strategic maps of the enterprise.

Kaplan, Norton, and Niven [17] consider strategic maps from the point of view of: the reflection of interrelations and dependences between separate purposes; the explanation of mutual effects arising in the course of the achievement of the purposes; the formation, at heads, of an understanding of the dependences and values of separate goals; and the promotion of a common understanding of the strategy. Each direction can contain several goals. Figure 4 shows a strategic map for an enterprise in the field of engineering services as an important aspect in assessing its QMS.



**Figure 4.** Strategic map of enterprises in the field of engineering services based on a balanced scorecard for QMS assessment  
 Source: constructed by the author using [18]

At the next stage of the analysis, it is necessary to select key indicators in terms of BSC directions. It is advisable to choose an equal number of indicators, namely 5 indicators from each area, and make their calculations for the period (per year). It is known that most performance appraisal systems are based on the annual budget and operational plan of the enterprise. Therefore, it should be noted that these systems focus on short-term periods and tactics, rather than strategy. Along with traditional systems, the BSC also includes financial indicators as one of the most important performance measurement criteria, but also emphasizes the importance of non-financial indicators.

An important component of the BSC is financial. Its main task is to increase the profitability of work performed (services), return on equity, net cash flow, and net profit. Financial goals are at the heart of the goal tree, but there is a close relationship with goals in marketing, internal processes, and staff development. In terms of the financial component, it is necessary to calculate the following indicators: the ratio of absolute liquidity; total liquidity; long-term borrowing; return on equity; and return on assets.

Within the client component, the company's management must identify key market segments for the implementation of engineering services (or works). This will strengthen the marketing and sales strategy and lead to an increase in financial performance in the future. To solve this problem, it is advisable to analyze such factors as market segment share, the number of regular customers and major competitors, profitability of sales, and the share of receivables.

The business process component of an engineering enterprise identifies the main processes that need improvement. The efficiency of business processes determines the value of the company's offer, which depends on the number of customers involved and the final financial result [19]. For the key business processes of an engineering company, it is necessary to determine the parameters that characterize these processes and develop performance indicators. In our case, the following indicators were determined that correspond to the business environment of the enterprise: product profitability; depreciation rate and suitability of fixed assets; turnover of current assets; and profitability of the enterprise to perform works (or services).

Staff training and development is an essential component of BSC, as staff form the key chain of successful businesses. The main performance indicators include: employee satisfaction and pride in their work; skills, awareness, competence, and high qualification; and the ability to make management decisions based on evidence. The main indicators within this component are: the coefficient of professional development; staff profitability; staff turnover; and the actual amount of assets per employee [20–25].

A balanced system of indicators of an engineering enterprise is the basis for creating a BSC for its divisions. Each unit must develop its own systems of indicators that meet the goals and strategies of the enterprise as a whole. This process is called "cascading," when a complex system of indicators is built in which lower-level indicators "work" to achieve the target values of upper-level indicators.

BSC allows one to systematically implement a company's strategic plans, transferring them to the operational level of management and monitoring the implementation of the strategy based on key performance indicators.

The approach to QMS evaluation based on determining the economic effect and economic efficiency of QMS based on the ratio of results from its operation and the cost of its implementation is noteworthy. It is known that, in accordance with the requirements of ISO 9001:2015, the QMS of the enterprise must be integrated into the business processes of the company, and the effectiveness of their implementation is a fundamental tool for their evaluation. A comparative analysis of business process costs before and after implementation was conducted to assess the QMS of the engineering enterprise. The research and calculations were carried out within the framework of the fundamental and applied research works of the Odessa National Economic University, on the topic: "Improving the design of facilities as an important component of the quality management system of Chornomorenergospetsmontazh LLC in accordance with the requirements of the international standard ISO 9001:2008."

The total cost of ensuring the quality of work ( $C_{\text{qual}}$ ) at the engineering company can be determined by the formulas:

$$C_{\text{qual}} = C_{\text{work}} + C_{\text{cons}} \quad (1)$$

where  $C_{\text{work}}$  – the cost of work;

$C_{\text{cons}}$  – the cost of correcting defects (inconsistencies) after the work of the consumer.

For an enterprise in the field of engineering services, it is clearly established which costs belong to each of these categories, as well as how and by whom they will be reproduced. The basis of calculations are the costs of performing the main business processes of the enterprise.

$$C_{\text{qual}} = C_{\text{des}} + C_{\text{elec}} + C_{\text{el.equip}} + C_{\text{commis}} + C_{\text{cons}} \quad (2)$$

where  $C_{\text{des}}$  – the cost of design work;

$C_{\text{elec}}$  – the cost of electrical work;

$C_{\text{el.equip}}$  – the cost of work on the manufacture of electrical equipment and metal structures;

$C_{\text{commis}}$  – the costs of commissioning;

$C_{\text{cons}}$  – the cost of correcting defects (inconsistencies) after the work of the consumer.

By increasing or decreasing some cost groups, other groups may increase or decrease accordingly. By increasing the cost of preventive measures, it is possible to achieve a reduction in losses from defects (inconsistencies) and a reduction in control and testing.

One of the most effective ways to reduce the cost of work (or services) is to minimize costs for all groups. Therefore, when comparing changes in costs, one should choose the option that gives the greatest savings.

In modern practice, in the organization of work (or services) and cost planning for quality assurance, the largest share in the total costs is the cost of control, whereas the smallest is the cost of preventing defects (inconsistencies) [26–32]. This does not take

into account that the control at a significant cost does not in itself increase the quality, but only allows one to separate the high quality from the low quality.

In this regard, the most optimal scheme is the distribution of costs with an emphasis on costs associated with the prevention of defects (inconsistencies) in the performance of certain types of work at the engineering company.

Changing the level of quality of work (or services) performed leads to a change in the cost of their performance on the one hand, and the cost of the consumer on the other. Thus, the performance of works (or services) of another level of quality and their consumption cause the following situations:

1. The costs of the contractor (services) increase, and the costs of the consumer decrease.
2. The costs of the executor of works (or services) decrease, and the expenses of the consumer increase.
3. The costs of the contractor (services) and the consumer are reduced.
4. The costs of the contractor (services) and the consumer increase.

The components of costs are determined and their calculations are performed when performing the main business processes of Chornomorenergospetsmontazh LLC, namely:

- object design;
  - electrical work;
  - for the manufacture of electrical equipment and metal structures;
  - commissioning works.
1. We can calculate the cost of design work for 2012 –  $C_{des0}$  (before the introduction of QMS and its certification for compliance with the requirements of the international standard ISO 9001) and 2013 –  $C_{des1}$  (after the introduction of QMS). In 2012–2013, the hryvnia exchange rate was kept at a stable level of 8 UAH / USD.

$$C_{des0} = C_{wag0} + C_{soft0} + C_{el0} + C_{pap0} + C_{exam0} + C_{post0} + C_{train0} + C_{cons0} \quad (3)$$

where  $C_{wag0}$  – wage costs;

$C_{soft0}$  – software costs;

$C_{el0}$  – electricity costs;

$C_{pap0}$  – paper costs;

$C_{exam0}$  – costs for examination of projects;

$C_{post0}$  – the cost of posting workers to facilities;

$C_{train0}$  – staff training costs;

$C_{cons0}$  – the cost of correcting defects (inconsistencies) after the work of the consumer.

$$C_{des0} = 135,000\$ + 11,250\$ + 5,000\$ + 1,250\$ + 50,000\$ + 33,750\$ + 11,250\$ + 2,500\$ = 250,000\$$$

The cost of project work after the implementation of QMS (Exercise 1) is calculated by the formula:

$$C_{des1} = C_{wag1} + C_{soft1} + C_{el1} + C_{pap1} + C_{exam1} + C_{post1} + C_{train1} + C_{cont.proj1} + C_{tend1} + C_{exp1} + C_{mod1} + C_{cons1} \quad (4)$$

where  $C_{wag1}$  – wage costs;

$C_{soft1}$  – software costs;

$C_{el1}$  – electricity costs;

$C_{pap1}$  – paper costs;

$C_{exam1}$  – costs for examination of projects;

$C_{post1}$  – the cost of posting workers to facilities;

$C_{train1}$  – staff training costs;

$C_{cont.proj1}$  – costs of quality control of project implementation;

$C_{tend1}$  – costs of tender market monitoring;

$C_{exp1}$  – the cost of expanding jobs;

$C_{mod1}$  – the cost of modern office equipment;

$C_{cons1}$  – the cost of correcting defects (inconsistencies) after the work of the consumer.

$$C_{des1} = 135,000 \$ + 22,500 \$ + 5,000 \$ + 1,250 \$ + 20,000 \$ + 5,000 \$ + 50,000 \$ + 33,750 \$ + 17,500 \$ + 31,250 \$ + 3,750 \$ + 1,875 \$ = 326,875 \$$$

Profit from design work ( $P_{des0}$ ) for 2012 amounted to 265,000\$

Profit from design work ( $P_{des1}$ ) for 2013 amounted to 353,025\$

- The calculation of costs for electrical work before the introduction of QMS engineering enterprise (Celec) is carried out according to the formula:

$$C_{elec0} = C_{cost0} + C_{to0} + C_{prot0} + C_{equip0} + C_{lubr0} + C_{train0} + C_{post0} + C_{spec0} + C_{subcontr0} + C_{en0} + C_{instal0} + C_{cons0} \quad (5)$$

where  $C_{cost0}$  – wage costs;

$C_{to0}$  – the cost of providing power tools;

$C_{prot0}$  – the cost of protective equipment;

$C_{equip0}$  – equipment maintenance costs;

$C_{lubr0}$  – costs of fuels and lubricants;

$C_{train0}$  – staff training costs;

$C_{post0}$  – the cost of posting workers;

$C_{spec0}$  – the cost of renting special equipment;

$C_{subcontr0}$  – costs of subcontractors;

$C_{en0}$  – energy costs;

$C_{instal0}$  – costs of installation and dismantling;

$C_{cons0}$  – the cost of correcting defects (inconsistencies) after the work of the consumer.

$$C_{elec0} = 1,250,000 \$ + 18,750 \$ + 18,750 \$ + 62,500 \$ + 2,500,000 \$ + 18,750 \$ + 500,000 \$ + 87,500 \$ + 1,200,000 \$ + 37,500 \$ + 3,000,000 \$ + 13,125 \$ = 8,706,875 \$$$

The cost of electrical work after the introduction of QMS to the enterprise (Vem1) is calculated by the formula:

$$C_{elec1} = C_{cost1} + C_{to1} + C_{prot1} + C_{equip1} + C_{lubr1} + C_{train1} + C_{post1} + C_{spec1} + C_{subcontr1} + C_{en1} + C_{instal1} + C_{cons1} \quad (6)$$

$$C_{elec1} = 1,375,000 \$ + 15,000 \$ + 16,250 \$ + 56,250 \$ + 2,250,000 \$ + 22,500 \$ + 475,000 \$ + +75,000 \$ + 1,187,500 \$ + 35,000 \$ + 2,625,000 \$ + 9,375 \$ = 8,141,875 \$$$

The profit from electrical work before the introduction of QMS ( $P_{elect0}$ ) in 2012 amounted to 9,229,287.5 \$

The profit from electrical work after the introduction of QMS ( $P_{elec1}$ ) in 2013 amounted to 8,793,225 \$

3. We can also calculate the cost of work on the manufacture of electrical equipment and metal structures before the introduction of QMS to the engineering enterprise ( $C_{el.equip0}$ ) by using the formula:

$$C_{el.equip0} = C_{cost0} + C_{compon0} + C_{el0} + C_{equip0} + C_{train0} + C_{prot0} + C_{cons0} \quad (7)$$

where  $C_{cost0}$  – wage costs;

$C_{compon0}$  – costs of components and materials;

$C_{el0}$  – energy costs;

$C_{equip0}$  – equipment maintenance costs;

$C_{train0}$  – staff training costs;

$C_{prot0}$  – the cost of protective equipment;

$C_{cons0}$  – the cost of correcting defects (inconsistencies) after the work of the consumer.

$$C_{el.equip} = 135,000 \$ + 750,000 \$ + 17,500 \$ + 5,000 \$ + 2,500 \$ + 3,750 \$ + 1,000 \$ = 914,750 \$$$

The costs of performing works on the manufacture of electrical equipment and metal structures after the introduction of QMS at the engineering enterprise ( $C_{el.equip1}$ ) are calculated by the formula:

$$C_{el.equip1} = C_{cost1} + C_{compon1} + C_{el1} + C_{equip1} + C_{train1} + C_{prot1} + C_{cons1} \quad (8)$$

$$C_{el.equip1} = 147,500 \$ + 687,500 \$ + 15,000 \$ + 4,375 \$ + 3,125 \$ + 3,500 \$ + 625 \$ = 861,625 \$$$

Profit from the performance of works on the manufacture of electrical equipment and metal structures prior to the introduction of QMS to the enterprise ( $P_{el.equip0}$ ) amounted to 969,635 \$

The profit from the performance of works on the manufacture of electrical equipment and metal structures after the introduction of QMS ( $P_{el.equip1}$ ) amounted to 930,555 \$

4. The calculation of costs for commissioning work before the introduction of QMS to the engineering enterprise ( $C_{commis0}$ ) is carried out according to the formula:

$$C_{commis0} = C_{cost0} + C_{to0} + C_{equip0} + C_{el.lab0} + C_{lubr0} + C_{train0} + C_{post0} + C_{el0} + C_{cert0} + C_{cons0} \quad (9)$$

where  $C_{cost0}$  – wage costs;

$C_{to0}$  – the cost of providing power tools;

$C_{equip0}$  – the cost of protective equipment;

$C_{el.lab0}$  – the cost of maintaining electrical laboratory;

- $C_{lubr0}$  – costs of fuels and lubricants;
- $C_{train0}$  – staff training costs;
- $C_{post0}$  – the cost of posting workers;
- $C_{el0}$  – energy costs;
- $C_{cert0}$  – costs for electrical laboratory certification;
- $C_{cons0}$  – the cost of correcting defects (inconsistencies) after the work of the consumer.

$$C_{commis0} = 500,000 \$ + 3,750 \$ + 3,750 \$ + 25,000 \$ + 37,500 \$ + 3,125 \$ + 125,000 \$ + 4,375 \$ + +5,000 \$ + 1,875 \$ = 709,375 \$$$

The costs of commissioning after the introduction of QMS to the engineering enterprise ( $C_{commis1}$ ) are carried out according to the formula:

$$C_{commis1} = C_{cost1} + C_{tot1} + C_{equip1} + C_{el.lab1} + C_{lubr1} + C_{train1} + C_{post1} + C_{el1} + C_{cert1} + C_{cons1} \quad (10)$$

$$C_{commis1} = 525,000 \$ + 3,125 \$ + 3,125 \$ + 25,000 \$ + 31,250 \$ + 3,500 \$ + 100,000 \$ + 3,750 \$ + + 5,000 \$ + 1,250 \$ = 701,000 \$$$

The profit from commissioning works before the implementation of QMS to the enterprise (2012) ( $P_{commis0}$ ) amounted to 751,937.5 \$

The profit from commissioning after the introduction of QMS to the enterprise (2013) ( $P_{commis1}$ ) amounted to 757,080 \$

To calculate the annual economic effect of the introduction of QMS to the enterprise, it is necessary to determine the total costs of work before and after the implementation of QMS ( $C_{qual0}$  and  $C_{qual1}$ ) and the total profit of the respective periods of the enterprise – 2012 and 2013 ( $P_0, P_1$ ).

$$C_{qual0} = 250,000 \$ + 8,706,875 \$ + 914,750 \$ + 709,375 \$ = 10,581,000 \$$$

$$C_{qual1} = 326,875 \$ + 8,141,875 \$ + 861,625 \$ + 701,000 \$ = 10,031,375 \$$$

The total profit by type of activity before the introduction of QMS ( $E_0$ ), and after its implementation ( $E_1$ ) is:

$$P_0 = 265,000 \$ + 9,229,287.5 \$ + 969,635 \$ + 751,937.5 \$ = 11,215,860 \$$$

$$P_1 = 353,025 \$ + 8,793,225 \$ + 930,555 \$ + 757,080 \$ = 10,833,885 \$$$

The economic effect for 2012 and 2013 is determined by the formulas:

$$E_0 = P_0 - C_{qual0} \quad (11)$$

$$E_1 = P_1 - C_{qual1} \quad (12)$$

$$E_0 = 11,215,860 \$ - 10,581,000 \$ = 634,860 \$$$

$$E_1 = 10,833,885 \$ - 10,031,375 \$ = 802,510 \$$$

$$E \text{ implem} = E_1 - E_0 = 802,510 \$ - 634,860 \$ = 167,650 \$$$

## 4. Conclusions

The proposed areas for the evaluation of quality management systems in enterprises in the field of engineering services can be effective means of improving the activities of companies. The algorithm for the expert evaluation of the quality management systems of engineering services is an effective tool for analyzing problems with companies. It has a wide range of applications, including internal audits, assessing QMS processes in the context of ISO 9001:2015, and risk assessment. To apply the methodology of a balanced scorecard, a strategic map of an enterprise in the field of engineering services has been developed, which focuses efforts on significant processes and indicators for evaluating the quality management system. Comparative analysis of the costs of business processes of the enterprise in the field of engineering services before and after the introduction of QMS allowed the authors to determine the economic effect, which was 167,650 \$.

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