QUALITY CONTROL DEVELOPMENT AT THE STRATEGIC LEVEL

Lim Chandeth, Antonina Shostakovska, Petro Tsymbal, and Ganna Vlasova

Abstract. The paper deals with the scientific and methodological approach to quality control of the industrial enterprise development at the strategic level based on adapting the control system to the life cycle stages of the organizational structure and products of the industrial enterprise, through which the transition between the stages of the life cycle and the quality of the enterprises' development in a strategic term can be detected. In terms of the products' life cycle, the task of control at the strategic level is to detect promptly the stage when the products no longer meet the needs of the market, and to control the transition efficiency from stage to stage. To solve this task, it is proposed to use the following indicators: the dynamics of sales volumes; the dynamics of the products' market share; the coefficient of products' competitiveness; the dynamics of products' profitability; the coefficient of product expectation on the market, etc.

Keywords: adaptation, control system, quality, development, stages, life cycle, industrial enterprise

JEL Classification: C44, D81

Authors:

Lim Chandeth
Panha Chiet University, 13-20-24, Sangkat Teuk Laak 3, Khan Toul Kok, Phnom Penh, Cambodia, 12158
E-mail: chandethlim@gmail.com
https://orcid.org/0000-0001-5261-0829

Antonina Shostakovska
European University, 16V Vernadsky Boulevard, Kiev, Ukraine, 02000
E-mail: av_kafgp@ukr.net
https://orcid.org/0000-0001-8948-5777

Petro Tsymbal
National University of the Fiscal Service of Ukraine, 31 University Street, Irpin, Ukraine, 08200
E-mail: tsymbal52@meta.ua
https://orcid.org/0000-0002-7244-4669

Ganna Vlasova
European University, 16V Vernadsky Boulevard, Kyiv, Ukraine, 02000
E-mail: vlasovaann@ukr.net
https://orcid.org/0000-0002-5616-3904

1. Introduction

Managing the quality of industrial enterprise's development effectively is impossible without taking into account the life cycle. Moments of the life cycle stages are very important for an industrial enterprise, and the quality of enterprise development depends on what management decisions were made. When considering an industrial enterprise as an economic system under the life cycle refers to the stages of the process, covering all the states of the system, from the moment of the enterprise's establishment and to its shutdown (Blanchard & Fabrycky, 2010). Also, it should be borne in mind that an industrial enterprise is an artificial, not a living system, therefore, the closing stage is not mandatory. That is, the life cycle of an industrial enterprise can be regarded as a limited set of stages or states in which the enterprise is developing. Depending on what stage of the life cycle the industrial enterprise is, it is necessary to focus attention on various aspects of activities. Thus, in the initial stages of the life cycle, it is necessary to increase control of costs, and in the stages of maturity the main thing is to control and forecast the income for timely adaptation to changes in the competitive environment.

Moreover, in terms of quality control over the industrial enterprise's development, the life cycle includes both that of the enterprise as an organizational structure and the life cycles of products. These components of the overall life cycle of an industrial enterprise determine which factors are subject to strengthened control and analysis to ensure timely correction and direction of development in the most promising trajectory.

2. Literature review

Quality management ensures that an organization, product or service is consistent. It has four main components: quality planning, quality assurance, quality control and quality improvement (Rose & Kenneth, 2005). As systemic thinking is bringing more holistic approaches to quality, the process and products are considered together rather than as independent factors in quality management. The influence of quality thinking has spread to non-traditional applications outside the walls of manufacturing, extending into service sectors and into areas such as sales, marketing and customer service (Selden & Paul, 1998).

The issue of quality control development at the strategic level is not new among today's publications of scientists who offered tools to handle the components of this issue (Huang et al., 2018; McAdam et al., 2019; Rehhausen et al., 2018). But it should be noted that these researchers did not consider sufficiently the specificity of control at the strategic level; moreover, the issue of adapting the control system to those stages of the life cycle, which is now an industrial enterprise, remains beyond their analysis. That is, the life cycle of an industrial enterprise can be regarded as a limited set of stages or states in which the enterprise develops (Azevedo et al., 2017). Depending on what stage of the life cycle the industrial enterprise is, it is necessary to focus attention on various aspects of activities. Thus, in the initial stages of the life cycle, it is necessary to increase control over costs, and in the stages of

maturity, there should be monitoring and forecast of income in order to timely adapt to changes in the competitive environment.

Moreover, in terms of quality control over the industrial enterprise's development, the life cycle includes that of the company as an organizational structure and the life cycles of its products (Ali et al., 2019). These components of the overall life cycle of an industrial enterprise determine which factors are subject to strengthened control and analysis to ensure timely correction and direction of development in the most promising trajectory.

The findings proved that scientific community around the world analysed quality control development from the different points of views: competitive advantages (Boiko et al., 2019; Dźwigoł et al., 2020; Kwilinski et al., 2020); production costs (Dementyev & Kwilinski, 2020); research methodology (Dźwigoł & Dźwigoł-Barosz, 2018; Dźwigoł, 2019a); controlling in the management process (Dźwigoł & Wolniak, 2018); enterprise restructuring process (Dźwigoł, 2019b); national security (Dzwigoł et al., 2019a); investment attractiveness (Dzwigol et al., 2019b Lyulyov, et al. 2017); management system at an enterprise (Dźwigoł et al., 2019c); innovation development (Kondratenko et al., 2020; Kuzior & Zozuľak); sustainable development (Dalevska et al., 2019; Kuzior et al., 2019; Lyulyov et al., 2019; Vasylieva et al., 2018; 2019); ICT development for the management (Kwilinski, 2017; 2018a; 2018b; 2018c; 2018d; 2019; Kwilinski et al., 2019a; 2019b; 2019c; 2020a; Kwilinski & Kuzior, 2020; Tkachenko et al., 2019a; 2019b; 2019c); financial activity (Kwilinski et al., 2020b; Pająk et al., 2016); and energy security (Pająk et al., 2017).

3. Methods

When considering the quality control over an industrial enterprise development from the standpoint of operational, tactical and strategic control, adaptation to the life cycle refers to strategic control. Strategic quality control of the industrial enterprise's development is characterized by the following features: it covers significant time periods in which significant changes in the environment occur; it summarizes the conclusions of operational and tactical control; it provides the basis for determining the further strategic objectives of the industrial enterprise; it determines the main types of products of the industrial enterprise and monitors the need for their changes; it creates a knowledge base on developing industrial, financial, marketing, personnel, innovation, investment and other activities of the industrial enterprise; it provides a comparison of the achieved quality development indicators with possible alternatives; it serves as a basis for correcting strategic plans; it creates the information basis for the long-term distribution of the industrial enterprise's resources; it establishes performance indicators for further quality control development, both strategic and operational and tactical; it provides study of the environment and adaptation to it.

It is proposed to control the quality of the industrial enterprise's development at the strategic level to carry out both the assessment and analysis of the trajectories of quality indicators of development that are comparable to the stages of the industrial enterprise's life cycle. In turn, the industrial enterprise's life cycle is characterized by the state of the environment and by

the stage the components of the overall life cycle of the enterprise are at. Finding a company, its products or technologies at individual stages of the life cycle determines which strategic goals can be set for an enterprise and how the quality of development should be monitored.

When analysing an industrial enterprise as an organizational structure, the following stages of the life cycle are traditionally separated (Voronina, 2010; Romanov, Basenko, and Zhukov, 2009). These are: the stage of creation, on which the organizational structure is formed, the assortment of products and technologies production is determined, contacts with the key contractors are established; the stage of development, at which the required level of specialization is achieved, formal communications are established, production volumes are expanded and the staff is growing, and the organizational culture of the enterprise crystallises; the stage of maturity, at which the organization receives the maximum effect from the previous stages, above all, the economic effect; the stage of the crisis, at which traditional methods of activity are ineffective because of inconsistencies with the external environment that has undergone significant changes.

The task of controlling the quality of the industrial enterprise development in terms of controlling the life cycle of an organizational structure is to ensure the transition from the first and second stages to the third one, and the maximum long-term retention in the third stage (maturity stage) with the timely detection of signs of the fourth stage (crisis) in order to avoid it by implementing restructuring (return to the second stage).

In order to identify the organizational structure's crisis, the control system for the industrial enterprise development at the strategic level should promptly identify changes in the external environment that adversely affect the economic efficiency of the enterprise and cannot be eliminated without restructuring and reorganization of the enterprise. Also, the monitoring system for the industrial enterprise development should oversee the achievement of the goals and objectives that were previously set for solving problems that need to be reorganized.

As indicators that characterize the quality of the industrial enterprise's development in terms of control over the life cycles of the organizational structure, the following are the most relevant indicators: conformity of the branch network to the actual market; the risk of antimonopoly investigations; compliance of capacities with demand volumes; an indicator of decision-making efficiency; indicators of the dynamics of overall economic efficiency, etc. The first three indicators give an opportunity to assess how the current organizational structure of the industrial enterprise is in line with the external environment, and whether there are signs of transition from the third stage of the life cycle (maturity) to the fourth (crisis) one.

The correspondence of the branch network to the actual market is proposed as a comparison of the amount of support costs to the amount of savings from its reduction in the case of an over-developed network, or as a comparison of the amount of the network support costs to the amount of potential revenue loss from the lack of branches in the event of a lack of network development:

$$M_v^F = \begin{cases} \dfrac{V_v^{\sup} - V_v^{red}}{Vv^{\sup}}, m_v > m^o \\[3mm] \dfrac{V_v^{\sup} - V_v^{los}}{V_v^{\sup}}, m_v < m^o \end{cases} \qquad (1)$$

$$V_v^{\sup} = \sum_t \left(r_t \cdot V_t^{\sup} \right) \qquad (2)$$

$$V_v^{red} = \sum_t \left(r_t \cdot V_t^{red} \right) \qquad (3)$$

$$V_v^{los} = \sum_t \left(r_t \cdot V_t^{los} \right) \qquad (4)$$

where M_v^F – conformity of the network of branches of the industrial enterprise's organizational structure to the actual market for v-th network option;

$V_v^{\sup}$ – the cost of maintaining an additional network of affiliates for v-th the network option for the time period considered;

V_v^{red} – saving on reducing the network of branches for the v-th variant of the network for the considered time period;

V_v^{los} – the amount of potential revenue loss due to the lack of affiliates for the v-th option for the network over the period considered;

m_v – number of affiliates for the v-th option of the network;

m^o – the optimal number of branches at the current level and distribution of demand for the industrial enterprise's products;

r_t – discount rate t-th period for bringing monetary indicators to a single measurement;

$V_t^{\sup}$ – costs to support an additional network of affiliates t-th period;

V_t^{red} – savings from reducing network affiliates t-th period;

V_t^{los} – amount of possible income loss from the absence of affiliates t-th period;

V – number of branch network options;

$v = 1,...,V$.

Branch network options are considered over a period of time that is adopted at an industrial enterprise as a basis for strategic management. At the same time, for each time period, there may be various versions of the organizational structure of the industrial enterprise's branches and subdivisions. The cost of the solution for each of these options is reduced to one period due to the discount rate. This indicator allows controlling the development of the enterprise in accordance with changes in volumes and geography of demand. If the indicator is beyond the scope of standards, an industrial company must make strategic decisions on creating new

branches and production facilities, or vice versa, reducing existing ones to optimize logistics costs.

Capacity compliance ratio reflects whether distribution and capacity are relevant to the demand geography. This indicator is related to the previous one and provides an opportunity to control the initial signs of gaps between the production and consumption of industrial products. The calculation of the gap is proposed to take into account the cost of production and consider the same negative as excess production over consumption, and vice versa:

$$R^{SD} = \frac{\sum_{g,k} \left| Q_{g,k}^S - Q_{g,k}^D \right| \cdot P_{g,k}}{\sum_{g,k} Q_{g,k}^D \cdot P_{g,k}} \tag{5}$$

where R^{SD} – an indicator of the gap between industrial products' production and consumption;

$Q_{g,k}^S$ – production output k -th species in the g -th region in the natural measure;

$Q_{g,k}^D$ – consumption of products k -th species in the g -th region in the natural measure;

$P_{g,k}$ – the cost of producing k -th species in g -th region;

K – the number of product types manufactured by an industrial enterprise;

G – the number of geographic regions in which the company is present;

$k = 1,...,K$;

$g = 1,...,G$.

An indicator of the antitrust investigations risk is relevant for large industrial enterprises, which, due to their successful operation, seized a large market share, which leads to the risk of applying antimonopoly legislation to them.

In case of excessive risk of antimonopoly measures, the industrial enterprise must restructure its organizational structure, for example, splitting up the company into several smaller ones.

An indicator of decision-making efficiency reflects whether the industrial enterprise's organizational structure meets the requirements of modern management. With the enterprise growth, the management system may not be able to keep up with the scale of activity and the increasing complexity of the organizational structure; therefore, monitoring the indicator of decision-making efficiency makes it possible to assess the quality of how this particular aspect of the industrial enterprise's management develops. The indicator of decision-making efficiency consists of speed estimations, formalization and automation of the decision-making process, and the calculation is based on the principle of "passing through a bottleneck", that is, the worst of the component results is chosen:

$$D^{des} = \min \left\{ D^{spd}, D^{frm}, D^{atm} \right\} \tag{6}$$

where D^{des} – an indicator of the decision making efficiency of the industrial enterprise;

D^{spd} – the rate of decision-making of the industrial enterprise;

D^{frm} – an indicator of formalization of the decision-making process at an industrial enterprise;

D^{atm} – an indicator of automation of the decision-making process at the industrial enterprise.

The speed of decision-making is evaluated as the weighted average for a typical set of decisions on managing an industrial enterprise, with the weighting of each decision depending on the terms of its approval or acceptance:

$$D^{spd} = \frac{\sum_{\alpha}\left(w_{\alpha}^{spd} \cdot p_{\alpha}^{art}\right)}{3} \tag{7}$$

$$w_{\alpha}^{spd} = \begin{cases} 1 \,|\, unsatisfactory \\ 2 \,|\, satisfactory \\ 3 \,|\, excellent \end{cases} \tag{8}$$

where D^{spd} – the rate of decision-making of the industrial enterprise;

w_{α}^{spd} – assessment of the speed of acceptance or approval α -th typical solution at an industrial plant;

p_{α}^{art} – a fraction α -th a typical solution in the total number of management decisions reviewed by an industrial enterprise.

Table 1. Evaluating the speed of decision making in the organizational structure of the industrial enterprise

The level at which the decision arises / the level at which the decision is approved or accepted	Rate estimation		
	Excellent	Satisfactory	Unsatisfactory
Strategic / Strategic	less than 3 hours	less than 1 day	more than 1 day
Strategic / Tactical	less than 5 hours	less than 1 day	more than 1 day
Strategic / Operational	less than 1 day	less than 2 days	more than 2 days
Operational / Strategic	less than 2 days	less than 3 days	more than 3 days
Operational / Tactical	less than 1 day	less than 2 days	more than 2 days
Operational / Operational	less than 1 day	less than 2 days	more than 2 days
Tactical / Strategic	less than 5 hours	less than 2 days	more than 2 days
Tactical / Tactical	less than 1 day	less than 2 days	more than 2 days
Tactical / Operational	less than 5 hours	less than 2 days	more than 2 days

Source: the authors' own research.

Speed is evaluated when coordinating decisions among different levels of management, or among different units at the same level. The evaluation criteria are shown in *Table 1.*

Evaluation of the managerial decision formalization is made by analysing job descriptions and establishing, firstly, how complete the description of the processes necessary to make a decision in job descriptions is, and secondly, whether there are conflicts among various job descriptions.

$$D^{frm} = \frac{\sum_{\alpha}\left(C_{\alpha}^{frm} \cdot w_{\alpha}^{frm} \cdot p_{\alpha}^{art}\right)}{3} \qquad (9)$$

$$w_{\alpha}^{frm} = \begin{cases} 1\,|\,unsatisfactory \\ 2\,|\,satisfactory \\ 3\,|\,excellent \end{cases} \qquad (10)$$

$$c_{\alpha}^{frm} = \begin{cases} 1\,|\,absent \\ 0,5\,|\,insignificant \\ 0,2\,|\,essential \end{cases} \qquad (11)$$

where D^{frm} – the indicator of decision-making formalization at the industrial enterprise;

c_{α}^{frm} – evaluation of the existence of conflicts in the adoption or approval of a typical solution at an industrial enterprise;

w_{α}^{frm} – evaluation of the formalization of acceptance or approval α -th typical solution at an industrial plant;

p_{α}^{art} – a share α -th of the typical solution in the total number of management decisions considered at the industrial enterprise.

The evaluation criteria of whether the formalization of the processes of managerial decision making in the job descriptions is sufficient and transferred to the quantitative assessment are shown in *Table 2.*

Evaluation of whether there exist collisions at the acceptance or approval of model decisions at an industrial enterprise is proposed based on the following assumptions. In the absence of collisions, a coefficient equal to one is used and formalization estimates are not adjusted. If there is no more than one conflict when the same function or process according to the instructions is to be performed by different persons with the same authority, then the coefficient 0.5 is used. If there are more collisions, then it significantly worsens the possibility of effective management, therefore it is necessary to use a coefficient of 0.2. The indicator of automation of the decision-making process at the industrial enterprise is calculated as a share

of business processes, the execution of which is accompanied in the information system of the enterprise.

Table 2. Evaluation of the Decision-Making Formalization in the Organizational Structure of the Industrial Enterprise

Type of management decision	Rating		
	Unsatisfactory	**Satisfactory**	**Excellent**
Approval of decisions	Missing in job descriptions	Only liability is established	Established responsibility and timing
Solutions development	Missing in job descriptions	Only the basic principles of decision making are defined	There are separate methodological guidelines and guidelines
Decomposition of solutions	Missing in job descriptions	The responsibility and basic principles of decomposition are defined	A hierarchy of decomposition is established
Control over execution of decisions	Missing in job descriptions	Only liability is established	Criteria and norms of control are established

Source: the authors' own research.

Also, when analysing an organizational structure, indicators that are less related to life cycles can be used, but they can provide additional information on the quality of the industrial enterprise's development: the coefficient of lanquity, the coefficient of functions duplication, the coefficient of centralization, the coefficient of information use efficiency, the coefficient of the control level, the coefficient of territorial concentration (Olubodun et al., 2010).

Indicators of the dynamics of overall economic efficiency, which are subject to control at the strategic level, provide an opportunity to identify and assess the change in the life cycle stages of an industrial enterprise. These indicators include: profitability; market share; the company's market value; production volumes, etc.

Thus, depending on the stage at which the vital organizational structure of the cycle is, the basic indicators of control can differ. At the stage of creation, the main thing is the correspondence of the branch network to the actual market and the matching of capacities to demand volumes. At the stage of development, the indicators of market share, volumes of production and sales, and market value of the company are coming to the fore. At the stage of maturity, the importance of the risk indicator for antimonopoly investigations, the efficiency of decision-making, and the market value of the company increases. At the stage of the crisis, the main indicators are profitability, as well as those indicators that are related to the causes of the crisis.

Thus, the proposed indicators provide an opportunity to monitor the quality of development and life cycles of industrial production at the strategic level. At the stage of research and development, the main factor is the coefficient of product expectation on the market; at the stage of introduction into production and market output, these are the dynamics of sales volumes and the dynamics of the products' share in the market; in the stage of maturity and maximum sales, these are the dynamics of sales volumes, the dynamics of profitability of products and the coefficient of competitiveness of products; and at the stage of aging and withdrawal from the market, it is the dynamics of products' profitability.

Consequently, the quality control of the industrial enterprise's development at the strategic level requires considering the life cycle of an enterprise, first of all, taking into account the life-cycle stage of its organizational structure and the life-cycle stages of the products it manufactures. Depending on the life-cycle stages, various indicators are evaluated, which makes it possible to analyse the quality of the enterprise development and to take management decisions in order to increase the effectiveness of the industrial enterprise's strategic development.

4. Results and Discussion

The proposed models of quality control over the industrial enterprise's development at the strategic level were tested at PJSC "Keramash", which allowed identifying strategic threats for the enterprise and developing recommendations on preventive management of the development under conditions of changing stages of the enterprise's life cycle. PJSC "Keramash" is not a new enterprise, as its organizational structure has been at the stage of maturity for a long time. Therefore, the task of control at the strategic level is to monitor the signs of the beginning crisis phenomena that need to be reorganized and restructured. Products manufactured by PJSC "Keramash" comprise thermal equipment, which was introduced to the market long ago.

Thus, for the control at the strategic level, the following indicators were selected: the risk of antimonopoly investigations, the efficiency of decision-making, the dynamics of changes in sales volumes, the coefficient of products' competitiveness. Besides, for the risks' timely identification at the onset of the crisis stage, the products' profitability has been added to the control indicators. The PJSC "Keramash" results of the quality control over the industrial enterprise's development at the strategic level are summarised in *Table 3.*

The analysis of these indicators made it possible to draw conclusions about the quality of PJSC "Keramash" development in the strategic term considered and to develop recommendations for improving the development strategy. As a strategic term, the last five years of the company's operation were considered from 2012 to 2016. It is established that for the enterprise there is no risk of antimonopoly investigations. But the efficiency of decision-making turned out to be equal to 0.52, which indicates the availability of opportunities for improving the organizational structure and decision-making system.

Table 3. Results of Quality Control Development of PJSC "Keramash" at the Strategic Level

Indicator	Rating
The risk of antimonopoly investigations	Absent
An indicator of decision-making efficiency	0.52
The coefficient of competitiveness of products	0.80
The dynamics of changes in sales volumes	0.61
The dynamics of products' profitability for the considered period	0.34
Cost-effectiveness of products in the last period	0.28
The dynamics of the enterprise's (assets) profitability for the considered period	0.08
The enterprise's (assets) profitability in the last period	0.10

Source: the authors' own research.

Among the three components, the worst of which determines the efficiency of decision-making at industrial enterprises, the bottleneck was the indicator of formalizing the decision-making process. The speed of decision making is also slightly higher than average, with the coefficient equal to 0.57. In comparison with most Ukrainian industrial enterprises, the automation of the decision-making process, whose coefficient was 0.75, is quite high. Thus, we can conclude that the development of an enterprise as an organizational structure requires the adoption of measures to improve the speed and formalization of decision-making. The positive value of the profitability of PJSC "Keramash" assets as a value for 2016, as well as aggregated indicator of profitability dynamics of assets, are both positive from the point of view of development quality. Moreover, the profitability of assets in 2016 was more than aggregated over the last five years, including the crisis of 2014-2015, which indicates the steady position of PJSC "Keramash" at the stage of maturity.

Indicators of production manufactured by PJSC "Keramash" also demonstrate that it is in the stage of constant maturity. The indicator of the volume of product sales is more than zero and less than one, which shows that, even for the strategic management period considered, there were declines in sales, but, overall, the trend is positive. The profitability of products is slightly lower than the aggregated indicator of profitability dynamics, but, in general, both of these indicators are at a rather high level, which gives grounds to conclude that the products of PJSC "Keramash" are still far from the stage of aging. However, fluctuations in sales volumes in the long run require attention to reduce dependence on economic crises in consumer countries.

Consequently, the quality control of the PJSC "Keramash" development at the strategic level allowed maintaining that: PJSC "Keramash" products and the enterprise as a whole are at the stage of constant maturity; PJSC "Keramash" products have a high degree of profitability and competitiveness; the system of making management decisions at PJSC "Keramash" is

satisfactory, but to compete under modern conditions, it needs to be improved and modernized; for PJSC "Keramash" the risks of economic crises in countries that consume its thermal equipment are high; for PJSC "Keramash" development, it is necessary that the strategy of enterprise development includes measures aimed at improving the decision-making system and expanding the presence on the markets of other countries.

If the proposed measures are implemented, the calculated economic effect consists of profits due to the new markets' development and the costs reduction resulting from more effective decision-making and implementation of the measures proposed as a result of control at the tactical level. Negative and positive components of the economic effect are as follows: additional profit from selling products in the markets of the Baltic and Eastern Europe makes up $ 8.6 million; reduction of production cost accounts for $ 2.1 million; expenses on developing representative offices in the markets of other countries amount to $ 1.3 million; modernization of equipment and staff qualification development in order to prevent the growth of the percentage of shortages with the intensification of production make $ 2.1 million; implementation of Information Systems for Supporting the Making of Administrative Decisions accounts for $ 0.7 million.

Thus, the expected expenses on implementing the proposed measures will amount to $ 4.1 million, while additional profits and savings will account for $ 10.7 million. The overall economic effects will make $ 6.6 million.

5. Conclusions

It has been found that changing the life-cycle stages is very important for an industrial enterprise and depends on what management decisions were made. Therefore, for the effective control over and overall management of the quality of industrial enterprise's development it is necessary to take into account life cycle. Depending on what stage of the life cycle the industrial enterprise is, it is necessary to focus attention on various aspects of activities.

Among the indicators characterizing the quality of the industrial enterprise's development in terms of monitoring the life cycles of the organizational structure, the most relevant are the following: the correspondence of the affiliates network to the actual market; the risk of antimonopoly investigations; capacities' compliance with demand volumes; the indicator of decision-making efficiency; indicators of the dynamics of overall economic efficiency, etc.

Depending on the stage at which the vital organizational structure of the industrial enterprise life cycle is, the basic indicators for control can differ. At the stage of creation, the main thing is the correspondence of the branch network to the actual market and the matching of capacities to demand volumes. At the stage of development, indicators of the market share, volumes of production and sales, and the company's market value are coming to the fore. At the stage of maturity, the significance of the indicator of the antimonopoly investigations risks, the efficiency of decision-making, and the company's market value increases. At the stage of

the crisis, the main indicators are profitability, as well as those indicators that are related to the causes of the crisis.

The task of control at the strategic level in terms of the products life cycle is to timely detect the stage when the products no longer need the market, and to control the transition efficiency from stage to stage. To solve this problem, it is proposed to use the following indicators: the dynamics of sales volumes; the dynamics of the products share in the market; the coefficient of products competitiveness; the dynamics of products profitability; the coefficient of product expectation on the market, etc.

The proposed indicators provide an opportunity to monitor the quality of development and life cycles of the industrial enterprise products at the strategic level. At the research and development stage, the main factor is the coefficient of product expectation in the market; at the stage of introduction into production and market output these are the dynamics of sales volumes and the dynamics of the share of products in the market; in the stage of maturity and maximum sales, these are the dynamics of sales volumes and the coefficient of product competitiveness; on the stage of aging and withdrawal from the market, it is the dynamics of products profitability.

References

Ali, M.M., Rai, R., Otte, J.N. & Smith, B. (2019). A Product Life Cycle Ontology for Additive Manufacturing. *Computers in Industry,* 105, 191-203. https://doi.org/10.1016/j.compind.2018.12.007

Azevedo, A., Faria, J., & Ferreira, F. (2017). Supporting the Entire Life-Cycle of the Extended Manufacturing Enterprise. *Robotics and Computer-Integrated Manufacturing*, 43, 2-11. https://doi.org/10.1016/j.rcim.2016.05.009

Blanchard, B.S., Fabrycky, W.J. (2010). *Systems Engineering and Analysis. Prentice Hall International Series in Industrial & Systems Engineering.* Cambridge: Pearson.

Boiko, V., Kwilinski, A., Misiuk, M., & Boiko, L. (2019). Competitive Advantages of Wholesale Markets of Agricultural Products as a Type of Entrepreneurial Activity: the Experience of Ukraine and Poland. *Economic Annals-XXI, 175*(1-2), 68-72. https://doi.org/10.21003/ea.V175-12

Dalevska, N., Khobta, V., Kwilinski, A., & Kravchenko, S. (2019). A Model for Estimating Social and Economic Indicators of Sustainable Development. *Entrepreneurship and Sustainability Issues, 6*(4), 1839-1860.

Dementyev, V.V., & Kwilinski, A. (2020). Institutsionalnaya Sostavlyayuschaya Izderzhek Proizvodstva [Institutional Component of Production Costs]. *Journal of Institutional Studies, 12*(1), 100-116. https://doi.org/10.17835/2076-6297.2020.12.1.100-116

Dźwigoł, H., & Dźwigoł-Barosz, M. (2018). Scientific Research Methodology in Management Sciences. *Financial and Credit Activity: Problems of Theory and Practice, 2*(25), 424-437.

Dźwigoł, H.; & Wolniak, R. (2018). Controlling w procesie zarządzania chemicznym przedsiębiorstwem produkcyjnym [Controlling in the Management Process of a Chemical Industry Production Company]. *Przemysl Chemiczny, 97*(7), 1114—1116. https://doi.org/10.15199/62.2018.7.15

Dźwigoł, H. (2019a). Research Methods and Techniques in New Management Trends: Research Results. *Virtual Economics*, *2*(1), 31-48. https://doi.org/10.34021/ve.2019.02.01(2)

Dźwigoł, D. (2019b). The Concept of the System Approach of the Enterprise Restructuring Process, *Virtual Economics, 2*(4), 46-70.

Dzwigoł, H., Dzwigoł–Barosz, M., Zhyvko, Z., Miskiewicz, R., & Pushak, H. (2019a). Evaluation of the Energy Security as a Component of National Security of the Country. *Journal of Security and Sustainability Issues,* 8(3), 307-317. http://doi.org/10.9770/jssi.2019.8.3(2)

Dzwigol, H., Aleinikova, O., Umanska, Y., Shmygol, N., & Pushak, Y. (2019b). An Entrepreneurship Model for Assessing the Investment Attractiveness of Regions. *Journal of Entrepreneurship Education, 22,* (SI1), 1-7.

Dźwigoł, H., Shcherbak, S., Semikina, M., Vinichenko, O., & Vasiuta, V. (2019c). Formation of Strategic Change Management System at an Enterprise. *Academy of Strategic Management Journal, 18*(SI1), 1-8.

Dzwigol, H., Dzwigol–Barosz, M., & Kwilinski, A. (2020). Formation of Global Competitive Enterprise Environment Based on Industry 4.0 Concept, *International Journal of Entrepreneurship,* 24(1), 1-5.

Huang, Q., Yang, S., Shi, V., & Zhang, Y. (2018). Strategic Decentralization under Sequential Channel Structure and Quality Choices. *International Journal of Production Economics*, 206, 70-78. http://dx.doi.org/10.1016/j.ijpe.2018.09.033

Kondratenko, V., Okopnyk, O., Ziganto, L., & Kwilinski, A. (2020). Innovation Development of Public Administration: Management and Legislation Features. *Marketing and Management of Innovations,* 1, 87-94. https://doi.org/10.21272/mmi.2020.1-06

Kuzior, A. & Zozuľak, J. (2019). Adaptation of the Idea of Phronesis in Contemporary Approach to Innovation. *Management Systems in Production Engineering,* *2*(27), 84—87. https://doi.org/10.1515/mspe-2019-0014

Kuzior, A., Kwilinski, A., & Tkachenko, V. (2019). Sustainable Development of Organizations Based on the Combinatorial Model of Artificial Intelligence. *Entrepreneurship and Sustainability, 7*(2), 1353-1376. http://doi.org/10.9770/jesi.2019.7.2(39)

Kwilinski, A. (2017). Development of Industrial Enterprise in the Conditions of Formation of Information Economics. *Thai Science Review, Autumn 2017,* 85 – 90. https://doi.org/10.5281/zenodo.1414236

Kwilinski, A. (2018a). Mechanism of Formation of Industrial Enterprise Development Strategy in the Information Economy. *Virtual Economics, 1*(1), 7-25. https://doi.org/10.34021/ve.2018.01.01(1)

Kwilinski, A. (2018b). Mechanism for Assessing the Competitiveness of an Industrial Enterprise in the Information Economy. *Research Papers in Economics and Finance, 3*(1), 7-16. https://doi.org/10.18559/ref.2018.1.1

Kwilinski, A. (2018c). Mechanism of Modernization of Industrial Sphere of Industrial Enterprise in Accordance with Requirements of the Information Economy. *Marketing and Management of Innovations,* 4, 116-128. http://doi.org/10.21272/mmi.2018.4-11

Kwilinski, A. (2018d). Trends of Development of the Information Economy of Ukraine in the Context of Ensuring the Communicative Component of Industrial Enterprises. *Economics and Management, 1*(77), 64-70.

Kwilinski, A. (2019). Implementation of Blockchain Technology in Accounting Sphere. *Academy of Accounting and Financial Studies Journal, 23*(SI2), 1-6.

Kwilinski, A., Dalevska, N., Kravchenko, S., Hroznyi, I., Kovalenko, I. (2019a). Formation of the Entrepreneurship Model of e-Business in the Context of the Introduction of Information and Communication Technologies. *Journal of Entrepreneurship Education, 22*(SI1), 1528-2651-22-S1-337: 1-7.

Kwilinski, A., Tkachenko, V., & Kuzior, A. (2019b). Transparent Cognitive Technologies to Ensure Sustainable Society Development. *Journal of Security and Sustainability Issues, 9*(2), 561-570 http://doi.org/10.9770/jssi.2019.9.2(15)

Kwilinski, A., Pajak, K., Halachenko, O., Vasylchak, S., Pushak, Ya., & Kuzior, P. (2019c). Marketing Tools for Improving Enterprise Performance in the Context of Social and Economic Security of the State: Innovative Approaches to Assessment. *Marketing and Management of Innovations,* 4, 172-181. http://doi.org/10.21272/mmi.2019.4-14

Kwilinski, A., & Kuzior, A. (2020). Cognitive Technologies in the Management and Formation of Directions of the Priority Development of Industrial Enterprises. *Management Systems in Production Engineering, 28*(2), 133-138. https://doi.org/10.2478/mspe-2020-0020

Kwilinski, A., Slatvitskaya, I., Dugar, T., Khodakivska, L., & Derevyanko, B. (2020a). Main Effects of Mergers and Acquisitions in International Enterprise Activities. *International Journal of Entrepreneurship, 24*(Special Issue: Entrepreneurship, Innovation Management and Sustainability), 1-8.

Kwilinski, A., Dzwigol, H., & Dementyev, V. (2020b). Model of Entrepreneurship Financial Activity of the Transnational Company Based on Intellectual Technology. *International Journal of Entrepreneurship, 24*(Special Issue: Entrepreneurship, Innovation Management and Sustainability), 1-5.

Kwilinski, A., Litvin, V., Kamchatova, E., Polusmiak, J., & Mironova, D. (2020c). Information Support of the Entrepreneurship Model Complex with the Application of Cloud Technologies. *Journal of Entrepreneurship Education, 23*(SI1), 1-9.

Lyulyov, O. V., & Pimonenko, T. V. (2017). Lotka-Volterra Model as an Instrument of the Investment and Innovative Processes Stability Analysis. *Marketing and Management of Innovations*, 1, 159-169.

Lyulyov, O., Pimonenko, T., Stoyanets, N., & Letunovska, N. (2019) Sustainable Development of Agricultural Sector: Democratic Profile Impact among Developing Countries. *Research in World Economy, 10*(4), 97-105. https://doi.org/10.5430/rwe.v10n4p97

Mcadam, R., Miller, K., & Mcsorley, C. (2019). Towards a Contingency Theory Perspective of Quality Management in Enabling Strategic Alignment. *International Journal of Production Economics*, 207, 195-209. https://doi.org/10.1016/j.ijpe.2016.07.003

Olubodun, F., Kangwa, J., Oladapo, A. & Thompson, J. (2010). An appraisal of the level of application of life cycle costing within the construction industry in the UK, *Structural Survey, 28*(4), 254-265. https://doi.org/10.1108/02630801011070966

Pająk, K., Kamińska, B., & Kvilinskyi, O. (2016). Modern Trends of Financial Sector Development under the Virtual Regionalization Conditions. *Financial and Credit Activity: Problems of Theory and Practice, 2*(21), 204-217. https://doi.org/10.18371/fcaptp.v2i21.91052

Pająk, K., Kvilinskyi, O., Fasiecka, O., & Miśkiewicz, R. (2017). Energy Security in Regional Policy in Wielkopolska Region of Poland. *Economics and Environment, 2*(61), 122-138.

Romanov, A.A., Basenko, V.P., & Zhukov, B.M. (2009). *Development and Product Life Cycle. Marketing in structural and logical schemes.* Moscow: Academy of Natural Sciences.

Rose, K. H. (2005). *Project Quality Management: Why, What and How. Fort Lauderdale.* Florida: J. Ross Publishing.

Rehhausen, A., Koppel, J., Scholles, F., Stemmer, B. & Wende, W. (2018). Quality of Federal Level Strategic Environmental Assessment – A Case Study Analysis for Transport, Transmission Grid and Maritime Spatial Planning in Germany. *Environmental Impact Assessment Review,* vol. 73, 41-59.

Selden, Paul H. (1998). Sales Process Engineering: An Emerging Quality Application*. Quality Progress, 31*(12), 59–63.

Tkachenko, V., Kwilinski, A., Klymchuk, M., & Tkachenko, I. (2019a). The Economic-Mathematical Development of Buildings Construction Model Optimization on the Basis of Digital Economy. *Management Systems in Production Engineering, 27*(2), 119-123. http://doi.org/10.1515/mspe-2019-0020

Tkachenko, V., Kwilinski, A., Korystin, O., Svyrydiuk, N., & Tkachenko, I. (2019b). Assessment of Information Technologies Influence on Financial Security of Economy. *Journal of Security and Sustainability, 8*(3), 375-385. http://doi.org/10.9770/jssi.2019.8.3(7)

Tkachenko, V., Kuzior, A., & Kwilinski, A. (2019c). Introduction of Artificial Intelligence Tools into the Training Methods of Entrepreneurship Activities. *Journal of Entrepreneurship Education, 22*(6), 1-10.

Vasylieva, T., Lyeonov, S., Lyulyov, O., & Kyrychenko, K. (2018). Macroeconomic Stability and Its Impact on the Economic Growth of the Country. Montenegrin Journal of Economics, 14(1), 159-170.

Vasylieva, T., Lyulyov, O., Bilan, Y., & Streimikiene, D. (2019). Sustainable Economic Development and Greenhouse Gas Emissions: The Dynamic Impact of Renewable Energy Consumption, GDP, and Corruption. *Energies, 12*(17). http://doi.org/10.3390/en12173289

Voronina, O.M. (2010). Influence of Stages of the Life Cycle of the Enterprise on its Market Strategies. *Management, Economics and Quality Assurance in Pharmacy*, 2, 36-41.

Voronina, O.M. (2010). Vpliv etapiv zhittyevogo ciklu diyalnosti pidpriyemstva na jogo marketingovi strategiyi [Influence of Stages of the Life Cycle of the Enterprise on its Market Strategies]. *Management, Economics and Quality Assurance in Pharmacy, 2*, 36-41. (in Ukrainian).