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# MECHANISM OF FORMATION OF INDUSTRIAL ENTERPRISE DEVELOPMENT STRATEGY IN THE INFORMATION ECONOMY

*Aleksy Kwilinski*

**Abstract.** The article establishes that under the conditions of the information economy, industrial enterprises need a development strategy that takes into account the peculiarities of world changes in the spheres of production, marketing, management, etc. To solve this problem, a mechanism has been developed for forming a strategy for the development of an industrial enterprise in the information economy, based on the model of harmonization of specialized business processes with business process management, integration of management systems of specialized business processes into the general system of management of an industrial enterprise, as well as informatization and automation of business process management of the enterprise. Implementation of the developed mechanism into the practice of managing the development of an industrial enterprise provides an opportunity to increase its competitiveness, increase sales and reduce the cost of production.

***Keywords:*** mechanism, strategy, development, industrial enterprise, information economy, business processes, management, automation

***JEL Classification:*** C130, L690, G140

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## 1. Introduction

The management of the development of an industrial enterprise requires the development of an appropriate strategy, in which the measures for the development of certain spheres of the industrial enterprise are combined and coordinated, and the development peculiarities due to the influence of the external environment are taken into account. In the conditions of the information economy, special attention needs to be paid to the development of the managerial sphere of an industrial enterprise, which is the completion of the development of other fields, and the integration of automation, robotization and informatization measures developed within the framework of this development into the overall strategy for the development of an industrial enterprise.

The digital economy is expanding in several ways. Global production of information and communications technologies (ICT) goods and services now amounts to an estimated 6.5% of global gross domestic product (GDP), and some 100 million people are employed in the ICT services sector. Exports of ICT services grew by 40% between 2010 and 2015. Worldwide e-commerce sales in 2015 reached $25.3 trillion, 90% of which were in the form of business-to-business e-commerce and 10% in the form of business-to-consumer (B2C) sales. UNCTAD estimates that cross-border B2C e-commerce was worth about $189 billion in 2015, which corresponds to 7% of total B2C e-commerce. Sales of robots are at the highest level ever, worldwide shipments of three-dimensional printers more than doubled in 2016, to over 450,000, and are expected to reach 6.7 million in 2020. And by 2019, the volume of global Internet traffic is expected to increase by factor of 66 from what it was in 2005 (UNSTAD, 2017). Top 10 economies by value added of ICT services in 2015 are shown in *Fig. 1.*

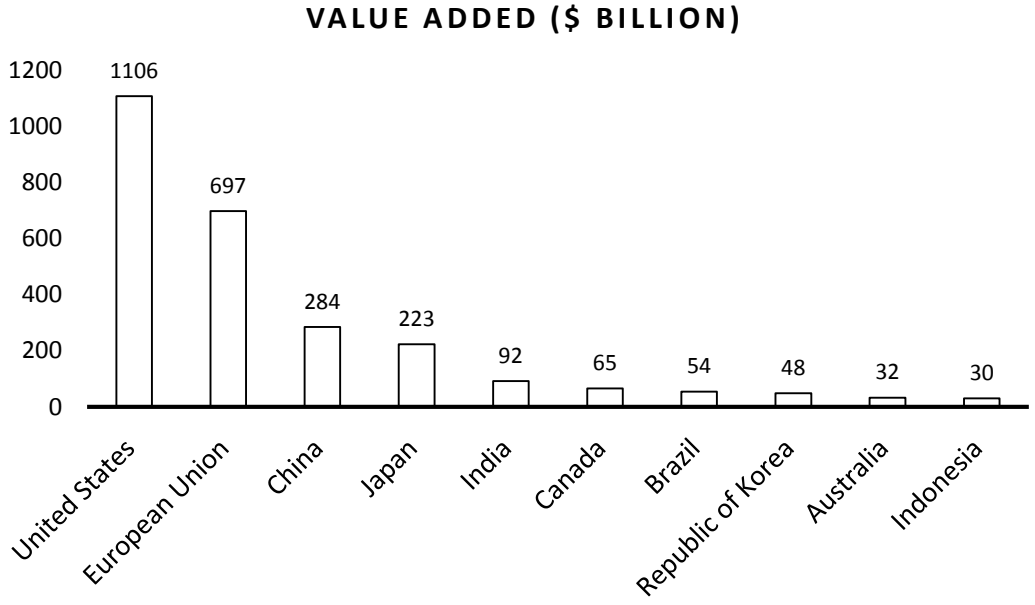


**Figure 1.** Top 10 economies by value added of ICT services in 2015
*Source:* own research on the basis of Eurostat data.

Top 10 economies by number of Internet users in 2015, and growth rates in number of users, 2012−2015 are shown in *Fig. 2.*

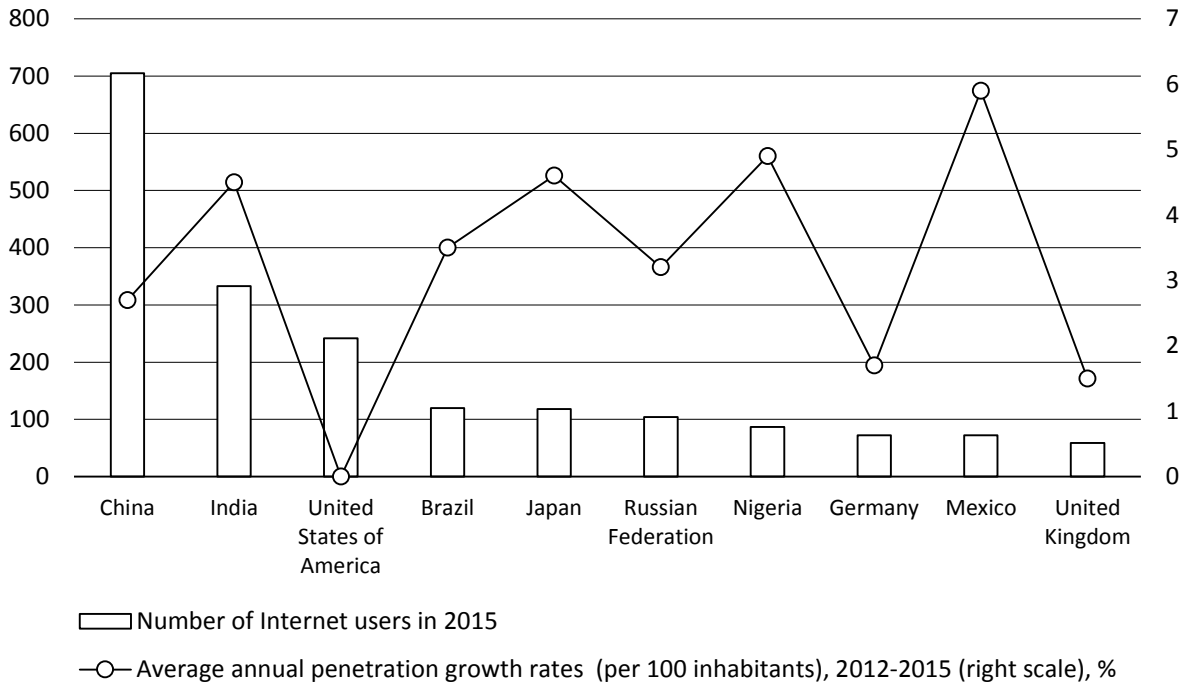


**Figure 2.** Top 10 economies by number of Internet users in 2015, and growth rates in number of users, 2012−2015
*Source:* own research on the basis of Eurostat data.

UK businesses around the world make intelligent use of information technology and data. Together with the government's industry, it began a program to support the aspirations of industrial enterprises to take advantage of all the opportunities provided by the information economy. The program should reach 1.6 million enterprises over the next five years. The program will be built on existing governmental support, including tips on improving their cyber security and protecting their intellectual property (Information economy strategy UK, 2013).

Consequently, it is necessary to take advantage of such perspectives for the development of industry in general and the development of enterprises in particular.

## 2. Literature review

Some questions about the specifics of the information economy were discussed in the papers (Arrow, 1999; Bagheri & Hjorth, 2007; Aumann & Heifetz, 2002; Brynjolfsson & Saunders, 2009; Elsneret al., 2015; Kwilinski 2018; Lacy et al., 2010; Lakhno et al., 2018; Lippman & McCall, 2015; Marston et al., 2011; Morris, 2009; Mycielski, 1992; Reddy et al., 2009; Roome, 2013; Shenhar et al., 2007; Sun et al., 2017; Douma & Schreuder, 2013; Yakubovskiy et al.,

2017). However, despite the considerable contribution of scientific works, existing approaches differ in their narrow orientation; therefore, the study of their individual advantages and restrictions in use will allow determining the main directions of development in the conditions of the information economy.

Sustainable development is much debated as the burning challenge of the 21st century (Lacy et al., 2010). The most commonly accepted definition, penned by the Brundtland Report (World Commission on Environment and Development (WCED), 1987), is the process of development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable development is a systems issue (Roome, 2013), which requires that understanding of the system's problems flow from larger systems to smaller systems and involve multi-stakeholder perspectives (Bagheri & Hjorth, 2007).

Some authors propose to develop and implement a strategy for enterprise development through the construction of an integrated information system whose task is to provide managers with quality information. The peculiarity of this system is the use of integrated reporting, which makes it possible to establish a dependency between the indicators of enterprise sustainability, its ability to create value and reduce reputational risks. Integration is generally considered to go beyond mere interoperability to involve some degree of functional dependence (Panetto, 2007; Tvaronavičienė, 2014).

The main disadvantage of the approach is financial development, due to which insufficient attention is paid to the automation and informatization of the manufacturing sphere, which are very important in the conditions of the modern economy (Pajak et al., 2016).

One of the main factors that will have an impact on the development of industrial enterprises in the information economy is cloud technology, for which global leaders need to develop an appropriate IT development strategy (Marston et al., 2011). They offer an IT strategy for the development of an industrial enterprise in five directions: the development of infrastructure, services, applications, business processes and sourcing. Thanks to this, industrial enterprises will be able to benefit from data processing and the ability to quickly change the corporate information system. But cloud storage is just one of the newest technologies that provides benefits in the functioning of the enterprise in the information economy, so the other areas of the development need to be taken into account to ensure sustainable development of the enterprise.

The main tool for the development strategy is an information system for automating management decisions (Reddy et al., 2009). The main features of the proposed system are the consideration of external factors in determining the direction of development of economic potential, using of fuzzy modeling and modeling of organizational interaction. The result should be an active, passive or compensatory development model. Ignoring the need for modernization of the industrial sphere of industrial enterprises and the need to reconcile this

modernization with the general strategy of enterprise development should be noted among the discussion points of this approach.

Jan Mycielski (1992) proposed an approach to automating the process of choosing an enterprise development strategy in a market environment and uncertainty, based on this approach, the game model and information system for its calculation are taken. The main criterion for optimizing the development strategy is the profit of the enterprise. But it is not sufficiently described which market uncertainty has been taken into account in the model, as well as how it is proposed to adapt to the modern information economy.

Adaptation of enterprises to the modern economy requires the creation of the appropriate infrastructure and proposes a strategy for the development of the information infrastructure of the machine-building enterprise (Hroznyi et al., 2018). The main attention in the proposed strategy is given to the informatization of the management system, the modernization of the organizational structure, the scientific substantiation of the composition of the management apparatus. However, the question of production, marketing, supply and other important for the manufacturing enterprise spheres of activity remained out of sight.

If you consider the strategy in individual projects, then the strategy research has focused largely on the strategic alignment perspective based on deliberate planned strategy between projects and parent organizations as a factor for successful projects and successful execution of organization strategy (Morris, 2009; Shenhar et al., 2007). Recent research acknowledges the strategic character of individual projects, enabling them to emerge strategy with stakeholders so that they are competitive in the project context (Vuori, 2013).

## 3. Methods

The analysis of the results of the research on the development of the industrial enterprise made it possible to establish that most researchers in solving the problem of forming a strategy for the development of an industrial enterprise in the modern economy are considering only individual components of the strategy, and generally development is considered in the general sense, without taking into account the features of the information economy. The enterprises that carry out production activities need to take into account the development of the manufacturing sector in the development strategy, and then build a strategy for general development, including the development of management, taking into account the need for automation, robotization and informatization of production and management processes in accordance with the requirements of the information economy. To solve this problem, a mechanism of the formation of the development strategy of an industrial enterprise in the information economy was developed, the main interrelations of which are shown in *Fig. 3.*

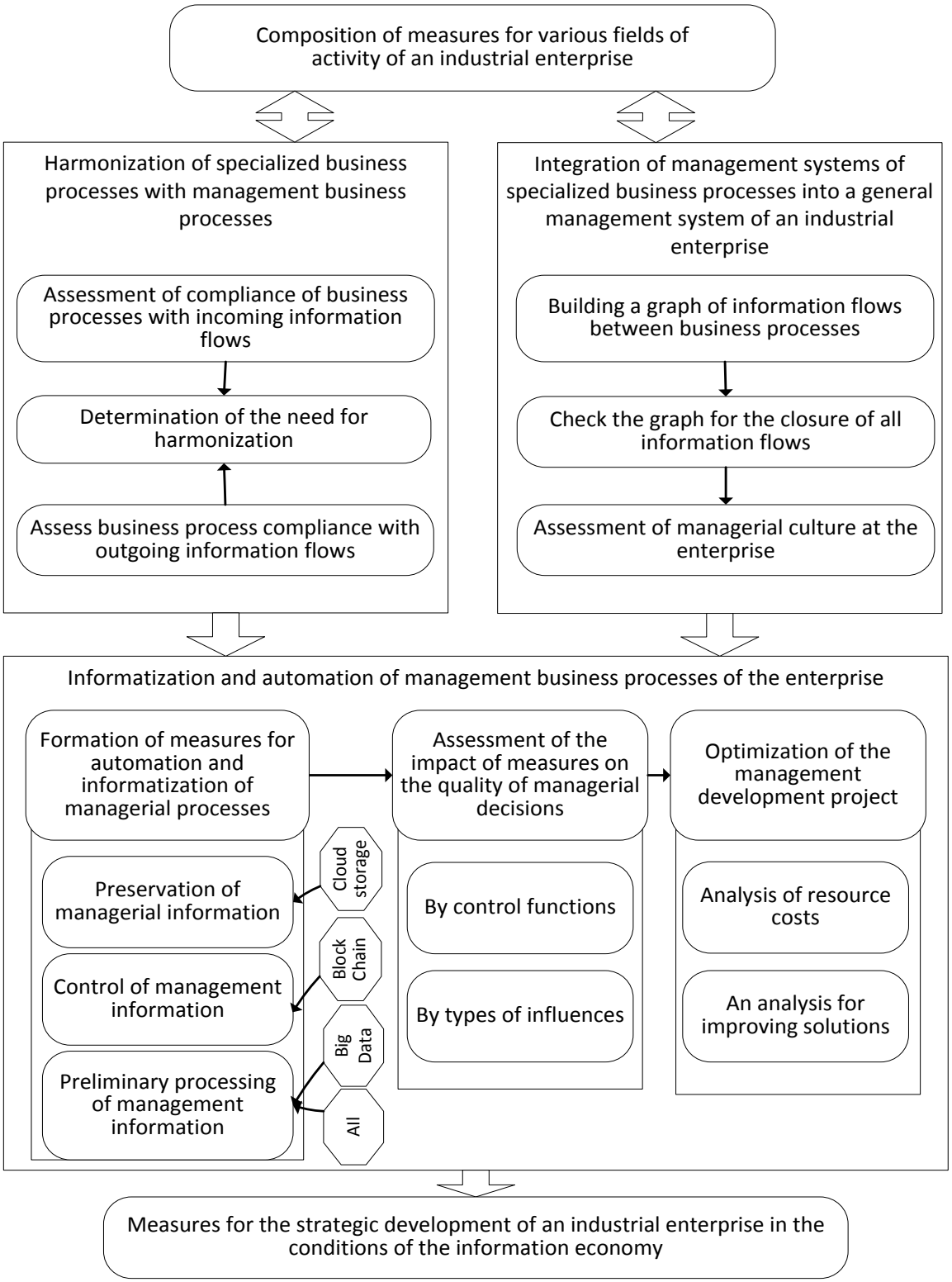


**Figure 3.** The mechanism of the development strategy formation of the industrial enterprise in the information economy
*Source:* own research.

It is proposed to distinguish the process of development of the management system of an industrial enterprise and the development of certain spheres of its activity. Moreover, in these spheres of activity of the industrial enterprise the production and management fields deserve special attention, because it is in these directions that the backlog from the world leaders negatively affects the efficiency of the industry. In each field of activity of an industrial enterprise there are specialized business processes that need to be improved, first of all, by automation and informatization in accordance with the requirements of the information economy. In addition, most enterprises need to improve the overall business process management.

The peculiarity of the information economy is the emergence of the latest methods to support the adoption of managerial decisions that ensure the availability of the necessary information and accelerate its processing, which makes it possible to develop more grounded management decisions.

From the point of view of a typical industrial enterprise, the main directions of improvement of the enterprise management system are:

- informatization and automation of business processes of the enterprise;
- integration of management systems of specialized business processes into a general management system by an industrial enterprise;
- harmonization of specialized business processes with management business processes.

The proposed mechanism of the development strategy formation of the industrial enterprise in the information economy has at the entrance the projects of modernization of other spheres of the industrial enterprise activity in the conditions of the information economy, including modernization of the industrial sphere of the enterprise, which is of particular importance in the conditions of the information economy. For these projects a composition of measures for various fields of activity of an industrial enterprise is carried out, the result of which is the basis for the development of a management system by an industrial enterprise.

With the development of an industrial enterprise in the information economy, informatization and automation of the business processes of the enterprise are a central element of development, as information from all specialized departments conducting the curriculum of certain spheres of the industrial enterprise activity should be assembled in a single decision-making center. It makes no sense to improve other areas of the industrial enterprise in accordance with the requirements of the information economy if the management system of the industrial enterprise as a whole cannot effectively communicate with the relevant departments and control the implementation of specialized business processes.

Business process management refers to the processes that result in the obtaining of managerial results or management (decision-making, control, analysis, etc.). The purpose of business process management is to manage other business processes (Suleymanova & Omarova, 2017).

In order to ensure the effectiveness of the managerial business processes of an industrial enterprise in the conditions of the information economy, the following tasks should be performed: information preservation management, information control management, information pre-processing management in order to support decision-making.

Preserving the management information and giving the access to it to all managers who need it become non-trivial tasks in a situation where information collection is carried out on many sites, especially when production and sales of products are distributed. For this purpose, it is expedient to use cloud storage that solves most of the problems of scaling and distributed collection and use of information.

Control of the management information is the provision of access to information only to those employees who have the appropriate rights, as well as the logging of changes made by responsible persons. To ensure that logs are unaltered, the most effective use of encryption algorithms BlockChain.

Preliminary processing of managerial information to support decision-making in the information economy has a huge amount of data collected, so the information system should use technologies of artificial intelligence (artificial intellect, AI) and processing big data (BigData).

**Table 1.** Range of evaluation of measures on informatization and automation of business process management

| Type of management function | Type of influence on the decision | | |
|---|---|---|---|
| | Speed | Reasonableness | Complexity |
| Planning | [-5;5] | [-5;10] | [-10;5] |
| Organization | [-10;10] | [-3;3] | [-3;3] |
| Motivation | [-5;5] | [-4;8] | [-7;7] |
| Control | [-4;4] | [-3;3] | [-10;10] |

*Source:* own research.

Successful fulfillment of all these tasks and positive characteristics of the informatization of business process management constitute the overall quality of managerial decisions. Measures of informatization and automation of managerial business processes increase the quality of managerial decisions. Each of the measures can have both a positive and a negative impact on each of the managerial functions implemented by the business process management. In addition, each measure positively or negatively affects the speed, reasonableness and complexity of making managerial decisions. Thus, as a whole the measure affecting the informatization and automation of business process management must find the sum of all its influences. To form a plan for informatization and automation of business process

management, it is proposed to evaluate each of the possible measures in the ranges shown in *Table 1.*

To choose which of the possible measures should be implemented, it is proposed to use an optimization model whose purpose is to maximize the quality of managerial decisions:

$$\sum_{u}\left(\beta^{u}\cdot\sum_{f,s}\alpha_{\mathrm{f,s}}^{u}\right)\rightarrow\max, \tag{1}$$

$$\sum_{u}\left(\beta^{u}\cdot\sum_{s}\alpha_{\mathrm{f,s}}^{u}\right)\geq G_{f}, \tag{2}$$

$$\sum_{u}\left(\beta^{u}\cdot R^{u}\right)\leq \mathrm{G^{R}}, \tag{3}$$

where $\beta^{u}=0\ \mathrm{or}\ 1$ – a logical variable that reflects whether it should be implemented u-th an event on informatization and automation of managerial business processes;

$\alpha_{\mathrm{f,s}}^{u}$ – quantitative impact assessment u-th an event on informatization and automation of managerial business processes for the quality of managerial decisions for f-th type of management function and s-th type of influence on the decision;

$G_{s}$ – the minimum need to improve the quality of managerial decisions by the s-th type of influence on the decision;

$G_{f}$ – the minimum need to improve the quality of managerial decisions for the f-th type of management function;

$G^{R}$ – available resources for implementing information and automation of business process management.

The integration of management systems for specialized business processes into the general management system of an industrial enterprise is the coordination of the channels of information transfer from the specialized units to the general system of management of the enterprise and in the opposite direction. It is necessary to ensure the following qualities:

- for each upstream information flow from specialized business processes there should be a corresponding receiving information flow from business process management;
- for each downstream information stream from management business processes there should be a corresponding receiving information stream from specialized business processes;
- each message must be processed - replied, redirected or included in the pool of information for further management decision.

All this can be done through the use of an appropriate information system that provides electronic document management and control of the movement of information messages. Moreover, in addition to technical support, an appropriate management culture at the

industrial enterprise is also required, in which managers of all units perform all necessary actions for the processing of information messages. The following indicator is proposed to evaluate the effectiveness of management culture in the processing of information messages:

$$In^K = \frac{\sum_i \left( w_i^K \cdot h_i^K \cdot b_i^K \right)}{\sum_i \left( w_i^K \cdot \tilde{h}_i^K \right)}, \quad (4)$$

where $In^K$ – the indicator of the efficiency of management culture in the processing of information messages;

$w_i^K$ – the importance of the type of information messages to which the i-th message relates;

$h_i^K$ – the time actually spent on the performance of an i-th notification;

$b_i^K$ – variable (0 or 1), which shows if the required action has been taken on the i-th notification;

$h_i^K$ – the time for which the regulation is required for action on the i-th notification;

$i = 1,...,I$ – the index of actions that were analyzed in assessing the effectiveness of management culture in the processing of information messages.

An assessment of the importance of the action depends on its type and direction of the information message, which is shown in *Table 2.* The value of the received indicator of the effectiveness of management culture in the processing of information messages can be in the range from 0 to 1. The units correspond to the case of complete fulfillment of all duties on processing of information messages, without delays and omissions.

An indicator of the effectiveness of management culture in the processing of information messages can be calculated as a whole for all interactions of the industrial enterprise, and for certain types of interaction it is considered taking into account only informational messages between a separate unit or department and management, or only for certain types of specialized business processes.

Harmonization of specialized business processes with business process management is the creation of tools for balancing the information capabilities of related business processes.

That is, the input capabilities of business processes should correspond to those informational messages that come to them, and outsourcing must meet the requirements for the information that the recipient needs from the business process.

**Table 2.** Dependence of the importance of actions when processing information messages on their type

| Recipient of an information message | Action | Importance |
|---|---|---|
| Lower link | Response to the acceptance of the order | 1 |
| | Response to the execution of the order | 1 |
| | Information on the current state of the protocol | 2 |
| | Informing about emergency events | 5 |
| Upper link | Confirmation of receiving an informational message | 1 |
| | Order | 3 |
| | Inclusion to the pool of information for further processing | 2 |
| Conjoined peer link | Informing about the need for coordination | 2 |
| | Coordination | 2 |
| | Forwarding | 1 |

*Source:* own research.

To ensure the harmonization of specialized business processes with business process management, the following measures can be used:

- providing workers with technical means of collecting and transmitting information;
- training of information technology personnel;
- creation of systems of the automated information gathering and forecasting of the course of the business process;
- creation of automated information systems for all involved in the business process;
- creation of presentations and information systems, etc.

To determine if measures are needed to harmonize specialized business processes with business process management, it is suggested to use indicators of incoming and outgoing information flows for their loading.

To calculate, it is suggested to use the formula:

$$Cor_i^{In} = \frac{\sum_n \sum_a w_{a,n}^{Cor}}{\mathrm{N_i}}, \quad (5)$$

where $Cor_i$ – the indicator of correspondence to the load of the information flow of the i-th business process;

$w_{a,n}^{Cor}$ – estimation of the a-th characteristic of correspondence to the load of the information flow of the i-th business process in the n-th direction;

$N$ – the number of directions on which the information communication is carried out by the i-th business process.

In order to assess the incoming flows compliance, it is proposed to consider the following characteristics:

- suitability of the qualification of the compliance officer, which reflects the availability of the required qualities in the employee who, according to the job descriptions, must create informational messages;
- the ability to replace a responsible employee reflects whether there are employees who have the required qualities and can perform the necessary functions;
- the influence of the human factor is an assessment of the quality of the formalization of the instructions and processes for creating information messages, and which, in this case, the false actions of the responsible employee can influence the quality;
- the sufficiency of technical support for the receipt of information messages, their presentation and analysis, as well as means of further processing.

Quantitative evaluations of the characteristics of compliance with the information load of the incoming information flows from the specialized business processes and business process management are shown in *Table 3.*

**Table 3.** Characteristics of compliance with the information load of incoming information flows

| Characteristics | Qualitative assessments | Quantitative estimates |
|---|---|---|
| Sufficiency of qualification in the responsible employee | Enough | 0.30 |
| | Satisfactory | 0.15 |
| | Inappropriate | 0.00 |
| Ability to replace responsible employee | Exist | 0.20 |
| | There is in part | 0.10 |
| | Not exist | 0.00 |
| Impact of human factor | There are systems of reminder and control | 0.20 |
| | Execution depends entirely on the employee | 0.10 |
| Sufficient technical support | Full | 0.30 |
| | Partial support | 0.15 |
| | Hand-crafted | 0.00 |

*Source:* own research.

It is proposed to evaluate the conformity of incoming flows on the basis of the following characteristics:

- the degree of automation of the formation of information messages, which characterizes how exactly the collection, processing and sending of information are carried out - automated or with the use of manual intervention of the responsible officer;
- the existence of formal rules for the formation of information messages, such as the approved form of reporting, "protection against mistakes" (foolproof) when filling data, algorithms for performing functions of interaction in job descriptions;

- the adequacy of technical support characterizes the availability of means for collecting, processing, sending information and monitoring the performance of the function of information interaction.

Quantitative evaluations of the characteristics of compliance with the information load of the output information flows, specialized and managerial, are shown in *Table 4.*

Thus, the evaluation of compliance indicators with the information load of incoming and outgoing information flows gives an opportunity to evaluate the business process as a whole and analyze the components of this indicator for identifying the primary sources of the problem and developing measures for their elimination.

**Table 4.** Characteristics of the correspondence to the information load of the output information flows

| Characteristics | Qualitative assessments | Quantitative estimates |
|---|---|---|
| The degree of automation of the formation of information messages | Enough | 0.40 |
| | Satisfactory | 0.20 |
| | Unsatisfactory | 0.00 |
| The presence of formal rules for the formation of information messages | Complete coverage of all functions | 0.30 |
| | Partial coverage of all functions | 0.15 |
| | Not developed | 0.00 |
| Sufficient technical support | Full | 0.30 |
| | Partial support | 0.15 |
| | Hand-crafted | 0.00 |

*Source:* own research.

The developed mechanism of formation of the development strategy of the industrial enterprise in the information economy is based on the assessment of the conformity of business process management with other advanced business processes and provides an opportunity to improve the efficiency of the management system of an industrial enterprise. In this case, computerization, automation and robotization of business processes are carried out in accordance with the requirements of the information economy, which ensures the high competitiveness of the industrial enterprise.

## 4. Results

Approbation of the developed mechanism of the formation of the development strategy of an industrial enterprise in the information economy was carried out at *Enterpise A* while improving the enterprise management system in accordance with the previously implemented modernization of the manufacturing sector and taking into account the impact of the information economy on both internal and external markets for thermal equipment in some countries.

As a result of the analysis of the competitiveness of *Enterpise A* it has been established that, for most indicators, the company has a better competitiveness than its competitors on the market. But according to the "Degree of enterprise representation in the information space", the raiting of *Enterprise A* was 0.40, while on average it reached 0.42 among its competitors. This area of evaluation relates mainly to the marketing sphere of the enterprise, therefore, in addition to the previously described modernization of the manufacturing sector, the development strategy of *Enterprise A* must also include the improvement of marketing communications.

As a result of building graphs of information flows between the improved business processes of the production and marketing areas of the *Enterpise A* business and analyzing the closure of the links between them, it has been established that there are inconsistencies that require the implementation of measures to integrate the management systems of specialized business processes into the general control system of the industrial enterprise.

Among the main problems identified, the following should be noted:

- the absence of high-level management information processes and models for handling information messages from the manufacturing sector about positive deviations from the plan of pre-term execution, saving of raw materials or fuel, etc.;
- the absence of a high level of management information processes and models for processing informational messages from the marketing sphere concerning previous requests to *Enterprise A*, which were not completed by contracts.

To solve these problems, it is necessary to implement the following measures:

- development of staff assessment and promotion criteria with positive deviations from the plan;
- developing approaches to the continued use of good practices that have led to positive deviations from the plan;
- identifying the respondents for analyzing the potential unsatisfied demand resulting from the use of Internet communications.

In turn, when evaluating compliance of management and specialized business processes with incoming and outgoing information flows, it has been established that at the managerial level there are problems in the following areas:

- most management business processes have an unsatisfactory level in terms of "Possibility of replacing a responsible employee" (for 56% there is no possibility of replacement, for 23% there is a partial replacement);
- for all managerial business processes, "Impact of the human factor," implementation depends entirely on the employee, and there are no mechanisms for reminding and controlling the execution;
- for all managerial business processes, "The degree of automation of the formation of information messages" is unsatisfactory, that is, routine managerial decisions do not require the development of fundamentally new approaches, but can be created by the template, not automated;

- for specialized business processes in the industrial and marketing spheres of "Enterprise A", the indicator "The availability of formal rules for the formation of information messages" is unsatisfactory, and in the job descriptions there are no necessary items.

To eliminate these problems, it is necessary to implement measures for the harmonization of specialized business processes with business process management:

- improvement of organizational structure and extension of job descriptions in order to ensure interchangeability of officials;
- introduction of information management systems for document management and project management;
- carrying out researches on automation of the development of routine managerial decisions;
- improvement of job descriptions in order to formalize the rules of formation of information messages.

Thanks to the above-mentioned measures to improve the quality of managerial decisions, in addition to optimizing the integral indicator of the quality of managerial decisions of an industrial enterprise in the conditions of the information economy, an economic effect can be obtained.

To calculate the economic effect, it is proposed to use the formula (Zhadko, 2014; Lobov, 2014):

$$\mathrm{EF}_{t1}^{t2} = \Delta Cost_{t1}^{t2} + \Delta Earn_{t1}^{t2} - \mathrm{I}ntr, \quad (6)$$

where $\mathrm{EF}$ – economic effect for the time period t1-t2 from the implementation of the mechanism for forming the development strategy of an industrial enterprise in the information economy;

$\Delta Cost_{t1}^{t2}$ – reduction of the cost price for the period t1-t2 as a result of implementation of the mechanism of the formation of the development strategy of an industrial enterprise in the information economy;

$\Delta Earn_{t1}^{t2}$ – increase in sales volumes during the period t1-t2 as a result of implementation of the mechanism for forming the strategy of development of an industrial enterprise in the information economy;

$\mathrm{I}ntr$ – costs for the implementation of the mechanism of the formation of the development strategy of an industrial enterprise in the information economy.

The calculation of the economic effect has been carried out over three years, and it has been assumed that the internal and external markets for thermal equipment will have the unchanged development trends and there will be no crises or sharp changes in demand. At the same time, the increase in sales volumes to *Enterprise A* comes at the expense of redistribution of the market through better quality of products, more competitive price and the newest method of marketing information communications. Reducing the cost of

production is achieved by increasing the efficiency of the equipment (rotation of the dyeing chamber, automation of the control system of the drying chamber), reducing the number of defects (primarily due to the automation of the entrance control of shaped metal rolling, as well as the rotation of equipment), increase in productivity as a result of reducing the number of downtime and increasing ergonomics of production operations.

Costs of the implementation of the mechanism of the development strategy formation of an industrial enterprise in the information economy consist of the cost of purchasing new equipment, training workers, purchasing computer equipment, developing an information system.

The components of the economic effect from the implementation of the mechanism of the development strategy formation of an industrial enterprise in the information economy is shown in the *Table 5.*

**Table 5.** Economic effect from the implementation of the mechanism of the development strategy formation of an industrial enterprise in the information economy

| Component of economic effect | Amount, thousand £ |
|---|---|
| Reduced cost as a result of increased productivity | 1200 |
| Decrease the cost as a result of automation and rotation of production operations | 5600 |
| Increased sales due to improved product quality | 4200 |
| Increased sales due to lower prices | 8700 |
| Increased sales due to more efficient customer service | 1200 |
| Costs for the development of the manufacturing sector | 9450 |
| Costs for development of marketing sphere | 560 |
| Costs for development of managerial sphere | 1300 |
| Economic effect | 9590 |

*Source:* own research.

Consequently, due to the implementation of the mechanism of the development strategy formation of an industrial enterprise in the information economy, the estimated economic effect at the *Enterpise A* is 9950 thousand pounds, which confirms the effectiveness and relevance of the proposed components of the development strategy.

## 5. Conclusions

Most researchers, when solving the problems of the development strategy formation of an industrial enterprise in the modern economy, consider only certain components of the strategy and consider the development of general content without taking into account the peculiarities of the information economy and the state of industry. Therefore, for enterprises that carry out production activities, it is necessary to develop a strategy taking into account

the need for automation, robotization and informatization of production and management processes in accordance with the requirements of the information economy.

In order to ensure high competitiveness, a mechanism of the development strategy formation of an industrial enterprise in the information economy is developed, which is based on the assessment of the conformity of business processes with other developed business processes and provides an opportunity to increase the efficiency of the management system of an industrial enterprise. In this case, computerization, automation and business processes are carried out in accordance with the requirements of the information economy.

The testing of the developed mechanism of the development strategy formation of the industrial enterprise in the information economy of enterprise A has been carried out, the enterprise management system has been improved taking into account the influence of the information economy on the internal markets of the thermal equipment of some countries.

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# DIVERSIFICATION OF ENERGY POVERTY IN CENTRAL AND EASTERN EUROPEAN COUNTRIES

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**Abstract.** Household energy security, and in particular affordability of energy services and the energy poverty issue, is a debated topic both at the EU level and at the level of individual countries. The aim of the paper is to investigate the energy poverty diversity in the Central and Eastern European countries. The energy poverty index that aggregates three aspects: availability and affordability of energy services, as well as household energy efficiency, has been presented. This framework allows for comparison between countries and discloses the diversity of their energy poverty profiles. Analysis of energy poverty indicates diversification of level and dynamics of this phenomenon in the studied countries. Among countries of Central and Eastern Europe, there are both countries, where the problem of energy poverty is the highest, and the lowest in Europe. Almost all studied group is characterized by decreasing level of energy poverty in that particular period. Analysis of index components indicates diversification of energy poverty profiles. Important factor shaping the ability to acquire energy services was also the consequence of economic crisis, especially lowering the level of incomes and the increase of energy prices as a result of increasing tax burdens imposed on energy carriers.

***Keywords:*** energy poverty, energy services affordability, households
***JEL Classification:*** E00, O52, R00

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## 1. Introduction

Energy markets in the EU countries are undergoing strong changes having two factors as their catalysts: technological progress and political decisions taken by the member countries and on the supranational level. The consequences of these processes are among others the introduction of market mechanisms to a strongly regulated sector, the reduction of access barriers to it and the increase of competition among entities operating on the energy markets, changes in the structure of energy supply resulting from the stricter environmental requirements. These changes have an influence on the functioning of households. On the one hand, they gained the possibility of active participation in the energy market, free choice of energy service suppliers or even participation in the market as prosumers. On the other hand, households have been put at higher risk due to the fluctuation of energy prices. Demand for energy is characterized by low price flexibility, and with the lack of substitutes or efficient possibilities to store energy, when the prices increase, expenses for energy services become a significant and difficult to control component of household budgets.

In this light, energy security of households must be considered in a wider sense, than only in the category of stability and continuity of energy supplies. It is especially important to pay attention to the ability of households to purchase energy services as well as to the problem of energy poverty. In the last decade these issues became the subject of interest, both by science and economic policy as well as for market regulators in the EU countries (Bouzarovski et al., 2012; Dagoumas and Kitsios, 2014; European Economic and Social Committee, 2010, 2013).

The aim of the following report is to analyze the energy poverty in the selected EU countries. The report proposes the energy poverty index, considering accessibility to energy services, the ability of households to purchase energy services as well as the level of energy efficiency in households The analysis will be conducted for six countries of Central and Eastern Europe (Bulgaria, Czech Republic, Poland, Rumania Slovakia, Hungary) and the Baltic States (Lithuania, Latvia and Estonia). The subsequent parts of the report will present the definition of energy poverty and the methods of measuring it, together with the concept of energy poverty measure, which will be then estimated for an indicated group of countries.

## 2. The idea of energy poverty

Energy poverty is a phenomenon of the lack of access of households to modern and safe energy services provided in an undisturbed, safe and ecologically responsible way with the aim of providing economic development (Pachauri and Spreng, 2011). Energy services were originally defined as access to energy and other sources of energy designed for the realization of elementary needs, mainly for the preparation of meals (International Energy Agency, 2002, 2010). Currently energy services are understood wider, as transforming the carriers of primary energy into the diversified streams of final energy provided to consumers: electric energy, heat, coolness, transport fuels. The types of energy services and the access to them for households can then differ depending on the level of economic development, accessible sources of energy or energy policy of a particular country, nevertheless the catalogue of

household needs realized due to the access to energy is relatively stable (lightning, keeping the right temperature at home, preparation of meals, transport, communication).

The above presented definition of energy poverty shows the features that should characterize energy systems. The first is the necessity to apply an adequate technology, which ensures seamless, undisturbed access to energy services with prices that are not a significant access barrier for households. Simplifying this, we could say that energy technologies should be as cheap as possible in conditions accessible for a particular society.

In relation with the above, we can indicate the existence of dependence between the wealth of society and the forms and diversification of used sources of energy (González-Eguino, 2015). Generally, wealthier countries are characterized by more diversified energy baskets, whereas the poorer countries have relatively small number of available energy sources, with a significant predominance of solid fuels (including biomass). At the same time, the increase in wealth of households results in replacing solid fuels by cleaner sources of energy. This dependency indicates abandoning cheaper and worse quality fuels (wood, wastes, kerosene) and choosing more efficient, modern sources of energy (electric power, liquid fuels) together with the increase in the wealth of households (Van der Kroon et al., 2013; Cook et al., 2005). The factor conditioning the choice of energy technologies is also the minimalization of the negative influence on the natural environment – intensive transformation of the natural environment for the needs of energy production, dedication of agricultural land for energy aims and the emission of greenhouse gasses.

Finally, the definition of energy poverty refers to the aim of providing access to energy services, which is an economic development. We should indicate at the same time, that this development is not understood only as reaching a suitable level of income (or in this case the size of energy consumption *per capita*). Nowadays the access to energy services is conditioned by meeting both the lower and the higher orders. Thereby the lack of access to suitable energy services leads not only to the deprivation in the scope of elementary needs of existence (such as: no possibility to keep the right temperature at home, to heat the water etc.), but also the elements necessary for self-development, such as: education, communication, participation in social life.

Reasons for the existence of energy poverty phenomenon can be twofold. Firstly, energy poverty can be the result of the physical lack of energy availability. Secondly, the impossibility to realize elementary energy needs can be caused by relatively high prices of energy services, which create economic barriers to access to them. The first mentioned reason relates to a greater extent to the countries with a lower level of development, whereas the problems with economic availability of energy can be also observed in highly developed countries. In order to underline the dissimilarity of the problem – physical access to energy services in developing countries and economic access to energy services in developed countries – while studying the second group, the term of fuel poverty will be applied simultaneously (Boardman, 2012; Healy and Clinch, 2002, 2004; Karpenko et al., 2018; Li et al., 2014; Moore, 2012; Tvaronavičienė, 2016).

## 3. Methodology of the study. Measures of energy poverty

Economic availability of energy is directly influenced by the factors that can be classified into three groups: price factors, income factors and factors conditioning the level of energy consumption in households. Among the price factors, besides 1) the level of prices for energy carriers and 2) diversification of tariffs for using energy, the significant factors are also 3) fiscal and environmental policies of the state, which decide on the rate of taxes and fees imposed on energy and 4) the scope of regulation of energy prices. The factors, which influence the burden of household budgets with energy costs are also 5) the types of used fuels and 6) the possibility to substitute them in order to lower the fuel costs.

The second group constitutes the income factors, the most important of which are as follows: 1) the sources and the amount of income obtained by households and 2) the amount of social transfers connected with the use of energy. The third group should include the factors determining the level of energy consumption and energy efficiency of households. Among the most important here are: 1) the type and energy consumption of the devices, which are used in households, 2) energy efficiency of the inhabited buildings and 3) customs and consumption patterns.

Among the factors indirectly influencing the level of energy poverty we should mention above all: 1) the size and the structure of a household that shape the specific energy needs of the household, 2) the legal right to the occupied property, conditioning the scope of decisions taken with the aim of improving energy efficiency and 3) the level of liberalization of energy market, influencing the diversification of energy offer and the possibility of active management for energy demand by the households.

Large quantity of factors shaping the level of energy poverty allows for the classification of households experiencing limited accessibility to energy services. In the first group of households the energy poverty is connected with the income poverty. Limitations of access to a wide range of energy services and high contribution of expenses on energy in the household budget are in this case the result of a low level of the obtained income. At the same time, it is worth noticing, that not every household with relatively low incomes will be immediately energy poor. High level of energy efficiency of such a household can simply counter negative influence of the income factors.

The second group made up of the households, which are not poor in the category of obtained income, nevertheless they experience energy poverty. The reason for such condition can be a high level of energy price, low level of energy efficiency of these households or the existence of both these factors at the same time.

Presently, both the social sciences and the economic practice, have not yet elaborated comprehensive and universal factor that will enable monitoring and international comparison of energy poverty level. Energy poverty is measured with the use of three alternative, supplemental methods. The first method underlines the necessity to provide access to

modern energy services. Energy poverty is measured here by the percentage of population without the access to electricity and using the most traditional sources of energy (wood, biomass, charcoal) to prepare meals. This concept was complemented by widening the scope of measured energy services by the use of household goods and services serving education, entertainment and communication. The above described indicators show the access of households to energy sources, but do not reflect costs connected with the consumption of energy and their energy efficiency.

The level of energy poverty can be also determined in relation to the minimal amount of energy that is necessary for meeting the elementary needs of the poorest households and the types of fuels used by these households. This way of measuring enables for a greater documentation of household diversity and consideration of the specificity of the examined community.

Finally, the level of fuel poverty can be measured by the level of expenses incurred by the households on energy services. It is assumed then, that the energy poor households are those that spend 10-15% of all incomes on energy services.

In international, comparative studies of energy poverty, the most commonly used estimation is, due to the lack of other measures, the answer to the question concerning the existence of difficulties in maintaining the adequate level of heat in the place of living, which is given to the household owners in the scope of study about conditions of life of EU-SILC citizens conducted by Eurostat. It seems, though, that for the needs of international comparisons, these estimations should be supplemented by at least data reflecting differences in burdens, which represent expenses for electricity and heat in household budgets. Due to this fact, in the following parts of this report, energy poverty is measured by the index that includes availability of energy services and the capability of households to purchase them, as well as the energy efficiency of the studied entities (Fig. 1). Merit of the index constitutes the sum of partial measurement (availability of energy services, capability to purchase energy services, energy efficiency), which were given equal weight (33.33%). The measurement is conducted with the use of data concerning: difficulties in maintaining adequate level of heat in the place of living, existing delays in housing payments, percentage of costs of housing maintenance in household budgets, consumption of energy in households and energy efficiency of buildings (measured by the percentage of population inhabiting places with leaking roofs, wet walls, floors and fundaments or not tight windows).

Energy poverty can be examined on a macro-, meso-, and microeconomic scale depending on the aim of the analyses and the level of aggregation of available data (Table 1). International comparisons of countries belonging to the EU are possible thanks to data collected by Eurostat and IEA (International Energy Agency). A significant source of information is the research on living conditions (EU-SILC). However, this data cannot be compared in a direct way. This is mainly due to the diversification of countries in terms of factors determining the level of energy poverty, including: structure of households and their budgets, energy and fiscal policy tools, sources of energy used in households, prices of energy, profile of housing substance

(including the structure of ownership). Additionally, the available data is both quantitative and qualitative.

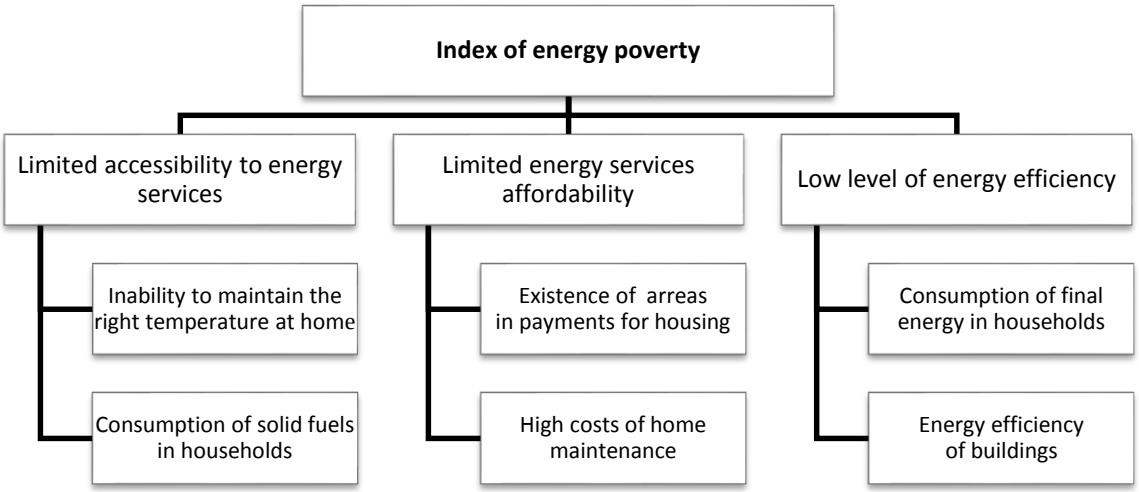


**Figure 1.** Construction of energy poverty index
*Source:* own research.

**Table 1.** Observation levels of energy poverty phenomenon

| Scale | Data sources | Aim of analysis |
|---|---|---|
| Macroeconomic level (international) | Macroeconomic data bases and international questionnaire research | International comparisons, observation of long-term trends |
| Macroeconomic level (national) | National statistics of household types and their budgets, living conditions, consumption of energy, deprivation forms of households | Description of types of energy poor households and tools of national economic policy designed to limit this phenomenon |
| Mesoeconomic level (sectorial or regional) | Regional and local data bases | Description of specificity of energy poor households of a particular region and tools of regional and local policy with the aim to limit the energy deprivation |
| Microeconomic level | Households data | Description of energy efficiency level of a household and methods to limit or prevent the problem of energy poverty |

*Source:* Dubois, U., & Meier, H. (2016). Energy affordability and energy inequality in Europe: Implications for policymaking. *Energy Research & Social Science*, 18, 21-35. https://doi.org/10.1016/j.erss.2016.04.015

Due to the above mentioned, the accepted study proceeding is the analysis of the distance to the countries with the highest level of such indicator. This method is used in international comparative studies, among others as a tool to evaluate regulatory practices. In the case of energy poverty, the highest observed level of the indicator relatively specifies the highest level

of this phenomenon. In the construction of the index, this means 100. The results for other countries are calculated in relation to the country that was characterized by the highest level of the observed phenomena. This enables for a more precise plotting of the relative position of the countries than ranking. The index values below 100 obtained by a certain country means, that this country did not reach the highest point values in all studied criteria. Referential values for each of the studied variables were calculated with the consideration of all member countries of the EU.

Time range of the analysis covers the years 2007-2016, and the study was conducted for the Central and Eastern European countries as well as the Baltics, for which the EU-SILC data is available. The scope of this analysis is conditioned by the availability and completeness of the data.

## 4. Analysis of energy poverty in selected EU countries

In the studied group of countries (with the exception of Lithuania) it was possible to observe the improvement of the situation in the scope of energy poverty (Table 2), though against all the EU countries, there are the economies, where the problem of energy poverty is particularly significant, which is indicated by the position in the ranking in all studied timespan. Exceptions are Slovakia, Czech Republic and Estonia, where the level of energy poverty is the lowest. Among the studied countries, the highest level of energy poverty in all the timespan can be observed in Bulgaria, which records the highest level of energy poverty in all EU.

**Table 2.** Energy poverty index for selected EU countries

| | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bulgaria** | 67% (1)* | 70% (1) | 61% (1) | 54% (1) | 56% (1) | 58% (2) | 57% (2) | 54% (2) | 52% (2) | 54% (2) |
| **Czech** | 34% (9) | 34% (13) | 32% (14) | 32% (17) | 35% (17) | 34% (17) | 33% (15) | 32% (16) | 31% (17) | 29% (18) |
| **Estonia** | 28% (19) | 28% (19) | 32% (16) | 33% (16) | 36% (16) | 35% (14) | 32% (17) | 30% (18) | 28% (21) | 26% (21) |
| **Hungary** | 41% (4) | 45% (5) | 38% (8) | 46% (6) | 50% (5) | 53% (4) | 50% (3) | 46% (4) | 42% (6) | 41% (4) |
| **Lithuania** | 35% (8) | 35% (10) | 35% (10) | 39% (10) | 47% (6) | 44% (8) | 42% (8) | 39% (10) | 41% (7) | 39% (6) |
| **Latvia** | 41% (6) | 42% (6) | 46% (4) | 50% (3) | 55% (2) | 53% (3) | 50% (4) | 46% (5) | 43% (5) | 35% (11) |
| **Poland** | 66% (2) | 56% (2) | 52% (2) | 53% (2) | 53% (3) | 51% (5) | 49% (5) | 46% (3) | 45% (4) | 43% (3) |
| **Romania** | 49% (3) | 52% (3) | 49% (3) | 48% (5) | 45% (7) | 47% (7) | 44% (7) | 36% (13) | 35% (13) | 34% (12) |
| **Slovakia** | 30% (16) | 21% (24) | 26% (22) | 24% (25) | 25% (26) | 24% (26) | 22% (28) | 22% (26) | 21% (26) | 17% (27) |

* In brackets there are the positions in the ranking of EU-28 countries; due to availability of data in 2007-2009 without Croatia, 2014-2016 without Malta.

*Source:* own research on the basis of Eurostat data (Eurostat Energy Statistics and EU-SILC).

### 4.1. Changes in the scope of energy services availability

The biggest difficulties in providing access to energy services existed in three countries: Bulgaria, Poland and Lithuania (Table 3, Fig. 2). Bulgaria is the country, where the highest percentage of population unable to maintain the right temperature of houses was recorded. This percentage in the studied period decreased significantly (from 67.4% in 2007 to 39.2 in 2016), however it still remained the highest both in the studied group of countries, and in the EU-28.

In the case of Poland the value of the indicator reflecting the availability of energy services results from a high contribution of solid fuels in the consumption of final energy. The data indicate specifically shaped structure of energy sources used in households, where the contribution of solid fuels reaches 34%, which is a tenfold of the average of EU-28, which amounts to 3.4%. For comparison, in Ireland and the Czech Republic, which are the next when it comes to the consumption of solid fuels, this indicator in 2016 stood at 14.7% and 12.5% respectively.

The level of consumption of hard coal by Polish households results from the widespread use of solid fuels for heating purposes. Almost half of all domestic households, that is 49.2%, use heating installations (to heat rooms) which use solid fuels, among which the most common fuels were hard coal and fuelwood. In cities, solid fuels are used by one third of households (28%), and in the country by almost all households (92.8%). Coal and wood were usually used simultaneously or alternatively in the same installations. Reversible boilers used by 47.7% and single-purpose boilers used by 29.3% of households were heated by solid fuels and almost all households (97% and 93.3% respectively) used them as basic installations. Moreover, 15.3% of households used the most traditional heating installations, such as stoves in rooms (mainly tiled stoves), and the further 7% of households using solid fuels used fire places, mostly with closed input. These installations provided the fundamental source of heating rooms in 83.3% and 19.7% of households, respectively. Such shaped structure of using fuels results from the structure of prices for energy carriers for the households, where hard coal remains the cheapest fuel.

Decreasing availability of energy services in Lithuania also deserves our attention, In the case of this country, percentage of population declaring difficulties with maintaining the right temperature at homes increased over twofold in the studied period (from 33.2% in 2007 to 74.7% in 2016). What is interesting, between 2010 and 2013, in the period of the greatest growth of the indicator, the consumption of solid fuels in households in Lithuania also increased. The percentage of solid fuels in the total consumption of energy till 2009 was at the level of 3.3%, in 2010 it increased to 4.4%, and in 2013 it amounted to 5.1%. This phenomenon is in accordance with the previously presented concept, according to which households experiencing difficulties with access to energy services (here: heating) use solid fuels to a larger extent.

**Table 3.** Changes of indicator limiting accessibility to energy services in selected EU countries between 2007 and 2016

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bulgaria** | 68% | 66% | 64% | 60% | 62% | 65% | 64% | 63% | 59% | 59% |
| **Czech Repulic** | 22% | 20% | 19% | 20% | 25% | 27% | 26% | 28% | 26% | 24% |
| **Estonia** | 6% | 3% | 3% | 4% | 5% | 6% | 5% | 4% | 4% | 4% |
| **Hungary** | 14% | 11% | 11% | 12% | 16% | 20% | 20% | 17% | 15% | 14% |
| **Lithuania** | 21% | 23% | 24% | 24% | 45% | 44% | 39% | 40% | 46% | 43% |
| **Latvia** | 17% | 15% | 15% | 16% | 27% | 24% | 25% | 22% | 20% | 15% |
| **Poland** | 67% | 65% | 63% | 61% | 65% | 64% | 63% | 61% | 60% | 59% |
| **Romania** | 25% | 19% | 18% | 15% | 17% | 16% | 17% | 16% | 18% | 19% |
| **Slovakia** | 6% | 8% | 7% | 6% | 8% | 9% | 9% | 9% | 9% | 8% |

*Source:* own research on the basis of Eurostat data (Eurostat Energy Statistics and EU-SILC).

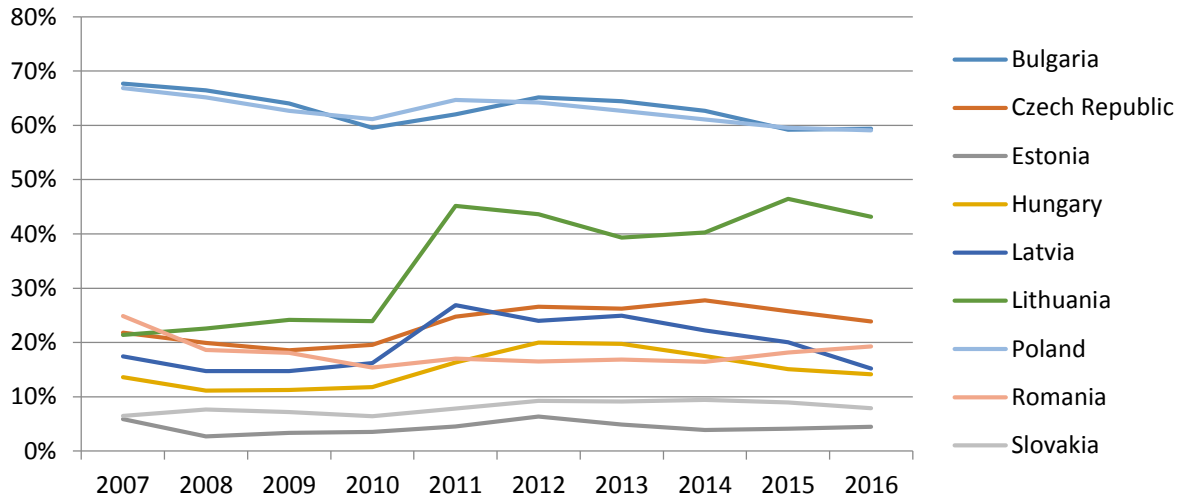


**Figure 2.** Changes of indicator limiting accessibility to energy services in selected EU countries between 2007 and 2016
*Source:* own research on the basis of Eurostat data.

### 4.2. Changes in the ability to acquire energy services

In the accepted methodology, the ability of households to acquire energy services (Table 4) is shaped by two variables: percentage of the households getting behind with the on-time payments for using homes and percentage of households, for which the payments for using homes are high. For the first criterion the referential countries were Bulgaria (between 2007 and 2011) and Greece (between 2012 and 2016), because these countries recorded the highest values of the indicator in the respective periods. For the second criterion, the

referential countries were Bulgaria (in 2007), Denmark (between 2009 and 2010) and Greece (in 2008 and between 2011 and 2016).

**Table 4.** Changes of indicator limiting the ability to acquire energy services in selected EU countries between 2007 and 2016

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bulgaria** | 100% | 80% | 64% | 63% | 68% | 67% | 68% | 60% | 55% | 63% |
| **Czech Republic** | 31% | 33% | 25% | 29% | 27% | 22% | 22% | 19% | 16% | 15% |
| **Estonia** | 20% | 19% | 25% | 31% | 36% | 29% | 25% | 24% | 18% | 15% |
| **Hungary** | 56% | 47% | 51% | 61% | 67% | 61% | 55% | 46% | 33% | 30% |
| **Lithuania** | 27% | 21% | 25% | 41% | 44% | 33% | 30% | 23% | 21% | 21% |
| **Latvia** | 37% | 37% | 47% | 58% | 67% | 52% | 45% | 38% | 30% | 24% |
| **Poland** | 54% | 37% | 36% | 43% | 44% | 38% | 34% | 31% | 22% | 21% |
| **Romania** | 62% | 78% | 71% | 78% | 69% | 74% | 65% | 49% | 40% | 39% |
| **Slovakia** | 52% | 18% | 37% | 33% | 29% | 22% | 20% | 19% | 18% | 7% |

*Source:* own research on the basis of Eurostat data (Eurostat Energy Statistics and EU-SILC).

The adoption of the criterion of ability to acquire energy services enables for a distinction of two groups of countries. The first group constitutes the countries, where the limitations in the ability to acquire energy services were on the increase between 2008 and 2011, and later decreased significantly (Fig. 3). This group of countries reported relatively quick increase in energy prices in the period of crisis. It is worth emphasizing, that the level of energy prices is influenced by the market factors, fiscal and regulatory policies of the country, and in the countries belonging to the studied subgroup the additional burdens in the scope of taxes from energy were introduced to respond to the crisis. These changes include in particular: excise duty imposed on electricity, energy carriers (oil, natural gas, coal) and transport fuels (petrol, diesel) as well as taxes connected with the emission of CO2.

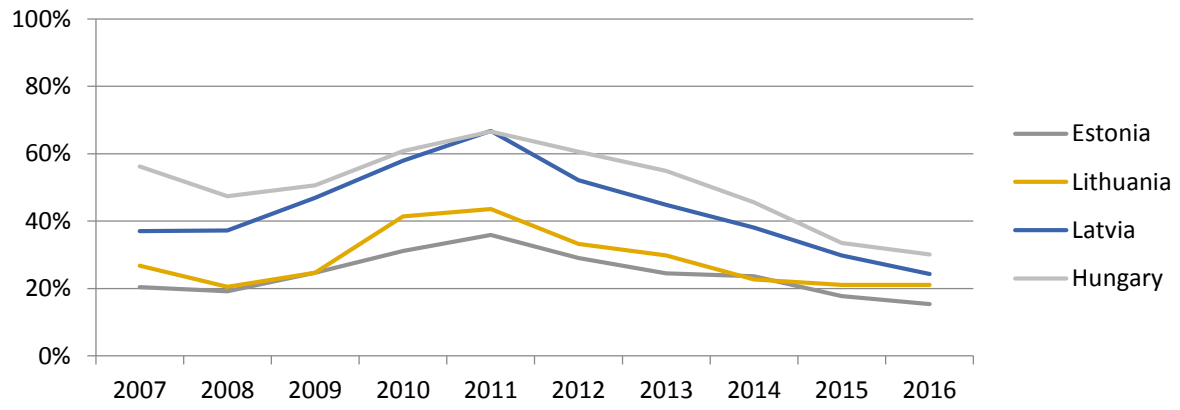


**Figure 3.** Changes of indicator limiting the ability to acquire energy services in Hungary and the Baltic States between 2007 and 2016
*Source: own* research on the basis of Eurostat data.

The second group of countries constitutes the economies, where limitations in the ability to acquire energy services successively decrease (Fig. 4). This is the result of relatively stable energy prices (which increase in the case of Poland is additionally regulated by the state) and the increase of income levels of households.

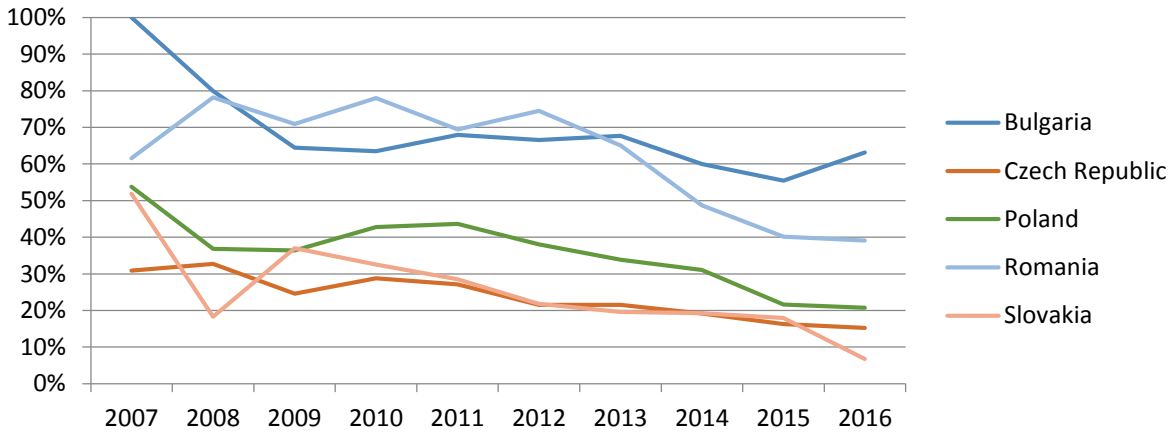


**Figure 4.** Changes of indicator limiting the ability to acquire energy services in Bulgaria, the Czech Republic, Poland, Romania and Slovakia between 2007 and 2016
*Source:* own research on the basis of Eurostat data.

### 4.3. Changes in the energy efficiency of households

According to the adopted method of measurement, changes in the energy efficiency of households are shaped by two factors: consumption of energy in households and level of energy efficiency of buildings inhabited by these households. The level of energy consumption is influenced by changing consumption patterns and changes in the household equipment for modern appliances, the use of which requires access to different forms of energy, whereas the biggest changes take place in the use of electricity. The referential country during all studied period was Luxembourg, where the consumption of energy in households was the highest. In the studied group of countries relatively higher level of energy consumption (Fig. 5) was recorded in five countries (Estonia, Latvia, the Czech Republic, Poland and Hungary).

The second indicator (energy efficiency of buildings) enables to observe changes in energy efficiency resulting from the improvement in the state of buildings inhabited by the studied households. During the studied period this indicator was decreasing successively in all countries, except Hungary, where according to EU-SILC data, the level of this indicator increased from 19.2% to 26.7%. Hungary is therefore a country, where the shaping of energy efficiency in households (Table 5) is influenced both by the level of energy consumption and by the low efficiency of residential buildings.

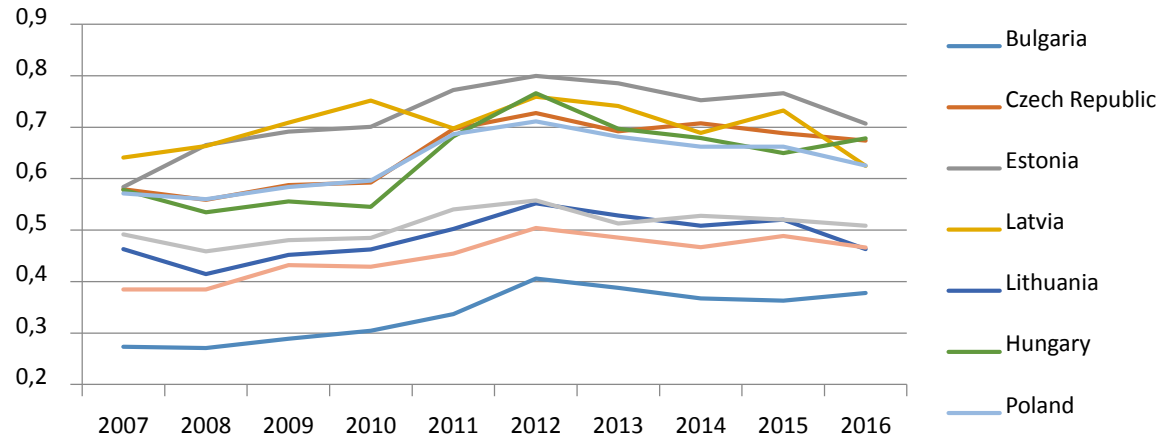


**Figure 5.** Changes of energy efficiency indicator in selected EU countries between 2007 and 2016
*Source:* own research on the basis of Eurostat data.

**Table 5.** Changes of energy efficiency indicator in selected EU countries between 2007 and 2016

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bulgaria** | 33% | 63% | 53% | 39% | 38% | 42% | 40% | 38% | 41% | 39% |
| **Czech** | 50% | 50% | 53% | 48% | 52% | 53% | 50% | 49% | 50% | 47% |
| **Estonia** | 58% | 61% | 68% | 64% | 66% | 71% | 67% | 62% | 62% | 58% |
| **Lithuania** | 57% | 61% | 57% | 53% | 52% | 56% | 58% | 54% | 56% | 53% |
| **Latvia** | 67% | 75% | 78% | 76% | 72% | 83% | 80% | 76% | 80% | 67% |
| **Poland** | 79% | 65% | 58% | 54% | 51% | 52% | 50% | 47% | 54% | 50% |
| **Romania** | 59% | 58% | 57% | 50% | 49% | 50% | 50% | 44% | 47% | 45% |
| **Slovakia** | 33% | 38% | 35% | 33% | 38% | 42% | 37% | 37% | 37% | 36% |
| **Hungary** | 55% | 77% | 51% | 65% | 66% | 77% | 77% | 75% | 78% | 78% |

*Source:* own research on the basis of Eurostat data (Eurostat Energy Statistics and EU-SILC).

## 5. Overview

The analysis of energy poverty indicates diversification of level and dynamics of this phenomenon in the studied countries. Among the countries of Central and Eastern Europe, there are both the countries, where the problem of energy poverty is the highest (Bulgaria), and the lowest in Europe (Slovakia). Nevertheless, almost the whole studied group is characterized by decreasing level of energy poverty during that particular period. The analysis of the index components indicates diversification of energy poverty profiles. Some countries experienced difficulties in the scope of two criteria: either the accessibility and affordability of energy services (Bulgaria) or the accessibility of energy services and energy efficiency

(Latvia and Hungary). Other countries were characterized by high indicators only in one of the studied areas (Poland – accessibility of services, Romania – energy services affordability, Estonia – energy efficiency). Important factor shaping the ability to acquire energy services was also the consequence of economic crisis, especially lowering the level of incomes and the increase of energy prices as a result of increasing tax burdens imposed on energy carriers.

## 6. Conclusions and recommendations

The aim of the conducted study was an analysis of the level and the reason for energy poverty in selected EU member countries. Results indicate, that the Central and Eastern European countries report relatively high level of energy poverty. The presented diversification of the countries indicates, that it is not possible to implement uniform programs counteracting energy poverty on the EU level. These activities should remain the domain of member countries and should be conducted on the national level.

Instruments of the state policy aimed at fighting the energy poverty should include diversification of households' profiles experiencing this problem. Identification of the main reasons for the creation of energy poverty is important for the creation of solutions that will reduce the scale and the scope of this phenomenon. In the case of households that are poor in the income and energy category, the reduction of economic poverty is the necessary condition of reducing the energy poverty. However, if the energy poverty affects the households with average incomes, nonetheless constituting sensitive groups, the role, character, scope and efficiency of the state impact changes.

Because of the factors shaping energy poverty, we can distinguish three directions of actions that enable the reduction in the scope of this phenomenon: direct financial support of households, shaping the system of energy tariffs, which enables for the reduction of expenses on energy services as well as instruments supporting the improvement of energy efficiency in households. What is important, among the indicated actions, only the improvement in energy efficiency allows to counteract the phenomenon of energy poverty in the longer run. Other actions are only interim actions, because they do not lead to the elimination of the reasons for the phenomenon. It should be also underlined, that the used instruments should have a selective character. Their correct addressing requires more precise studies conducted on a microeconomic level.

As it was already mentioned, diversification of the countries makes it impossible to conduct policy that would prevent energy poverty on the EU level. At the same time, however, it is worth starting a discussion about the costs of transforming energy systems. Important is the fact, that the costs of this process do not deepen the phenomenon of energy poverty and do not worsen the situation of the most sensitive groups of households.

When discussing further research on energy poverty on international level there is a need for common definition. The present lack of such agreement means that there are no official figures about the extent of energy poverty, and it estimates the range in dependence on the

metrics that are used. Although it is not possible to implement common economic policy against energy poverty, globally-accepted definition would provide better recognition and political visibility of the problem, clarify terminological confusion, standardize statistics and measures and therefore help to achieve links with other policy domains.

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# SCIENTIFIC AND METHODICAL APPROACH TO ADAPTIVE DIVERSIFICATION OF INDUSTRIAL ENTERPRISE DEVELOPMENT UNDER CRISIS CONDITIONS

*Hanna Tarasova*

**Abstract.** The article establishes that Ukrainian enterprises operate in the conditions of permanent economic crises and changes in the economic environment as a result of further integration of Ukraine into the world markets. This leads to the discrepancy between the state of domestic industrial enterprises and the requirements of the economic environment. To solve this problem, a scientific and methodical approach has been developed to adapt the diversification of the industrial enterprise development in a crisis that is based on the assessment of the existing and potential crises and the formalization of the assessment of the crisis impact, which enables an industrial enterprise to justify diversification measures in order to adapt to the crisis and to save the planned strategic development benchmarks.

***Keywords:*** adaptation, diversification, development, industrial enterprise, assessment, strategic reference points, crisis

***JEL Classification:*** L230, C530, O210

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## 1. Introduction

For Ukrainian industrial enterprises, which are still in the fourth technological stage, not only is the adaptation to crisis important, but also the diversification is, in order to increase competitiveness as a response to global technological and marketing changes.

Adaptation of the industrial enterprise in the general sense means the process of accumulation and use of information in the enterprise management system, the purpose of which is to achieve optimal state or behavior in an unstable external environment and under conditions of insufficient information. When adapting, the parameters and structure of the system, the algorithm of functioning, business processes, etc. can change (Glushkov et al., 1974; Prokopenko & Shishatsky, 2014).

Diversification in the context of the development of an industrial enterprise is an increase in diversity in the implementation of enterprise development. This may be an expansion of the range of products manufactured by the company, the change or expansion of the markets, the development of new technologies, etc. (Milovanov, 2006).

Accordingly, the adaptive diversification of the development of an industrial enterprise in a crisis means the process of accumulation and use of information on increasing the diversity of parameters and structure of an industrial enterprise, its technologies, product mix and business processes in response to existing or expected crisis.

## 2. Literature review

The issue of anti-crisis adaptation and diversification of industrial enterprises was dealt with by many domestic researchers, who considered some aspects of this problem.

O. Kuzmin and Kh. Drymalovska (2013) suggested diversification as an aspect of increasing competitiveness in order to better overcome crises. They believe that at the present stage of development, the diversification of Ukrainian industrial enterprises is not given enough attention. The diversification development in Ukrainian industrial enterprises is proposed to carry out simultaneously in many areas. The main directions should be strengthening of competitive positions in the national market and access to the world market, modernization of production technologies, expansion of markets, creation of new workplaces, optimization of utilization of production capacities, attraction of scientists and inventors (Hroznyi et al., 2018). But practical recommendations for the implementation of the proposed directions of diversification are not provided, which limits the use of this approach.

P. M. Maidanevych (2014) offers to calculate a comprehensive comparative characteristic of the competitive status depending on the stage of the life cycle, which reflects the potential of the enterprise, its position on the market, as well as the ability to maintain its position under the influence of destabilizing factors of the environment (Milovanov, 2006). He considers it necessary to build a development strategy depending on the life cycles of the enterprise, when

managing the development of an industrial enterprise under crisis conditions. The main disadvantage of this approach is to respond to a crisis that has already occurred without forecasting future probable crises.

Diversification as a component of strategic development of the enterprise is considered by I.O. Gadzevych (2014), who proposed a model for evaluating the appropriateness of diversification, which is based on the comparison of income from diversification and the cost of its implementation. The main purpose of enterprise management is to select such diversification projects that would not significantly damage the financial and economic condition of the enterprise and its main activities during the implementation of these projects. Also, diversification projects are evaluated in terms of risks calculated on the basis of the yield model of the fixed assets. The disadvantage of this approach is to consider diversification as an independent value that the enterprise does in any case, rather than respond to the challenges of the environment. Insufficient attention is also paid to forecasting the state of the internal and external environment of the company, which will affect the effectiveness of diversification projects.

Methods of providing financial stability of the enterprise under crisis conditions are considered in the works (Delas et al., 2015; Lakhno et al., 2018; Pająk et al., 2016), in which the directions of carrying out the enterprise sanation and innovative ideas search for realization of the anti-crisis strategy are investigated. Particular attention in these studies is drawn to the need for timely prediction of the onset of the crisis, but specific tools for addressing this issue are not proposed.

The solution of the problem of an industrial enterprise development through the formation of a mechanism for the adaptation of industrial enterprises to the external environment was proposed in the works of K. Orlova (2013, 2015). The basis of the proposed mechanism is the determination of responsive behavioral reactions that reflect a set of the industrial enterprise processes and arise in response to external factors. It provides an opportunity to carry out a multidimensional survey of the enterprise, identify the problems of development and build a system of actions for adaptation to the conditions of the environment. The disadvantage of this approach, as of many others, is the ignoring of the need for forecasting crises and the lack of formalized adaptation models. Consequently, most researchers who solved the problem of adapting the industrial enterprise to the crisis through diversification did not pay enough attention to forecasting crises, formalizing the process of assessing the current or future crisis, and to the diversification not only as a response to the crisis, but also as a preservation of the general vector of strategic development.

To implement the adaptive diversification of the industrial enterprise development under crisis conditions, it is necessary to determine what crisis threatens the enterprise - internal or external. Problems of enterprise development under crisis conditions are considered in the works Sabatino (2016), Chung et al. (2013), Laperche et al. (2011), Cerrato et al. (2016), Kapitsinis N. (2018). In the theory of systems, the crisis is considered as the state of the system, in which its parameters take threshold, critical values. After their achievement, the

probability of returning the system to a normal state is very small. After entering the crisis state, either the destruction of the system or its transformation usually occurs.

In the aspect of the development of an industrial enterprise under crisis conditions, it should be borne in mind that the crisis of the environment is considered only in terms of its threat to the enterprise, and not to the environment itself.

Thus, with the adaptive diversification of the industrial enterprise, it is necessary to distinguish between the internal crisis of an industrial enterprise and the crisis conditions of the environment.

## 3. Methodology

Crisis conditions of the environment are such parameters of the environmental system, which adversely affect the state of the industrial enterprise (Naidoo, 2010; Swan, 2009). The internal crisis of an industrial enterprise is its parameters, which have arisen not because of the influence of the external environment, but because of internal disorders. Consequently, for the adaptive diversification of the industrial enterprise development, five types of information-analytical support should be used (Figure 1):

- provision for forecasting of external crises;
- provision for assessing existing external crises;
- provision for forecasting of internal crises;
- provision for assessing existing internal crises;
- provision for developing adaptation diversification measures.

Provision for forecasting external crises includes tools for constructing the trends of key environmental indicators and the calculation of models of quality jumps in the external environment. Key indicators of the environment include those indicators that directly affect the financial performance of the industrial enterprise (Williamson & Zeng, 2009). First of all, it is the capacity of the market of products that the enterprise produces. Moreover, under the market size is meant not only the volume of total sales of such products, but the division of the market in quality, value, brand awareness and other basic characteristics of products. Each such division is treated as a separate loss. Dividing is necessary to analyze the possibility of a crisis for an industrial enterprise (Wong, 2009) if demand for its products is reduced, as well as for further internal product diversification, that is, changes in some characteristics of products in order to reach the neighboring sectors of the market.

Also, depending on the peculiarities of the industrial enterprise activity, the availability of raw materials, labor supply, availability of credit resources, exchange rates (if the enterprise carries out foreign economic activities) may include key indicators.

To predict the external crisis, it is proposed to calculate the coefficients of reaching the crisis, which take into account how the crisis will affect the key indicators of the production of the company and its products:

$$K_p^{cr} = \frac{\sum_{s=1}^{S}\left(k_p \cdot \max\left(0, \frac{K_s^{base}}{K_s^{ftr}} - 1\right)\right)}{\sum_{s=1}^{S} k_s}, \quad (1)$$

where $K^{cr}$ – assessment of the crisis for the sales market of the p-th type of industrial enterprise products;

$k_s$ – the coefficient of proximity of the s-th type of loss of the market to the market of sales of the p-th type of products;

$K_{p,s}^{base}$ – the value of the market capacity for the s-th loss in the base period for the p-th type of products;

$K_{p,s}^{ftr}$ – the value of market capacity for the s-th loss in the forecast period for the p-th type of products;

$S$ – the number of market losses that are being analyzed.

The closer the coefficient $K^{cr}$ is to 0, the less the expected crisis is. The value of the coefficients of closeness of the s-th type of loss of the market to the market of sales of the p-th type of products is determined in the range from 0 to 1, where 1 corresponds to the full coincidence with all the characteristics of the products manufactured by the industrial enterprise.

The second tool for forecasting external crises, the response to which needs diversification is the calculation of models of qualitative jumps in the external environment. Qualitative jumps mean not a slow change in key indicators, which can be predicted through trend analysis, but fast or instantaneous changes. For example, they are changes in the technology of production, the substitution of goods by fundamentally different ones or in general, the disappearance of demand for it. Such models need to take into account the scientific and technological progress and analysis of innovative developments in those industries which include the industrial enterprise.

The second component of the adaptive diversification of the industrial enterprise development, which is providing for the evaluation of existing external crises, uses both information from the external environment and the results of the forecasting of external crises. The latter information is necessary to analyze the danger that the future crisis has. It is proposed to calculate the environmental impact on the Balanced Scorecard (BSC) and to analyze the impact of the crisis on competitors and consumers.

The final stage of the adaptive diversification is the adjustment of the enterprise development strategy in accordance with the chosen scenario

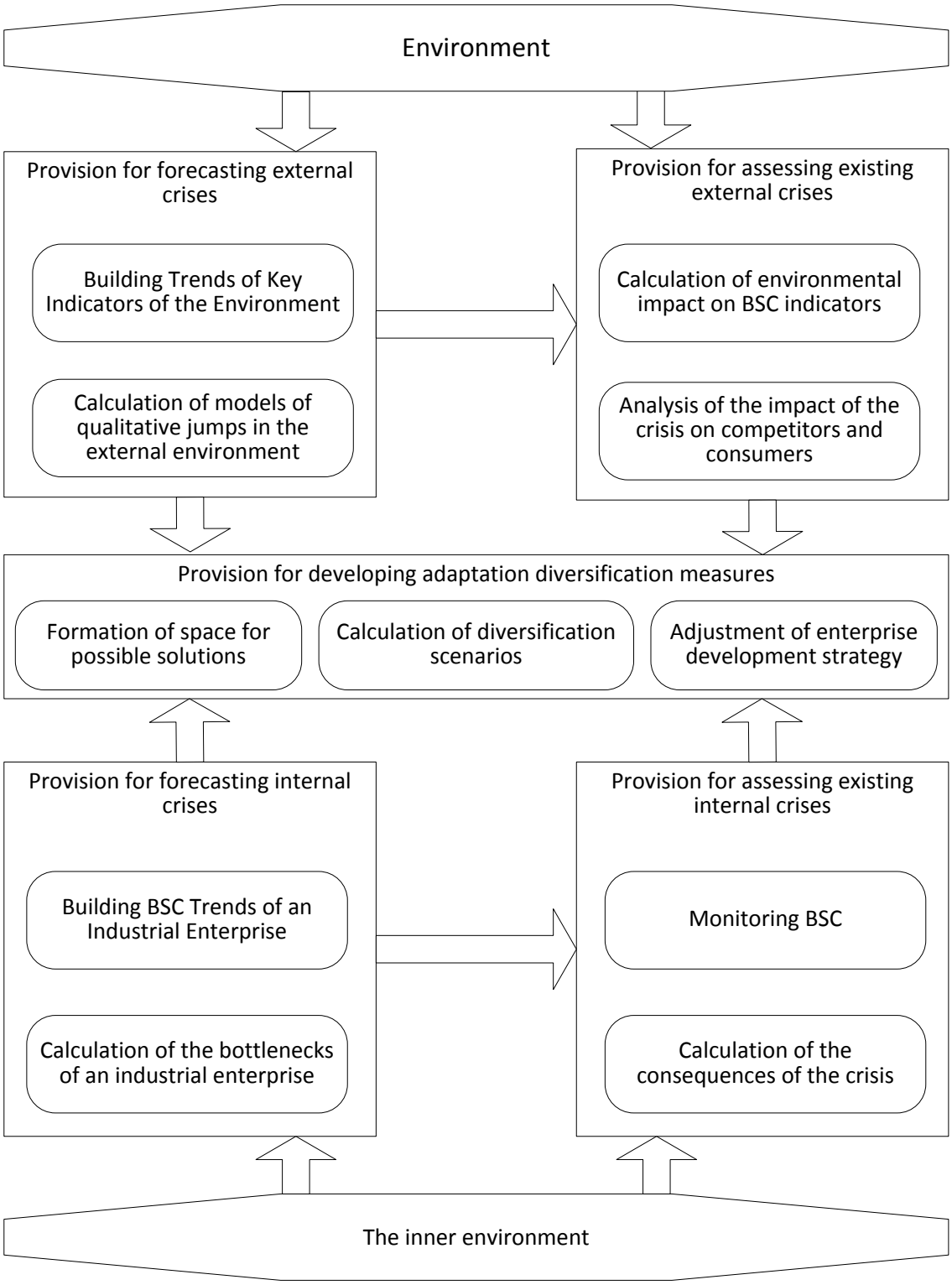


**Figure 1.** Adaptive diversification of the industrial enterprise development under crisis conditions
*Source:* own research.

To do this, the measures identified as appropriate by the optimization model for the selection of diversification scenarios should be added to the strategic plan.

Thus, a scientific and methodological approach to adaptive diversification of the industrial enterprise development under crisis conditions that is based on assessing existing and potential crises and formalizing the impact assessment of the crisis enables the industrial enterprise to justify diversification measures in order to adapt to the crisis and to preserve the planned strategic guidelines of the development.

**Results and discussion**

Practical testing of the developed scientific and methodical approach to the adaptive diversification of the industrial enterprise development under crisis conditions was carried out at PJSC “Kerammash”. An analysis of the external and internal environment of the enterprise made it possible to conclude that there is a risk of decreasing solvent demand due to the high cost of the enterprise production in comparison with competitors and the general decrease of economic activity (Table 1). It is expected that the volume of sales will decrease by 13.6%, while the cost of sales will decrease only by 10.1%. This is due to an increase in labor costs, and, in particular, an increase in the cost of imported equipment for the production of thermal equipment.

**Table 1.** Forecast of the crisis consequences for PJSC “Kerammash”

| Indicator | 2016 | 2017 | 2018 (forecast) |
|---|---|---|---|
| Net income from sales of products (goods, works, services), ths. UAH | 69646 | 64939 | 56100 |
| Cost of sold products (goods, works, services), including | 54267 | 52883 | 47563 |
| Material costs, ths. UAH | 43141 | 28971 | 27940 |
| salary expenses, ths. UAH | 14935 | 17130 | 15630 |
| Deductions for social events, ths. UAH | 2902 | 3204 | 2768 |
| Amortization, ths. UAH | 1647 | 1705 | 1820 |
| Net financial result, ths. UAH | 6263 | 3021 | 2610 |

*Source: calculated by the author.*

The main products of PJSC "Kerammash" are electric and gas industrial furnaces, most of the production capacities are occupied by their manufacture. But in crisis-time due to lack of orders for main products the company switches to the development of spare parts and secondary products (Table 2). At the same time, the assortment of secondary products is negligible and cannot replace the main one.

**Table 2.** Sales dynamics of PJSC "Kerammash"

| | | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| Main products | Part, % | 88,4 | 100 | 49,3 | 81,3 | 71,1 |
| | Volume, ths. UAH | 92011 | 40203 | 10835 | 56669 | 46174 |
| Secondary products | Part, % | 11,56 | 0 | 50,7 | 18,7 | 28,9 |
| | Volume, ths. UAH | 12027 | 0 | 11143 | 13035 | 18768 |

*Source:* calculated by author.

The solution to this problem is possible due to the following diversification actions:

- diversification of the marketing network and access to new markets with traditional products;
- vertical diversification of the development of the production of spare parts and components of the products,
- horizontal diversification of the development of the production of new products, which can be produced on the existing equipment.

Specific measures to diversify the marketing network include participating in exhibitions in Belarus and Kazakhstan, and opening new sales offices in these countries.

Vertical diversification includes measures for the introduction of regenerative burners into production. Burners are one of the main components of gas industrial furnaces, and the imported burners, which are currently used in the production of PJSC "Kerammash," significantly increase the cost.

Horizontal diversification involves the development of production of new types of products for which there is an unsatisfied demand: cremator-insinerator and dyeing chamber.

The result of the implementation of actions on adaptive diversification of PJSC "Kerammash" is an increase in the net realizable sales and a decrease in the cost price (Table 3).

**Table 3.** Influence of adaptive diversification on indicators of PJSC "Kerammash"

| Indicator | Without adaptive diversification | With adaptive diversification |
|---|---|---|
| Net income from sales of products (goods, works, services) | 56100 | 61102 |
| Cost of sold products (goods, works, services) | 47563 | 50880 |

*Source: calculated by the author.*

Due to the diversification of production and marketing network of PJSC "Kerammash", an economic effect is expected at the expense of an increase in sales volumes and reduction of the cost price. At the same time, additional costs for research and development and participation in exhibitions are needed to carry out the planned diversification activities. The components of the economic effect are given in Table 4.

**Table 4.** Components of the economic effect of implementing adaptive diversification at PJSC "Kerammash"

| Revenue or savings | | Costs | |
|---|---|---|---|
| Indicator | Amount, ths. UAH | Events | Amount, ths. UAH |
| Increase in sales revenue | 5002 | Development and introduction into production of creator-incinerator | 320 |
| | | Participation in exhibitions in Belarus and Kazakhstan | 150 |
| Reduction in the cost of sold products | 3317 | Development and introduction of production of regenerative burners | 180 |
| Revenue or savings | 8319 | Costs | 650 |

*Source: calculated by the author.*

Due to diversification of production and marketing network of PJSC "Kerammash", the estimated economic effect will be 7669 ths. UAH.

Thus, a scientific and methodical approach to adaptive diversification of the industrial enterprise development under crisis conditions was developed. The approach is based on a hierarchical structure of the effects of the crisis and economic and mathematical models for assessing the enterprise's crisis coverage, assessing the relationship between changes in the environmental indicators and the company's system of indicators, determining the direction of change of indicators and calculating diversification scenarios.

The practical testing of the developed scientific and methodical approach to the adaptive diversification of the industrial enterprise development in the conditions of the crisis at PJSC "Kerammash" was carried out.

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# ITERATIVE SIGNAL PROCESSING IN ANTICIPATORY MANAGEMENT OF INDUSTRIAL ENTERPRISE DEVELOPMENT

*Bożena Kamińska*

**Abstract.** The article proposes the use of an iterative approach in anticipatory management that is based on a two-stage iteration of the noise correction of the detected signal and the establishment of a signal response base, which ensures obtaining the most accurate original content of the signal and the scope of the industrial enterprise by the intensity of its manifestation. It is expedient to establish a maximum and a minimum threshold value of the force of the detected and devoid of noise original signal in the established field of activity of the industrial enterprise (review base). Setting the maximum and minimum threshold values is a necessary task, both in the case of forecasting the onset of crisis events, and in the case of identifying favorable conditions for development. It is proved that the principle of iterative signal processing is universal for controlling signals, which indicate the approach of critical events and opportunities for development. The developed approach can be applied in the anticipatory management in the internal and external environment of the industrial enterprise.

***Keywords:*** management, development, signal, enterprise, iteration, filter, noise, correction, management decision.

***JEL Classification:*** C600, M110, M210

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## 1. Introduction

Receiving signals about changing the state of the external and internal environment of an industrial enterprise prior to the occurrence of the events related to the change of this state in the future is the first step in anticipatory management if this type of management is applied to the enterprise. Ignoring signals or delaying their interpretation leads to significant consequences, especially if the company implements a development program that is usually associated with an orientation towards the market, competitors, consumers, financial and credit institutions (Berry et al., 2007).

Therefore, the monitoring of such signals, their identification, detection in a particular area of the enterprise is an urgent task, the solution of which requires the development of an appropriate approach, which in its properties ensures the accuracy of the recognition of the signals of the approaching crisis or changes in the conditions of development and operation of industrial enterprises. This approach is an iterative one (Cockburn, 2008; Larman & Basili, 2003), unlike classical approaches: systemic, process, functional, and others. This approach to management is most often used in cases where it is necessary to carry out work in parallel with the continuous analysis of the results obtained and adjusting the previous stages of work.

## 2. Literature review

The feasibility of using the iterative approach has been proven in a number of scientific studies and publications.

In the work (Voloshchuk, 2014) it is proposed to use the iterative approach as one of the analytical tools for managing the economic security of an industrial enterprise, where the criteria of classification are the steps (iterations) of the procedures for assessing the economic security of the enterprise and their respective task of formation of analytical tools.. The author developed a two-stage iterative cycle for assessing the economic security of an industrial enterprise, where, at the first stage, individual blocks are evaluated; and the second stage is an integral estimation of the data array defined at the previous iteration stage.

R. R. Tan et al. grounded the necessity of using an iterative approach in modeling the optimal production program of an industrial enterprise (Tan et al., 2016). Thus, the author developed economic-mathematical models that are used in various iterations and differ both in the composition of restrictions and in the form of criteria indicators. In this case, individual iterations are carried out at different stages of the formation of the production program. The advantage of using the principles of an iterative approach is the increase in the efficiency of optimization calculations when forming an enterprise's production program and reducing the cost of analyzing the market demand.

The need to use an iterative approach in the process of developing and adopting managerial decisions is emphasized (Pamučar et al., 2017; Kuzylyak et al., 2016; Pająk et al., 2016, 2017; Kwilinski, 2018). To streamline the process of making managerial decisions as a set of formal

and informal procedures, the authors are encouraged to use the technology of decision-making, which will allow to analyze the decisions made earlier and to make optimal managerial decisions. This process is presented in the form of several iterations:

1. Setting a task.
2. Preparation of managerial decisions.
3. Adoption of managerial decisions.
4. Implementation of the approved managerial decisions (Kuzylyak et al., 2016).

Using the proposed approach will provide an improved quality assessment of probable managerial decisions that involves the collection and processing of operational data from the uncertain and risk area and the development of managerial decisions using iterative cycles (repetitions).

Using an iterative approach in management, due to the use of an unlimited number of stages of iteration (repetition) of input data processing, will improve the quality of managerial decisions.

In the anticipatory management, such input data to be processed are the signals coming from the internal and external environment of the industrial enterprise and inform about the approach of the crisis, threats to the industrial enterprise or the creation of potential opportunities for the development of the organization, favorable conditions for the implementation of strategic development activities (Ashley & Morrison, 1997). Therefore, despite the sufficient number of scientific papers on the methodology of the iterative approach, the spectrum of its action in the anticipatory management remains insufficiently studied.

## 3. Methodology

The main tools for such monitoring include:

### 3.1. Concurrent analysis

The purpose of this type of environmental monitoring tools is to determine the economic state of the industry, the main directions of its development, the level of competition and competitive positions of the main players of the market, to analyse the closest competitors to the investigated enterprise, to analyse the prospects of the industry, etc.

In the general form of competitive analysis, the identification of weak and strong environmental signals is reduced to the following stages:

1. Definition of the time period within which an analytical assessment will be carried out.
2. Definition of product market boundaries.
3. Definition of geographical boundaries of the market.
4. Identification of the economic entities on the market.

5. Calculation of the volume of the commodity market and the share held by the business entity.
6. Determination of the degree of market saturation.
7. Identification of barriers to entry.
8. Assessment of the competitive environment (Norik, 2005*).*

When using this tool as the main one during monitoring, the main attention is paid to the competitors, as a factor of direct influence on the state of the enterprise, therefore, the analysis of the internal environment is secondary.

**3.2. Comparative industry analysis**

This type of analysis is carried out on the basis of comparison of the main indicators of production and economic activity of enterprises operating in one industry:
- profit;
- sales;
- cost of manufactured goods;
- profitability;
- wage fund;
- investments;
- volume of produced products, etc.

Comparison of the data of the enterprise and other enterprises-competitors is made on the same indicators with the average industry values. The advantage of using this tool as the main one in monitoring is the ability to identify weak and strong signals regarding the use of insufficient production capacity, marketing policy effectiveness, etc.

**3.3. Resource analysis**

It consists of describing and evaluating financial, organizational and technological resources (creating a resource profile), comparing the profile created according to the market requirements (identifying the strengths and weaknesses of the rated entity), and identifying specific competencies (the strengths and weaknesses of the rated entity are compared with the strengths and weaknesses of the underlying asset of a competitor). Only the internal environment of the enterprise is analyzed and evaluated. The influence of environmental factors is completely excluded. The basis for further development of the strategy is the comparison with the activities of the main competitor (Ognev & Chernyshenko, 2013).

**3.4. Competitive analysis on the model of "Five Forces" by M. Porter**

The use of this type of analysis as a tool for environmental monitoring involves analyzing the main external forces:
- market power of suppliers;
- market power of consumers;

- market power of competitors;
- the threat of the emergence of new competitors on the market;
- the threat of the appearance of analogue products on the market.

**4. Results and discussion**

The scheme of application of the iterative approach in the processing of signals in anticipatory management is presented in Figure 1 (part 1a and 2b).

Receipt of signals for the first stage of the iteration cycle is based on the results of continuous monitoring of the internal and external environments of the industrial enterprise (Guselbaeva & Pachkova, 2015).

The analysis involves two steps:

1. Assignment of quantitative indicators to determinants of five forces by expert assessment.
2. Analysis of the strengths and weaknesses of the current competitive situation, as well as possible compensatory measures.
3. SNW analysis. The purpose of this analysis is to characterize and assess the internal environment of the enterprise in three positions:
   - strong (advantages of the enterprise activity);
   - weak (restrictions in the activity of the enterprise);
   - neutral.

When applying this type of evaluation analysis exclusively for the internal environment of the enterprise as a resource, as a result you can see signals for expansion of activity or vice versa collapse.

4. STEP (PEST) analysis. It is carried out by means of a detailed description and evaluation of social, technological, economic and political factors affecting the organization's activities.

The factors of direct and indirect impacts of the organization's external environment are described and analyzed in details. The estimation of the factors of the internal environment is completely excluded (Hedouri et al., 2007). According to the results of this type of analysis, it is possible to draw conclusions on the identification of signals for the implementation of measures related to the development of the industrial enterprise or the introduction of preventive measures to ensure the production and economic performance of current activities.

5. SWOT analysis. This type of analysis is the most common among the main tools for monitoring the threats and opportunities for enterprise development, which involves identifying strengths and weaknesses in the company's activities, identifying development potential and evaluating opportunities for implementing strategic measures.

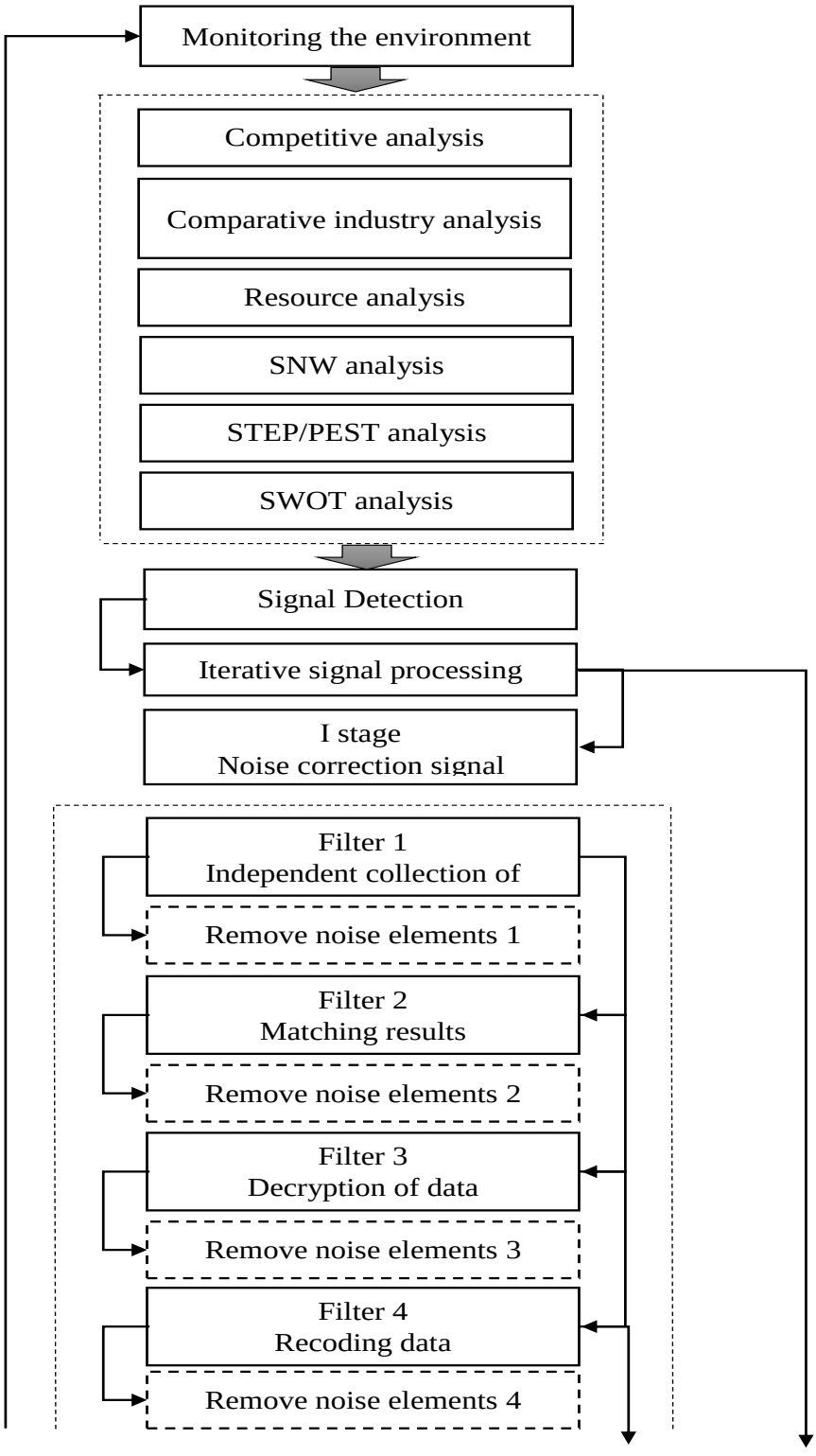


**Figure 1a.** An iterative approach in anticipatory management of the development of an industrial enterprise (part 1)
*Source:* own research.

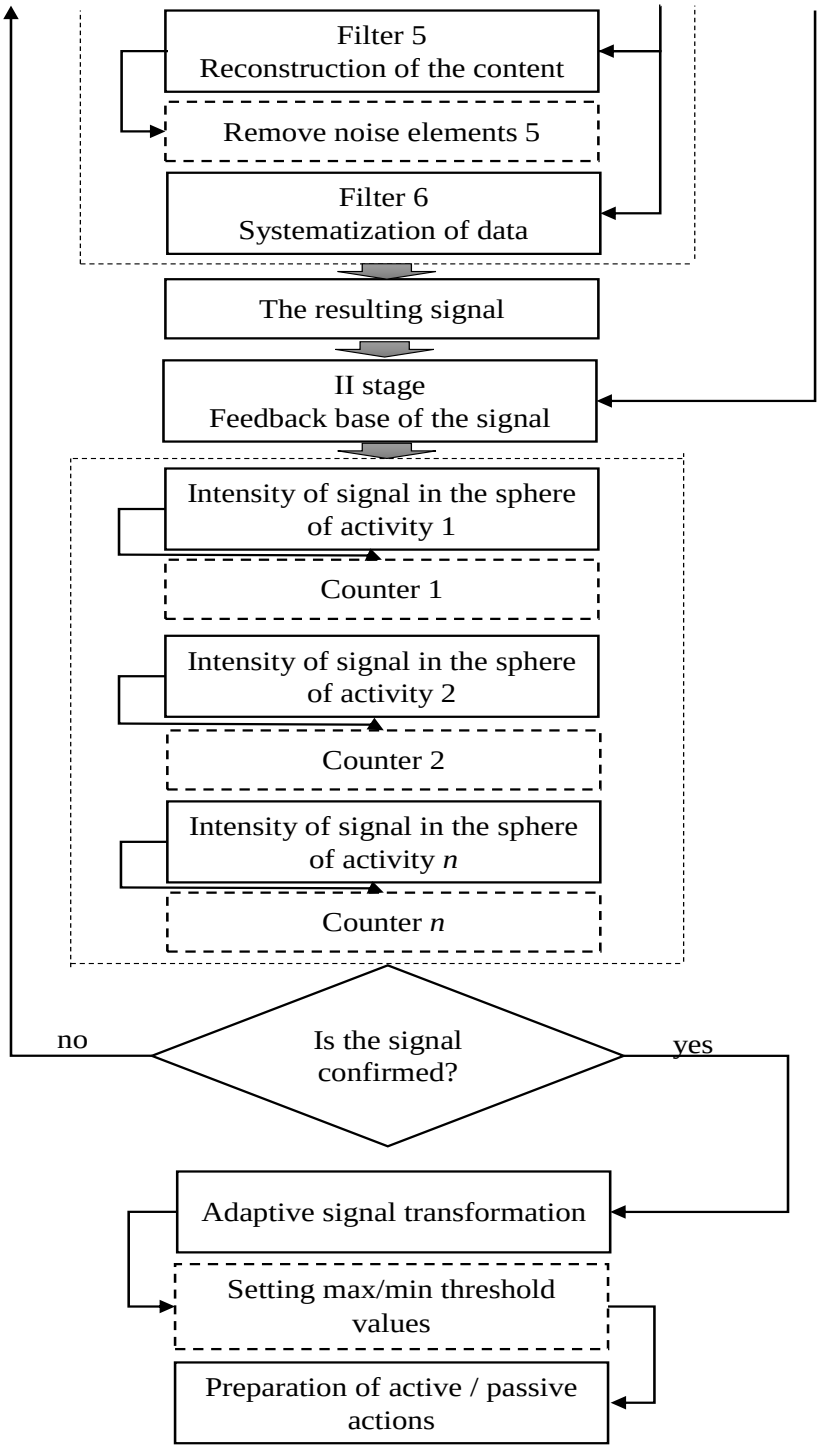


**Figure 1b.** An iterative approach in anticipatory management of the development of an industrial enterprise (part 2)
*Source:* own research.

There are different interpretations of SWOT analysis, but the main stages are reduced to the following:

Stage 1 - Definition of goal. SWOT-analysis is always carried out for a certain purpose, it is not abstract. Strengths and weaknesses, opportunities and threats - concepts are relative and depend on time, place, character of actions of subjects.

Stage 2 - Definition of the object of research. The analysis can be subjected to the company as a whole, separate units (branches, etc.) or a business unit.

Stage 3 - Identify the strengths and weaknesses in terms of the goal.

Stage 4 - Identify market opportunities and threats in terms of the goal (Barinov & Kharchenko, 2006; Milova & Chernyshenko, 2015).

According to the results of using one of the presented (or several) tools for monitoring the state of the industrial enterprise environment for the purpose of detecting impulse messages about a crisis or favorable development opportunities, a weak signal can be set, which is then transferred to the iterative processing unit (Figure 1).

In the block of iterative processing, the received signal passes through the first stage of the iterations - the stage of noise correction of the signal. This stage can be characterized as a procedure for setting up an outgoing message that was detected during a monitoring process that was distorted by external noise.Noise in this context should be understood as random variances of various kinds of information distorting the output signal data. Also, noise can be called the difference between the content of the input signal and the content of the resulting signal after the noise correction.

To perform the noise correction of the signal in the first stage of the iterative signal processing, which was discovered by means of monitoring the internal and external environment of the industrial enterprise, it is proposed to use appropriate filters, through which the passage through which gradually eliminates the noise distorting the original content of the signal. Each installed noise correction filter in the first stage of iterative processing as a result of its work must process the content of the signal for a minimum time interval, the longer the time is spent on noise processing, the higher the noise concentration increases (over time, the received signals acquire new content, which is explained by the dynamics of the external environment, the influx of distorted information in the media, using of technologies of reflexive attacks of rival enterprises, etc.).

The criteria for the effectiveness of filters are as follows:
- minimum processing time of the signal;
- the optimum amount of computing resources;
- the quality of the result.

Each filter of the first stage of the iterative signal processing has a certain purpose and tasks, where at the output (from switching from one to another filter) a "purified" signal from a certain amount of noise must be transmitted. If, as a result of one or more filters, a signal was transmitted without sufficient noise reduction, the iterative loop will return to the required filter, where the number of repetitions that is necessary to clear the signal occurs.

Thus, by varying the number of processing iterations in the first stage and the degree of noisiness detected during the monitoring signal, it becomes possible to control such indicators as the quality of the formation of the resulting signals and the speed of the iteration cycle.

The first stage of the noise processing of the signal is proposed to be carried out through the passage of six filters, where after each there is removal of noise.

So, the purpose of the first filter is to conduct an independent self-scanning environment for determining the authenticity of the signal entering the block of iterative processing. The following methods can be used in the first filter operation:

- polls;
- interviews;
- scanning;
- focus groups and others.

According to the results of the first noise correction filter, the second filter receives a signal with a cellular difference in the amount of noise.

The second filter compares the results obtained by its own independent collection of materials on the topic of the detected signal with the content of the signal received from the internal or external environment. By the results of the second filter, the noise is removed again. On the third filter of the first stage of the iterative signal processing information is obtained from the adjacent topics that distort the original content of the signal (for example: according to the monitoring results, a signal has been received that changes the expectations of consumers about the output of a new type of product manufactured by an industrial enterprise, the removal of noise in the second filter in this An example will be the appearance of analogue products on the market, purchasing power of consumers, etc.).

The purpose of the third filter is to decode the signal data, which is already presented with the noise difference that occurred through the passage of the first and second filters. Turning to the example of the signal about changing the expectations of consumers, here the decoding will be a rough approximation to the original content of the signal (Is there a change in consumer expectations regarding the technical or economic characteristics of the product? or qualitative characteristics?). Approximate focusing on the original content of a signal deprived of noise on previous filters of noise correction will allow to define a coarse description of the coordinates of the field of useful information that was inserted into the signal before its distortion in time.

The purpose of the fourth filter is to adapt the decoded signal in the conditions of the operation of the industrial enterprise. If the content of the signal after passing through the previous filters and the loss of noise will not be related to the activities of the industrial enterprise, the end of the iterative cycle can be considered without going to the fourth filter. If, based on the results of the transcoding of the content of the signal, it is concluded that this signal carries information about the approaching threat or the creation of favorable opportunities for the implementation of development measures, such a signal with the adapted (recoded) content in relation to the industrial-economic activity of the industrial enterprise passes to the fifth filter.

The purpose of the fifth filter is the final reconstruction of the original content that was inserted into the signal to distort it in time before it is detected in the process of monitoring the internal and external environment. Through the passage of this filter, the signal that was pre-processed from the noise component on the first, second, third, and fourth filters of the first stage of the iterative processing into the last is removed the remnants of noise, or the so-called "zero information", which does not contain information about the original content of the signal, but only increases the width of its spectrum due to noise. If the result of the work of the previous filters is qualitative and corresponds to the previously established criteria for the effectiveness of the filters, enterprise managers will be able to obtain the original content ("body") of the signal, the correct interpretation of which will provide the basis for the preparation and adoption of management decisions on the development of the industrial enterprise, however, these solutions will be conditional, more detailed specification will be possible after passing the second stage of the iterative signal processing and confirmation or refutation signal.

On the sixth and final filter of the first stage of the iterative signal processing there is a systematization of data, the purpose and tasks of which are:

- data generation for noise correction at subsequent iterative cycles;
- compilation of calculations to determine the difference between the signal (original content and the presence of noise, zero information) that was detected during the monitoring and reconstructed content of the signal received as a result of passage through filters;
- generalization of data about distorted information, grouping it on a basis for use as a tool for iterative processing of analog signals.

Systematizing the data on the sixth filter and inserting it into a database for future work on noise processing will allow more efficient removal of noise at subsequent iterations, obtaining a better resultant signal and losing less time for its processing.

After passing the first stage of the iterative signal processing, the resulting signal falls on the second stage of the iterative processing - the establishment of the signal response base at the industrial plant. At this stage, the scope of activity of an industrial enterprise is divided into blocks, where by means of the meter the highest frequency of the intensity of the manifestation of the resulting signal is established. As the base blocks for the activities of the enterprise can be distinguished:

1. Production.
2. Staff.
3. Material security.
4. Finance.
5. Investments.
6. Marketing.
7. Administrative and management personnel.
8. Security service of the industrial enterprise.
9. Accounting.
10. Quality and standardization service.
11. Design and development department.
12. Planning department.

Counter the frequency of the resulting signal in a given area of the industrial enterprises (or a few at a time) reflects the severity of the signal by which to draw conclusions about the confirmation or refutation of the detected signal.

If the signal is refuted, that the counter displays zero or very low frequency intensity of display signal in a given area of the industrial enterprises actions of returning to the initial phase - monitoring of the environment (a priori this stage is to carry continuous nature) to signal detection of the occurrence of critical events or identifying potential for developing.

If, after passing the second stage of the iterative processing of the establishment of the base of the response of the signal, the sphere of activity of the enterprise was detected, where the average (high) frequency of the intensity of the resultant signal is recorded, an adaptive signal transformation occurs, that is, conditional management decisions prepared during the passage of the fifth filter of the first stage iterative signal processing will be practical in nature, corrected for possible changes that occurred in time, which was spent on the second stage of the iterative signal processing.

It is expedient to establish a maximum and a minimum threshold value of the force of the detected and devoid of noise of the original signal in the established field of activity of the industrial enterprise (review base). Setting the maximum and minimum threshold values is a necessary task, both in the case of forecasting the onset of crisis events, and in the case of identifying favorable conditions for developing.

Depending on the thresholds obtained, active or passive manual actions are set.

Active actions include:
- jerk;
- overtaking competitors;
- conquest of new markets;
- production of a new type of product;
- development of investment projects;

- expansion of the park of production equipment;
- introduction of new technological lines;
- modernization of the park of production equipment;
- acquisition of assets;
- diversification;
- expansion of the range of products;
- opening of new directions of activity;
- rebranding;
- absorption of competitors;
- increase in the number of staff, etc.

Passive actions include:

- preservation of current values of indicators of production and economic activity;
- preservation of the existing market share;
- partial reduction of staff;
- saving of share capital;
- partial preservation of production;
- release of investment funds from development projects;
- reduction of development programs, etc.

Depending on the set maximum and minimum threshold values of the strength of the detected signal in a given area of the enterprise, a combination of several types of active and passive actions of the management to respond to the state of the internal and external environment is allowed.

Thus, the proposed use of the iterative approach anticipatory management, which is based on two-step iteration correction of signal noise and installation base response signal, providing a maximum precision of the original signal content and scope of industrial enterprises for the intensity of its manifestation. The developed approach can be applied in anticipatory management both in the internal and external environment of an industrial enterprise. The principle of iterative signal processing is versatile to control signals indicating the approach of critical events and opportunities for development.

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# REFLEXIVE COORDINATION OF COMMUNICATIONS IN THE CONSTRUCTION OF MODELS FOR THE DEVELOPMENT OF AN INDUSTRIAL ENTERPRISE

*Oleksii Bezchasnyi*

**Abstract.** The article develops the mechanism of hierarchical-reflexive coordination of communications at the enterprise, which involves coordinating the actions of management agents in the process of interactions. It was established that in the process of implementation of the mechanism of hierarchical coordination of communications, the interests of agents are coordinated in the horizontal and vertical directions. Accordingly, two types of reflection are used: informational (horizontal coordination) and strategic (vertical). The mutual influence of these types of reflection and the mismatch of the interests of agents within the hierarchy levels lead to contradictions and conflicts of inter-level (vertical) interactions. It is proved that reflection serves as the central management of the enterprise, it is the same task of the administrative function of coordination, at the same time, the task of coordination is the reflection of decisions that are taken as part of their coordination functions. Moreover, due to reflection there is a certain selection, filtering of management information, and coordination in turn serves as a managerial task that allows the company to move in the chosen direction.

***Keywords:*** reflection, coordination, communication, model, mechanism, development, industrial enterprise, interaction, hierarchy

***JEL Classification:*** M120, C610, O120

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## 1. Introduction

Constant changes in the socio-political, economic and other conditions of modern life require from the person changes in its value orientations and social orientations. New economic conditions in particular require a new understanding of the role of time in society and objects of the economy, the realization that management is a science with certain laws, and possessing it requires time and appropriate professional training. In the science of management, the past half century has accumulated many theories and approaches, and one of the most popular is the approach in which management is understood as a process consisting of interconnected, continuous actions that are equally important for the development and success of the organization. These actions are called management functions and, depending on the specifics of the object of management, allocate them to one or another set.

## 2. Literature review.

In the theory of management is aimed at ensuring the stability of the system.

Representatives of the cybernetic school (Viner, 1958) consider management as a "targeted influence" in complex mobile systems that can move from one state to another. Due to such influences, you can maintain the stability of the system and maintain its dynamic balance with the environment, and due to the internal factors of the system. D.M. Gvishiani (1972) observes that such an approach reduces management to a set of concrete actions; while outside the control sphere there are those processes and phenomena that precede actions of the result.

Management as an artificially created human process is opposed to the order of nature in the work I. Prigogine and I. Stingers (1984). In their view, the actions of the management are aimed at resisting the forces of nature and they are completely subjective. This idea makes the discussion thesis of cybernetics that the management system is self-governing, and its stability can be provided by internal factors.

Consequently, the definitions of "management" are given visualize differently positioned accents, due to which we have different interpretations that influence the further development of ideas about the management of a specific object and the need to allocate certain components to improve the efficiency of such management.

The object of this research is an industrial enterprise our task is to formulate conditions for its more effective development taking into account modern laws and market requirements, a new type of economic behaviour, adapting all aspects of production activity to a changing and complicated situation in Ukraine. At this time, we consider only one of the whole set of conditions that is related to the role of the employee and his contribution to the final results of the enterprise.

In other words, the purpose of this unit is to find effective ways of managing labor, which ensure the activation of the human factor (Aubrey, 2015).

The first one who accumulates the energy of the industrial enterprise development and directs it in a certain direction is the management of the enterprise.

In order for the leader to act consciously and not as a blind man, he must be armed with all kinds of professional means necessary for management - the information resource, personnel, which collectively form the appropriate focal point, in which all communication flows converge and which develops a strategy of moving the company forward.

Coordination as a key function of the named centre allows you to trace and ensure compliance with the operating regime, performed operations and procedures proposed standards and norms. Thanks to it, the management functions are performed continuously and uninterruptedly. The object of coordination activity is both managed and managment system. To coordinate their action among themselves and to avoid ineffective duplication of functions is a complex task of management of the production-economic system, including the industrial enterprise.

The Latin term "coordination" ("c" (cum) - together and "ordinatio" - ordering), means not just the coordination, but the coordination of the actions of several elements in the system. The system in which the coordination provides an additional movement is not static, but dynamic and is in constant motion. Depending on which direction the system chooses in the universe of human activity, the role of coordination among other management functions depended.

For example, such a role is constructive if it is understood as an agreement, a connection, an order, respectively (actions, concepts, constituents of something) (Gaponenko & Pankrukhin, 2004). It depends on the goals set by the enterprise, if this is understood as the process of uniting the work of divisions and other structural components of the enterprise (Burkov & Novikov, 2004).

The following is the most commonly used definition in the special scientific literature for coordination.

Coordination is the process of achieving the unity of efforts of all subsystems (divisions), organizations for the realization of tasks and goals (Parakhina & Ushvitskiy, 2003).

Coordination - management activity, which is to ensure the interconnection and coherence of subjects, objects and processes of work in time and space (Gaponenko & Pankrukhin, 2004).

Coordination is the achievement of consistency in the work of all parts of the system by establishing rational connections between them (Hedouri et al., 2007).

As it proves M.D. Mesarović (1970), the central principle of coordination is the principle of observance of feedback. Following it, the head has the opportunity to correct the decision and monitor the progress of its implementation, if necessary, making the necessary adjustments. Thus, at each stage of the management decision, it is possible to remove information about the implementation, analyze it and develop it and make possible corrective points that can improve the implementation of the decision. In extreme cases, an ineffective decision, if not timely received information about its ineffectiveness, can be canceled at all.

Such changes in the external and internal environment occurring at the enterprise are based on the implementation of solutions for adaptation and correction, resource manoeuvre, and this forms the content of coordination.

An important form of manifestation of the mechanisms of self-regulation and self-preservation of the system is coordination V.D. Rudashevsky (1990). He believes that the highest level of complexity are those measures that relate to the qualitative transformation of the entire system.

A separate task of managing an enterprise in the process of coordination is the achievement of a coherent operation of systems that are at a lower level of its hierarchy (Mesarović et al., 1970). To do this, G.L. Morrisey believes that it is necessary to create conditions for the organization members to perform the actions necessary to achieve the goals of the organization (Morrisey, 1977).

Consequently, the above definitions of the term "coordination" reflect two interrelated aspects of the concept - the coordination of interests and the provision of interaction of elements. It is through coordination that relations between the subjects of management activity can be defined, which can be defined as horizontal, that is, the links between disparate directly by the subjects of management activity.

Based on research objectives, the main task of coordination is to achieve consistency in the work of all units of the organization by establishing rational ties between them. Such consistency allows to ensure continuity and continuity of the management process. This task may be the basis for defining the concept of "coordination of managerial decisions at industrial enterprises," which we understand as the mechanism for establishing rules of interaction between the subjects of management activity in the enterprise.

From the foregoing it can be concluded that coordination as a function of the management process at industrial enterprises is very important. Without coordination of actions and decisions of separate units of the enterprise it is impossible to professionally manage it, in this case, the implementation of strategic plans will be impossible.

Vertical coordination was the object of research in the theory of hierarchical managment system, so it is traditionally considered that processes of coordination arise in organizations such as "hierarchy" to reconcile goals and objectives. It is mandatory to have a coordinator in

place on the principles of stimulation and restriction. Coordination efforts largely depend on the style of leadership: if the style is authoritarian, coordination is based on the Statute and laws, the hierarchy; In a liberal style, informal methods are used, and so on.

The main roles of coordination activities: preventive (anticipation of problems and difficulties); eliminates (eliminating interruptions in the work of the organization); stimulating (improving the organization even in the absence of a problem); regulating (preserving the existing scheme of work).

There are number of approaches to coordination:

- informal non-programmed coordination, carried out on a voluntary basis and without a prior plan, is based on mutual understanding, general attitudes, interests and psychological stereotypes;
- programmed impersonal coordination, carried out in complex organizational structures, is based on standard impersonal methods and rules of work that are laid down in plans, programs, projects for frequent problems of coordination;
- programmable individual coordination, carried out in order to ensure that the performer does not interpret the tasks and directions of their work on their own;
- programmatic group coordination, conducted in the form of collective discussion at the meetings, which allows for individual preferences, group and general organizational interests, and the opinions of various narrow-profile professionals (Mesarović et al., 1970).

Problems of coordination in management work in one way or another are disclosed K. Bagrinovsky (1977), V.N. Burkov and D.A. Novikov (2004), D. Kahneman and A. Tversky (1979), T. Klebanova et al. (2002), H. Dźwigoł and M. Dźwigoł-Barosz (2018), Almeida J., Silvestre C., Pascoal A. (2008), L. Hossain and A. Wu (2009), W.S. Alaloul, M.S. Liew, and N.A. Zawawi (2016), K. Pająk et al. (2016), Y. Wang, Y. Liu, and C. Canel (2018), and so on. But constant practical achievements in this area require the continuation of scientific description and theoretical substantiation of this phenomenon on the basis of new models and approaches. But first we consider some basic methodological provisions for further theorizing.

The modelling of the task of coordination of work in project management on the basis of the use of the theory of fuzzy sets is carried out in the work C.Y. Lam and K. Tai (2018). In the work (Vasiliev, 1973) also widely discussed are the issues of information support for the coordination of the activities of structural elements at all levels of the hierarchical pyramid enterprise management.

Three types of coordination for enterprise management systems were proposed by W.G. Ouchi. In particular, he highlighted: rigid (authoritarian), economic (market) and organizational type of coordination using the procedures for coordinating interests. In his work (Ouchi & Jaeger, 1978) an attempt was made to formulate a methodological approach to the synthesis of these three types of coordination for integration into the situational mechanism of preparation and adoption of managerial decisions at the enterprise, and formalizing it to the level of specific economic and mathematical models.

As for industrial enterprises, Ukranian researchers T.S. Klebanova, E.V. Moldavskaia, and Kh. Chang (2002) proposed a classification of coordination activities according to the following criteria: operational, investment, financial and economic, reflexive, marketing, innovative, reflexive. The last of the criteria of coordination - reflexive - in the opinion of the authors, should become a key point in the adoption and agreement of management decisions.

Thus, in our further considerations, there are grounds for discussing a reflexive approach to the preparation and adoption of managerial decisions at industrial enterprises (Dymchenko, 2013) (Malchik, 2010). Further research here requires organizational, methodological, methodological and other problems, since the processes of awareness, rationality of decision making by market participants, etc are not described in detail at present, and even more so these descriptions have not been verified by the corresponding formal models.

Consequently, for the management of an industrial enterprise, the manager must first establish a management activity (his own "reflexive" activity (Kalinescu, 2013), and then coordinate - by involving subordinates - an adequate object activity for him.

Reflexion (reflexio (Latin) – turning back, reflection) is understood as the form of human theoretical work aimed at understanding their own actions and laws. The content of reflection is determined by subject-sensory activity. Reflexion is the realization of practice, the objective world. Simultaneously, this is the method of philosophy. In the XVIII century Devid Yum (1998) refers to the reflection of secondary perceptions (perception), those ideas that are based (secondary) on the already realized sense perception (primary). A. Schopenhauer (2000) defines reflexion, as a phenomenon of secondary order, which is preceded by a visual representation, generalization to the concept, and then reflection as a reproduction of the primary visual material, meaningful in certain notions of the world.

L.P. Grimak (1991) suggests that René Descartes identified reflexion with the individual's ability to concentrate on the content of his thoughts, abstracting from all external; J. Locke shared the philosophy and feeling, interpreting the first as a special source of knowledge - internal experience (reflection), in contrast to the external, based on feelings. Psychologist S.L. Rubinstein (2000) deduced the definition of reflection in terms of two ways of life: the first - is the direct life in interpersonal relationships, the second (reflection) - is the ability of a person to take a position outside of life, to look at life from the side, it is through reflection, he argued, there arises a person's philosophical awareness of life, and therefore its moral formation takes place.

It is important for us in these definitions to identify (and this is common in them) that a person reflects on his own thoughts, feelings and other spiritual achievements - thoughts (Descartes), feelings (D. Hume and J. Locke), the will (A. Schopenhauer), the life (S.L. Rubinstein). Similarly, the reflection in management is possible in a person only in relation to his own activities.

**3. Methodology**.

As it is deepened into the subject of research, we can say that the reflection for the subject of governance itself gives a new quality of understanding of the situation, since it summarizes it even more by introducing its actualization, specification, coordination and demand itself. Of the many manifestations, hidden, and even potentially possible variants of the situation, the subject of management (in our case, the head of an industrial enterprise) chooses one such generalization, which, on the one hand, allows us to focus on the development of something specific, on the solution of some, on the opinion of the head, the most actual problem in this situation, and, and, on the other hand, allows you to bring management beyond the framework of the program of reflective management. Concrete contributes to the development of management process due to the fact that the subject of management overcomes the complexity of infinite variety of practices, updating for itself in one of its area. The property of the specifics of reflexive management partially corresponds to the situation that exists in any professional field - each of them "in-itself" is specialized. But there is also a significant difference: management works with the whole continuum of problems, whereas any other professional activity deals with a certain (always limited) context.

Withdrawing from the reflexive control of external constraints, we arrive at a certain self-sufficiency of the subject of control. And the essence of the practice of reflexive management can now be considered self-actualization of its subject. In other words, a professional manager (leader), unlike a person who performs a reflection for self-development and solves certain personal tasks, performs socially significant work (building an institution and integrating it into a general social context with different types of transactions), engages in such their activities are professional institutions and personnel.

Any professional task, which not related to management also needs reflexive moves of performer and concentration on a particular actual task for this activity at that time, that is, a certain specialization. But the manager works with all the contexts of the problem, while the development of a professional task all the time narrows the field of general search and actualises individual skills and predispositions of a person.

In view of this, we distinguish the features of reflexive management, which are:

- actualization of socially significant demand;
- construction of a set of unique managerial concepts (abstractions) and relations in this set - the so-called conceptual enterprise;
- implementation of the conceptual enterprise - management activity, including through the involvement of professional experts in the conceptual enterprise conceptualization;
- coordination of management activities in the construction of the organizational structure of the industrial enterprise.

Consequently, we have proved that reflection serves as the central management of the enterprise is the same task of the administrative function of coordination, at the same time, the task of coordination is the reflection of decisions that are taken within their framework of

managerial coordination functions. Moreover, due to reflection there is a certain selection, filtering of management information, and coordination in turn serves as a managerial task that allows the company to move in the chosen direction.

In the field of enterprise management, the preservation of effective and appropriate coordination is ensured through the reflection of reconciling decisions. The word "concordance" here indicates that there is communication between different actors of management and we have predictions that more subjects facilitate a more balanced and responsible management decision. In addition, in the process of reflection, the effects of learning and mutual enrichment as a result of informative exchange are constantly revealed. As a management support function, coordination covers the idea of information provision inherent in information-oriented coordination concepts. In contrast to the latter, the information task here follows from the highest management function of coordination, and thus it is included in the internal organization field of action.

On the basis (Lepskiy, 2006) created figure 1, which presents the characteristics of traditional and new types of enterprises that have an organizational structure of different levels of rigidity. This allows us to draw conclusions about certain aspects of the organization of reflexive processes in industrial enterprises of the XX and XXI centuries.

The comparison of the characteristics of the organizational structure of enterprises represented in Figure 1, typical to the past and present century, gives grounds for talking about:

1) increase the role of subjective attitude towards employees on the part of managers - each employee should be not formally, but sincerely interested in the results of the enterprise, and management should take into account his view on the management and organization of production processes;

2) increase responsibility for the result and its differentiation by level of authority or level of employee contribution to the production process;

3) increasing the role of reflexive technologies in building a communicative enterprise system;

4) new requirements for basic knowledge, skills and communication skills of employees;

5) creation of conditions for the development of reflexive abilities of "carriers of reflection."

To consolidate this conclusion, we quote the statement of the well-known management theorist Piter Drucker: "The foundation of modern society, economics and human relations is not technology or information and not productivity. The foundation of modern society, economy and human relations is a managed organization as a social institution whose purpose is to achieve the result" (Drucker, 2007).

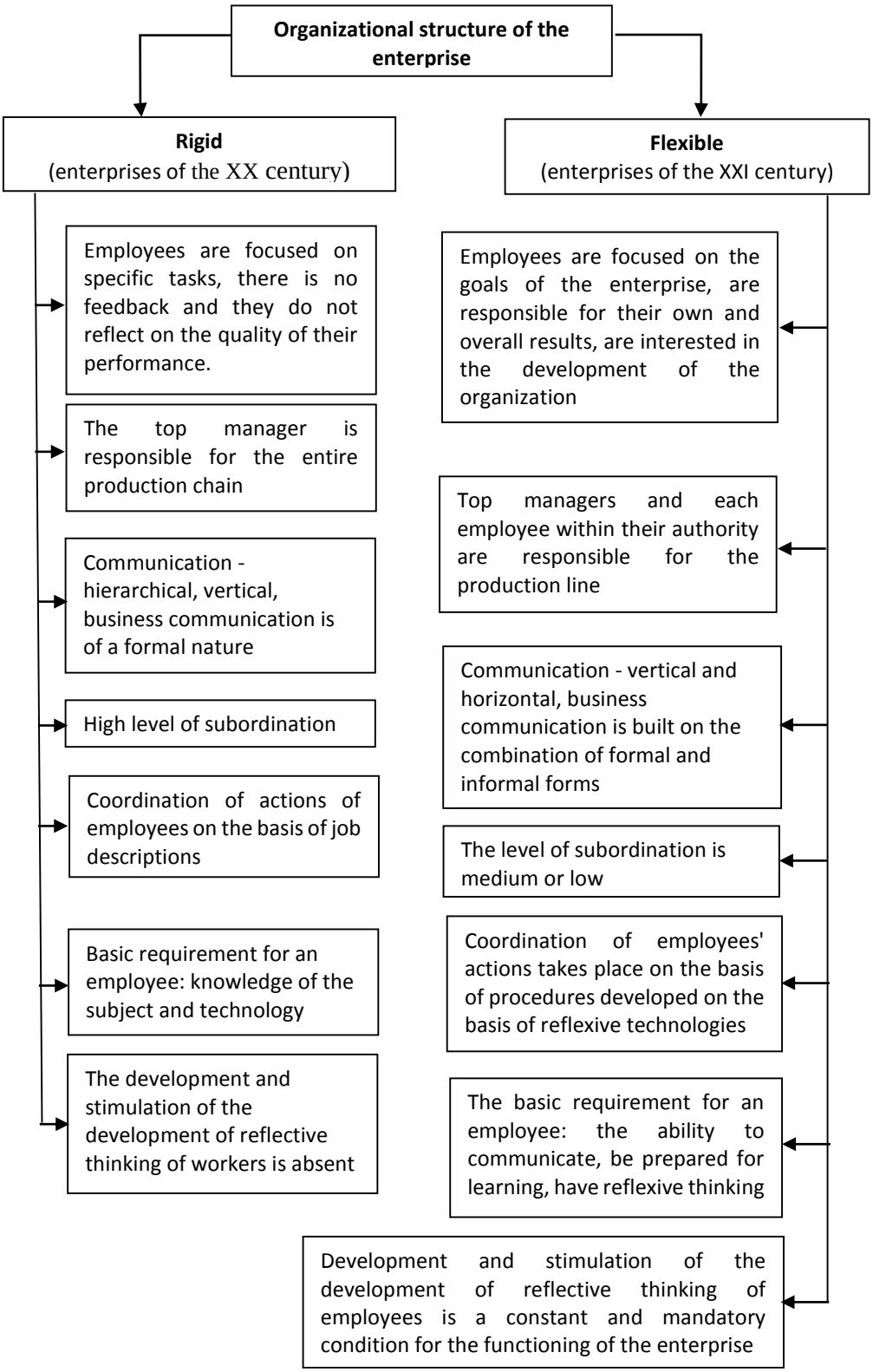


**Figure 1.** Types of organizational structure of the enterprise and its characteristics (communicative, reflexive, coordination)
*Source: formed by the author on the basis (Lepskiy, 2006).*

The managerial coordination function always takes into account the goals of the higher order enterprise (as the individual leader applies the entire set of information for the solution - both beyond the management system and the one that reflects the communicative connections within the system). Given the appearance of possible deviations caused by incomplete or distorted information about the actual state of affairs of the enterprise, the performance of tasks of reflective coordination is exposed to such principled methodological difficulties.

First, the system of communication at the enterprise in practice is formed not according to the given parameters, but arises from extremely complex relations of exchange and interactions. Because of this, it is difficult to achieve a clear subordination and build a structured hierarchical system that is geared towards strict adherence to rules and goals.

Secondly, the reflection of the subjects of management may be too broad, focused on specific details, which can be omitted from the attention of the higher order objectives. Therefore, there is a need for constant verification of goals, their specifics to individual tasks and the perfect tools for evaluating the results. Thirdly, when evaluating management activities, there are accounting problems. On the one hand, managerial action in most cases has an immediate effect on several goals, and on the other, several management measures can affect one and the same purpose.

These three major problems can be limited, but not completely solved. The latter has great consequences for the organization of coordination of economic processes in the enterprise.

Under the traditional type of organizational structure of an enterprise, if the manager even delegates' powers, then in order to control and verify the "delegated" activities, there is an established idea of how one or other function must be performed. It is here that the property of reflectivity, through which changes in the policy direction of development does not occur - because the direction of development and key issues is developed on the basis of the vision of such a leader. That is, there is an effect of the identity of the manager and the enterprise.

If the organizational structure of the company is based on the principles of reflexive management (that is, as the ratio of officials (managers and specialists) of the enterprise), then each manager's attitude to the subordinates is adequate to the structure of his own activities, that is, any problem (if you look at it through the prism of the structure) can always be localized to the exact and sole responsible official for it. And this localization is achievable and carried out within the activities of the head of this person. Accordingly, the professional duty of the manager of the lowest level is not to "issue" the problem beyond his own activities (that is, at the upper levels of management).

And any problem, if the company operates the principle of reflexive management, manifests itself at an adequate level in the activity of a specific manager or specialist responsible for it. The property of coordination at the same time always provides sufficient informational completeness of the given official for the professional solution of the problem.

In view of this, there is no need to reflect the organizational structure of the enterprise in the form of a scheme in order to trace the way of solving the problem and participation in these particular units. Because an official who is responsible for solving it situatively creates a team that can solve it. This practice is accepted, for example, in Japanese firms that do not have a certain organizational structure (Duncan, 1999), and where the delegation of fragments to subordinates (one of the main points of structuring) is determined only by the organization of each manager of his own activities, provided that it can and should change, accompanied by change, removal, and constantly evolving as changes of external circumstances and as the improvement of their activities by leaders of different levels of government.

Figure 2 shows the feedback control scheme required by the manager who manages the traditional methods. This scheme manager should apply to each object of the set of processes (technological, economic, industrial, etc.), which are carried out by its subordinate managers and specialists with a diverse and quite complex professional activities for everyone.

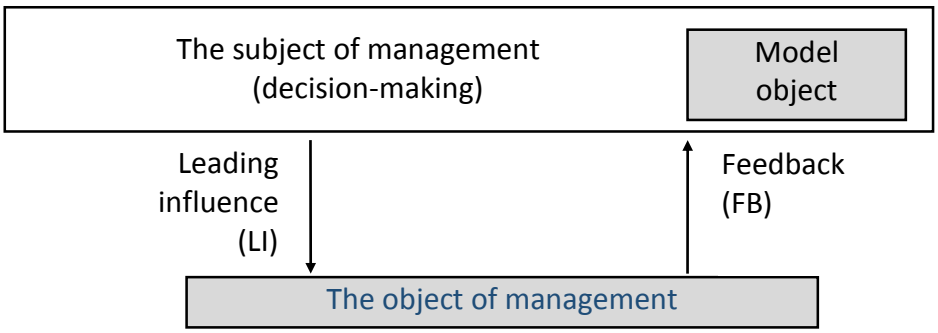


**Figure 2**. Feedback control scheme
*Source: formed by the author (Duncan, 1999).*

In order to make competent decisions and act according to the above scheme, the manager should not only know the specifics of individual processes of the enterprise, but also perform a coordinating function between these processes. Such, is not feasible for one person, therefore in the practice of management are used two simplifying methods:

1) the head enters into operation an institution of deputies, who take over the work or part of the work in separate areas (and models), thereby unloading the first person (relations between the head and deputies are not formalized - these deputies differ from the heads of subordinate units);

2) the models, which the manager works are so simplistic that activities within their framework become accessible to him.

In both cases, the application of such a scheme (figure 3), the leader really "loses" in personal competence.

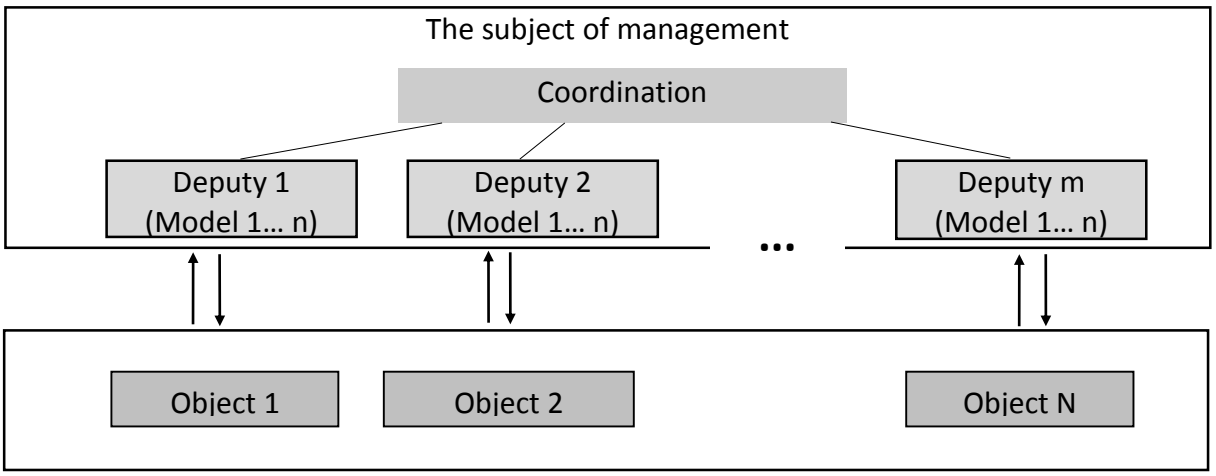


**Figure 3.** Real control circuit with feedback
*Source:* developed by the author

In the first case, it releases part of its activities from the hands, and in the second case, the models are so "simplistic" that they do not reflect the real state of affairs. And then, in the presence of local and contradictory interests in the subordinates, the head can take inadequate real situation solution. In the first case, he also receives additional "human" problems - in connection with the introduction of new officials (deputies) into the scope of their activities.

The complexity of the position in this control scheme is to achieve the adequacy of the model of the managed object, as well as the appearance of the model itself. What the basis for building the model of the enterprise or its individual production processes? A priori, it does not exist, nobody represents its director. To consider that the head (for example, from many years of experience in various positions at a given or similar enterprises) is competent enough to construct such a model (or models) - also wrong, because in such a competence the head of the model eliminates the very necessity.

In addition, this feedback scheme can not reflect the situation of enterprise development, when a new production process is being built, there is no existing function of the existing enterprise, but there is a function only of the activities of the manager and therefore can not reveal in the scheme the subject - cognitive relations.

## 4. Results and discussion

There is a need to consider the functions of coordination in a differentiated way - as a management function and as a function of management support that would simultaneously provide the enterprise with the tasks of distribution, stimulation, provision of communications, coordination of interests, etc. This would have a purposeful influence on the decision-making model of management agents to ensure their coordinated interaction in

accordance with the rules established by the coordination centre, which are aimed at achieving the common goal of the operation/development of the enterprise.

The solution of the above-mentioned coordination tasks in hierarchically organized management structures, including industrial enterprises, is impossible without formalizing the interconnection of the elements of the corresponding mechanism, which determines the feasibility of constructing an object model for the coordination of managerial processes within a hierarchical reflexive approach.

Before defining the main and secondary levels of coordination and modeling the relationships, it is necessary to identify key management objects, find out their place in the structure of the enterprise, identify and describe their information potential.
Immediately predict that the key objects of the general mechanism of coordination of managerial processes at the enterprise are most tied to the goals of the operation / development of the system $Z, z = \overline{1,Z}$. According to the goals formulate more specific tasks within the overall strategy of enterprise development. This allows the whole spectrum of goals to be divided into separate blocks (tasks) $B, b = \overline{1,B}$ and bring it to the level of local solvable tasks $C, c = \overline{1,C}$.

At traditional enterprises, where the management structure has the form of hierarchy, according to the levels of hierarchical control, all tasks are distributed. At the same time, the strategic and coordination tasks of management are separated from operational activities: strategic directions and goals of development formulate top managers, they also take the most important industrial and economic decisions; coordinates the activities of all divisions of the enterprise middle management level; operational management of tasks and organization of activities in structural sub-divisions engaged in management of the lower level. Means and methods for reaching the set goals operational level of management (lower and partially middle managers) develops and performs independently, but only within the framework of those relationships and interdependencies that are established within the enterprise and are regulated by senior management.

R.N. Lepa (2006) has developed a general scheme of management of an industrial enterprise, having identified the following levels of governance: government (level 0); general manager (level 1); managers for functional areas (level 2); heads of enterprise divisions (level 3); specialists of enterprise divisions (level 4); enterprise operating system (level 5). Having taken this scheme for the methodological basis of the mechanism of coordination of management processes, we denote a hierarchically organized structure of an industrial enterprise that contains six key levels of management $I_i, i = \overline{0,5}$.

Objects organizational structure of the enterprise, which are distributed at certain levels of the hierarchy, are management agents responsible for the implementation of a certain range of tasks assigned to them, functions $F$, $f = \overline{1,F}$. The latter may take the form of job descriptions,

production, technological, financial, design, information tasks, etc., but their main characteristic is the establishment of communicative information interchange in order to fulfill these tasks.

If we return to the management scheme, which we adopted for the methodological basis of the developed mechanism for coordination of managerial processes,then for level 0 - members of the board of directors of the enterprise, level 1 - general manager, level 2 - managers of functional directions (for the industrial enterprise - chief engineer, chief economist, chief of production, heads of main workshops, chief accountant, deputy director of commercial matters, deputy of personnel and social issues, etc.), level 3 - heads of enterprises a (heads of departments and shops of industrial enterprises), level 4 - specialists of enterprise divisions, level 5 - operating system of the enterprise.

In the process of implementation of the mechanism of coordination of managerial processes in the enterprise, agents interact with each other through information links. Considering the connections in hierarchical organizational systems, the authors of the work (Burkov et al., 1989) substantiate their horizontal and vertical direction, emphasizing that the vertical direction shows not only the subordination relations (as traditionally), but also the movement of information flows from the bottom up and in the opposite direction, while the horizontal links show the position of the control elements relative to the external environment and among themselves within the framework of the considered level of the hierarchy. Thus, the information reflexive links of agents within a single level of the hierarchy are defined as horizontal interactions of agents, interlayer interactions - as vertical ones.

On the example of a pair of management agents, we consider the possible types of interactions that arise in the process of coordinating management processes at enterprises. Assume that certain management agents $A_j^i$ i $A_q^k$ (where $j(q)$ - serial number of management agent at $i(k)$ - th level of the hierarchy) interact with each other in the process of coordinating management processes $v_k \supset \left[ A_j^i, A_q^p \right]$.

Then:

at $i \neq p$ observe a horizontal connection, or interaction of agents within the same level of management;

at $i = p$ observe a horizontal connection, or interaction between management agents of different levels of the hierarchy;

if $\begin{cases} j = q \\ i = p \end{cases}$ - there is a reflection of the management agent about their own ideas about reality, the principles of their activities, etc. (autoreflection).

In addition, the presence of strategic and informational reflection in the process of interaction of management agents should be noted. Information reflection is the process and result of the agent's reflection on the values of the uncertain parameters that these opponents are aware of and their opponents think (other agents); strategic reflection is the process and

result of the agent's reflection on which decision-making principles is used by his opponents (other agents) within the framework of the awareness he attributes to them as a result of information reflection, that is, strategic reflection precedes the decision-making by the agent of the chosen actions (Novikov & Chkhartishvili, 2002).

The development of the mechanism of hierarchical and reflexive coordination at the enterprise involves the coordination of the agents of management in the process of interactions of agents $v_k$ with the help of information flows $G_{v_k}$, which contain a large number of indicators $\left\{X_{G_{v_k}}\right\}$ on realization of planned (target) tasks of enterprise management.

At the same time moving from the top down to the hierarchical structure of the set $\left\{X_{G_{v_k}}\right\}$ is detailed according to the level of the hierarchy. Thus, each of the agents of the respective levels of management has a set of planned indicators $\left\{X^{t}_{G_{v_k}}\right\}$, which corresponds to the goals of enterprise development at a certain point in time *t*. But, each of the agents of management perceives sets of such indicators $\left\{X^{t}_{G_{v_k}}\right\}$ through the prism of their own intentions and goals, which requires the consideration of reflexive components in the process of implementing the mechanism of coordination of managerial processes. In addition, it is important to take into account the completeness of the agents of management awareness, their competence and the motives for making decisions when implementing relevant planning tasks.

Thus, there is a need to take into account the subjective factor of the perception of the agents of management of the relevant indicators of management in the composition of information flows $G_{v_k}$. To do this, in the object model of the coordination of managerial processes in the enterprise within the hierarchical-reflexive approach to determine $G_{v_k}$ except for sets of planned indicators $\left\{X_{G_{v_k}}\right\}$ distinguish characteristics of information flows $\left\{H_{G_{v_k}}\right\}$ and appropriate intents of control agents $\left\{U^{A_j^i}_{G_{v_k}}\right\}$. At the same time, under the characteristics of information flows $\left\{H_{G_{v_k}}\right\}$ is the probability of distortion of the truth due to the incompetence or ignorance of the agents of management, and the probability of ambiguous interpretation of the information received, which is determined by the intentions (intentions) of the agents $\left\{U^{A_j^i}_{G_{v_k}}\right\}$ of management $\left\{U^{A_j^i}_{G_{v_k}}\right\}$ in the process of implementing the scheduled management tasks.

Thus, in the process of implementing the mechanism of hierarchical coordination, the interests of agents are coordinated horizontally and vertically. Accordingly, for such an agreement, two types of reflection are used: informational (horizontal coordination) and strategic (vertical). The mutual influence of these types of reflection and the mismatch of the interests of agents within the hierarchy levels lead to contradictions and conflicts of inter-level (vertical) interactions. In view of this, the necessity of using the tools of complex harmonization of the interests of the participants of interactions within the framework of the mechanism of hierarchical and reflexive coordination is updated.

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