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ASSESSMENT OF EFFICIENCY OF USAGE OF THE EARLY WARNING SYSTEMS FOR THE MACHINE-BUILDING ENTERPRISE MANAGEMENT

Abstract

Methods of assessment of the economic efficiency of the early warning systems on the criteria vector and ratio of the actual situation of enterprises to the predictable one for the small machine-building enterprises are analyzed and improved.

Key words:

Efficiency, systems of the early warning, machine-building enterprise, assessment method.

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Problem definition. To provide the effective work of machine-building enterprises under the market conditions, which are specified by the increase of the role of the world competitiveness, rapid change of the environment, markets and competitors, it is necessary to use the method of strategic management on weak signals, which provides the wide usage of the information concerning early warning system (EWS). Effectiveness of machine-building enterprise management on the basis of the weak signals considerably depends on the formation of the new infrastructure, where EWS plays an important role. The given system on the basis of permanent assessment of information concerning the factors of impact on the enterprises sideways the external and internal environment provides the revelation of the weak signals, which speak about the early features of the potential possibilities or crisis situations. Timely revelation of the weak signals of EWS provides the hours resource for the enterprise for the adoption of corresponding managerial solutions. The quick response on changes, which take place in the enterprise environment, requires organization of the permanent monitoring of information, assessment of factors of impact, revelation and analysis of weak signals and adoption of managerial solutions within the framework of EWS. Under such management, enterprise is considered as an open system which is permanently adapted to the environment.

The key problem of the adaptation of enterprise to the instability of the environment is perception and formation of response on weak signals. In the sources [22, p. 41–42] the responses on the new tasks are offered to be divided into three types:

- first – provides minimal changes, the main attention is concentrated on the revelation of the reasons, which require changes and their disposal;
- second – stereotype approach under which the managerial tasks are solved by means of previously tested approaches;
- third – complex reconstruction of the management system according to the content of the new tasks.

The developed systems of data collection and analytical processing, which can be used as an alternative to EWS are very expensive and complex in exploitation, require additional expenditures for the adaptation to the new conditions of work of the concrete enterprise and tasks of the weak signals revelation. The usage of such means requires involving of skilled specialists and additional expenditures on exploitation. Developed EWS is simple to service and is oriented on the small machine-building enterprises.

It is expedient to choose the concrete information system for the weak signals revelation under the system of enterprise management according to its efficiency, which speaks about the quality of the given task fulfillment in comparison with some standard [2, p. 222]. Sources of the effectiveness of EWS implementation at the enterprise are: adoption of the grounded managerial solutions; additional income by means of the change in the internal environment of the enterprise subject to the novelty and complexity of tasks, which emerge; obtaining of competitive advantages; increase of the quality of products; increase of the productivity of labor.

Therefore, the problem of choosing of methods of assessment and effectiveness of information EWS exploitation and the system of enterprise management on weak signals is urgent.

Analysis of the latest researches and publications. The questions concerning assessment of effectiveness of information technologies introduction for the enterprise management are highlighted in the works of native and foreign scholars: K. H. Skrypkin, I. F. Chernovolenko, V. O. Osmiatchenko, O. O. Pysarchuk [4] and others. But in the given works there are no complete and accurate methods of assessment of information systems effectiveness, which can be used in the enterprise management.

Analysis of literature [5–8], which estimated the effectiveness of enterprise management, showed that for the given purpose, such methods are used: method of comparison, grouping, mathematical statistics, factorial analysis, ordered estimate, rating methods, method of expert estimation, fuzzy logic and neural networks.

Methods of comparison are based on the disclosure of deviations of actual value from the basic one. The disadvantage of such methods is the ambiguous interpretation of management effectiveness in case when some indicators are improved and others are declined [5].

Method of grouping comes down to the separation of homogeneous groups according to the defined features and assessment of the enterprise managerial efficiency among the examined enterprises. The given method is one of methods of rating assessment of the enterprise managerial efficiency, inasmuch as it does not consider the influences of all factors (features) on the enterprise managerial efficiency.

Methods of mathematical statistics which are used for the assessment of the effectiveness of management are based on the examination of the indicators with the functional interdependence. The disadvantage of the given methods is the necessity of the great number of initial information and impossibility of determination of interrelations among all indicators.

Matrix method is used for the estimation of the effectiveness of productive and economic activity but it also can be used for the estimation of the effective-

ness of management activity, which is specified by means of qualitative indicators.

Method of ordered estimate is based on the normative system of indicators, which are ordered subject to the rates of growth. The disadvantage of such method is impossibility of construction of an indicators system, estimating the level of the management efficiency. Assessment of the management efficiency by means of Delphi method is based on the usage of a great number of partial indicators, which show the different aspects of enterprise management and multicriteria approach [7]. The disadvantage of such methods is their subjective nature.

Methods of fuzzy logic provide assessment of enterprise management effectiveness both on the basis of usage of quantitative and qualitative information about the enterprise functioning [8]. The above noted methods provide the transition of the qualitative utterances of experts into the quantitative meaning and removal of disadvantages of methods which are based on the calculations and estimations of financial indicators.

Neural network methods of assessment of enterprise management efficiency are based on the usage of considerable hour volumes of information concerning enterprise functioning. The disadvantages of the neural network methods are non-transparency of obtaining of results and complexity of their assessment.

Disadvantages of the above noted methods are the impossibility of provision of assessment of information systems efficiency without consideration of their influence on the enterprise management by means of adoption of grounded managerial solutions.

Objective of the article. The article aims at development of methods of assessment of information EWS effectiveness and systems of management on its basis by the small machine-building enterprises.

Assessment of EWS economic effectiveness. To solve the task concerning the assessment of EWS economic efficiency the approach offered in the source [9], is applied. In this work for the assessment of the economic efficiency of corporate information system (CIS) the indicator, calculated on the basis of the following correlation is used:

$$K = -\sum_{k=0}^{n-1} \frac{C_k}{(1+d_1)^k} \prod_{i=0}^{k} p_i + \prod_{i=0}^{n} p_i \sum_{j=1}^{m} \frac{(D_j - E_j)}{(1+d_2)^{j+n}}, \qquad (1)$$

where K – economic efficiency of CIS; C_k – expenditures for the implementation of CIS at the end of k-that schedule date $(k = \overline{0, n-1};$; expenditures at the beginning of the first schedule date of implementation $C_0 = 0)$; n – number of schedule dates of CIS implementation; d_1 – coefficient of CIS discounting during its imple-

mentation; p_i – probability of the fact that *i*-schedule date of CIS implementation will be finished successfully (up to the beginning of the implementation of $p_0 = 1$; $i = \overline{0, n-1}$); factor $\prod_{i=0}^{n} p_i$ shows the probability of successful finish of all schedule dates of CIS implementation and beginning of its exploitation; D_j – enterprise incomes from the exploitation of CIS at the end of *j*-schedule date of exploitation ($j = \overline{1, m}$); m – number of schedule dates of CIS exploitation; E_j – expenditures of enterprise for CIS exploitation at the end of *j*-schedule date of exploitation ($j = \overline{1, m}$); d_2 – coefficient of CIS discounting during exploitation.

In formula (1) expenditures for CIS implementation (investment expenditures) C_j ($j = \overline{1, m}$) are known from the business plan of work of enterprise. The enterprise income from exploitation of CIS D_j ($j = \overline{1, m}$) is calculated on the basis famous estimation procedure of income from the productive application of technological equipment. Coefficients of discounting d_i (i = 1, 2) are defined on the basis of analysis of the financial statements of enterprise, outlet market conjuncture, its products and forecast of inflation index. Probabilities of successful end of the schedule dates of implementation p_i ($k = \overline{0, n-1}$) are determined by means of financial and technological analysis.

Formula (1) describes the economic effectiveness of CIS which is implemented during n schedule dates of implementation and is exploited during m schedule dates of exploitation under condition. In this formula it is expected that during each schedule date of exploitation, CIS in all time intervals brings equal economic effect.

The sources of economic effect from the implementation of EWS at the machine-building enterprises are: decrease of the labor intensity of works concerning the early recognition of weak signals about the threats and capabilities; increase of the consistency of the process of weak signals revelation; increase of hour resource for the adoption of grounded managerial solutions; obtaining of competitive advantages; additional income by means of realization of capabilities and timely response concerning threats.

The identified and recognized weak signals of EWS, which come from the enterprise environment, are used as information for adoption of managerial solutions. Perceiving of weak signals is the basic for enterprise management. Subject to the power (1st, 2nd 3d, 4th and 5th levels), nature (capabilities, potential dangers) and subject matter of the signal (economic, social and cultural, political, productive and technological, market, competitive, international) the type of reaction and mechanism of enterprise development is chosen.

To estimate the economic effectiveness of EWS it is necessary to consider the peculiarities of enterprise management according to weak signals. The main peculiarity of such management is necessity of consideration of additional expenditures R_{jr}, which are connected with the adaptation of the enterprise to the changes of environment. The noted expenditures are calculated as follows:

$$R_{jr} = f(V_{jr}, X_{jr}, Z_{jr}),$$

where V_{jr} – signal strength, X_{jr} – nature of signal, Z_{jr} – subject matter of signal, *jr* – period of time (quarter), which belongs to *j*-schedule date. The noted expenditures are channeled on realization of changes, which will provide the solution of tasks before for the enterprise.

Incomes from the EWS exploitation in *jr* period of time are calculated as follows:

$$D_{jr} = f(YP),$$

where *YP* – managerial solutions, which influence on the economic, social and cultural, political, productive and technological, market, competitive and international environment. In practice, incomes D_{jr} from EWS exploitation are offered to calculate as follows:

$$D_{jr} = D_{jrP} - D_{jrR},$$

where D_{jrP} – predicted quarterly enterprise income; D_{jrR} – actual quarterly enterprise income.

Assessment of economic EWS efficiency with the consideration of the peculiarities of enterprise management according to the weak signals are calculated as follows:

$$K = -\sum_{k=0}^{n-1} \frac{C_k}{(1+d_1)} \prod_{i=0}^{k} p_i + \prod_{i=0}^{n} p_i \sum_{j=1}^{m} \sum_{r}^{g} \frac{(D_{jr} - E_{jr} - q_{jr} R_{jr})}{(1+d_2)^{j+n}} \qquad (2)$$

where q_{jr} – threshold coefficient, which is amounted to:

$$q_{jr} = \begin{cases} 0, & \textit{when there are no signals from EWS} \\ 1, & \textit{when there are signals from EWS} \end{cases}$$

Without consideration of expenditures on the implementation (investment expenditures) economic efficiency K_m of the developed EWS at the end of *m*-schedule date of exploitation amounted to

$$K_m = \sum_{j=1}^{m} \sum_{r=1}^{g} \frac{(D_{jr} - E_{jr} - q_{jr} R_{jr})}{(1+d_2)^{j+n}} \qquad (3)$$

In formula (3) without taking into consideration the change of the coefficient of discounting d_2 we can obtain the assessment of economic efficiency K_{jr} of the developed EWS for each r quarter of j schedule date:

$$K_{jr} = D_{jr} - E_{jr} - q_{jr} R_{jr} \quad (4)$$

From the received formula (4) we can see that, while revelation of the weak signals the quarterly EWS effectiveness is decreased on the cost value R_{jr}, which are necessary for the adaptation of enterprise to the changes of environment. For the practical application, the quarterly assessment of EWS effectiveness K_{jr} which functions at the enterprise, it is important to have results of EWS work and data concerning report of enterprises.

Assessment of EWS effectiveness according to the vector of criteria. To estimate the EWS effectiveness we use the approach [4] which is based on the application of the methods of multi-criteria analysis for the formation of the partial criteria of the integrated estimation of the system effectiveness. Calculation of the integrated estimation of effectiveness will be conducted by the scheme of compromises, offered in works [4, 10]. In accordance with the noted scheme, the integrated estimation of EWS effectiveness is calculated as a complex of discrete partial criteria in consequence with such expression:

$$E(y_0) = \sum_{i=1}^{b} \gamma_{0i} (1 - y_{0i})^{-1} \Rightarrow \min, \quad (5)$$

where $i = 1,\ldots,b$ – number of included into complex partial criteria of EWS effectiveness; γ_{0i} – i- normalized weighting coefficient; y_{0i} – normalized estimation of effectiveness of i- partial criteria of effectiveness.

Assessment of EWS efficiency on the basis of the given approach will be conducted in such sequence:

1) formation of the list of indicators which influence on EWS effectiveness for the small machine-building enterprises;

2) determination of the scale of changes of numeric value of partial criteria of EWS effectiveness for the small machine-building enterprises;

3) calculation and normalization of generalized criteria of EWS efficiency according to the technological, ergonomic and economic components;

4) calculation and normalization of the integrated estimation of EWS efficiency;

5) determination of the linguistic category of effectiveness.

The given approach is based on the formation and estimation of indicators and criteria which shows the positive effect from the system functioning. The principal task of EWS is timely determination of the potential threats and possi-

bilities for the enterprise and formation of corresponding managerial positions and recommendations. For that purpose, EWS should effectively provide the realization of such tasks: accumulation, collection and analysis of internal and external information which influences on enterprise; calculation of priority vectors and generalized integral indicator of influence on enterprise; determination of weak signals and factors, which influence on their emergence.

Considering the stages of assessment of EWS effectiveness we shall pay attention to EWS which are used at the small machine-building enterprises.

At the first stage of assessment of EWS efficiency we form the list of indicators for the technological ergonomic and economic categories.

Technological indicators are defined by the hardware and software, on the basis of which EWS are realized. The category of technological indicators of EWS depends on such indicators: memory capacity for information accumulation; productiveness of computer system, maintainability of hardware and software; accuracy and speed of information processing; operational efficiency of strategic information introduction; expedience of revelation and recognition of weak signals; visualization of results of information processing.

Category of ergonomic indicators defines the hardware and software of EWS according to convenience and effectiveness of the work of the system users.

Category of economic indicators shows the value of hardware and software of EWS, expenditures for personnel maintenance and training and incomes from the system exploitation.

The list of indicators which influences on the effective work of EWS is presented in the Table 1.

For each category of indicators the requirements to the criteria of EWS effectiveness are formed

$$\begin{cases} F_{пам} \Rightarrow \max; F_{пр} \Rightarrow \max; F_{над} \Rightarrow \max; F_{\text{івр}} \Rightarrow \max; F_{ове} \Rightarrow \max; F_{івр} \Rightarrow \max; \\ \text{H}_E \Rightarrow \max; \\ S_{аз} \Rightarrow \min; S_{зпз} \Rightarrow \min; S_{спз} \Rightarrow \min; S_{екс} \Rightarrow \max. \end{cases} \quad (6)$$

The list of the partial criteria of EWS effectiveness is contradictory inasmuch as it depicts the effective and cost estimation model.

At the second stage of assessment of EWS efficiency is defined by the scale of changes of discrete values of technological, ergonomic, economic indicators of efficiency. While formation of such scale of changes we shall pay attention to the EWS of the small machine-building enterprises. The formation of scale of numeral changes of indicators of effectiveness is carried out by means of expert questionary. The obtained scale of numeral changes is presented in the Table 2.

Table 1

List of indicators of effectiveness

Category indicators	Indicators	Denotation
F_T – technological	Memory capacity of computer system	$F_{пам}$
	Productivity of computer system	$F_{пр}$
	Maintainability of hardware and software (availability factor)	$F_{над}$
	Validity of EWS functioning (probability of error while information transfer)	$F_{ін}$
	Operational efficiency of strategic information introduction	$F_{ове}$
	Probability of revelation and recognition of weak signals	$F_{ієр}$
H_E – ergonomic	Convenience of users' work (number of simultaneously fulfilled interacted tasks)	H_E
S_E – economic	Value of hardware	$S_{аз}$
	Value of system-wide software	$S_{зпз}$
	Value of specialized software	$S_{спз}$
	Operational costs	$S_{екс}$

Table 2

Scale of numeral and normalized values of indicators of EWS effectiveness

Indicators of effectiveness	Scale of numeral values
Memory capacity of computer system – $F_{пам}$	4–5 GB
Productivity of computer system – $F_{пр}$	100–800 mln.oper./sec
Maintainability of hardware and software (availability factor) – $F_{над}$	0,99–0,9999
Validity of EWS functioning (probability of error while information transfer) – $F_{ін}$	10^{-10}–10^{-12} backspace
Operational efficiency of strategic information introduction – $F_{ове}$	2–2,5 hours.
Probability of revelation and recognition of weak signals – $F_{ієр}$	0,7–0,98
Convenience of users' work (number of simultaneously fulfilled interacted tasks) – H_E	1–7
Value of hardware – $S_{аз}$	45–50 thouands of UAH
Value of system-wide software – $S_{зпз}$	30–40 thouands of UAH
Value of specialized software – $S_{спз}$	5–10 thouands of UAH
Operational costs – $S_{екс}$	2–4 thouands of UAH

At the third stage of assessment of EWS effectiveness the generalized criteria of EWS effectiveness according to technological, ergonomic, economic components are calculated. On the basis of the source (5) the expressions for calculation of generalized criteria of EWS effectiveness according to technological, ergonomic, economic components are presented:

$$\begin{aligned}
&F_T = \gamma_{\text{пам0}}(1-F_{пам0})^{-1} + \gamma_{\text{пр0}}(1-F_{пр0})^{-1} + \gamma_{\text{над0}}(1-F_{над0})^{-1} + \gamma_{\text{ін0}}(1-F_{ін0})^{-1} + \\
&+ \gamma_{\text{овв0}}(1-F_{овв0})^{-1} + \gamma_{\text{івр0}}(1-F_{івр0})^{-1} \Rightarrow \min \\
&H_E = \gamma_{\text{E0}}(1-H_{E0})^{-1} \Rightarrow \min \\
&S_E = \gamma_{\text{аз0}}(1-S_{аз0})^{-1} + \gamma_{\text{зпз0}}(1-S_{зпз0})^{-1} + \gamma_{\text{спз0}}(1-S_{спз0})^{-1} + \gamma_{\text{еас0}}(1-S_{екс0})^{-1} \Rightarrow \min
\end{aligned} \tag{7}$$

Using the expressions (7) and value of indicators of effectiveness from the Table 2, we calculate the value of generalized criteria of EWS effectiveness for the small machine-building enterprise «Energoterm» according to technological, ergonomic, economic components:

$$F_T = (1-0{,}8)^{-1} + (1-0{,}2)^{-1} + (1-0{,}9)^{-1} + (1-0{,}1)^{-1} + (1-0{,}8)^{-1} + 0{,}7(1-0{,}8)^{-1} = 25{,}86$$

$$H_E = (1-0{,}3)^{-1} = 1{,}75$$

$$S_E = (1-0{,}9)^{-1} + (1-0{,}75)^{-1} + (1-0{,}5)^{-1} + (1-0{,}5)^{-1} = 18$$

To calculate the integrated estimation of EWS effectiveness of the enterprise «Energoterm», we conduct norm setting of received values of generalized criteria of EWS effectiveness in accordance with the following expressions:

$$\begin{aligned}
&F_{T0} = \frac{F_T}{\max F_T}, \\
&\max F_T = \gamma_{\text{пам0}}(1-[\max F_{пам} - \Delta])^{-1} + \gamma_{\text{пр0}}(1-[\max F_{пр} - \Delta])^{-1} + \gamma_{\text{над0}}(1-[\max F_{над} - \Delta])^{-1} + \\
&+ \gamma_{\text{ін0}}(1-[\max F_{ін} - \Delta])^{-1} + \gamma_{\text{овв0}}(1-[\max F_{овв} - \Delta])^{-1} + \gamma_{\text{івр0}}(1-[\max F_{івр} - \Delta])^{-1}, \\
&H_{E0} = \frac{H_E}{\max H_E}, \\
&\max H_E = \gamma_{\text{E0}}(1-[\max H_E - \Delta])^{-1}, \\
&S_{E0} = \frac{S_E}{\max S_E}, \\
&\max S_E = \gamma_{\text{аз0}}(1-[\max S_{аз} - \Delta])^{-1} + \gamma_{\text{зпз0}}(1-[\max S_{зпз} - \Delta])^{-1} + \gamma_{\text{спз0}}(1-[\max S_{спз} - \Delta])^{-1} + \\
&+ \gamma_{\text{екс0}}(1-[\max S_{екс} - \Delta])^{-1},
\end{aligned} \tag{8}$$

where Δ – coefficient of safety (Δ = 0,1, …, 0,3), which is used to avoid the erroneous operation while norm setting.

Using the expressions (8) and values of indicators of effectiveness from the Table 2, we calculate the norm setting of the value of generalized criteria

$$\max F_T = (1-[1-0{,}1)^{-1} + (1-[1-0{,}2])^{-1} + (1-[1-0{,}1])^{-1} +$$
$$+ (1-[1-0{,}2])^{-1} + (1-[1-0{,}1])^{-1} + 0{,}7(1-[1-0{,}1])^{-1} = 47$$
$$F_{T0} = \frac{F_T}{\max F_T}, = \frac{25{,}86}{47} = 0{,}55$$
$$\max H_E = (1-[0{,}86-0{,}1])^{-1} = 4{,}17;$$
$$H_{E0} = \frac{H_E}{\max H_E} = \frac{1{,}75}{4{,}17} = 0{,}42,$$
$$\max S_E = (1-0{,}97)^{-1} + (1-[1-0{,}1)^{-1} + (1-[1-0{,}1)^{-1} + (1-[0{,}9-0{,}1)^{-1} = 58{,}33;$$
$$S_{E0} = \frac{S_E}{\max S_E} = \frac{31{,}69}{58{,}33} = 0{,}54;$$

Obtained normalized value of the generalized criteria of effectiveness according to the technological, ergonomic, and economic components we write into the Table 3.

At the fourth stage we calculate and set norms of the integrated estimation of EWS effectiveness. For the enterprise «Energoterm» the calculations of the integrated estimation of EWS effectiveness will be conducted under the following expressions:

$$E_S = \gamma_{T0}(1-F_{T0})^{-1} + \gamma_{H0}(1-H_{E0})^{-1} + \gamma_{S0}(1-S_{E0})^{-1} \Rightarrow \min$$
$$E_S = 0{,}5(1-0{,}55)^{-1} + 0{,}75(1-0{,}42)^{-1} + 0{,}8(1-0{,}54)^{-1} = 4{,}14$$

Under the calculation of the integrate estimation of EWS effectiveness we use the weighted coefficients, which provide the domination of criteria of the certain group over another one. To adopt the solutions concerning the EWS efficiency we conduct the norm setting of the integrated estimation of EWS effectiveness in accordance with the following expressions:

$$E_{S0} = 1 - \frac{E_S}{\max E_S},$$
$$\max E_S = \gamma_{T0}(1-[\max F_{T0} - \Delta])^{-1} + \gamma_{H0}(1-[\max H_{E0} - \Delta])^{-1} + \gamma_{S0}(1-[\max S_{E0} - \Delta])^{-1} \quad (9)$$

In formula (9) to calculate $max\ E_S$ it is necessary to take the maximal value of $max\ F_{T0}$, $max\ H_{T0}$, $max\ S_{E0}$, which are obtained from the formula (8) when the coefficients of safety are decreased. With the consideration of the increase of coefficient of safety the given values will be the following: $max\ F_{T0}$ = 0,9, $max\ H_{T0}$ = 0,8 та $max\ S_{E0}$ = 0,9. Using the maximal values of $max\ F_{T0}$, $max\ H_{T0}$, $max\ S_{E0}$ we calculate the normalized integrated estimation of EWS effectiveness

$$E_{S0} = 1 - \frac{E_S}{\max E_S},$$

$$\max E_S = 0{,}5(1-[0{,}9-0.1)^{-1} + 0{,}75(1-[0{,}9-0{,}1])^{-1} + 0{,}8(1-[0{,}9-0{,}1])^{-1} = 10{,}25$$

$$E_{S0} = 1 - \frac{E_S}{\max E_S} = 1 - \frac{4{,}14}{10{,}25} = 0{,}6$$

Calculated and normalized values of the EWS effectiveness for the enterprise «Energoterm» are written into the Table 3.

At the fifth stage EWS effectiveness is defined in the linguistic form. Inasmuch as after the normalization of the value of integrated estimation of EWS effectiveness can be varied within the limits of zero to 1, the assessment of efficiency in the linguistic form is defined using the scale of the Table 4.

Table 3

Calculated and normalized values of the EWS effectiveness for the enterprise «Energoterm»

Generalized criteria		Integrated estimation	
Calculated	Normalized	Calculated	Normalized
F_T = 25,86	F_{T0} = 0,55		
H_E= 1,175	H_{E0} = 0,42		
S_E = 18	S_{E0} = 0,54	E_S =4,14	E_{S0} =0,6

Table 4

Scale of estimation of EWS effectiveness in the linguistic form

Integrated estimation of efficiency E_{S0}	Linguistic estimation of efficiency
1,0–0,7	High
0,7–0,5	Good
0,5–0,4	Satisfactory
0,4–0,2	Low
0,2 and lower	Unsatisfactory

For EWS «Energoterm», the normalized value of the integrated estimation E_{S0} = 0,6, in accordance with the data of the Table 4 corresponds to the linguistic estimation of the effectiveness – «good».

Assessment of EWS effectiveness in accordance with the ratio of the actual situation of the enterprise to the predicted one. Revelation and recognition of the weak signals of EWS provides their following perception by the environment as information for the formation of the regulating action. Therefore, the effectiveness of enterprise management with EWS usage will be defined by the ratio of the actual situation of enterprise to the predicted one which does not consider the changes of the environment. For the complex estimation of enterprise situation we use the generalized integral indicator of influence, which considers the hierarchic interrelation and interdependence of all groups and factors of influence on the enterprise [11]. The effectiveness of enterprise management $E_п$ with the usage of EWS for the period of its exploitation will be defined according to the following formula:

$$E_п = \frac{\sum_{j=1}^{h} \frac{I_{jR}}{I_{jP}}}{h},$$

where h – number of quarters for which the effectiveness of EWS is defined; I_{jR} – real quarterly generalized integral indicator of influence on enterprise; I_{jP} – predicted quarterly generalized integral indicator of influence on enterprise.

For the enterprise «Energoterm», the effectiveness of enterprise management with the usage of EWS for the period of two years of exploitation $E_п$=0,85, which in accordance with the data of the Table 4 corresponds to the linguistic estimation of effectiveness – «high».

Conclusions:

1. Economic effect from EWS implementation at the small machine-building enterprises depends on the following parameters: 1) incomes of enterprises, which are formed by means of timely revelation of weak signals concerning threats and potential possibilities, adoption of grounded managerial solutions, which provide the obtaining of competitive advantages, realization of potential possibilities and timely response on threats; 2) enterprise expenditures connected with EWS exploitation; 3) additional expenditures for the adaptation of enterprise to the changes of environment.

2. To estimate EWS efficiency according to the vector of criteria, the multicriteria model is used.

3. Estimation of EWS effectiveness according to the vector of criteria provides the fulfillment of the following stages: 1) formation of the list of indicators of EWS effectiveness; 2) determination of the scale of changes of numerical values

of the indicators of EWS effectiveness; 3) calculation and normalization of the generalized criteria of EWS efficiency according to technological, ergonomic and economic components; 4) calculation and normalization of the integrated estimation of EWS effectiveness; 5) determination of the linguistic category of effectiveness.

4. Effectiveness of enterprise management with the usage of EWS is defined by the ratio of actual generalized integral indicator of influence on the enterprise, which considers the hierarchic interrelation and interdependence of all groups and factors of influence to the predicted one.

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