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ECONOMETRIC MODELLING OF ECONOMIC SECURITY IN BUSINESS OPERATIONS MANAGEMENT

The article deals with econometric modeling of economic security. The model of evaluating transaction costs effect on the level of enterprise economic security is provided. The econometric models of evaluating economic security that are used in research are based on panel data. According to the results, the reserves for increasing the general level of economic security due to transaction costs reduction are revealed.

Key words: economic security of an enterprise, panel data, transaction costs management system, operations management, econometric modeling.

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ЕКОНОМЕТРИЧНЕ МОДЕЛЮВАННЯ ЕКОНОМІЧНОЇ БЕЗПЕКИ В УПРАВЛІННІ ВИРОБНИЧИМИ ПОТОКАМИ

Розглянуто питання економетричного моделювання економічної безпеки. Представлено модель оцінки впливу операційних витрат на загальний рівень економічної безпеки підприємства. Економетричні моделі оцінки економічної безпеки, використані у дослідженні, ґрунтуються на панельних даних. За результатами дослідження виявлено величину резервів підвищення загального рівня економічної безпеки за рахунок зниження рівня операційних витрат підприємства.

Ключові слова: економічна безпека підприємства, панельні дані, система управління операційними витратами, операційний менеджмент, економетричне моделювання.

Statement of the problem

The modern Ukrainian economy is rapidly developing. The essential stochastic indicators influence on the unevenness and significant differences of economic processes. The indicators have uncertainty and extreme nature of the actions. In addition, the unpredictability of socio-economic systems increases on all levels of management due to the processes of regionalization and globalization. The domestic enterprises have to survive in such conditions. The reducing risks in decision making are main indicator in this

process. It is required the development of effective enterprise's management system. In connection with, there are set of issues and threats of loss of economic security.

The implementation of a wide range of objectives which include sustainability and stability, economic independence of the enterprises is one of the possible way by maintaining an appropriate level of economic security. The lack of economic security decisions at the enterprise level causes the disasters effects for the whole economy. Therefore, the first precondition of providing senior level economic security is enterprise economic security on the whole. It requires the development of effective operational system of enterprise. The process of evaluations and analysis of economic security would be given priority in the system.

Analysis of recent research and publications

The economic security management system is complex. The system includes elements of subsystem of enterprise. The operation subsystem is a crucial indicator of business operations management. According to the results of the resent scientific research [1–5], a sufficient level of economic security can not be achieved without enough reliable operations in the production system and its elements. In turn, as rightly pointed out in the paper [1], the economic security mechanism of the company have to provide the reliability and stability of the informational and material flows. It is the main integrating factor of security. Taking this into account, it is appropriate to provide the scheme of productive enterprise system (fig. 1).

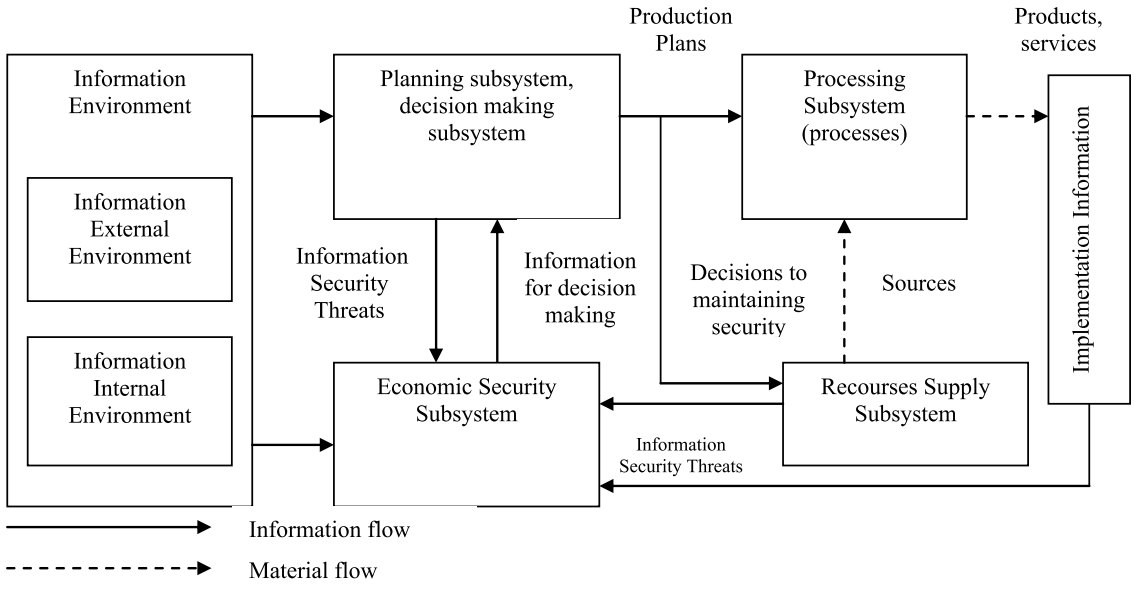

Fig. 1. The scheme of enterprise production system

The production system consists of the following major subsystems according to the general approaches and fundamental theories of operations business. There are manufacturing, maintenance, planning subsystems. The production system is manufacturing subsystem that includes all functions required to design, produce, distribute, and service a manufactured product.

The security subsystem provides feedback for the production mechanism. The processing subsystem is crucial system. It carries out output that is directly related with the input information and materials transformation to the production results (products or services). The value of enterprise sustainability indicators depends on effective operation management, which is based on estimation of economic security [1, 2, 4, 5]. It requires an integrated approach to the developing of security system. In these terms security management performs the regulatory process and decision-making. It provides reducing of operational costs, increasing of productivity, increasing of products and services quality in the manufacturing cycle. Also it provides a high value of stability and reliability of the production system. The indicator of enterprise economic security in this case is minimizing the total operational costs and production risks for all subsystems. Information about threats from each subsystem is crucial for the decision-making of security management. The threats in the manufacturing cycle include [1]:

Resources Supply Phase – changing the payment terms and deadlines of supply, rising prices for resources;

Materials and Resources Acceptance Phase – product does not meet to the condition contracts and quality standards;

Transfer of the Warehouse Component Products Phase – theft, unplanned destocking;

Production Process Phase – breach of technologies, reducing of production capacity, defective products;

Packaging of Products Phase – higher costs and inefficient use of the brand, defective packaging material, rise in the cost of work;

Delivery to the Warehouse Phase – supply disruption, loss of things, defective of the packaging.

The formulation of objectives

The resources reserves, witch involved in producing system, is important for the enterprise security. The analysis of the theoretical approaches and investigated problems in estimation of the economic security in business operations management allowed to carry out the aim of research. It involves the creation economic mathematical models to estimate correlation between operating costs and level of economic security. The econometric models, which used in research, were based on pool data. Also we investigated additional opportunities to increase security by reducing operational costs.

Presentation of main materials

Management is carried out by different methods in various situations. Keep in mind, there is the main obstacle to improve economic security, witch consists of slow changing transformation process in the enterprise. It is necessary to carry out operative response to possible threats that slow down enterprise development. Particularly, it is very important involvement in the production process of resources reserves due to the very low level of economic security in enterprises. Therefore, it is reasonable to develop of economic security directions, based on a set of measures, witch related with evaluation of internal reserves and saving financial resources.

The analysis of the types of functional specifications allows develop of model specification for the investigated sample. The model can be achieved by multiple nonlinear econometric models. The values of independent variables specify changing by the integral level of economic security in the model (1). The range of economic security level is [0; 1].

$$y_t = \frac{1}{1+\exp(a_0 + a_1 \cdot x_{1t} + a_2 \cdot x_{2t} + a_3 \cdot x_{3t} + a_4 \cdot x_{4t})} + \varepsilon_t \quad (1)$$

$$Y_i = \begin{bmatrix} Y_{i1} \\ \vdots \\ Y_{iT} \end{bmatrix}; x_{id} = \begin{bmatrix} x'_{i1} \\ \vdots \\ x'_{iT} \end{bmatrix}; \varepsilon_i = \begin{bmatrix} \varepsilon_{i1} \\ \vdots \\ \varepsilon_{iT} \end{bmatrix}; a_{0i} = \begin{bmatrix} a_{01} \\ \vdots \\ a_{0n} \end{bmatrix} i = \overline{1,9}; t = \overline{1,T}; d = \overline{1,4},$$

where y_t – economic security level in moment t; x_{1t} – cost of good sold; x_{2t} – the marketing costs; x_{3t} – administrative costs; x_{4t} – other operational costs.

Construction of a correlation matrix among the explanatory variables indicates that any given couplet of right-hand-side variables are creating multicollinearity problems. Correlation values testify a multicollinearity problem in the model. White test establishes that the residual variance of a variable in a regression model is not constant: that is for heteroscedasticity. It have been investigated a set of different specifications and statistical evaluation criteria of adequacy to avoid these problems. There are the set of steps of the econometric modeling.

Step 1. Null hypothesis: there is relationship between explained variables in the model. Variables were divided into endogenous and exogenous.

Step 2. Null-hypotheses on the second step: there is the type of functional specification. The panel data models may contains individual differences in the each case of the investigating sample set. Such differences and the appropriate type of specification are identified by series of statistical tests. Null

hypothesis: there is no fixed effects model. $H_0 : \mu_i = \mu_j$ for all i, j for the combined model, that μ is the constant for all objects of the sample data. There is alternative hypothesis: $H_1 : \mu_i \neq \mu_j$ at least one pair i, j, corresponding to the fixed effects model. This pair of hypotheses can be tested by the F-test:

$$F = \frac{R^2_{FE} - R^2_{pool}}{1 - R^2_{FE}} \frac{nT - n - d}{n - 1} \overset{H_0}{\sim} F(n-1, nT - n - d), \quad (2)$$

where R^2_{FE} — multiple correlation coefficient for model with fixed effects; R^2_{pool} — multiple correlation coefficient of combined model; n — the numbers of enterprises; T — the numbers of times; d — the numbers of independent variables.

The test for significance of random effects model is carried out by Lagrange multipliers test. The test, based on relevant statistics, was proposed by Breush and Pagan [3]:

$$LM = \frac{nT}{2(T-1)} \left(\frac{\sum_{i=1}^{n} \left(\sum_{t=1}^{T} e_{it} \right)^2}{\sum_{i=1}^{n} \sum_{t=1}^{T} e_{it}^2} - 1 \right)^2, \quad (3)$$

where e_{it} – residuals of combined regression model.

The null hypothesis is H_0: the combined regression model is particular case of the random effects model, where there are no $\sigma_u^2 = 0$. If hypothesis H_0 is true and there is normal distribution of errors, then LM statistic has an asymptotic χ^2 distribution with one degree of freedom.

The specification of the model was tested is appropriate using Hausman test:

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})' \hat{\Phi}^{-1} (\hat{\beta}_{FE} - \hat{\beta}_{RE}), \quad (4)$$

where $\hat{\Phi}$ – covariate matrix $(\hat{\beta}_{FE} - \hat{\beta}_{RE})$, which has asymptotic distribution χ^2 with d degrees of freedom; $\hat{\beta}_{FE}$ – vector of fixed effects parameters; $\hat{\beta}_{RE}$ – vector of random effects parameters.

We test null hypothesize H_0: the estimates of random effects model is effective and reasonable. It does not different between regression coefficients of the fixed effects model. So, if alternative hypothesis H_1 is true, then the difference between the random effects and fixed effects model are significant, but estimates of the fixed effects model are reasonable.

Step 3. The step involves check the available statistical data on multicollinearity, heteroscedasticity of the structure, the repair of missing data. The choice of estimation method of the model parameters depends on the type of functional specification. It is checked whether there is a forecasting model, created in the previous stages, is corresponded to the type of the developed model.

Step 4. The assumptions were formulated about the stochasticity properties of variables, residual homoscedasticity and autocorrelation, using appropriate statistical criteria. The autocorrelation test is conducted by the Durbin- Watson statistic.

Step 5. The step involves estimation of correlation between variables by the coefficient of multiple correlation (R). The explanatory variable variation, independent variables variation are determined by the coefficient of determination (R^2).

The coefficient of determination, adjusted coefficient of determination and multiple correlation coefficient indicates the overall adequacy of the provided models. Heteroskedasticity and autocorrelation of models residuals were investigated by Durbin-Watson statistics, nonparametric Goldfeld-Quandt test. The model was tested for the effect of multicollinearity. It was allowed to apply method of evaluating the model parameters. The best specification model was provide, based on the values of Student's test for regression parameters and coefficient of determination (table 1).

Table 1

Evaluation models of enterprise's economic security level

№	Enterprise	Model Specification	Multiple correlation coefficient	Coefficient of determination
1	JSC “Avtramat”	$y_1 = \frac{1}{1+\exp(-0{,}590 \cdot x1 + 0{,}130 \cdot x1 - 0{,}281 \cdot x2 + 1{,}369 \cdot x3 - 0{,}478 \cdot x4)}$	0,990	0,982
2	JSC “Odesskiy FAM”	$y_5 = \frac{1}{1+\exp(0{,}078 \cdot x1 - 1{,}127 \cdot x2 + 0{,}0015 \cdot x3^3 + 0{,}054 \cdot x4)}$	0,734	0,539
3	JSC “Olevskiy factory of tractor normal”	$y_6 = \frac{1}{1+\exp(-0{,}509 + 1{,}201 \cdot ^{x1} - 0{,}289 \cdot x2 + 0{,}851 \cdot x3^2 - 0{,}727 \cdot x4)}$	0,952	0,907
4	JSC “Nizhinskiy FAM”	$y_7 = \frac{1}{1+\exp(1{,}556 - 0{,}053 \cdot x1 - 1{,}992 \cdot x2 + 0{,}414 \cdot x3 + 0{,}242 \cdot x4)}$	0,795	0,632
5	JSC “Red Star”	$y_9 = \frac{1}{1+\exp(-1{,}123 - 0{,}0142x1 + 0{,}013 \cdot x2^2 + 1{,}49 \cdot x3 - 0{,}047 \cdot x4)}$	0,813	0,661

The possibility of increasing economic security by the reduction of operating costs was investigated. The average values of operations costs and their possible reduction on 10 % is given in table 2.

Conclusions

The results analysis suggests that a reduction of cost of goods sold, marketing costs, administrative and other operating costs by 10 % would increase the level of economic security: at the JSC “Avtramat” – 27 %; at the JSC “Odessa FAM” – 15 %, at the JSC “Olevskiy factory of tractor normal” – 10,34 %, at the “Nizhinsky” – 26,48 % at the JSC “Red Star” – 29,52 %. The results can be achieved by the way:

– reducing material costs by finding and buying cheaper raw materials and components, reducing loss of material due to the prevention of cost overruns during the transportation, warehousing and working area, as well as during their direct use, reducing the cost of raw materials through their savings and the use of new materials;

– reducing labor costs by reducing benefits that are not included in the cost of production (gifts, rewards for performance for the year and other one-time fee);

– reducing transportation costs for the delivery of products;

– reducing of construction temporary structures cost.

Table 2

Enterprise's economic security level and operational costs

№	Enterprise	Average level				Average economic security level ($У_i$)	Predicted economic security level ($У_{ipr}$)
		Cost of goods sold (X_1)	The marketing costs (X_2)	Administra-tive costs (X_3)	Other operational costs (X_4)		
1	JSC “Avtramat”	44,36	0,98	7,64	27,66	0,106	0,135
2	JSC “Odesskiy FAM”	33,08	2,27	5,02	28,41	0,172	0,195
3	JSC “Olevskiy factory of tractor normal”	297,56	12,76	18,14	148,62	0,336	0,346
4	JSC “Nizhinskiy FAM”	20,32	1,25	5,46	15,13	0,209	0,241
5	JSC “Red Star”	3,56	73,34	0,52	0,26	0,218	0,241
6	JSC “Avtramat”	12,6	0,26	1,83	0,76	0,210	0,266
7	JSC “Odesskiy FAM”	110,59	9,12	3,5	49,13	0,212	0,274

Thus, the proposed estimation model allows to increase economic security level by reducing operating costs. It will stabilize and enhance enterprise economic security.

Prospects for future research

In conclusion it should be noted, that the model can be used in management system for the increasing of economic security level in way one chosen direction of economic recovery. These measures are sufficiently effective in the event of a crisis. But the maximum effect of their use can be obtained implementing these measures at the enterprises in low-class of economic security. The security system can reduce risks of threats in the production system and business processes of the enterprise. It would provide of achieving the company's strategic objectives, creating an effective mechanism for adaptation to the market environment.

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