Modernization determinants by ensuring economic security of enterprises in the competitive conditions

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Summary
The study develops methodological aspects for modeling the determining impact of modernization on the enterprise's economic security in development competitive conditions using the model of speed, stability and spaciousness of modernization. Modeling the determining impact of modernization on the enterprise's economic security in a competitive conditions involves: firstly, the formation of estimated modeling indicators in accordance with the speed, stability and spaciousness of the enterprise's modernization; secondly, establishing the weight of indicators in the assessment system using the tools of cognitive judgment; thirdly, the establishment of reference values of sound evaluation indicators; fourthly, the calculations of the integrated impact assessment of the modernization's determining impact modeling on the enterprise's ensuring economic security in a competitive conditions; fifthly, conducting calculations and analytical summarization of the results. To determine a comprehensive integrated indicator of the modernization changes impact on the competitiveness and economic security of enterprises, we use the correlation method of the calculated value with the reference value, as well as use weights for groups of calculations. Approbation of modeling of determining influence of modernization on maintenance of economic safety of the enterprise in competitive conditions of development by authors was carried out concerning such enterprises, as: JSC "Ukrzaliznytsia", SE "Ukraerorukh", SE IA "Boryspil", SE "Ukrposhta", KP "Kyivpastrans".

Key words:
Economic Security of the Enterprise, Competitiveness, Modernization Determinants, Integration Influence, Speed of Realization, Stability of Innovations, Space of Modernization.

1. Introduction

Modern conditions for the development of economic systems at both the micro and macro levels are characterized by high uncertainty, which negatively affects their development in competitive conditions. Instability and a high degree of uncertainty in the economic development systems' conditions at different levels is also accompanied by the rapid development of technology, the introduction of innovations, the processes of digital transformation. These and other positive factors against the background of instability and systemic structural crises determine the relevance of economic systems' modernization, which is a determinant of economic systems' security at different levels in today's competitive conditions.

The aim of the study is to develop methodological aspects for modeling the determining impact of modernization on the enterprise's economic security in competitive conditions using the model of "speed, stability and spaciousness of modernization".

2. Literature Review

Many articles by scientists are devoted to the features of economic security of enterprises in a competitive environment, among which are: Aleksandrov I., Rasskazova O. (2020) [1]; Arefieva O., Arefiev S. (2021) [2]; Azhaman I., Zhydkov O. (2020) [3]; Belyakova G., Belyakov S. (2020) [4; 5]; Butko M., Popelo O. (2020) [6]; Gonchar O., Khachatrian V. (2020) [7]; Graf P., Rowland Z. (2020) [8]; Khanin S., Derhaliuk M. (2021) [9]; Khudolei V., Bespalov M., Tulchinsky R., Kholivko N. (2021) [10]; Kleshchov A., Terentiev O. (2020) [11]; Korepanov G., Yatskevych I. (2020) [12]; Krawczyk-Sokolowska I., Pierscieniak A. (2021) [13]; Rementsov A., Lebedeva N. (2021) [14]; Revko A. (2020) [15]; Saloid S. (2021) [16]; Samiilenko H., Khudolei V. (2021) [17]; Samoilovych A., Garafonova O. (2021) [18]; Shkarlet S., Ivanova N., Dubyna M., Zhuk O. (2020) [19]; Sytnyk H., Vysochyn I. (2021) [20]; Sychev M., Evstafieva A. (2020) [21] et al.

The study (Belyakov et al., 2020) analyzes the process of taking into account the impact of the level of scientific and technological development of the state on the foreign trade potential of machine-building enterprises [4; 5]. The aim of the article (Azhaman et al., 2020) is to study the process of forming the economic potential of service companies for repair and maintenance of vehicles

Manuscript received August 5, 2021
Manuscript revised August 20, 2021
https://doi.org/10.22937/IJCSNS.2021.21.8.16

[3]. Scientists (Kleshchov et al., 2020) study the problems of assessing the potential and improving energy efficiency in mining enterprises [11].

The article (Graf et al., 2020) is based on a study of the company's activities and assessment of its potential using the FCFF discounting methodology [8]. Researchers (Krawczyk-Sokolowska et al., 2021) have identified key factors in the development of innovation potential of Polish enterprises, taking into account the characteristics of innovative enterprises and their impact on the economy [13]. According to the results of the study (Korepanov et al., 2020) it is determined that the assessment of the potential of financial stability is one of the main tasks of commercial diagnostics of enterprises, which are characterized by negative development dynamics [12].

At the heart of the researchers' article (Sychev et al., 2020) is a study of risk assessment of the use of economic potential, which the authors divided into resource, production and financial [21]. The aim of the article (Belyakova et al., 2020) is to form a model of information technology platform for the development of foreign trade potential of machine-building enterprises, as well as features and main components of the information technology platform [4; 5].

Scientists (Gonchar et al., 2020) study the financial activities and economic security of enterprises in today's conditions of instability [7]. The research of scientists (Rementsov et al., 2019) is devoted to topical issues of effective management of the use and development of the production potential of the enterprise [14]. The article (Alexandrov et al., 2020) develops an approach to quantitative assessment of the potential and intellectual capital of agro-industrial companies [1].

3. Methodology

In the study, the authors used general and special methods of scientific knowledge. In addition, a systematic approach was used to model the determining impact of modernization on the enterprise's economic security in competitive conditions.

4. Results

It is necessary to use a methodical approach, which involves using the model of "speed, stability and spaciousness of modernization" in order to model the determining influence of modernization on the enterprise's economic security in the development competitive conditions in the opinion of the authors. The stages of modeling are presented in Fig. 1.

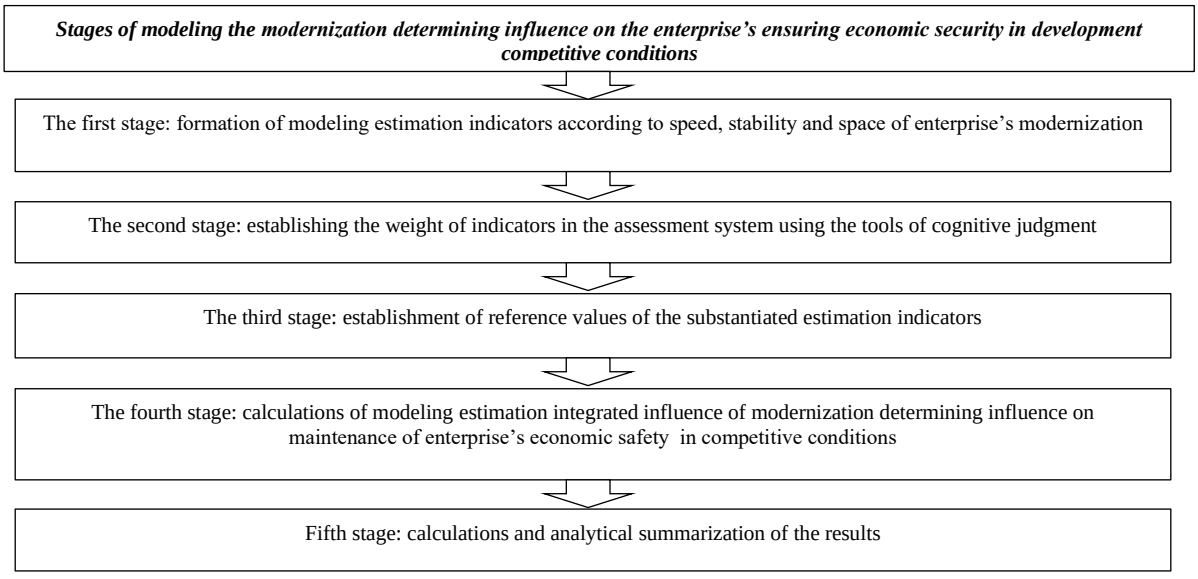

Fig. 1. The Stages of modeling the determining influence of modernization on the enterprise's ensuring the economic security competitive conditions
Source: suggested by the authors

Let is consider in more detail the stages of modeling the determining impact of modernization on the enterprise's economic security in competitive conditions.

At the first stage, the formation of estimation indicators of modeling is carried out. They are justified in relation to the speed, stability and spaciousness of the enterprise modernization.

To model the determining impact of modernization on the enterprise's economic security in development competitive conditions, the evaluation indicators were used, which are presented in table 1. The calculation of evaluation indicators is based on the financial and analytical reporting of enterprises.

Table 1: Estimates of modeling the modernization determining influence on the enterprise's ensuring the economic security in development competitive conditions and their calculations

Indexes	Formula for calculation	Legend
1. Evaluation indicators speed of modernization 1.1. Rate of investment	$I=Ip/Ib$	p – estimated value in the current period; b - base value in the previous period; I - rate of investment; Tm - rate of modernization; Tc - dynamics of costs for innovative activities of the enterprise; Kk - dynamics of changes in the capitalization rate of the enterprise; TI - change in the duration of the innovation and investment process; R - resource intensity of the innovation and investment process; Tt - rate of development of a new market or technology; D - level of digitalization of technologies; IK - the level of the intellectual potential activation; HR - share of highly qualified staff in the total number of employees; K - scale of modernization; Tp - rate of change in the value of the enterprise potential; Pr - profitability of innovation and investment projects; Rt - return on investment; M - change in market share; Mc- modernization costs for the period; Ic - cost of innovation; o - time of the technology development; n - time from the appearance of technologies on the market; P - number of operations, processes at the enterprise; K_{HR} - staff with higher education; H - total number of staff, Am - cost of modernized assets; A – value of the assets of the enterprise; Pc - cost of potential; Ein – cost of the effects of the application of innovations; $Einv$ – income from investment activities
1.2. Pace of modernization	$Tm=Mcp/Mcb$	
1.3. Dynamics of innovation costs	$Tc=Icp/Icb$	
1.4. Dynamics of changes in the capitalization rate of the enterprise	$Kk=Kk_p/Kk_b$	
1.5. Changing the duration of the innovation and investment process	$TI = TIp/TIb$	
2. Estimates of sustainability modernization 2.1. Resource consumption	$R = Rp / Rb$	
2.2. Speed of the development of a new market or technology	$Tt = Tt\ o/\ Tt\ n$	
2.3 Level of digitalization of technologies	$D = A_D/A$	
2.4. Level of the intellectual potential activation	$IK = IKp/IKb$	
2.5. Share of highly qualified staff in the total number of employees	$HR= K_{HR}/H$	
3. Evaluation indicators spatiality modernization 3.1. Scale of modernization	$K =Am/A$	
3.2. Rate of change in the value of the enterprise potential	$Tp = Pcp/Pcb$	
3.3. Profitability of the project implementation	$Pr = Ein/Ic$	
3.4. Return on investment	$Rt = Einv /Mc$	
3.5. Change in market share	$M=Mp/Mb$	

Source: suggested by the authors.

Modeling the modernization determining impact on the enterprise's economic security in competitive development is implemented through the consistency of quantitative, cost and regulatory indicators of enterprise development economic security, which together allow a comprehensive analysis of the dynamics, cost, and direction of the modernization process.

At the second stage of modeling, the modernization determining impact on the enterprise's economic security in development competitive conditions it is necessary to establish the weight of indicators in the evaluation system using the tools of cognitive judgment (see Table 2).

Table 2: Establishing the weight of indicators in the "3S" model using the tools of cognitive judgment, %

Indexes	Cognitive judgments of experts											Average value
Estimates of modernization speed	25	20	25	30	20	20	25	30	20	35	20	23,6
Estimates of sustainability of modernization	40	40	40	35	35	40	40	45	20	35	40	37,3
Estimates of spatial modernization	35	40	35	35	40	35	45	25	45	45	40	39,1
The total weight of the parameter, h.	100	100	100	100	100	100	100	100	100	100	100	-

Source: summarized by the authors based on expert assessments.

Consistency of cognitive judgments of experts is established by applying the concordance coefficient. In this case, we will consider acceptable the value of the coefficient close to 1, and less than 0.4 - unacceptable. Formulas for the calculations are as follows:

$$w = \frac{12\sum \Delta^2}{n^2(m^3 - m)} \quad (1)$$

where n - is the number of surveyed specialists;

m - is the number of variations of the obtained estimated values of indicators;

Δ - deviation.

Deviation in the average sum of ranks is by the formula:

$$\overline{\sum p} = n \times (m+1)/2 \quad (2)$$

To calculate the consistency of the experts' statements, a rank gradation of their estimates is performed (Tables 3-5). We assign ranks to the received estimations in the range from 1 to 9 (that corresponds to quantity of ranges of an estimation with a step in 5 points).

Table 3: Ranks gradation of the estimations of the indicators weight in parameters of factor influence of the integration speed by modernization

Indexes	Expert assessment											Total rank	Δ	Δ^2
	1	2	3	4	5	6	7	8	9	10	11			
1. Estimates of the speed of modernization	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.1. Rate of investment	7	5	4	6	6	5	6	6	5	5	5	60	27	729
1.2. Pace of modernization	6	6	2	5	4	5	6	2	7	5	5	53	20	400
1.3. Dynamics of innovation costs	4	6	8	6	5	4	6	8	4	8	6	65	32	1024
1.4. Dynamics of changes in the capitalization rate of the enterprise	5	7	8	5	8	8	6	8	6	8	6	75	42	1764
1.5. Changing the duration of the innovation and investment process	8	6	8	10	8	8	6	8	8	8	7	85	52	2704
														$\sum\Delta^2$=6621

Source: evaluated by the authors.

The average sum of ranks $\overline{\sum p} = 11 \times (5+1)/2 = 33$.

$$w = \frac{12 * 6621}{11^2 * (5^3 - 5)} = 0,9119.$$

Concordance coefficient for speed parameter indicators:

Table 4: Ranks gradation of the estimations of the indicators weight in parameters of factor influence of the integration stability by modernization

Indexes	Expert assessment											Total rank	Δ	Δ^2
	1	2	3	4	5	6	7	8	9	10	11			
2. Estimates of sustainability of modernization	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2.1. Resource consumption	5	5	5	6	7	7	5	6	5	5	5	61	28	784
2.2. Speed of the development of a new market or technology	6	7	6	7	5	6	6	6	6	4	6	65	32	1024
2.3 Level of digitalization of technologies	7	7	7	8	6	6	7	7	7	8	6	76	43	1849
2.4. Level of the intellectual potential activation	5	5	5	4	6	4	5	4	5	8	5	56	23	529
2.5. Share of highly qualified staff in the total number of employees	7	6	7	5	6	7	7	7	7	7	8	74	41	1681
														$\sum\Delta^2$=5867

Source: evaluated by the authors.

Concordance coefficient for indicators of the stability parameter:

$$w = \frac{12 * 5867}{11^2 * (5^3 - 5)} = 0,8081 \cdot$$

Table 5: Ranks gradation of the estimations of the indicators weight in parameters of factor influence of the space integration by modernization

Indexes	Expert assessment											Total rank	Δ	Δ^2
	1	2	3	4	5	6	7	8	9	10	11			
3. Estimates of the space of modernization	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3.1. Scale of modernization	6	7	5	5	5	4	5	5	5	9	7	63	30	900
3.2. Rate of change in the value of the enterprise potential	6	5	7	6	6	4	5	4	5	5	7	60	27	729
3.3. Profitability of the project implementation	6	5	3	5	6	8	5	6	5	2	4	55	22	484
3.4. Return on investment	7	5	7	7	6	7	6	6	2	7	6	66	33	1089
3.5. Change in market share	5	8	7	7	7	7	9	9	8	6	6	79	46	2116
														$\sum\Delta^2$=5318

Source: evaluated by the authors.

Concordance coefficient for spatial parameter indicators:

$$w = \frac{12 * 5318}{11^2 * (5^3 - 5)} = 0,7325 \cdot$$

Thus, the presented calculations proved the acceptability of the indicators selected for evaluation at the first stage of modeling, taking into account the consistency of expert judgments.

At the third stage of the determining modeling influence of modernization on ensuring the enterprise's economic security in the competitive conditions of development is the establishment of reference values of reasonable estimates.

At the fourth stage, we carry out final estimation calculations of integrated modeling influence of determining influence of modernization on maintenance of enterprise's economic safety in development competitive conditions by a formula:

$$C = S_p * q_p + S_t * q_t + S_n * q_n \quad (3)$$

where Sp, St, Sn – respectively, the parameter of speed, stability and spatial coverage of the determining impact of modernization on the enterprise's economic security in competitive conditions;

qp – respectively, the importance of the parameters of speed, stability and spatial impact of modernization on the enterprise's economic security in competitive conditions.

If the indicator of the integrated modeling impact the determining impact of modernization on the enterprise's economic security in competitive conditions of development (C) is less than 1, we can say that the deterministic impact of modernization on the enterprise's economic security is insufficient. In addition, if more than 1 influence is sufficient and contributes to economic security.

The speed of modernization changes, as described above, is based on monitoring the dynamics of innovation and investment renewal and the duration of the process and is calculated by the formula:

$$S_p = \sum_{i=1}^{n} \frac{Pi}{Pe} * q_i = \frac{I}{I_e} * 0.232 + \frac{Tm}{Tm_e} * 0.205 + \frac{Tc}{Tc_e} \times \times 0.155 + \frac{Kk}{Kk_e} * 0.245 + \frac{TI}{TI_e} * 0.164 \quad (4)$$

where Pi – speed indicators at the enterprise;

Pe – reference value of the dynamics of indicators;

i – the number of indicators in the parameter;

I – rate of investment;

Tm – rate of modernization;

Tc – the dynamics of costs for innovative activities of the enterprise;

Kk – the dynamics of changes in the capitalization rate of the enterprise;

TI – change in the duration of the innovation and investment process.

Stability of the company's integration into the competitive conditions through modernization mechanisms is based on the formula:

$$S_t = \sum_{i=1}^{n} \frac{Ti}{Te} * q_i = \frac{R}{R_e} * 0.223 + \frac{Tt}{Tt_e} * 0.259 + \frac{D}{D_e} \times \times 0.205 + \frac{IK}{IK_e} * 0.164 + \frac{HR}{HR_e} * 0.132 \quad (5)$$

where Ti - indicators of stability of the enterprise integration;

Te – reference values of stability indicators;

i – the number of indicators in the parameter;

R – resource intensity of the innovation and investment process;

Tt – speed of development of a new market or technology;

D – the level of digitalization of technologies;

IP – the level of activation of intellectual potential;

HR – the share of highly qualified staff in the total number of employees.

The space of the enterprise modernization, which determines the future market share and market position in the coverage of innovations and products, is calculated by the formula:

$$S_n = \sum_{i=1}^{n} \frac{Ni}{Ne} * q_i = \frac{K}{K_e} * 0.195 + \frac{Tp}{Tp_e} * 0.227 + \frac{\mathrm{Pr}}{\mathrm{Pr}_e} \times \times 0.241 + \frac{E}{E_e} * 0.195 + \frac{M}{M_e} * 0.141 \quad (6)$$

where Ni – indicators of stability of the enterprise integration;

Ne – reference values of stability indicators; and - the number of indicators in the parameter;

K – modernization scale (the share of coverage of enterprise assets);

Tp – the rate of change in the value of the enterprise potential;

Pr – profitability of innovation and investment projects;

Rt – return on investment;

M – change in market share.

The last stage consists in approbation of the offered approach of modeling of determining influence of modernization on maintenance of economic safety of the enterprise in competitive conditions of development and carrying out of analytical results as a result of the received data.

As an example of testing the modeling of the determining impact of modernization on the economic security of the enterprise in competitive conditions, the authors chose the following enterprises: JSC "Ukrzaliznytsia", SE "UkrAerorukh", SE "ASU", SE IA "Boryspil", JSC "Ukrposhta", KP "Kyivpastrans". The table 6 presents calculations for the proposed model solution.

Table 6: Results of determining modeling influence calculations of modernization on maintenance of enterprise's economic safety in competitive conditions of development

Period	Indicators			
	The scope of coverage of the determining modernization impact on economic security	The stability of the determining modernization impact on economic security	The speed of the determining modernization impact on economic security	The level of impact modernization on the enterprise's economic security in competitive conditions
JSC "Ukrzaliznytsia"				
2016	0,929	0,221	0,479	1,619
2017	0,909	0,251	0,588	1,714
2018	0,861	0,277	0,061	1,198
2019	0,873	0,314	0,051	1,132
2020	0,852	0,334	0,073	1,262
Average	*0,885*	*0,279*	*0,250*	*1,385*
JSC "Ukrposhta"				
2016	0,462	0,927	0,424	1,811
2017	0,734	0,423	0,213	1,362
2018	0,492	0,694	0,544	1,732
2019	0,674	1,119	0,413	2,201
2020	0,522	0,998	0,553	2,062
Average	*0,577*	*0,832*	*0,429*	*1,834*
SE "ASU"				
2016	0,240	0,330	0,212	0,782
2017	0,628	0,353	0,204	1,185
2018	0,636	0,355	0,179	1,169
2019	0,670	0,291	0,104	1,065
2020	0,760	0,317	0,091	1,168
Average	*0,587*	*0,329*	*0,158*	*1,074*
SE "Ukraerorukh"				
2016	0,530	0,077	0,351	0,959
2017	0,473	0,076	0,398	0,947
2018	0,424	0,474	0,379	1,277
2019	0,497	0,051	0,051	0,552
2020	5,875	0,771	0,771	12,572
Average	*1,560*	*0,290*	*0,390*	*3,261*
SE IA "Boryspil"				
2016	0,752	0,279	0,143	1,173
2017	0,718	0,367	0,169	1,254
2018	0,775	0,432	0,154	1,361
2019	0,963	0,534	0,206	1,703
2020	0,957	0,273	0,129	1,359
Average	*0,833*	*0,377*	*0,160*	*1,370*
KP "Kyivpastrans"				
2016	0,800	0,212	0,055	1,067
2017	0,752	0,166	0,122	1,041
2018	0,705	0,182	0,142	0,029
2019	0,956	0,222	0,044	1,221
2020	0,095	0,018	0,005	0,118
Average	*0,662*	*0,160*	*0,074*	*0,695*

Source: constructed by the authors based on the evaluation results

The results of calculations presented in table 6 show that almost all enterprises have a sufficient modernization impact level on the enterprise's economic security in a competitive conditions because the value of C is greater than one. The exception is KP "Kyivpastrans" which in 2018 and 2020 this figure was less than 1 and the average value was 0.695. KP "Kyivpastrans" also has the lowest values of sustainability and speed of modernization impact. JSC "Ukrzaliznytsia" has the lowest value of the scope of modernization changes. The largest value of the modernization impact level on the enterprise's economic security in the development competitive conditions is SE "UkrAerorukh", which is almost twice as much as the integrated value of the impact of modernization KP "Kyivpastrans".

5. Conclusions

The scientific novelty of this study is to develop modeling of the modernization determining impact on the enterprise's economic security in competitive development, which, in contrast to existing approaches, involves the formation of estimates and their weighting factors in

accordance with the speed, stability and spaciousness modeling of the modernization determining influence. Fifteen indicators were selected throughout the evaluation day, based on which the parameters of speed, stability and spatial coverage of the modernization determining impact on the enterprise's economic security in competitive conditions were determined.

This approach has a practical importance because it makes it possible to identify changes in the economic security of the enterprise in competitive conditions because of the realization of its modernization potential.

The approbation of the selected enterprises showed that five of the six surveyed enterprises have a sufficient indicator of the integrated modernization impact modeling on economic security, which contributes to economic security. Best position on the integrated modernization impact is the SE "Ukraerorukh" and the worst position KP "Kyivpastrans".

In the context of the study, it should be noted that further research requires the development of a management system for modernization potential as determinants of enterprise's economic security, which will help increase the enterprises' competitiveness in modern conditions.

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