MODELING ASSESSMENT OF INVESTMENT SECURITY OF ENTERPRISES TO ENSURE SUSTAINABLE DEVELOPMENT OF THE STATE

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Abstract. The article proposes the author's modeling of assessing the investment security of enterprises to ensure the sustainable development of the state. The impact of investments on the size of the gross domestic product was studied. The efficiency of investments was analyzed separately for large, medium and small enterprises. The integral indicator of the assessment of investment security of enterprises is calculated. Using the method of exponential smoothing, the predicted values of the amount of investments from various sources were calculated. The proposed modeling of the assessment of investment security of enterprises to ensure the sustainable development of the state can be used in practical work by entrepreneurs, state authorities or other interested market stakeholders.

Keywords: *Innovations, investments, investment security, sustainable economic development, modeling of enterprise investment security assessment.*

Introduction

Assessment of investment security of Ukrainian enterprises is important in the context of ensuring the sustainable development of the state. A stable inflow of investments into the national economy is an important prerequisite for socio-economic development, the creation of new jobs, the development of industry and the formation of a new type of knowledge-based economy. At the same

time, the dynamism of the institutional environment, the imperfection of regulatory support for the regulation of sustainable development and investment policy requires a constant review of methods for assessing the investment security of enterprises, taking into account current trends.

Literature review. In the scientific world, there is a significant amount of research on the modeling of the security assessment of enterprises to support the sustainable development of the state. Z. Varnaliy and A. Mehmed deeply investigate the need to ensure the financial security of business entities (Varnaliy and Mehmed, 2022). T. Obidennova and Yu. Degoeva offer the author's method of investment analysis and cost effectiveness assessment when investing funds in the creation of a management system, which is absolutely necessary to support sustainable development (Obidennova and Degoeva, 2022). M. Melnychuk offers methodical approaches to assessing the investment attractiveness of a small business entity in the context of market changes (Melnychuk, 2022). I. Horobinska defines a methodical approach to assessing the sustainability of enterprises based on a two-component assessment (Horobinska, 2022). N. Bryukhovetska and O. Khasanova consider the advantages and disadvantages of existing methods of assessing the investment attractiveness of enterprises (Bryukhovetska and Khasanova, 2009). A wide range of researchers offer an innovative set of methodological tools, which should be included in our research (Mayovets et al., 2021; Gryshchenko et al., 2021; Stolyarov et al., 2022; Semenov et al., 2021). Without diminishing the importance of the listed works of scientists, we note the need to deepen and expand the methods of assessing the investment security of enterprises to ensure the sustainable development of the state, taking into account the modern development of the state.

Research methodology. To assess the investment security of Ukrainian enterprises, we will determine the impact of investments on the value of the gross domestic product. The information base of the research is data on the size of investments received from various sources during 2010-2020. We denote by t the serial number of the year in the given period.

Let's denote the amount of investments at the expense of state budget funds by x1, local budget funds by x2, own funds of enterprises and organizations by x3, bank loans and other loans by x4, funds of non-resident investors by x5.

Since the impact of investments on the size of the gross domestic product can be manifested after a certain period of time, we will determine the correlation coefficients between the size of investments and the size of GDP several years after the implementation of these investments. We denote by ki(Δ) the correlation coefficient between the value of xi and the value of the gross domestic product Δ years after the implementation of the i-th type of investment. These coefficients are determined by the formula:

$$k_i(\Delta) = \frac{\sum_{t=1}^{T-\Delta}(x_i(t)-\bar{x}_{i\Delta})(w(t+\Delta)-\bar{w}_\Delta)}{\sqrt{\sum_{t=1}^{T-\Delta}(x_i(t)-\bar{x}_{i\Delta})^2 \sum_{t=1}^{T-\Delta}(w(t+\Delta)-\bar{w}_\Delta)^2}} \quad (1)$$

where xi(t) is the value of the indicator xi in the tth year of the retrospective period, w(t+Δ) is the value of the gross domestic product in the year whose number in the retrospective period is equal to t+Δ, T is the duration of the retrospective period (T=11), x ̅_iΔ - the average value of the indicator xi for the time interval from t=1 to t=T-Δ, w ̅_Δ - the average value of the GDP value for the time interval from t= Δ+1 to t=T.

To check the significance of the obtained correlation coefficients, we will use the Student's test. We determine the empirical value of this criterion using the formula:

$$t_{emp}(i,\Delta) = \frac{k_i(\Delta)\sqrt{T-\Delta-2}}{\sqrt{1-(k_i(\Delta))^2}} \quad (2)$$

If the obtained value exceeds in absolute value the critical value t_kr (α,T-Δ-2) of this criterion, which corresponds to the confidence probability α and the number of degrees of freedom T-Δ-2, then the correlation coefficient is considered significant. The value of the confidence probability α is chosen equal to 0.95.

We will evaluate the impact of investments on the value of the gross domestic product within three years from the moment of making these investments. To do this, we determine the correlation coefficients ki(Δ) and the empirical values of the Student's criterion temp(i, Δ) when Δ changes from 0 to 3. The results of the calculations are shown in Table 1.

Table 1.

Correlation coefficients between the amounts of investments and the volume of GDP and the corresponding values of the Student's criterion

Investments for the account	$k_i(0)$	$k_i(1)$	$k_i(2)$	$k_i(3)$	$t_{emp}(i, 0)$	$t_{emp}(i, 1)$	$t_{emp}(i, 2)$	$t_{emp}(i, 3)$
state budget funds	0,6747	0,9217	0,6085	-0,1317	2,7426	6,7192	2,0287	-0,3256
funds from local budgets	0,1101	0,3474	0,3913	0,1266	0,3322	1,0478	1,1248	0,3127
own funds of enterprises and organizations	0,9582	0,7275	0,0515	-0,5996	10,0480	2,9989	0,1366	-1,8353
bank loans and other loans	0,9087	0,7264	0,1436	-0,4975	6,5310	2,9897	0,3839	-1,4047
funds of non-resident investors	0,3744	0,2021	-0,0569	-0,4831	1,2112	0,5838	-0,1508	-1,3516

Source: calculated by the authors

Critical values of the criterion t_kr (α,T-2)=1.8331, t_kr (α,T-3)="1.8595" , t_kr (α,T-4)="1.8946" , t_kr (α, T-5)="1.9432" .

Comparing empirical and critical values of Student's criterion, the following conclusions can be drawn

The relationship between GDP and investments made in the current year at the expense of state budget funds (correlation coefficient 0.6747), at the expense of own funds of enterprises and organizations (correlation coefficient 0.9582) and at the expense of bank credits and other loans (correlation coefficient 0.9087).

The relationship between GDP and investments made last year at the expense of state budget funds (correlation coefficient 0.9217), at the expense of own funds of enterprises and organizations (correlation coefficient 0.7275) and at the expense of bank loans and other loans (correlation coefficient 0.7264).

The relationship between GDP and investments made in the year before last at the expense of the state budget was revealed (correlation coefficient 0.6085).

No connections were found between GDP and investments made in the year before last at the expense of own funds of enterprises and organizations and at the expense of bank credits and other loans.

No relationship was found between GDP and investments made three years ago.

No connections were found between GDP and investments at the expense of funds from local budgets and funds from non-resident investors.

We will investigate the effectiveness of investments separately for large, medium and small enterprises. We denote the amount of capital investment in large enterprises through Q1, in medium-sized enterprises through Q2, and into small enterprises through Q3. The value of investments Qj in the tth year of the retrospective period is denoted by Qj(t). To evaluate the efficiency of investments for the jth group of enterprises (where j=1 corresponds to large enterprises, j=2 to medium enterprises, and j=3 to small enterprises), we will take the following indicators:

P1j - volume of sold products (million USD);

P2j – net profit (thousands of US dollars);

P3j is the profitability of all activities.

The value of the Pkj indicator in the tth year of the retrospective period is denoted by Pkj(t). Let's determine the correlation coefficients between the amounts of investments Qj and indicators Pkj in the year when these investments were made and a year after their implementation. We denote by ρkj(Δ) the correlation coefficient between the amount of investments Qj and the value of the indicator Pkj Δ years after these investments were made. These coefficients are determined from the equality:

ρ_kj (Δ)=(∑_(t=1)^(T-Δ) 〖(Q_j (t)-Q ̅_jΔ)(P_kj (t+Δ)-P ̅_kjΔ)〗)/√(∑_(t =1)^(T-Δ) 〖(Q_j (t)-Q ̅_jΔ)^2 ∑_(t=1)^(T-Δ) 〖(P_kj (t+Δ)-P ̅_kjΔ)^2 〗 〗) (3)

where T is the duration of the retrospective period (T=11), Q ¯_jΔ is the average value of the Qj indicator for the time interval from t=1 to t=T-Δ, P ¯_kjΔ is the average value of the Pkj indicator for the time interval from t= Δ+1 to t=T.

We determine the correlation coefficients ρkj(Δ) and the corresponding empirical values of the Student's criterion temp(j,k,Δ) for Δ=0 and Δ=1. The results of the calculations are given in Table 2.

Table 2.

Correlation coefficients between the amounts of investments and indicators of enterprise activity and the corresponding values of the Student's criterion

Indicators	$\rho_{kj}(0)$	$\rho_{kj}(1)$	$t_{emp}(j,k,0)$	$t_{emp}(j,k, 1)$
Large enterprises				
volume of sold products	0,887345	0,572489	5,773141	1,974897
net profit	0,230902	-0,49737	0,711944	-1,62156
profitability of all activities	0,16607	-0,5265	0,505225	-1,7516
Medium enterprises				
volume of sold products	0,945023	0,751176	8,669875	3,218661
net profit	0,383776	-0,27544	1,246799	-0,81042
profitability of all activities	0,352841	-0,31905	1,131285	-0,95218
Small businesses				
volume of sold products	0,725835	0,634379	3,16558	2,321141
net profit	0,214696	-0,51065	0,659467	-1,67988
profitability of all activities	0,240984	-0,40428	0,744906	-1,25018

Source: calculated by the authors

The corresponding critical value of Student's criterion for Δ=0 is t_kr (α,T-2)=1.8331, and for Δ=1 is t_kr (α,T-3)="1.8595". Therefore, for all types of enterprises, a significant impact of investments on the volume of sold products was found, but no impact of investments on net income and profitability of the entire activity was found.

Let's investigate the impact of investments in industry on the volume of the gross domestic product. To do this, we will determine the correlation coefficients between the amounts of investments in industry and the volume of GDP in the year when these investments were made and a year after their implementation. The indicated correlation coefficients are equal to 0.94852 and 0.62046, respectively. The empirical values of the Student's test are equal to 8.98456 and 2.23773, respectively, which exceeds the critical values. Therefore, investments in industry significantly affect the GDP in the year when they are made and in the following year.

Similarly, the impact on GDP of investments in intangible assets was studied. The correlation coefficients between the amounts of these investments and the volume of GDP in the year when the investments were made and a year after their implementation are equal to 0.67325 and 0.57997, respectively. The corresponding empirical values of the Student's test are 2.73152 and 2.01364, which exceed the critical values. Thus, investments in intangible assets also have a significant impact on the size of GDP in the current and next year.

To study the effectiveness of investment activity in general, we will define an integral indicator that combines indicators xi of investment values obtained from various sources. To create such an indicator, we normalize the indicators xi, that is, we transform them in such a way that the obtained indicators wi are dimensionless, and their values belong to the interval [0, 1]. For normalization, we use equality:

$$w_i(t) = \frac{x_i(t) - x_i^{min}}{x_i^{max} - x_i^{min}} \qquad (4)$$

Where wi(t) is the value of the indicator wi in the tth year of the retrospective period, 〖_x^(i 〖 max max⁡〖x_i 〗 (t)〗 ┬(1≤t≤T))〗, 〖_x^(i 〖 min min⁡〖x_i 〗 (t)〗 ┬(1≤t≤T))〗. The values of normalized indicators for different types of investments are shown in Table 3.

Table 3.

Values of normalized indicators of investment amounts obtained from various sources

Source of investment	Years										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
State budget funds	0,542	1,000	0,927	0,278	0,000	0,044	0,068	0,177	0,312	0,494	0,341
Funds from local budgets	0,133	0,281	0,339	0,209	0,000	0,092	0,327	0,631	0,802	1,000	0,805
Own funds of enterprises and organizations	0,431	0,777	1,000	0,948	0,352	0,000	0,100	0,248	0,510	0,567	0,409
Bank loans and other loans	0,481	0,908	1,000	0,844	0,219	0,000	0,028	0,041	0,174	0,411	0,343
Funds of non-resident investors	0,712	1,000	0,967	0,827	0,721	0,545	0,563	0,295	0,000	0,202	0,169

Source: calculated by the authors

The integral assessment of investment activity is determined from equality

W(t)=∑_(i=1)^5 〖β_i w_i (t)〗 (5)

where W(t) is the value of the integral assessment in the tth year, βi is the weighting factor of the indicator wi.

To determine the weighting coefficients βi, we will use the method of the modified principal component, which makes it possible to take into account the correlations between the indicators in the integral evaluation. Let's define the covariance matrix K, the elements of which are the covariance coefficients between the indicators wi and wj, where the indices i and j vary from 1 to 5. This matrix has the following form:

0,103205	0,011413	0,072622	0,092917	0,045667
0,011413	0,101852	0,00584	-0,01561	-0,08043
0,072622	0,00584	0,094342	0,100416	0,044314
0,092917	-0,01561	0,100416	0,12154	0,074104
0,045667	-0,08043	0,044314	0,074104	0,103839

We determine the maximum eigenvalue λmax of this matrix. To do this, we will solve the equation:

$$\begin{vmatrix} 0{,}103205-\lambda & 0{,}011413 & 0{,}072622 & 0{,}092917 & 0{,}045667 \\ 0{,}011413 & 0{,}101852-\lambda & 0{,}00584 & -0{,}01561 & -0{,}08043 \\ 0{,}072622 & 0{,}00584 & 0{,}094342-\lambda & 0{,}100416 & 0{,}044314 \\ 0{,}092917 & -0{,}01561 & 0{,}100416 & 0{,}12154-\lambda & 0{,}074104 \\ 0{,}045667 & -0{,}08043 & 0{,}044314 & 0{,}074104 & 0{,}103829-\lambda \end{vmatrix} = 0 \quad (6)$$

The maximum eigenvalue of the covariance matrix is the maximum root of this equation λmax = 0.3323. The weight coefficients βi are proportional to the squares of the coordinates of the eigenvector R=(r_1,r_2,r_3,r_4,r_5) of this matrix, which corresponds to the obtained maximum eigenvalue. The coordinates of this vector are determined from the matrix equation KR=λmaxR. After solving this equation, we get

r_1 = 0,4673, r_2 = -0,1557, r_3 = 0,4692, r_4 = 0,5927, r_5 = 0,4314.

The weighting coefficients βi are determined from the equality:

$$\beta_i = \frac{r_i^2}{\sum_{i=1}^{5} r_i^2} \quad (7)$$

We get β1 = 0.21837, β2 = 0.02424, β3 = 0.22015, β4 = 0.35129, β5 = 0.18611. Thus, the integral assessment of investment activity has the form:

W = 0.21837w1 + 0.02424w2 + 0.22015w3 + 0.35129w4 + 0.18611w5

The value of this estimate during the retrospective period is shown in Table 4.

Table 4.

Integrated assessment of investment activity

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
W	0,5180	0,9011	0,9620	0,7249	0,2885	0,1133	0,1592	0,1777	0,2608	0,4387	0,3360

Source: calculated by the authors

The dynamics of the integral assessment of investment activity is shown in Figure 1.

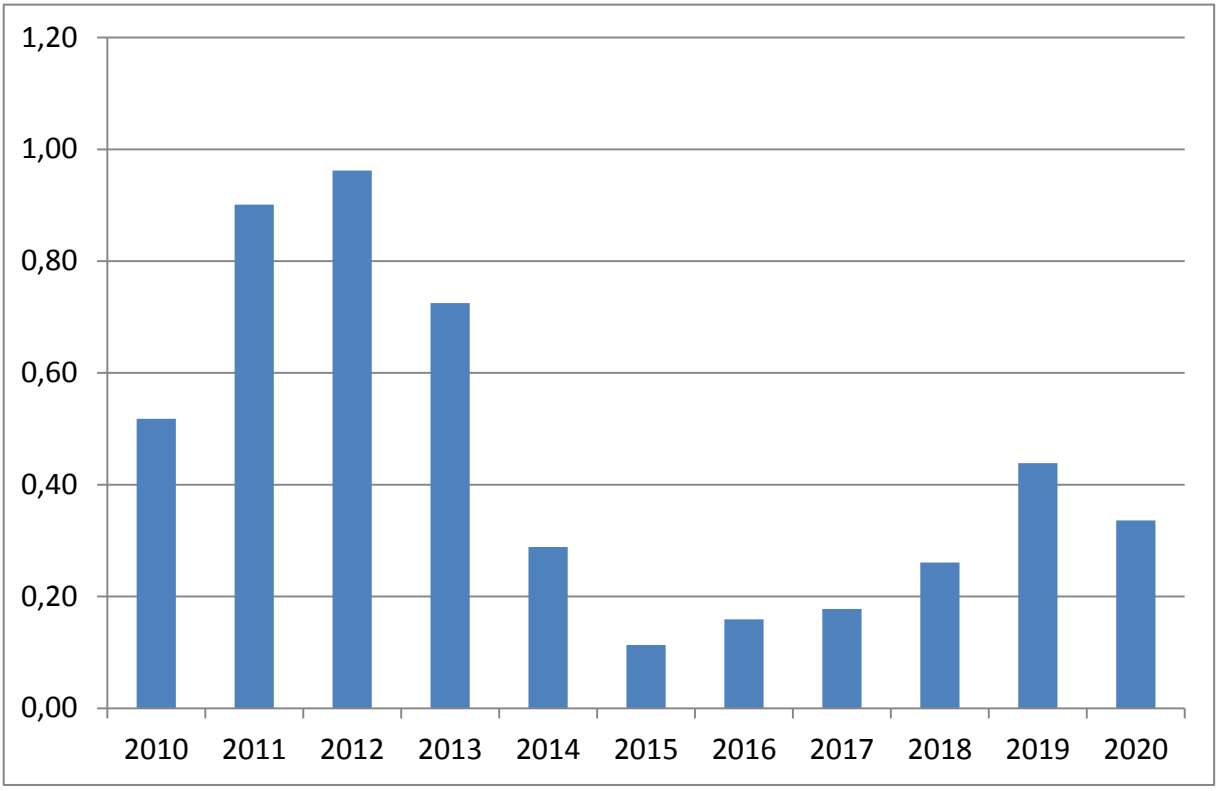

Figure 1. Dynamics of integrated assessment of investment activity
Source: calculated by the authors

In order to make decisions regarding the assessment of the level of investment security, it is important to obtain a scientifically based forecast of both the integrated assessment of investment activity and the volume of investments from various sources. To obtain such forecasts, it is advisable to use the method of exponential smoothing, which makes it possible to give greater weight to data obtained in relatively recent periods. When using this method, the series of dynamics is aligned on the basis of a weighted moving average, the weighting coefficients of which correspond to the exponential distribution law. The predicted indicator xi is approximated by the second degree polynomial x_i (t)=g_0+g_1 t+g_2 t^2/2!, the coefficients of which are determined by the method of least squares.

The values of the aligned series for the initial year of the retrospective period are calculated according to the formulas:

$$\begin{cases} x_i^1(t) = g_0 - \frac{1-\gamma}{\gamma} \cdot g_1 + \frac{(1-\gamma)\cdot(2-\gamma)}{2\cdot\gamma^2} g_2; \\ x_i^2(t) = g_0 - \frac{2(1-\gamma)}{\gamma} \cdot g_1 + \frac{2(1-\gamma)\cdot(3-2\gamma)}{2\cdot\nu^2} g_2; \\ x_i^3(t) = g_0 - \frac{3(1-\gamma)}{\gamma} \cdot g_1 + \frac{3(1-\gamma)\cdot(4-3\gamma)}{2\cdot\gamma^2} g_2, \end{cases} \quad (8)$$

where γ is a number from 0 to 1, which reflects the degree of increase in the weight of newer values of the indicator.

For the following years, the values of the aligned series are calculated on the basis of recurring equalities:

$$x_i^1(t) = (1-\gamma)x_i^1(t-1) + \gamma x_i(t)$$

$$x_i^2(t) = (1-\gamma)x_i^2(t-1) + \gamma x_i^1(t)$$
$$x_i^3(t) = (1-\gamma)x_i^3(t-1) + \gamma x_i^2(t) \quad (9)$$

When moving to each subsequent year, the values of the coefficients g0, g1 and g2 change dynamically. Their new values are calculated according to the formulas:

$$\begin{cases} g_0 = 3x_i^1(t) - 3x_i^2(t) + x_i^3(t); \\ g_1 = \frac{\gamma}{2(1-\gamma)^2}\left[(6-5\gamma)x_i^1(t) - 2(5-4\gamma)x_i^2(t) + (4-3\gamma)x_i^3(t)\right]; \\ g_2 = \frac{\gamma^2}{(1-\lambda)^2}\left(x_i^1(t) - 2x_i^2(t) + x_i^3(t)\right). \end{cases} \quad (10)$$

The values g0, g1, g2 obtained for the final year of the retrospective period are used to calculate the forecast value of the indicator according to the equation x_i (t)=g_0+g_1 t+g_2 t^2/2!, where the variable t takes values equal to the numbers of the years of the forecast period

The determined projected values of the amount of investments from various sources are shown in Table 5.

Table 5.

Projected amounts of investments

Sources of investment	Projected amount of investments, million USD				
	2021	2022	2023	2024	2025
State budget funds	343,230	376,091	452,464	572,347	735,742
Funds from local budgets	1978,011	1954,263	1888,532	1780,817	1631,119
Own funds of enterprises and organizations	14039,260	13686,590	13180,337	12520,502	11707,084
Bank loans and other loans	1591,264	1663,173	1805,748	2018,988	2302,895
Funds of non-resident investors	138,194	137,334	145,151	161,645	186,815

Source: calculated by the authors

Conclusions

Thus, we can determine that the integrated assessment of investment activity increases during the years 2010-2012, then by 2015 there is a significant decline, in 2016-2019 the assessment increases slightly, although it does not reach the level of 2012, and in 2020 the assessment is relatively decreases compared to the previous year. Modeling of the projected amounts of investments proved that funds from the state and local budgets, bank loans and other loans, funds from non-resident investors will tend to increase. At the same time, the own funds of enterprises and organizations will decrease during the forecasted five years. Thus, there is a need to review the state investment policy and develop tools to improve the investment attractiveness of our country. There is a need for state support for enterprises in order to accumulate reserve own funds, which will be involved to ensure the sustainable development of the enterprise. Only a balanced state investment policy can improve the socio-economic development of the state and support its sustainable development in the face of economic changes.

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