Assessment of the Regions' Investment Attractiveness for Post-War Recovery: The Case of Ukraine

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ABSTRACT

The paper analyzes the directions for Ukrainian economic recovery after the war. The successes stories of the countries, that restored their economies after the war, were explored. As a result, the best practices of Israel seem most suitable for Ukraine.

Also, present research determines the priority areas for raising the investment attractiveness of the Ukrainian regions and tests the practical application of the results of their investment appeal evaluation, primarily on the basis of our own approach for their marketing, advancement and disclosure the capability. The paper's uniqueness lies in its emphasis on the proposed marketing territorial investments, in accordance with the results of a comprehensive monitoring of the region-specific investment climate in Ukraine.

A number of indicators effects on the regions' investment attractiveness. Comparing the regions among themselves, according to its figures, gives a new leader every time. The proposed Rasch mathematical model allows obtaining an integral assessment of the regions' investment attractiveness with the appropriate ranking. Such estimates can be used both by investors at the initial stages of choosing a region for investment and by representatives of local authorities to assess the investment attractiveness of the territory for a certain period. The future recalculation of these data will be based on the situation at the front and changes in the economic structure of each region. After the war, the casualties of each region must be assessed and an international audit conducted.

Key words: Ukraine, post-war recovery, investment attractiveness, Rasch model, assessment.
Jel Classification: E 22.

1. Introduction

The post-war reconstruction of Ukraine should be aimed at a radical change in the structure of the economy, the transition from an agrarian-raw type to an industrial-innovative one, based on the creation of a modern high-tech. The destruction of Ukraine's infrastructure and economy is being discussed with various ideas, opinions, and visions after five months of war.

Ukrainian infrastructure and property were hardest hit by the Russian invasion. Final figures can be given after the war. Ukrainian companies need two things: first, to form partnerships with European and American companies for technology transfer, and second, to obtain financial resources. The European Council has already agreed to create a Trust Fund for Solidarity with Ukraine for its recovery after the end of the war with Russia.

A strong political will, a clear and unyielding position of the national elite in defence of national interests and the right of the Ukrainian state for innovative development and

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membership in the EU will be of decisive importance in the approval by international partners of the development scenario chosen by Ukraine.

It is fundamental to resolve the issue of providing Ukraine with international financial assistance, mainly on an irrevocable basis (90%) as a condition for ensuring its stability. For this, it will be extremely important for Ukraine to ensure the transparency of the spending money of foreign funds, to maintain the high level of trust that has been established between the authorities of Ukraine and the EU leadership, and not to spoil it due to corruption and misuse of funds. The Government of Ukraine, 2022, formed nine basic principles on which the plan for the rapid recovery of Ukraine is based (Fig. 1):

From June 23, 2022, Ukraine has become a candidate for membership in the European Union. The EU is a political, economic and cultural association with the characteristics of a confederation, which includes 27 European states with population of 447,706,209 people.
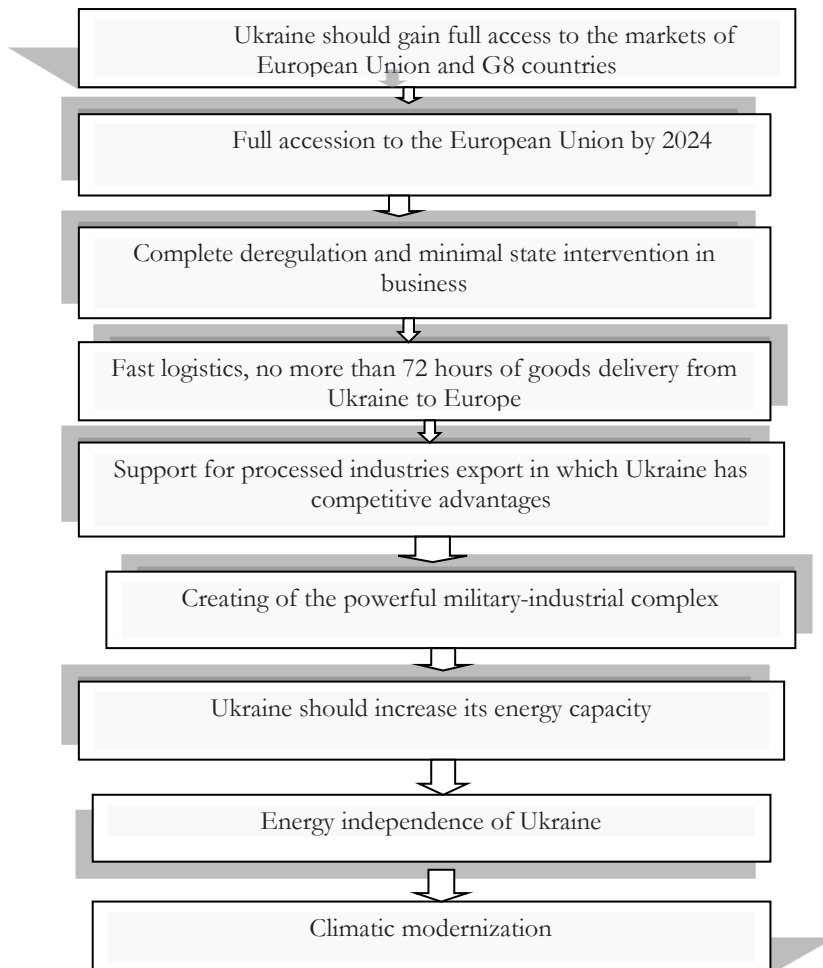

Fig. 1. Principles of Ukrainian economy recovering, which was formed by the Government of Ukraine

It should be noted that the post-war recovery of the economy is to a large extent country or region-specific, because the losses and the potential of the regions are different. The regional level was chosen to study, based on the fact that, while making decisions about investing, the foreign business community takes into account regional factors. The same is confirmed by our quantitative/empirical research of regional factors' influence on FDI. The innovative model of regional economic development ensures reproduction of the existing potential and attraction of investments, development of science and research and should be based on the creation of an innovative product.

2. Empirical analysis

The International Monetary Fund has announced that it expects Ukraine's GDP to fall by 35% by 2022 due to Russia's military invasion. On 12 October 2022, the IMF predicted that the Ukrainian economy would fall in 2022 and decided not to make any forecasts for Ukraine for the next 5 years. In 2022, GDP was expected to fall by 35% and inflation to reach 30%. The Fund will not make any forecasts for Ukraine for the next 5 years due to the high degree of uncertainty caused by the war unleashed by Russia. In addition, innovation processes in the industry in these regions showed unstable and declining dynamics. The destruction and losses suffered by Ukraine as a result of Russia's armed aggression have exposed the existing structural and technological problems of industrial regions, and put the task of urgently addressing them on the agenda. Thus, according to a joint estimate by the UN, the World Bank, the European Commission and the Government of Ukraine, during the year of war (from February 2022 to February 2023), the total amount of direct damage and losses incurred by the country reached USD 423.8 billion. The most affected were commercial and industrial enterprises (USD 96.7 billion), the residential sector (67.6), transport infrastructure (67.3), agriculture (40.2), energy and mining (USD 37.8 billion) (Himmelfarb 2023). Among the regions, the frontline industrial oblasts suffered the most damage and losses - Donetsk (USD 78.3 billion), Kharkiv (62.3), Luhansk (36.0) and Zaporizhzhia (USD 25.4 billion) oblasts. The needs for the reconstruction of these regions amount to 188.2 billion US dollars (Himmelfarb 2023). Due to the destruction of industrial enterprises, infrastructure, forced migration (8 million people, according to the National Bank of Ukraine) and the economic slowdown caused by the military invasion, the unemployment rate in Ukraine increased by 16% - from 9.8% in 2021 to 25.8% in 2022 - which is equivalent to 3.2 million people, consumer prices increased by 26.6% (for food - by 34.4%) according to Ministry of Finance in Ukraine (2022).

Technological backwardness, structural imbalance of the economy industrial oblasts of Ukraine (Slobozhansky, Prydniprovsky, Donetsk macro-regions), dominated by industries with low technology intensity and weak innovation activity, have remained their pressing problems for many years. Even in the pre-war period, the regions with the highest industrial potential (Dnipro industrial potential (Dnipro, Donetsk, Zaporizhzhia, Poltava oblasts) were lagging behind other regions in many parameters of innovation development. For example, by the State Statistics Service of Ukraine, if the share of innovatively active industrial enterprises in Dnipropetrovska and Donetska oblasts of innovatively active industrial enterprises in the total number of industrial enterprises was 15.1 per cent and

12.4 per cent, respectively, in Ivano Frankivsk and Ternopil regions - 22.4% and 39.6%. Despite the fact that industrialised regions provided the main share of the volume of innovative industrial products sold, the share of innovative products in regional industrial output was very low and did not exceed 3% (but with the exception of Donetsk (6.3%) and Luhansk (4.6%) oblasts. In addition, innovation processes in the industry in these regions showed unstable and declining dynamics. The destruction and losses suffered by Ukraine due to Russian armed aggression have exposed the existing structural and technological problems of industrial regions, and put the task of urgently addressing them on the agenda.

To rebuild Ukraine after the war, it is advisable to use the experience of countries that were at war and had economic success.

Table 1 shows examples of the countries' actions for rebuilding their economies after the war. The reconstruction plan of Israel and post-war plan of Germany are the most suitable for Ukraine. Israel's experience demonstrates the possibility of dynamic economic development even in the conditions of constant military threats.

However, there are a number of tools common to all the countries that were successfully restored after the war: liberalization of the economy, creation of a significant number of jobs by the state, the export orientation of the economy and an external financial resources infusion. But even with all tools of economic growth at one's disposal, it is important to use them effectively, because it depends on whether the country will succeed or join to the long list of failed examples, such as Afghanistan or Iraq. Israel's experience should be used to identify new growth points.

That is why a high share of spending money on the military sphere is inevitable. Two more wars - the Six-Day War (1967) and the Doomsday War (1973) - gave an important momentum to development of Israel's military-industrial complex. It was the field of the military industry that became the main employer and allowed the country to be the leader of the military industry, and the export of weapons became an important source of budget replenishment. So, the military-industrial complex in Ukraine and its development can become a new point of growth (Table 1).

Table 1. The experience of countries that restored their economy after the war

Recovery experience	years	Content of reforms	Result
Recovery of Europe and the Marshall Plan	1948 – 1953	The Marshall Plan was aimed primarily at industrial recovery. The mechanism was the following: the US government supplied goods and services to the recipient countries as part of the aid. The governments of these countries, in turn, sold goods to businesses and individuals, who paid the dollar value of them in local currency. Then this money was used for the needs of the countries. In general, most of money was spent on goods from the USA: $3.4 billion – on the import of raw materials and semi-finished products, $3.2 billion – on food, feed and fertilizers, $1.9 billion – on vehicles and equipment, $1.6 billion - for fuel. The accumulated funds could be used to invest in reconstruction, as was done in France and Germany, or to pay off the	According to the results of plan implementation, economies of the recipient countries grew by 30% compared to the pre-war period. The most successful were the restoration of West Germany (although only 9% of the entire fund went to it) and Italy.

		government's war debts, as happened in Great Britain. Funds were accumulated and controlled by special funds under the joint management of the authorities of the recipient countries and the United States. The same funds kept track of the country's needs and controlled spending.	
The economic miracle of West Germany	**1948 – 1960**	The ideology of the German economic miracle was generally liberal: the abolition of state monopolies and, at the same time, the stimulation of competition and investment, launching of privatization mechanisms. Due to the war, the country's money supply was reduced by more than 93%. Economic growth was based on the restoration and reorientation of military enterprises to the food, textile industry, and production of household appliances and cars.	In 1962, the level of industrial production in West Germany tripled its pre-war level. The Federal Republic of Germany held the second place in terms of gold and foreign exchange reserves and the third place after the USA and England in terms of industrial production. The average annual rate of economic growth in 1950–1966 was about 9.2%.
Italian boom	**1953 – 1973**	Italy received $1.5 billion in aid under the Marshall Plan. Mainly in the form of goods and equipment. In 1951, the Italian government developed and began to implement the so-called priority system. This system established the order, when the government would distribute raw materials, so that the big monopolists would be the first to receive raw materials that they believed, were in short supply at any given time. The same principle worked in the granting of loans: monopolies received 85 billion Italian lire in credit, while small and medium-sized businesses received 8 times less. For instance, "Fiat" received 35% of loans under the Marshall Plan. The domestic financial market was also inaccessible to small and medium-sized companies. Of the 600 billion lire collected from 1948 to 1952 through the issuance of shares and bonds, the largest part was again received by large concerns. As a result, Italian monopolists began to rapidly develop and capture foreign markets, which led to the growth of industrial production. In addition to supporting monopolies, an important step was the agrarian reform of 1950-1955. Its essence was that the state bought land plots with an area of more than 100 hectares, and then sold them to citizens for payments. Total of 1.5 million hectares of land were sold, that helped to increase the efficiency of agricultural production and create demand for the production of agricultural machinery.	Italy fully recovered after the war by the early 1950s, and in the period from 1953 to 1962, the volume of industrial production tripled. True, the significant monopolization of the economy led to the fact that the level of salaries did not increase much. Problems caused by excessive monopolization of the economy already arose at the end of the 60s, together with corruption and disproportions in the development of certain regions of Italy.
Japanese model	**1952 – 1962**	One of the key features is the definition of priority industries. If in the mid-1950s these were classic metallurgy, energy and shipbuilding, then in the 1960s	In 1956, in just ten years, GDP per capita exceeded the pre-war

		they were replaced by new priorities - electronics and automobile manufacturing. The national peculiarities were that although the state planning had an indicative-recommendatory character, it was followed on the scale of the entire country. Enterprises in priority industries received maximum of state support: subsidies, preferential loans, high tariffs on the import of ready-made competitive products, restrictions on foreign investments, and tools of outright dumping. A key element in the successful recovery of the country's economy was the bet on high-tech production.	level. During the recovery period, the average annual GDP growth per capita was 7.1%. Twelve years later, in 1969, Japan ranked second in the world in terms of GDP and industrial production,
South Korean miracle	1945 – 1980	During 1945-1960, only fundamental reforms were carried out - land and mass education. In the economy, the government tried to implement a policy of import substitution that turned out to be a failure - the country did not have sufficient natural resources and a domestic market. In the 1970s, the economy of South Korea completely ceased to be raw materials and switched to technological products began to develop heavy and chemical industry, but this had nothing to do with the post-war recovery.	From 1960 to 1980, South Korea had a stable economic growth of 8% on average; its GDP was many times higher than North Korea's GNP. In 1963-1969, an average annual GDP growth reached 35% in general. This growth laid the foundation for South Korea to become one of the world's leading economies by 2000.
Israel	1948 – 1962	Since 1952, Israel began the New Economic Policy implementation. It consisted of significant economy liberalization, in particular, the abolition of the distribution system and state regulation of prices. Israel also refused to issue money to cover expenses. At the same time, the country launched large infrastructure projects, such as the construction of the National Israel Water Pipeline, power plants and ports. Significant state investments went into the agricultural sector and light manufacture.	From 1954 to 1964, Israel's GDP grew by 10% (slightly less than the rate of the Japanese economy growth), consumption per capita increased by 221%, and the country practically achieved zero unemployment. And the most importantly, during this period, Israel attracted investments and was able to lay the foundations of its industry.

Source: data compiled by the authors on LB.ua

3. Research methodology definitions

Numerous definitions of the investment attractiveness of the region found in the economic literature contain the following general characteristics. Investment attractiveness is considered as an integral indicator of: feasibility of investing funds; the level of meeting the requirements or interests of the investor; the financial and property status of the region and its development prospects; a set of objective and subjective (external and internal) conditions.

Thus, it should be noted that there are various definitions of the category "investment attractiveness" from narrow to broad. There are various approaches and methods for assessing the investment attractiveness of the region. All modern methods can be divided according to two classification features: 1) data processing methods; 2) system of indicators.

According to data processing methods, two approaches can be distinguished: descriptive and rating approach. The descriptive approach consists of describing the absolute indicators, structure and dynamics of indicators of the region's development. The expert independently selects the most significant indicators and forms conclusions about the climate in the region based on them. Some authors give recommendations on the group and list of indicators that bring the investment attractiveness of the region, but do not offer a methodology for their evaluation. Thus, a set of indicators can be found in the works of Gomolska V. (2003), Khmarska I. (2003), Asaul O. (2004). The rating approach is carried out in the analysis of various aspects of the region development, the formation of analytical and synthetic indicators by groups and an integral indicator based on them. According to this indicator, or system of synthetic indicators, the rating of the region is increased according to the level of its attractiveness for the investor.

Also, Ukrainian methods include certain groups of macroeconomic indicators. However, each of the techniques contains only a part of these groups. However, working with macroeconomic statistics has a great advantage over conducting surveys in that it requires significantly fewer resources and costs.

The methods of Western agencies, in particular the World Bank, overcome previous shortcomings. They are not based on macroeconomic statistics, but on a survey of subjects of economic activity in a given region, that determine the degree and direction of influence of certain factors on their functioning. The results of those surveys are clear and can be grouped by type of activity. In this research were used econometrics models and methods of mathematical modelling.

The paper uses the Rasch model, which allows obtaining a generalised indicator of regions investment attractiveness of using both qualitative and quantitative indicators. In the case when the Rasch model is linear, it allows to use of a wide range of statistical calculations for data analysis. The Rasch model is probabilistic. The assessment of the regions' attractiveness does not depend on a set of assessment criteria, it has individual characteristics. The results of the measurements are objective, that is, they do not depend either on the person measuring, or on which measuring tool (test or questionnaire) is used. In addition to assessments of the regions' attractiveness, the model also allows to obtain an assessment of the feasibility of the criteria used to assess the investment attractiveness of regions. What is more, the evaluations of the criteria do not depend on the number of evaluated years.

To assess the investment attractiveness of the Ukrainian regions it is possible to use the Rasch model, that allows performing a comprehensive assessment of various indicators, both financial and indicators related to the production of minerals. This will make it

possible to assess the investment attractiveness in specific values. Advantages: simplicity, lack of subjective opinion of an expert, allows changing the evaluation indicators taking into account the requirements of investors.

To assess investment attractiveness, we use two methods: the analysis of the intensity of development (used with the help of the relative value of dynamics (traditional method)) and the adapted Rasch model for estimating latent variables (latent variables are indicators that cannot be measured explicitly, but can be only estimated through mathematical models, based on the measurement of observed variables), (Safarov et al 2012), that will make it possible to transform measurements made on a binomial or ordinal scale to be converted into qualitative data and analyse with quantitative methods. After completing the assessment of attractiveness, we will compare the results of the above methods.

4. Data and Results

In our case, in order to adapt the Rush model to the assessment of the regions' investment attractiveness, we select the objects that will be evaluated (the period from 2016 to 2021), introduce indicative variables (criteria) also give a description of the relationship between the objects, Table 2.

Table 2 The indicators of Ukrainian regions' dynamic development

Factors influencing for investment attractiveness	year	Dnipropetrovsk region	Kyiv region	Poltava region	L'viv region	Kharkiv region
Gross regional product, mln.hrn	2016	244,478	128,638	116,272	114,842	154,871
	2017	313,83	157,043	150,904	147,308	187,454
	2018	369,468	198,16	174,147	177,233	233,321
	2019	390,585	218,737	187,381	214,4	247,667
	2020	390,325	242,406	188,424	236,354	257,592
	2021	398,732	242,503	188,532	226,573	257,501
Volumes of sold industrial products, mln.hrn.	2016	324,367,5	82,596	125,958	67,388	130,771
	2017	417,904,2	94,319	158,928	81,891	166,609
	2018	481,481,0	114,297	186,76	100,229	190,358
	2019	454,124,0	100,146	168,53	105,287	185,639
	2020	427,668,5	125,836	159,281	111,282	175,687
	2021	670,478,3	157,978	241,571	146,99	231,411
Export of goods, $	2016	5,864,835	17,051,272	14,360,450	1275566	10,278,430
	2017	7,052,760	17,484,058	18,645,241	1585154	11,915,371

	2018	7,722,596	18,563,330	19,059,009	1895636	12,789,849
	2019	7,907,150	19,483,676	21,024,092	2202054	14,150,605
	2020	7,591,622	19,677,429	23,172,757	2322938	14,711,595
	2021	12,163,795	25,505,442	31,895,266	29,324,839	18,012,859
The number of employed workers, persons	2016	1,426,000	728	569	1,027,000	1,212,000
	2017	1,345,000	740	570	1,032,000	1,221,000
	2018	1,400,000	756	573	1,042,000	1,240,000
	2019	1,441,000	763	582	1,062,000	1,249,000
	2020	1,450,000	777	589	1,069,000	1,260,000
	2021	1,364,000	735	542	1,020,000	1,178,000
The number of personnel at industrial enterprises, persons	2016	593,1	332,4	219,6	282,2	344
	2017	608,5	303	220	296,4	354,3
	2018	619	316	229	327	371
	2019	656,8	328	220	363	403
	2020	665	329	209	353	395
	2021	671	331	208	352	393
Number of enterprises (infrastructure)	2016	25,584	17,83	8,989	15,586	20,435
	2017	27,892	19,339	10,188	17,933	22,597
	2018	29,119	20,054	10,958	19,233	23,793
	2019	31,191	21,077	11,439	20,48	25,051
	2020	30,827	20,32	11,104	20,911	25,144
	2021	30,901	20,111	11,003	20,111	25,142

Source: The table was compiled according to data of State statistics service of Ukraine

For example, to assess the Ukrainian regions investment attractiveness, it is necessary to select those regions that account for the largest share of GDP. According to statistical indicators, the most attractive are the Dnipropetrovsk (gross regional product 398,732mln.hrn), Kyiv (gross regional product 242,503mln.hrn), Kharkiv (gross regional product 257,501mln.hrn), Poltava (gross regional product 188,532mln.hrn), and Lviv (gross regional product 226,573mln.hrn) regions.

First of all, we evaluate each region separately, sum up the results according to the criteria, and compare the final evaluation of each region.

Considering the priorities and growth points of the regions is advisable when allocating investments.

Comparative characteristics of regions should be carried out according to the following criteria: GDP per capita; labour productivity, export; mining, number of industrial enterprises (infrastructure).

According to this method of assessing the investment attractiveness of the region, different types of indicators can be taken into account, both in dollars (GDP per capita) and in tons (labour productivity, mineral production).

The analysis of the regional development intensity is carried out using the relative value of the growth rate dynamics according to the formula:

$$d_{dyn} = y_1/y_0 \quad (1)$$

Within the framework of the study, the indicators of 2021 were chosen relative to the indicators of 2016.

The choice of the Rasch model is justified by the fact that it has some advantages over other models for assessing the attractiveness of existing objects, which are potentially investment-attractive regions, is a crucial aspect of the quality of objects in various fields of science.

It is advisable to consider the process of creation a model as a scheme of a set of aligned and controlled actions that carried out to achieve the goal.

At the first stage, the evaluations of objects are identified and described. At the second stage, the criteria for assessing the investment attractiveness of the region are defined. We determined that N is the region for assessment: A1, A2, ..., An and L are the criteria by which the assessment is carried out: K1, K2, ... KL. Let Uij be the evaluation of the i-th object by the j-th criterion. These criteria can be of different nature and have different dimensions.

To bring the estimates to a single scale, a normalization procedure is carried out, as a result of that all normalized estimates of the alternatives according to the Uij criteria will take values from the interval (0; 1). As a normalization algorithm, we use criteria of minimization (the smaller the indicator, the greater the measure of attractiveness of the object).

$$u_{ij} = \frac{max(U_{ij}) - U_{ij}}{max_i(U_{ij}) - min_i(U_{ij})} \quad (2)$$

Suppose that the subject is satisfied with the n-th object according to the j-th criterion at the Unj level (as a result of normalization, this indicator takes values from 0 to 1). The formula can be used to calculate the most simple indicator of the investment attractiveness of this object:

$$X_n = \sum_{j=1}^{L} x_{nj} \quad (3)$$

Next, we will use a probabilistic approach, where the probability Pnj is calculated according to Georg Rush's formula, which was obtained by him during the evaluation of latent variables.

These probabilities are interpreted as normalized estimates of objects according to u_{ij}criteria.

For application in practice, it is necessary to finds estimates of attractiveness of objects by period θ_i and the degree of fulfilment of criteria β_j on the basis of known evaluations of objects according to the criteria u_{ij}, which were obtained empirically with the help of expert evaluation by subjects.

The originality of the model lies in the fact that it is used for the first time to assess the investment attractiveness of territories. In Ukraine, at the moment, such a technique does not exist.

If we consider the Rasch model of latent variables estimation then according to it, the estimates of θ_I and β_j are obtained by the method of maximum likelihood. However, in Rasch's dichotomous model, the probabilities P_{ij} can take only two values - 0 or 1, that does not correspond to the model presented in the work, when the probabilities P_{ij} can take on values from a continuous spectrum from 0 to 1.

Due to this, it is proposed to use the method of least squares for these purposes, the application of which for solving similar problems is described in the works of (e.g.Barkalov et al 2014): the parameters θ_i and β_j are selected in a such a way that the sum of the squares of the deviations of the empirical data u_{ij} from the calculated probabilities is the smallest. In the future, we mathematically reduce to the minimization of the remaining amount:

$$S(\theta_i, \beta_j) = \sum_{i=1}^{m}\sum_{j=1}^{n}(u_{ij} - P_{ij})^2 = \sum_{i=1}^{m}\sum_{j=1}^{n}\left(u_{ij} - \frac{e^{\theta_i - \beta_j}}{1 + e^{\theta_i - \beta_j}}\right)^2 \rightarrow \min \qquad (4)$$

Estimates of θ_I and β_j obtained from this model will be measured on linear scales and the start of the countdown of them will be undefined.

The next step, at the III stage, will be the development of a forecast of the regions' investment attractiveness, where we will use normative conditions to calculate the indicator of attractiveness, namely, and the non-negativity of assessments. The author suggests using the formula (5) as a possible option, in which, after summing up the scores θ_i, β_j we will get an indicator of the attractiveness of the region:

$$P_{pr} = \left(\left(\sum_i \theta_i\right) + \left(\sum_j \beta_j\right)\right) \geq 0. \quad (5)$$

The presented model (3) assumes that all criteria have the same importance for subjects. However, in reality during the expert evaluation, the importance of criteria is usually different, and it must be taken into account when evaluating the attractiveness of objects. Classic models of expert evaluation take into account the importance of criteria for subjects by entering indicators of the weight of each criterion.

The calculation of problems (4) and (5) can be carried out using various software products, for example, in MS Excel using the add-on "Search for solutions" (Solver). Next, calculate the attractiveness criteria for each region by year sum them up and compare them. In that

instance, minimization of the criteria, the smaller the indicator, the greater the object's attractiveness and we will compare it with the indicators of the areas obtained on the basis of the analysis of the intensity of development.

As objects (A), the years from 2016 to 2022 are selected, for which the above-mentioned criteria are known, namely:

K1–GDP per capita, $;

K2 – labor productivity, $;

K3 – mining, tons

K4 - export, $ mln;

K5 – labor potential, mln. persons

K6 – number of enterprises,

In the future, we will normalize the data, as a result of that we will get a table with the initial data, which is necessary for calculation in conformity with the model. All indicators are measured on a single scale and all criteria are minimized.

Using the raw data, we determine the object evaluations by year θ_i^a, evaluation criteria β_j^a. Then, we calculate the probabilities P_{ij}.

Squares of deviations of the sum are determined by the formula:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}(u_{ij}-P_{ij})^2 \quad (6)$$

Then, according to the model (4) created, the criteria are summed and evaluated on a yearly basis to obtain an index that reflects the attractiveness of the region. As a result, based on the obtained data, we will form the table for comparison with attractiveness indicators based on the analysis of growth intensity and a more attractive area. The data for calculation are presented in Table 2.

Furthermore, the criteria are aggregated by year and evaluated according to the model created to obtain an index that reflects the investment attractiveness of the regions. Based on the obtained data, the investment attractiveness of Ukraine's regions is shown in Table 3. Depending on the calculations, it was determined that Dnepropetrovsk, Kyiv, Kharkiv and Lviv oblasts have the best investment attractiveness indicators. Over time, the model may be supplemented with indicators of security, destruction, damage, and energy independence.

Table 3

The indicators of regions' investment attractiveness

	Dnipropetrovsk region	Kyiv region	Poltava region	L'viv region	Kharkiv region
indicator	10.3	8.7	7.6	8.66	9.8

Source: calculated by the authors based on the table. 2

5. Conclusions

A number of indicators effects on the regions' investment attractiveness. Comparing the regions with each other according to each of them gives a new leader every time. The proposed Rasch mathematical model allows obtaining an integral assessment of the regions' investment attractiveness with the appropriate ranking. Such estimates can be used both by investors at the initial stages of choosing a region for investment and by

representatives of local authorities to assess the investment attractiveness of the territory for a certain period.

Based on the calculations, it was determined that Dnepropetrovsk, Kyiv, Kharkiv and Lviv oblasts have the best investment attractiveness indicators.

An international audit needs to be conducted to assess the losses in each region since the war. In order to recover Ukraine's economy, it is necessary to draw on the experience of countries that have experienced military events. The experience of Israel, that followed the path of developing the military-industrial complex, is the most suitable. It is expedient to support the existing points of growth, which are defined in the development strategies of the regions of Ukraine, but at the same time to develop new promising areas. New enterprises must be located on the territory of industrial parks in which the necessary infrastructure exists. The Government of Ukraine adopts a number of legislative acts that create preferential conditions for investments.

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