Dependence of Gross Regional Product in Ukraine on economic indicators: analytical and regulative tools

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Abstract.

The study identify various factors influencing the gross regional product in six Ukrainian regions (Vinnytsia, Zhytomyr, Kyiv, Lviv, Odesa, Kharkiv), which vary in terms of development and the impact of hostilities. The methodic encompasses theoretical generalisations, comparative analysis, data forecasting, decision tree, hypothetical, and cluster analysis. The indicators of influence were categorised into three distinct groups based on their impact levels on the gross regional product, namely strong, moderate, and weak. The construction industry has the greatest stabilizing effect. The reduction in the number of enterprises and employees did not lead to a decline of the gross regional product.

Key words: gross regional product, regional development indices, regions in Ukraine, decision tree, regional policy, enterprises.

1. Introduction.

The socio-economic situation of Ukraine's regions at the present stage is subject to a number of influences that determine the current trends of their development and shape their prospects of existence. Exogenous and endogenous challenges to the regional economy are of scientific and research interest in order to reveal the factors that change the indicators of regional development and the instruments of regulation of socio-economic development that ensure the trend of territories development in the right direction, taking into account the country's tasks. Awareness of the economic causes of the current state of the regions will help to determine the directions of their further development, which can protect the socio-economic sphere of the regions from crucial threats and, at the same time, contribute to the creation of the foundations for stabilizing the economy and the public sector. The need to develop a scientific and practical understanding of the causes of the current region status and to formulate criteria for achieving the goals of their future development is the reason for the relevance of this article. The study is based on the influence degree analysis of the indicators of socio-economic development of regions on the gross regional product (GRP).

In connection with the relevance of the subject of this article, we consider the lack or poor representation of scientific and practical developments in the systematic mathematical analysis of socio-economic indicators of regional development, their interdependence and impact on the resulting indicator to be a research gap; lack or poor representation of the analysis of groups of different regions, understanding the bases of their development will allow further interpolation of these conclusions to other groups of regions of Ukraine.

The purpose of the study is to identify the impact of indicators of socio-economic regional development on the gross regional product for further development of tools for adjusting these indicators to achieve the necessary predefined development goals.

The objectives of the study are: to analyze the impact of indicators of socio-economic development of Ukraine's regions on gross regional product; to determine the role of enterprises in the formation of GRP in different regions; to develop tools for regulating indicators of regions in order to change their dynamics in order to stabilize the situation; and to formulate the basis of regional development policy.

The scientific novelty of the work lies in the development of analytical and practical tools for the identification of the impact of socio-economic activity sectors in certain regions of Ukraine on the gross regional product and the formation of management tools for the regulation of these sectors in order to improve the indicators.

2. Literature review.

The scientific literature provides a thorough understanding of the current problems of regional development and the dynamics of their spread. It is important to be able to identify the problems of socio-economic development in order to provide an adequate response to the challenges of our time. We agree with the authors views on the current situation in the regions of Ukraine: the negative situations in the regions and ways of solving them are discussed in (Kyzym et al., 2021). In general, the uncertainty of regional development at the present stage is revealed in (Rodríguez-Pose et al., 2024).

Various aspects of the current socio-economic development of regions, the importance of certain areas in the formation of gross regional product (GRP) are the subject of extensive research by scientists. In particular, the comprehensive impact of Ukraine's integration into the global economic space on changes in the structure of the regional economy is highlighted in Shashina (2020).

The level of development of the region's economy in general, and the industrial sector in particular, plays a significant role in the formation and stability of the economic sphere. Much attention has been paid to the study of these issues. The productive capacity of regions in the context of economic sectors is presented in the article (Shultz et al., 2023). The diversity of regional development using the example of regional industrial structures is presented in (Bathelt H. et al., 2023). Changes in industrial production using local production systems are analysed in detail in (de Propris L. et al., 2019). We rely on these works in our research.

The mathematical tools for processing statistical data are well developed, especially with regard to the construction of the decision tree. For example, in the article (Amir et al., 2023), the decision tree algorithm was used to identify and evaluate the factors that influence the allocation of the road maintenance budget. The study (Shiyun et al., 2022) developed a model for financial risk analysis and early warning for enterprises based on a decision tree. Our study also uses a decision tree as the most relevant tool to identify the links between socio-economic indicators of regional development.

Crisis trends in regional development have a significant impact on the links between indicators. That is why we rely on a scientific basis that identifies threats to regional stability and suggests ways of dealing with them. Regional scientists have studied in detail ways to overcome crisis trends in Ukraine’s regions. For example, proposals for ensuring the sustainability of the regional system are presented in the article (Bril et al., 2021). Considerable attention is paid to ways of post-war regional recovery (Semigulina et al., 2024). The current scientific literature contains a wide range of information not only on regional development issues and factors of regional destabilization, but also on ways out of the crisis. Among the works, we note those related to rethinking the role of regions (Bailey et al., 2020), determining the impact of institutional changes in regional development policy on the unevenness of regional development in the EU (Camagni, 2020). Finally, the development of practical recommendations for eliminating points of instability in the regions should be based on a critical review of existing proposals by the authors and their own proposal.

In this context, we would like to positively evaluate the following topics: the latest tools for regulating the spatial development of regions that are being developed (Storonianska et al., 2024a, 2024b), the modern model of spatial development (Melnyk et al., 2023), proposals for structural changes and the development of intelligent specialization of regions (Shultz et al., 2021).

The collection and interpretation of data on the dynamics of regional development and the modelling of the situation evolution are given sufficient attention in scientific research. Sishi et al. (2021) demonstrated the optimization of business processes using the Decision Tree regression model. Oezsoy et al. (2009) analyzed the main factors influencing the formation of housing prices in Turkey using the decision tree method. In (Ghimiere et al., 2023), a machine learning algorithm for construction budgeting (decision tree, random forest, gradient boosting regressor, multiple linear regression) is considered. It was found that the decision tree model was more effective in capturing the non-linearity between variables than other models. In the article (Lee et al., 2022), the authors conducted a systematic literature review on the application of the decision tree method and predictive analytics in business decision making in various fields. The authors analyze the factors that influence the company's finances when using the decision tree method to analyze the company's financial risks.

A number of scientists have analyzed the impact of enterprises activity on the formation of GRP. In connection with the dependence of the gross regional product on the indicators of the socio-economic development of enterprises, it is worth mentioning the research of a number of scholars. In particular, (Xu et al., 2021) examine the impact of entrepreneurship on China's regional economic development, which is manifested according to the heterogeneity of regions. In the developed eastern and central regions of China, entrepreneurship has a positive impact on economic growth, while in the less developed western regions this impact is negative. The author (Neumann, 2021) examines the dependence of the impact of entrepreneurship on socio-economic development through the creation of new jobs, increased innovation activity and productivity growth. This impact depends on the development level of the region, the innovativeness of the firms, and the number of people and firms in the regions. Researchers (Content et al., 2019) have found that the link between entrepreneurial activity and economic growth varies according to the respective EU region and the quality of the entrepreneurial ecosystem in these regions. The researchers emphasize the importance of taking into account regional characteristics and the quality of entrepreneurial activity when developing relevant policies for EU regions.

In the context of the impact of the enterprises activities of on the regional economy, we note the works related to global productive networks. The economic capacity of regional economies and its influence on the formation of global productive networks is shown in (Poon, 2024). Global productive networks are extensively studied on the basis of the latest scientific approaches in (Boschma, 2024). The leading theories of modern regional

development and current challenges for the practical activities of firms in regions are reviewed in detail in Fratesi (2024).

Despite the existence of a number of studies revealing trends in the socio-economic development of regions and ways of their regulation, those areas of public life of regions remain insufficiently studied, the scientific and practical understanding of which and the development of regulatory tools for which will improve their indicators, the overall dynamics of their development and the resulting indicator – the gross regional product.

The analysis of extant literature facilitated the formulation of an opinion regarding the contemporary challenges faced by Ukraine's regions and the pivotal role of specific factors in their economic development.

3. Materials and methods.

The presented study is based on the analysis of socio-economic indicators of six regions of Ukraine. The article analyses an array of data (socio-economic indicators) on the socio-economic development of the following regions: Vinnytsia, Zhytomyr, Kyiv, Lviv, Odesa, Kharkiv. The regions in the article are from different parts of Ukraine; they are characterized by different indicators of socio-economic development and, at this stage, by different degrees of suffering from the hostilities. This inclusion of different territories in the analysis will allow us to understand the causes of their current status and to form an idea of the possibilities of influencing certain indicators in order to achieve a balanced development of the territories.

The paper uses the methods of comparative analysis (to compare statistical data for individual regions of the country), data forecasting (to identify trends in further development), theoretical generalizations to identify trends in the development of regions, decision tree – to predict the value of the target variable on the basis of several values; hypothetical – for assumptions about the further dynamics of socio-economic indicators of territories, systematization – to generalize and bring into a single system of socio-economic indicators of regional development.

The target variable for the analyzed regions is the gross regional product (GRP) as the main indicator of the region.

The influence of groups of socio-economic development indicators on the resulting indicator – gross regional product – has been studied. The article analyses the indicators of socio-economic development for the

studied regions, finds correlations between these indicators and GRP, and identifies variables for each region that, according to the proposed methodology, influence the target variable (GRP).

The study data on gross regional product was obtained from the websites of the Main Department of Statistics of Ukraine and territorial departments of statistics in Vinnytsia, Zhytomyr, Kyiv, Lviv, Odesa, and Kharkiv regions of Ukraine. The research period is from 2010 to 2021, with the final data for 2022-2024. Only discrete data on socio-economic development indicators and their impact on gross regional product are available, derived from monitoring reports on the implementation of regional development strategies for 2021-2027, published on the websites of local authorities in Ukraine.

The study takes into account the sharp deterioration of the political situation, the military operations in the east and the occupation of the Autonomous Republic of Crimea in the analysis of the dataset. This led to a decrease (deterioration, decline) in certain indicators of socio-economic development in 2014-2017, which is reflected in the analysis. In particular, the greatest deterioration was observed in construction, investment, export-import operations, changes in the territorial distribution of human capital and household income. In 2021, the indicators of 2013 were not reached, which shows that the potential in various sectors has not been restored.

Decision tree – regression was used in the analysis. A decision tree is a graphical diagram resembling a tree, where each node represents a decision or event, and each branch represents a possible option or outcome of that decision. It is a decision-making tool for a given set of data (1):

$$(x_1, x_2, \ldots, x_n, Y), \qquad (1)$$

where Y - the target variable to be analyzed and the variables $x_1, x_2, \ldots, x_n$ used to perform this task.

The main components of a decision tree are the root node (the initial node), internal nodes (intermediate solutions), leaf nodes (the final nodes, which are the final results) and branches (the lines connecting the nodes, representing possible options or paths) (Quinlan, 1986).

The basic idea is to divide the data into parts so that the average value in each part most accurately reflects the value of the target variable for that part.

The main steps in constructing a regression decision tree are as follows:

- find the variable that best splits the data into two parts. The criterion is to minimize the mean absolute error (MAE) (2):

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \bar{y}|, \quad \bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \tag{2}$$

- apply similar steps to the resulting subsets until stopping criteria, such as the minimum number of objects in a node or the maximum tree depth, are reached.

For each leaf node, we calculate the average value of the target variable among the objects in that node. This average value is the prediction for new data entering that node. Next, a regression decision tree model is created with a limited depth (max_depth=3). The next step is to perform the prediction on the test data and calculate the mean absolute error (MAE). Finally, the built tree is visualized for a better understanding of the decision structure.

In the study of the gross regional product indicator, the article distinguishes between the dependence of its value on indicators by type of economic activity (exports of goods, imports of goods, retail trade, wages, income) and by industry (construction products, industrial products, agricultural products, new construction). For each region and for Ukraine as a whole, correlations between GRP and the relevant variables are presented, decision trees are constructed, and auxiliary dependencies between the independent variables and the target variable (difference between exports and imports, share of wages in income, share of retail trade in GRP, share of construction products in GRP, share of agricultural products in GRP) are indicated.

Decision tree analysis was chosen as the main analytical tool because of its ability to identify non-linear links between socio-economic indicators and the target variable, as well as the high interpretability of the results. Unlike regression analysis, which often assumes a linear link between variables, the decision tree allows complex links to be modeled efficiently and interactions between factors to be taken into account. In addition, the method works well with large data sets, is robust to missing values and makes it easy to identify the most important predictors of GRP for each region.

K-fold cross-validation (k=3) was used to test the stability of the models.

Jupyter Notebook software was used for calculations and visualization.

Research limitations: The analysis in its current form is descriptive. A deeper understanding of the causal mechanisms of the impact of socio-economic development indicators on GRP will be provided by future studies using appropriate methods. In this study, decision trees were used to visualize and interpret key patterns. They have limitations in modeling complex economic interactions.

The limitations of the study in terms of analyzing the situation and predicting future trends are the constant changes in the country, which affect the forecasting capabilities. The limitations of the study in terms of data collection were the lack of separate data for 2022-2024 due to the rules of the State Statistical Service of Ukraine, the lack of separate data on foreign direct investment for the entire study period, and a certain fragmentation of data.

4. Results.

4.1. The link between socio-economic indicators on the example of one region.

The socio-economic development of regions differs in terms of indicators, which results in different degrees of influence of the same indicators on the gross regional product. The issues of differences in regional development, analysis of the current status of regions and ways to stabilize their socio-economic sphere are the subject of research by a number of scientists. The current living conditions in Ukraine's regions of and the world are presented in many works. The general context of global development and its impact on the regions of Ukraine is presented in the article (Borshchevskyi, 2021). The current problems of regional development are highlighted in the article (Kondratenko et al., 2022).

In particular, the variability and unpredictability of the external environment for the regional economy is the field of research of some scientists (Diemer A. et al., 2022). The socio-economic development of regions in conditions of instability is the research subject of the articles (Romanchukevych, 2020) and (Syniura-Rostun, 2022). The authors point to the existence of negative trends in Ukrainian regions.

The analyzed literature allowed the authors of the article to form their own vision of the current problems of Ukraine's regions and the role of certain factors in the development of their economies. As noted, the study is based on an analysis of socio-economic indicators of six Ukraine's regions – Kyiv, Kharkiv, Lviv, Odesa, Vinnytsia and Zhytomyr.

Let's take a closer look at the link between socio-economic indicators in Kharkiv region.

Fig. 1 visualizes the identified impact of the indicators of socio-economic development of Kharkiv region on the gross regional product.

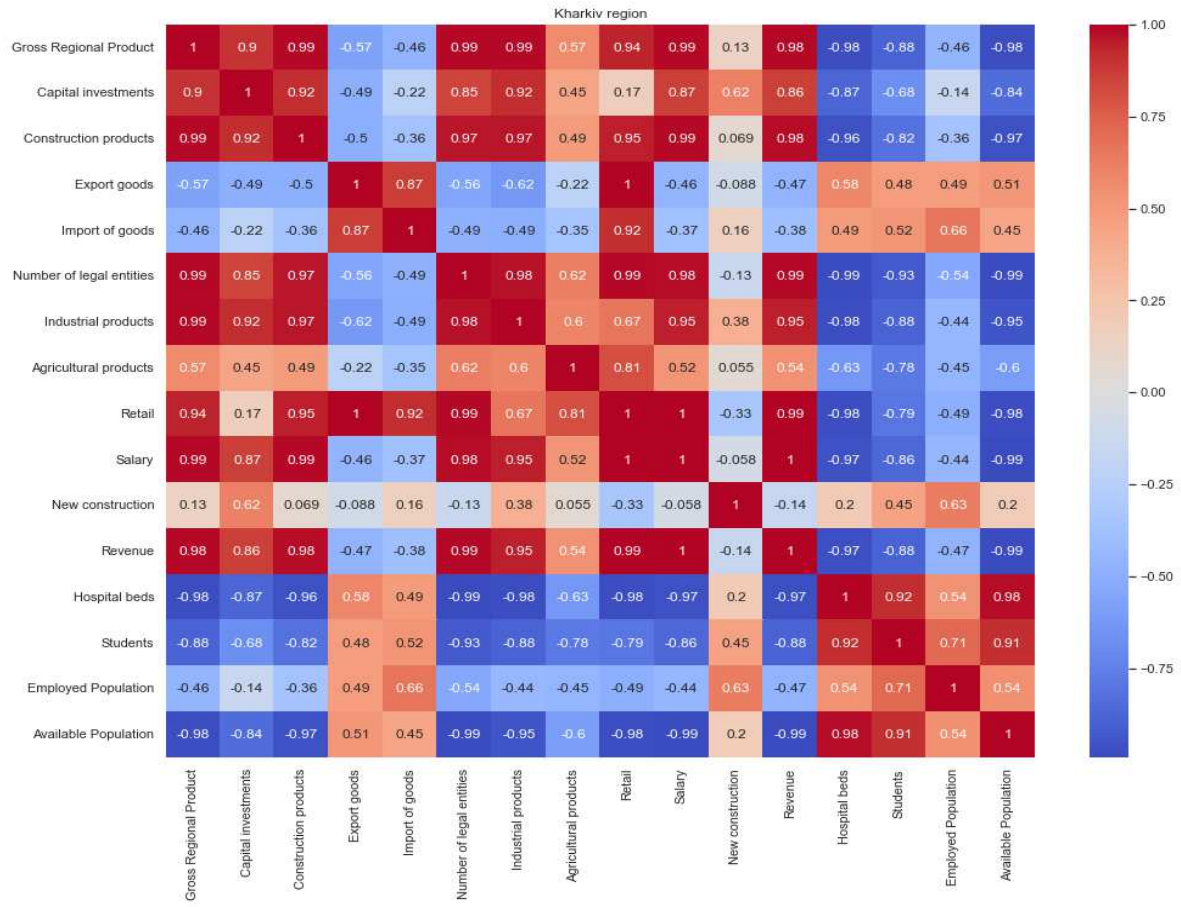

Figure 1. Correlation of indicators of socio-economic development in Kharkiv region.
Source: calculated by the authors based on the data of the Territorial Department of Statistics in Kharkiv region.

Figure 1 shows the correlations between different socio-economic indicators in the Kharkiv region. GRP has a strong positive correlation with investment (0.90), construction output (0.99) and income (0.98). This suggests that economic development is closely linked to investment and construction. The number of enterprises is also highly correlated with industrial products (0.99) and agricultural products (0.61). This suggests that the development of entrepreneurship stimulates production. On the other hand, GRP has a strong negative correlation with hospital beds (-0.98) and students (-0.88). This may reflect the structural characteristics of the region's economy, where high economic results are not always accompanied by the development of social infrastructure. Similarly, income has a negative link with hospital beds (-0.97) and students (-0.88), indicating a certain imbalance

in resources distribution. Retail trade and salaries have a strong correlation (0.999), which means that the level of salaries is highly dependent on sales in the region.

New construction is positively correlated with investment (0.62), confirming the importance of investment in the construction sector. The high correlations between economic indicators and the number of legal entities indicate the importance of entrepreneurial activity for economic growth.

In general, Figure 1 shows that the socio-economic development of Kharkiv region is highly dependent on investments, industrial production and construction, while social indicators are less integrated with economic indicators.

The proposed research tool, the decision tree, is used to assess the impact of various factors on the formation of gross regional product.

Figure 2 shows the decision tree for Kharkiv region.

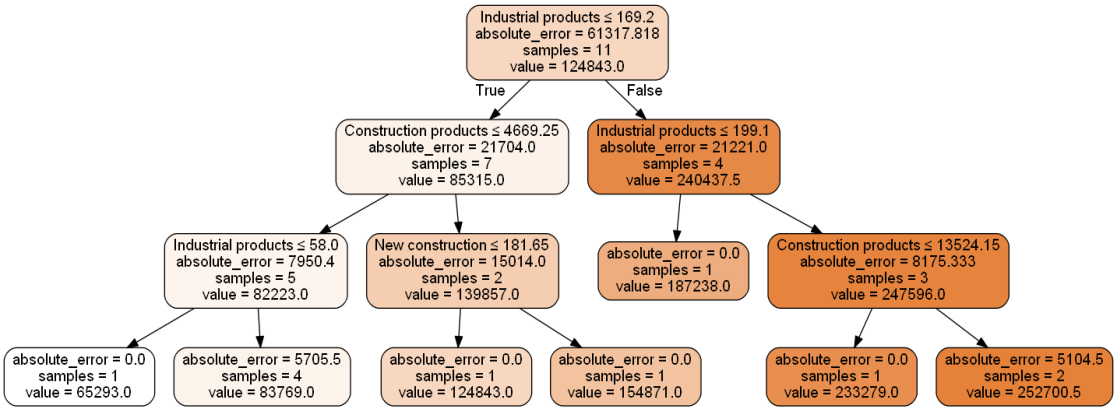

Figure 2. Decision tree for Kharkiv region.
Source: calculated by the authors.

The decision tree (Figure 2) models the link between the socio-economic indicators of Kharkiv region. Its structure shows how different factors influence the gross regional product. Let us comment on the main elements of the tree. The root node (top): the initial division is made at the level of industrial products with a value of 169.2. The node contains 11 samples with an average value of the target variable of 124843.0 and an average absolute error of 61177.818.

Left Branch (True): The branch is based on Construction Products with a value of 44669.25. The samples are further divided according to the amount of construction work. The bottom nodes (leaves) have an absolute error of 0, indicating perfect prediction for these samples. Right branch (False): The further division is based on the higher

values of industrial products above 199.1. This branch shows higher average values of the target variable, reaching a value of 252700.5. The absolute error for these nodes also decreases, indicating that the forecast improves with deeper granularity.

Figure 2 shows that the economic performance of Kharkiv region is highly dependent on industrial and construction output. The model predicts well under certain conditions, but needs to be refined to improve generalizability and reduce errors in some nodes.

Given the dependence of the gross regional product on indicators by type of economic activity (exports of goods, imports of goods, retail trade, wages, income) and by type of industry (construction products, industrial products, agricultural products, new construction), we will carry out additional analyses separately by groups of indicators. This will allow us to obtain more accurate and detailed data on the impact of indicators on gross regional product.

The analysis of data for the Kharkiv region is presented in Table 1 and Figures 3-4.

Table 1. Correlation between the GRP of Kharkiv region and indicators by type of economic activity and by industry

Correlation between GRP and types of economic activity	**GRP**	**Correlation between GRP and sectors of production**	**GRP**
Export of goods	-0.57	Construction products	0.99
Import of goods	-0.46	Industrial products	0.99
Retail trade	0.94	Agricultural production	0.57
Salary	0.99	New construction	0.13
Income	0.98		

Source: calculated by the authors.

The following conclusions can be drawn from Table 1. Wages, income, construction and industrial production are the strongest drivers of GRP, with correlations close to 1. Agricultural production makes a positive but moderate contribution, which underlines its importance, although less than industry and construction. Exports and imports of goods have a negative impact on GRP, which may indicate structural economic problems or dependence on foreign markets.

As can be seen from Table 1, there is a significant direct correlation between retail trade, wages and income on the one hand and GRP on the other. There is also a significant direct link between construction output and industrial output on the one hand and GRP on the other.

The visualization of the results is shown in Figures 3 and 4.

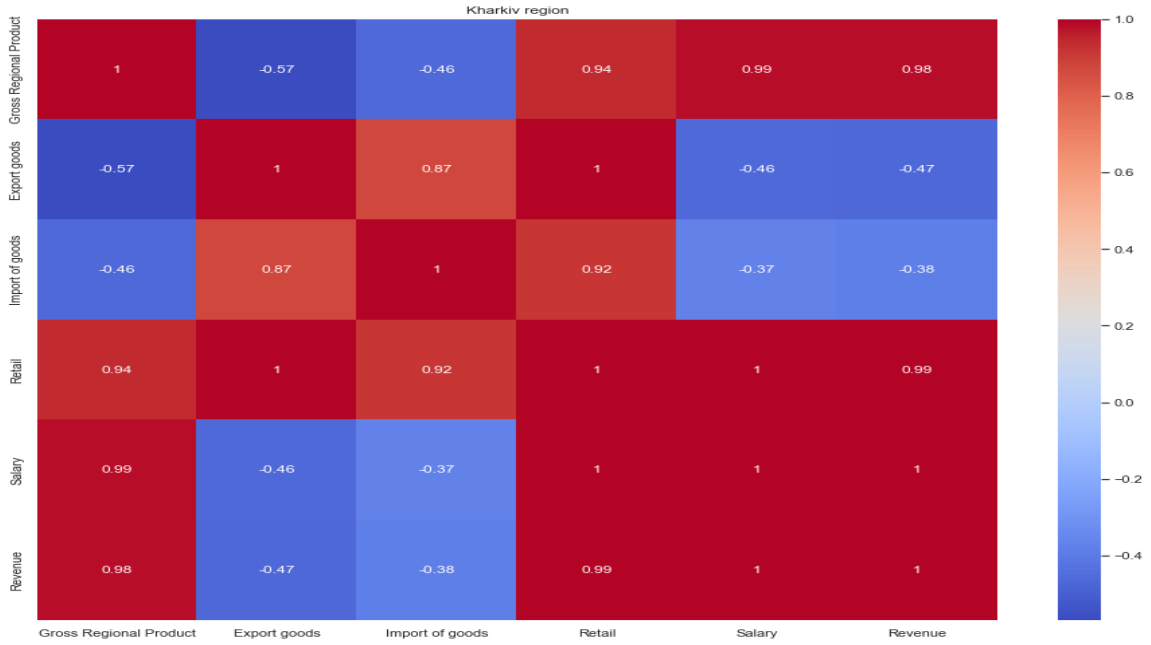

Figure 3. Correlation between gross regional product and economic activity in Kharkiv region.
Source: calculated by the authors.

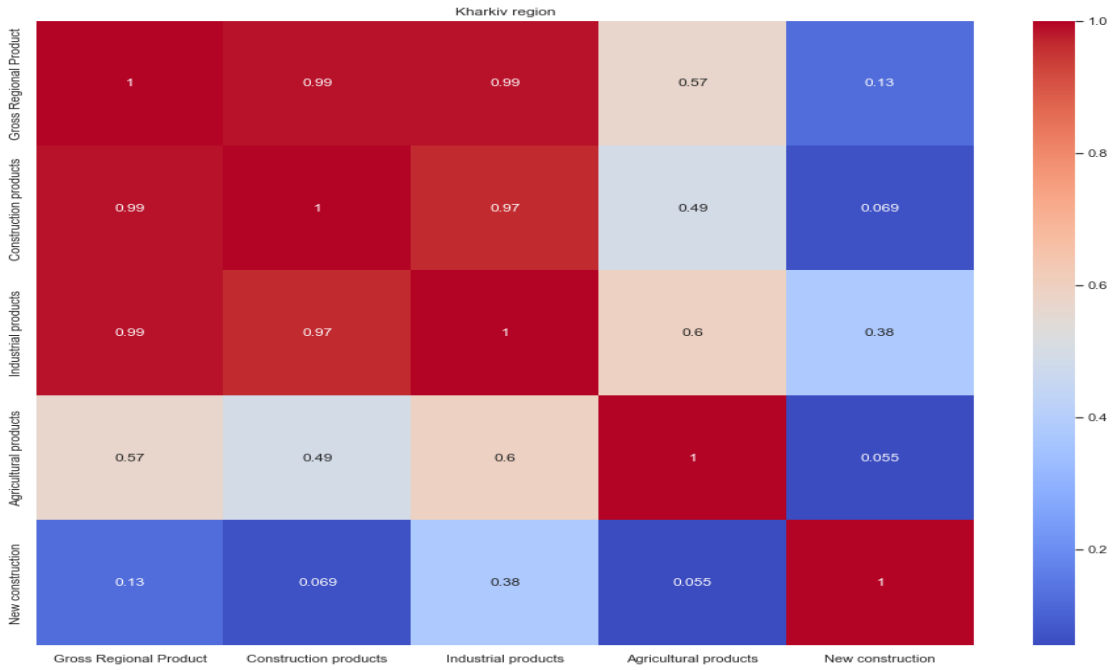

Figure 4. Correlation between gross regional product and by industry in Kharkiv region.
Source: calculated by the authors.

Decision trees and their graphical representation for Kharkiv region are shown in Figure 5.

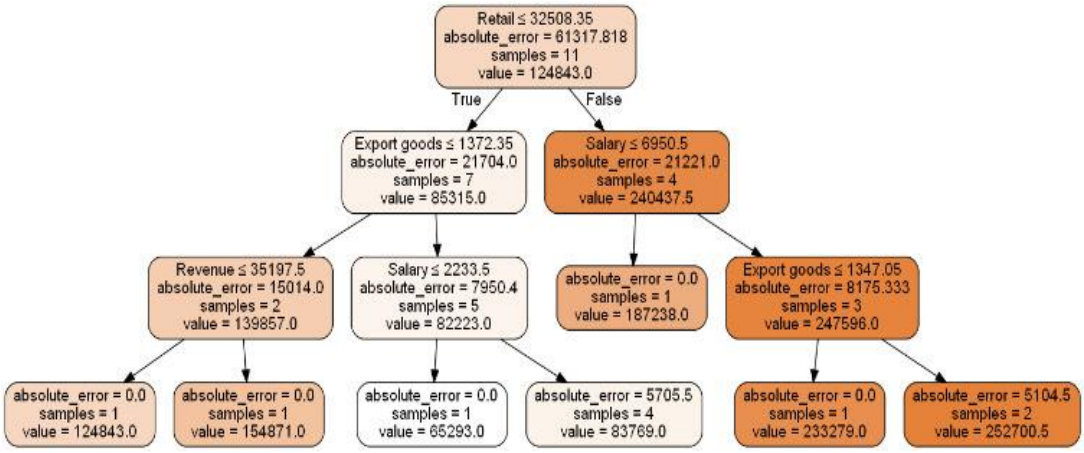

Figure 5. Decision trees for the dependence of indicators of socio-economic development of Kharkiv region by type of economic activity.

Source: calculated by the authors.

The following conclusions can be drawn from Figure 5. In the first decision tree (by type of economic activity), the most important factor is 'retail' (the first node of the tree). High retail performance is directly related to economic growth. Imports of goods have a negative impact on economic performance, which is consistent with the correlation (Table 1). Salary and turnover are important factors for GRP growth, as shown by their high correlations. In the second decision tree (by industry), construction and industrial production are the key factors. Their significant influence is confirmed by their high correlation coefficients (0.99). Agricultural products have a smaller but still significant influence. The errors in the nodes indicate that individual sectors (construction or industry) can generate different economic dynamics depending on the resources invested.

From Table 1 and Figure 5 it can be concluded that the main factors influencing GRP in economic activities are wages and incomes of the people and retail trade. In the production sectors it is industry and construction. Negative factors include dependence on imports of goods and low efficiency of new construction.

4.2. The link between the socio-economic indicators of other five regions

The next step was to analyze the indicators for the other five regions (in addition to Kharkiv region analyzed above) – Vinnytsia, Zhytomyr, Kyiv, Lviv, and Odesa. The data obtained indicate that the following indicators of the socio-economic regional development have the greatest impact on gross regional product: the

volume of construction output and new construction, exports and imports of goods, wages, incomes, industrial output and agricultural output. Accordingly, these indicators have been selected for further analysis.

Figure 6 shows the degree of dependence of regional gross regional product on the selected indicators. The analysis revealed both common and distinctive features of the dependencies. For example, the GRP of all the regions analyzed is significantly influenced by the indicators of construction products, wages and personal income. For five regions (except for Vinnytsia) it is imports of goods, for four (except for Vinnytsia and Zhytomyr) it is agricultural products, new construction for Lviv and Odesa, and exports of goods for Vinnytsia.

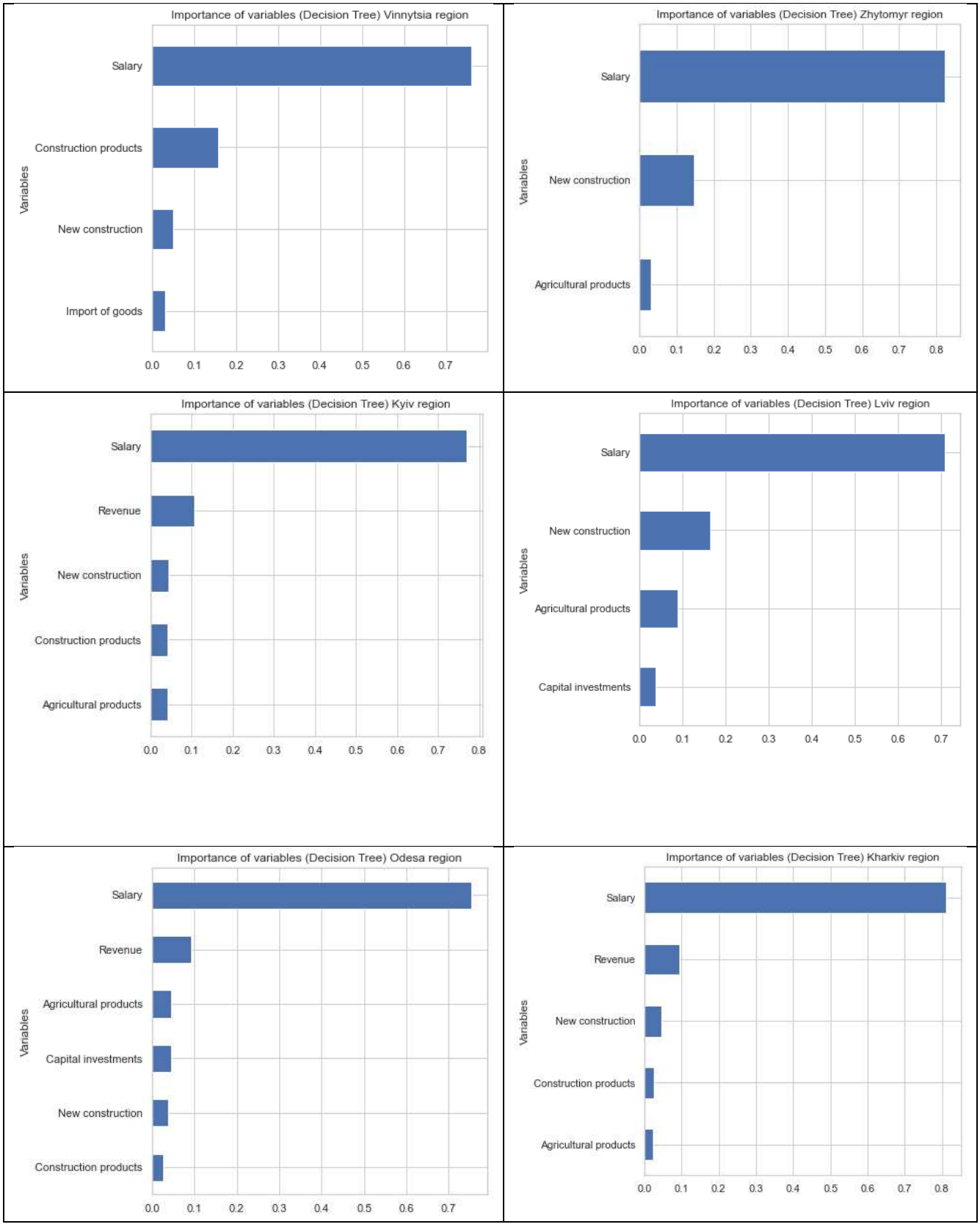

Figure 6. Impact of socio-economic development indicators on gross regional product in six regions of Ukraine (importance of variables).

Source: Calculated by the authors.

Analyzing the graphs of the impact of socio-economic development indicators on the gross regional product for six regions of Ukraine (Figure 6), we can conclude that the salary indicator is the most important among others in all regions. This indicates that the level of salaries is a key factor influencing the regional economic development. New construction also has a noticeable but less significant impact in all regions. This suggests that infrastructure development and investment in construction play a role, but are not dominant. The impact of agricultural products varies from region to region. In the agricultural regions, this factor plays a slightly more prominent role, although its overall importance remains small. Revenue also ranks after salary in the Kyiv, Odesa and Kharkiv regions. This may be due to the higher level of entrepreneurial activity in these regions.

In general, the analysis once again shows that the socio-economic development of Ukraine's regions is most determined by the level of wages, while other factors have an additional impact that depends on the specifics of each region.

4.3. Analysis of dependencies by indicators' groups.

Taking into account the dependence of the gross regional product on the indicators by type of economic activity (exports of goods, imports of goods, retail trade, wages, income) and by industry (construction products, industrial products, agricultural products, new construction), we will next carry out an additional analysis separately by groups of indicators. This will give us more precise and detailed data on the impact of the indicators on gross regional product.

The decision trees and their graphical representation for Kharkiv region are shown in Figure 7.

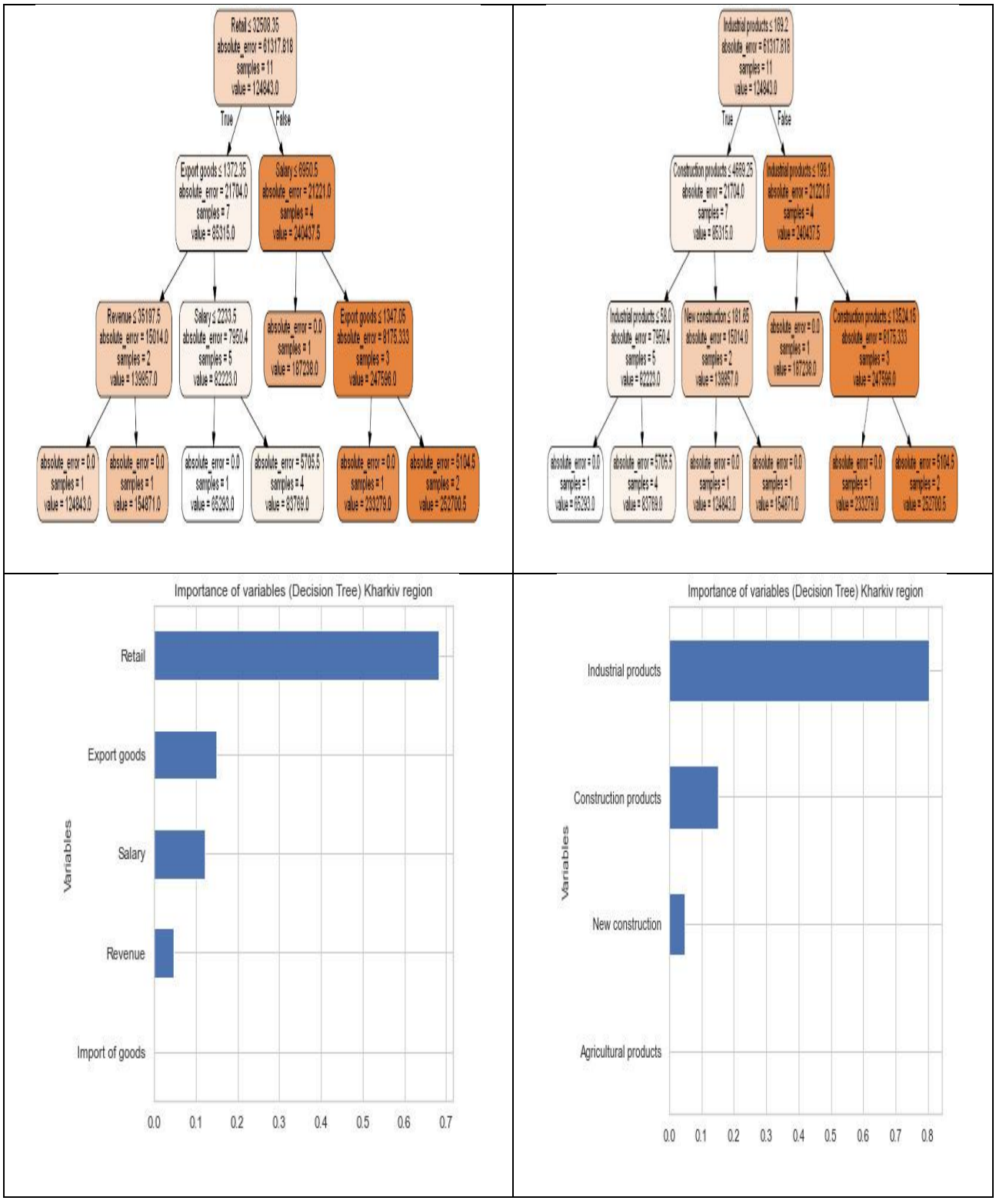

Figure 7. Decision trees for the dependence of indicators of socio-economic development of Kharkiv region by type of economic activity and by industry.

Source: calculated by the authors.

The analysis of statistical data on socio-economic development in all six regions of Ukraine allowed us to identify correlations between the region's GRP and these indicators. In general, for all six regions analyzed, the

correlation between regional GRP and types of economic activity is shown in Table 2, and between branches of the production sector – in Table 3.

Table 2. Correlation between GRP and indicators by type of economic activity.

Index	*The correlation coefficient between the GRP of the region and the indicator of socio-economic development (by type of economic activity)*					
	Vinnytsia	*Zhytomyr*	*Kyiv*	*Lviv*	*Odesa*	*Kharkiv*
Export of goods	0.98	0.67	0.45	0.96	-0.58	-0.57
Import of goods	0.57	0.66	0.00	0.29	-0.57	-0.46
Retail trade	0.99	1.00	0.96	1.00	0.99	0.94
Salary	0.99	0.99	0.99	1.00	1.00	0.99
Income	0.99	1.00	0.99	1.00	1.00	0.98

Source: calculated by the authors.

Table 2 shows that, depending on the type of economic activity, the following indicators are significant for regional GRP: for Vinnytsia region – exports of goods, wages and income; Zhytomyr region – wages; Kyiv region – retail trade, wages and income; Lviv region – exports of goods; Odesa region – retail trade; Kharkiv region – retail trade, wages and income.

Table 3 – Correlation of regional GRP with indicators by economic activity.

Index	*The correlation coefficient between the GRP of the region and the indicator of socio-economic development (by sectors of production activity)*					
	Vinnytsia	*Zhytomyr*	*Kyiv*	*Lviv*	*Odesa*	*Kharkiv*
Construction products	0.91	0.95	0.95	0.98	0.95	0.99
Industrial products	0.99	0.99	0.99	0.99	0.98	0.99
Agricultural products	0.79	0.93	0.55	0.92	-0.13	0.57
New Construction	-0.1	0.75	-0.35	0.77	0.26	0.13

Source: calculated by the authors.

As Table 3 shows, depending on the production sector, the following indicators are significant for the regions' GRP: for Vinnytsia region – construction products and industrial production; for Zhytomyr region – construction products, industrial products, agricultural products; for Kyiv region – construction products and industrial products; for Lviv region – construction products, industrial products, agricultural products; for Odesa

region – construction products and industrial products; for Kharkiv region – amount of construction products, amount of industrial products.

We would like to point out other limitations of the study. Given the high level of correlation shown in the correlation matrices, it would be worth considering possible multicollinearity between the variables. Multicollinearity may affect the stability and interpretability of the model. Regularisation techniques (Lasso, Ridge) can be applied to reduce the problem of multicollinearity. However, we note that this will be the subject of further research, since the choice of the optimal regularisation method depends on the specifics of the individual data on the socio-economic regional development.

4.4. The impact of enterprises' activity on GRP

GRP formation depends to a large extent on the results of enterprises activity in the regions. Here are the results of the analysis of the impact of the enterprises activities in the six studied Ukraine's regions on GRP. In the period from 2014 to 2020, the value added by enterprises in the Vinnytsia, Zhytomyr, Kyiv, Lviv, Odesa, and Kharkiv regions accounted for a significant share of gross regional product. In particular, the average value in Vinnytsia region is 40.5%, in Zhytomyr region – 37.6%, in Kyiv region – 75%, in Lviv region – 48.7%, in Odesa region - 54.5% and in Kharkiv region – 42.6%.

The dynamics of the share of the gross regional product created by enterprises tends to increase during the period under study. The average value of increase in GRP of enterprises in Vinnytsia region is 229.3 thousand EUR, in Zhytomyr region – 191.7; in Kyiv region – 836.1, in Lviv region – 642.6, in Odesa region – 486.6, in Kharkiv region – 502.8. The average percentage increase in the gross regional product produced by enterprises in Vinnytsia region is 18.35%, in Zhytomyr region – 22.66 %, in Kyiv region – 19.46 %, in Lviv region – 24.65 %, in Odesa region - 16.43 %, and in Kharkiv region – 16.54 %.

Growth in the volume of gross regional product produced by enterprises does not always depend on an increase in the number of enterprises in a given region. Over the period under review, the average number of enterprises in Vinnytsia region was 9,496.4, in Zhytomyr region – 6,699.1, in Kyiv region – 19,236.7, in Lviv region – 18,764.7, in Odesa region – 24,127.0, and in Kharkiv region – 23,825.4. The average value added per enterprise is 154.6 thousand EUR in Vinnytsia region, 140.0 in Zhytomyr region, 248.4 in Kyiv region, 160.2 in

Lviv region, 130.3 in Odesa region and 130.3 in Kharkiv region. The difference in the added value of enterprises reflects the level of development of the regions, the effectiveness of management actions and public investment programmes.

At the same time, the maximum deviation in the number of enterprises in Vinnytsia region is 851.43, in Zhytomyr region – 769.14, in Kyiv region – 1,839.86, in Lviv region – 3,178.71, in Odesa region – 3,123.00, and in Kharkiv region – 3,390.43. The lowest value in the surveyed regions was observed in 2016. Compared to the previous year, the number of enterprises in 2016 decreased by 8.44 % in Vinnytsia region, by 10.25 % in Zhytomyr region, by 1.84 % in Kyiv region, by 16.33 % in Lviv region, by 12.05 % in Odesa region, and by 18.06 % in Kharkiv region. The decrease in the number of enterprises from 2014 to 2016 can be explained by the economic crisis, political instability as a result of the outbreak of hostilities in eastern Ukraine and Crimea, and a decrease in the investment attractiveness of enterprises, which could lead to their bankruptcy.

With the reduced number of enterprises, their value added and their share in the total gross regional product in Vinnytsia and Zhytomyr regions are increasing. In particular, in 2016, in the Vinnytsia region, the value added increased by 34.43 % and the share of enterprises in the total gross regional product increased by 3.3 %. In Zhytomyr region, the indicators increased by 26.78 % and 1.66 %, respectively.

With a reduced number of enterprises, their value added increases and their share in the total gross regional product decreases in Kyiv, Odesa, and Kharkiv regions. Thus, in Kyiv region the value added of enterprises increased by 12.97 %, while their share in the total gross regional product decreased by 8.63 %. In Odesa region, the value added of enterprises increased by 12.25 %, while their share decreased by 3.8 %. In Kharkiv region, the value added of enterprises increased by 1.53 %, while their share decreased by 8.4 %. A different trend was observed in Lviv region, where the number of enterprises decreased by 4.42 %, while the share of enterprises in total regional GDP fell by 10.2 %.

The links are not clear cut. However, a decrease in the number of enterprises and an increase in the value added of such enterprises may indicate an increase in the efficiency of enterprises engaged in economic activity. The link between the value added of enterprises and the number of persons employed in these enterprises is different. For example, in Vinnytsia, Zhytomyr and Lviv regions, the number of employees decreased until 2015-2016 and increased in the following years. The correlation coefficient between the value added of enterprises and

the number of employees is 0.75 in Vinnytsia region, 0.97 in Zhytomyr region and 0.60 in Lviv region. The correlation is positive, indicating that the increase in the value added of enterprises depends on the increase in the number of persons employed.

Similar dynamics are observed at enterprises in Kyiv, Odesa and Kharkiv regions. Thus, there was a decrease in the number of employees until 2016-2017 and an increase in the following years. The correlation coefficients between the value added of enterprises and the number of employees in Kyiv and Odesa regions are negative and amount to -0.42 and -0.13, respectively, while in Kharkiv region the indicator remains positive and amounts to 0.21. This means that over the period under study, the number of employees in Kyiv and Odesa regions has been increasing with a decrease in the number of persons employed. In Kharkiv region there is a weak positive correlation between the increase in the number of employees and the increase in the value added of enterprises.

It can therefore be concluded that the gross regional product depends to a large extent on the socio-economic development of enterprises. Even in difficult economic conditions, the value added of enterprises increases despite the reduction in the number of enterprises and employees. This indicates that they are able to adapt to difficult conditions by increasing their productivity, thus ensuring a stable contribution to gross regional product.

4.5. Policy implications: measures to stabilise the situation

The analysis showed that the GRP of the regions is most influenced by different indicators depending on the region, with the predominance of construction and wages. The results obtained on the influence of socio-economic indicators of regions on the gross regional product show that the indicators can be divided into three groups according to their values: with a strong influence on the gross regional product, with a moderate influence on the gross regional product and with a neutral influence on the gross regional product. The indicators in the first group (called "strong impact") include those with a correlation between them and GRP ranging from 0.67 to 1.00. The indicators in the second group ("moderate impact") are those with a correlation between them and GRP of between 0.34 and 0.66. And the third group ("weak influence") are those with a correlation between them and GRP ranging from 0.01 to 0.33 (Table 4). These indicators are presented in Tables 2 and 3 above.

Table 4 – Gradation of the influence degree of socio-economic indicators of regions on GRP and their role in forming the regional economy

Indicators of strong impact on GRP	Indicators of moderate impact on GRP	Indicators of weak impact on GRP
0,67 – 1,00	0,34 – 0,66	0,10 – 0,33
Enhance the economic diversification of the region's economic structure and allow the development of innovative production	Allows to look for niche elements of production expansion and maintain stability	Ensure resilience to market and social fluctuations

Source: the author's elaboration.

Given the real situation and the unstable development of production sectors, the limited resources of public and local budgets to support industries, the intelligent specialization of regions, regional policy measures to stimulate the development and support of certain areas of economic activity should vary according to the contribution of an industry sector to the formation of gross regional product.

The current development of the regions has clearly shown that the formation of the gross regional product is influenced by those socio-economic indicators of the regions that hypothetically contribute to the maintenance of its main parameters. This is particularly true of the construction industry. The analysis carried out for each region makes it possible to develop both common and specific instruments for regulating the socio-economic development of the regions. Thus, the primary focus should be on stimulating the following industries that form a safety margin in each region: amount of construction products and new construction, exports and imports of goods, wages, incomes, industrial products and agricultural products. Given the need for regional specialization, attention should be paid to industries that will allow the full use of the natural and acquired potential of the regions and help them to achieve their goals.

At the same time, the need to maintain the balance of regional economic development and diversification of the sector sphere should be taken into account in order to protect against negative effects. We propose the following algorithm for selecting sector priorities for support (Figure 8):

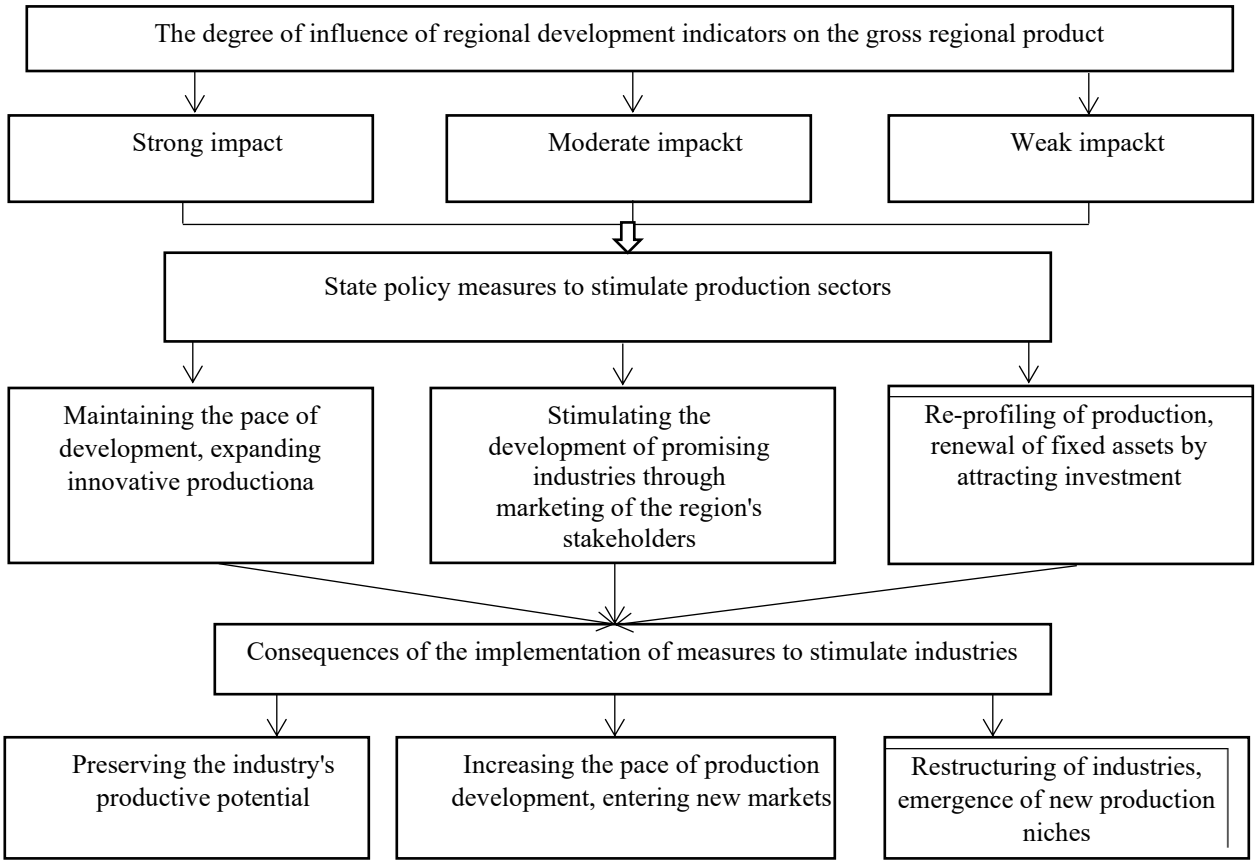

Figure 8. Algorithm for selecting sector priorities in the regions to stimulate their development
Source: author's elaboration.

Let us characterize the public policy measures to stimulate industries. Based on the gradation of the influence degree of regional indicators on GRP, a number of multisector measures are proposed for the analyzed regions. These measures are proposed taking into account the data in Tables 2 and 3, based on the calculations and analytical conclusions made, as well as the sector priorities and development prospects indicated in the regional strategies (2021-2027). The feasibility of the proposed measures is determined by the current situation in the regions and the efforts of local and public authorities to preserve pockets of stability and, if possible, prevent the growth of negative trends, taking into account the security situation in the region. The measures are aimed both at expanding production and making full use of resources, and at launching new activities that could become catalysts for the region's development.

These measures are as follows, according to the Figure 8.

1. Maintaining the pace of development and expansion of innovative production. Measures in this group include those that are part of a defined regional strategy. Sector priorities are formed depending on the specifics of the economic sphere and established business traditions. It is advisable to launch innovative production in those

areas that are developing steadily. At the present stage, factors should be taken into account to protect the economy from a slowdown and maintain sustainability. Such measures include:

Vinnytsia region: increasing exports of goods, maintaining the amount of industrial and construction products; maintaining the level of wages and incomes of the people.

Zhytomyr region: maintaining the amount of construction, industrial and agricultural production, maintaining the level of wages.

Kyiv region: maintaining construction and industrial output, increasing retail trade, maintaining wages and incomes.

Lviv region: maintaining construction, industrial and agricultural production, increasing exports of goods.

Odesa region: maintaining construction and industrial output, increasing retail trade.

Kharkiv region: maintaining the amount of construction and industrial production, increasing retail trade, maintaining the level of wages and incomes.

2. Stimulating the development of promising industries by marketing the region's stakeholders. The actions of this group are those that shape the strategic progress of the region's development and widen its prospects for the future. Three factors should be taken into account: maintaining the current specialization, identifying the interests of stakeholders and searching for industries of strategic importance.

Vinnytsia region: development of the agricultural sector, extraction of raw materials for construction; use of the region's transit potential;

Zhytomyr region: improvement of municipal infrastructure, use of the potential of existing industrial parks, livestock development;

Kyiv region: road repairs, reduction of the degree of ploughing to preserve agriculture; management of the exclusion zone (the area of the consequences of the Chornobyl accident);

Lviv region: efficient use of mineral deposits; attraction of a wide range of resources for tourism and recreation; fair transformation of coal mining communities in the context of decarbonisation;

Odesa region: use of the potential for alternative energy development; intensive use of recreational and rehabilitation potential; development of seaports;

Kharkiv region: development of the potential of the food industry and engineering; increase scientific and technological potential; use of vacant brownfield and greenfield areas.

3. Reprofiling of production, renewal of fixed assets by attracting investment. Among the measures in this group, we would like to highlight those that will contribute to the long-term renewal of the region's socio-economic sphere through restructuring, economic diversification and the creation of new industries. Such renewal should be based on the requirements of intelligent regional specialization and the knowledge economy. It should also take into account the need to ensure a low-carbon transition and economic stabilization.

Vinnytsia region: development of innovation and educational potential, increase of energy resources, active participation in cross-border cooperation;

Zhytomyr region: increase of tourism potential, use of forest plantations, elimination of consequences of military pollution and destruction;

Kyiv region: efficient use of water resources and minerals; preservation and expansion of alternative energy use, development of food, wood-processing and machine-building industries;

Lviv region: engaging IDPs in active economic activity; solving the problem of solid waste management; developing border infrastructure;

Odesa region: reducing dependence on external energy supplies and increasing domestic energy production; restoring soil fertility; repairing roads and related infrastructure;

Kharkiv region: eliminating the consequences of military pollution and destruction; solving unemployment problems; reducing threats to gas and coal deposits.

Specific projects to stimulate the activities of certain industries should be included in regional strategies.

5. Discussion.

From Tables 1,2,3 and Figures 5,7 it can be concluded that the main factors influencing GRP in economic activities are wages and incomes of the people and retail trade. In the production sectors it is industry and construction. Negative factors include dependence on imports of goods and low efficiency of new construction.

In order to increase the volume of GRP in Kharkiv region, it is therefore necessary to increase investment in trade, industry and construction, as well as to reduce dependence on imports by developing local production. It is also advisable to maintain a high level of wages, as this has a direct impact on economic growth.

The findings are similar to those of other researchers. After all, a number of articles have studied various spheres of economic activity in the regions of Ukraine and other countries of the world and how the dynamics of their development affects the unevenness of regional indicators (including GRP). For example, the changes in the components of real GDP on the example of different countries and the cyclical nature of these changes are studied in (Crevoisier et al., 2021). Regional wage inequality is examined in detail in Cortinovus et al. (2024). Regional income disparities, their dynamics and their impact on spatial inequality are analyzed in (Kemely et al., 2024).

These studies show the impact of different indicators on the economic and social spheres of regions and the varying importance of different sector factors in the formation of GRP. For example, the peculiarities of the educational process and employment indicators in their impact on regional disproportionality have been extensively studied (Filipetti, 2019). Considerable attention is paid to industrial development. New incentives for industrial revitalization are presented in (Capello et al., 2023). Regional transformations and emerging industries are highlighted in (De Propris et al., 2021).

When analysing the impact of socioeconomic development indicators in six Ukrainian regions on regional GDP (Figure 6), it can once again be concluded that wages are the most significant indicator in all regions. This finding indicates that wage levels are the primary factor influencing regional economic development. The construction of new buildings is also important, but to a lesser extent in all regions. This finding indicates that while infrastructure development and investment in construction are significant factors, they are not the primary contributors to the observed phenomenon. The impact of agricultural products varies according to geographical location. In agricultural regions, this factor is marginally more significant, although its overall importance remains negligible. Income is also the most significant factor after wages in the Kyiv, Odesa, and Kharkiv regions. This phenomenon can be attributed to the elevated level of economic activity observed in these regions.

The analysis indicates that the socioeconomic development of Ukrainian regions is predominantly influenced by wage levels, with other factors playing a subsidiary role, contingent on the particularities of each region.

6. Conclusion.

The study is based on the analysis of socio-economic development indicators of various industries in the context of their impact on gross regional product. It is shown that regions have both common and specific indicators in terms of the degree of their influence on the resulting indicator. It has been empirically established that the formation of GRP is most influenced by the results of enterprises in areas that can ensure the stability of development, in particular the construction production. It has been calculated that under the difficult economic conditions the value added of enterprises continues to grow, despite the reduction in the number of employees and the reduction in the number of enterprises themselves. This indicates the high adaptability of the business sector.

As a result of the analysis, the indicators of socio-economic development of the regions were categorised according to the degree of their impact on the gross regional product: strong, moderate and weak. The following areas of economic activity are currently the most important for the regions in terms of their contribution to GRP: Vinnytsia – exports of goods, wages and income, construction products, industrial production; Zhytomyr – wages, construction products, industrial products, agricultural products; Kyiv – retail trade, wages and income, construction products, industrial products; Lviv – exports of goods, construction products, industrial products, agricultural products; Odesa – retail trade, construction products, industrial products; Kharkiv – retail trade, wages and income, amount of construction products, amount of industrial products.

Determining the impact of various indicators of Ukrainian regions on the value of the gross regional product allowed us to develop tools to protect the regional economy from threats to stable socio-economic situation. Tools for regulation of regional development indicators for their improvement (both common to all regions and specific for each region) were proposed, and on this basis approaches to regional policy were formed.

The practical significance of the obtained results lies in their use in the development of incentive measures for the analyzed regions and the current and strategic framework of regional development. The analysis, evaluation and interpretation of data on socio-economic development of regions and cities of Ukraine will become the basis for modeling scenarios of their development and improvement of policies and instruments of their regulation.

The results can be used in the development of incentive measures for regions and the current and strategic bases of regional policy.

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The authors report there are no competing interests to declare.

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