I.J. Information Engineering and Electronic Business, **2026, 2, 1-23**
Published Online on April 8, 2026 by MECS Press (http://www.mecs-press.org/)
DOI: 10.5815/ijieeb.2026.02.01

Mathematical Modelling of the Ukrainian IT Industry Potential Assessment in the Context of Global Challenges

Artur Nikolaienko*
Department of Economy, State University 'Kyiv Aviation Institute', Kyiv, 03058, Ukraine
Email: artur.nikolaienko@gmail.com
ORCID ID: https://orcid.org/0009-0008-0251-7341
*Corresponding Author

Received: 13 March, 2025; Revised: 24 April, 2025; Accepted: 05 January, 2026; Published: 08 April, 2026

Abstract: In this article, practical issues are considered at the complex level, in the field of realizing mathematical modelling of the assessment of the potential of the Ukrainian IT industry in the conditions of global challenges. The purpose of the study is to analyze modern approaches to evaluating this potential using advanced mathematical methods, such as multifactorial regression, cluster analysis and factor analysis. The work describes in detail the methods that allow you to evaluate the relationships between the main economic, technological and social indicators that influence the globalized development of the modern IT sector in Ukraine. The study emphasizes the strategic importance of assessing the capabilities of the IT sector to solve modern economic and technological tasks. Within mathematical modeling in the work, an improved model of evaluation of the above potential is proposed in which the combination of considered methods with the combination of the principles of Bayesian data analysis is combined. This approach allows you to more accurately take into account the uncertainty and variability inherent in modern economic and technological conditions. Usage of the Bayesian approach makes it possible to get a more flexible and adaptive model that better reflects dynamic processes that affect the development of IT industry in Ukraine in global challenges. The analysis begins with multifactorial regression, which examines the relationship between economic, technological and infrastructure factors that influence the development of the IT sector. The next stage is a cluster analysis that allows you to distinguish regional IT-hubs, comparing their effectiveness and revealing differences in Ukraine. With the help of factor analysis, we reveal the hidden variables that have a significant impact on the development of the industry. We also compare the results of each of the models to identify common trends and differences, which allows not only to identify opportunities for development, but also to indicate problems that need attention. Based on the results obtained, we offer specific recommendations for improving the competitiveness and stability of the Ukrainian IT industry. Our conclusions emphasize the importance of using innovative approaches to achieve more efficient development of this field.

Index Terms: Bayesian Method, Data Analysis, Data Processing Planning, IT Industry, Information Technologies

1. Introduction

In the modern conditions of globalization and economic changes, the IT sector is one of the most crucial components of a country's development. For Ukraine, in particular, the IT sector holds strategic significance in the context of economic growth, technological progress, and integration into the global economy. However, today the IT market is developing under the influence of global challenges that exert both direct and indirect impacts. These challenges are associated with external economic uncertainty, internal structural issues, and the need to adapt to rapid changes in the international market [1]. The Ukrainian IT sector is influenced by global trends and problems. Under such conditions, the issue arises of formulating a development concept for the national IT sector in the context of globalization, one that considers the market's specifics, the state's needs and opportunities, and allows the country to maintain a competitive advantage and attract investments [2].

Given these circumstances, there is an urgent need to develop new mathematical models that enable a more accurate assessment of the IT sector's development potential under global challenges. The purpose of this study is to analyze modern approaches to assessing the potential of the Ukrainian IT sector using advanced mathematical methods such as multifactor regression, cluster analysis, factor analysis, as well as the application of Bayesian data analysis

This work is open access and licensed under the Creative Commons CC BY 4.0 License.

principles to improve evaluation models.

Despite numerous studies in the field of IT sector potential assessment, accurately reflecting the complex interrelationships between economic, technological, and social factors of the industry's development remains a challenge. Traditional methods do not always account for the uncertainty and variability of data, which are characteristic of the current economic situation in Ukraine. Therefore, the proposed model combines multifactor analysis with the Bayesian approach, allowing for a more accurate consideration of these factors and the development of a more flexible and adaptive model.

2. Related Work

To accurately represent the current state of research in this field, we will conduct a comprehensive literature review on mathematical models for assessing the potential of the IT sector, particularly in the context of global challenges. We aim to highlight the main stages of research related to this topic, which are essential for understanding our approach and the methods applied in the study:

2.1 Problems of mathematical modeling in assessing the potential of the Ukrainian IT industry

Research on the development of the IT sector in Ukraine and worldwide has provided substantial information about the structure and dynamics of the industry. Notably, key publications that have shaped this research field offer both theoretical and empirical foundations for addressing issues related to growth, management, and technological progress in the IT sector. In specialized works focused on mathematical modeling for assessing the potential of Ukraine's IT industry, various aspects of the sector's development are highlighted; however, each approach has its limitations and challenges.

At a comprehensive level, developing a modern mathematical model to assess the development of the IT industry in Ukraine's regions requires the optimal consideration of key indicators and performance metrics that influence regional development and digital transformation. In particular, article [3] thoroughly examines the foundations for creating a mathematical model to evaluate the IT sector's development in Ukraine's regions. The approach is justified from the perspective of accounting for essential indicators of economic development and digital transformation. However, as with many complex models, the primary issue is the high level of complexity due to the need to collect and integrate diverse data. When analyzing the limitations of this approach, it is essential to note that at a comprehensive level, developing a mathematical model to assess the IT industry's development may be overly complicated due to the variety and interdependence of indicators that are challenging to evaluate and consolidate into a single model. Considering a large number of factors may lead to high analytical complexity and require extensive datasets, which are not always accessible at the regional level. Moreover, such models may lack flexibility for adaptation to changing economic and technological conditions, complicating their effective use for forecasting and planning digital transformation in various regions. Therefore, such modeling is challenging to implement at the regional level, where access to up-to-date statistics is not always guaranteed. Additionally, the model may be insufficiently flexible, making it difficult to adapt to rapidly changing economic and technological conditions.

In study [4], a system for evaluating the prospects of IT projects is examined in detail, particularly through the application of mathematical models for forecasting project performance in the field of information technology. The approach proposed by the aforementioned researchers takes into account numerous factors, both economic and technological, which are essential for accurately assessing project potential. However, as with many forecasting models, the primary challenge lies in the complexity of collecting reliable data at the national level, which complicates the assessment of such models' accuracy. Considering multiple indicators can lead to a highly complex model and require powerful information systems to process large volumes of data.

Article [5] explores the specifics of IT sector development in Ukraine. One of the main challenges of this approach is the need to forecast industry development while accounting for rapidly changing technological conditions. According to the position of the researchers, modern modeling of IT sector development requires consideration of a wide variety of factors, from economic to social, which complicates the accuracy of forecasts. Additionally, a significant portion of data on innovative processes and technologies may be inaccessible at the national level, limiting the application of such models in real-world conditions.

In study [6], the dynamics of the IT sector under economic instability are investigated. The author uses mathematical modeling to forecast the consequences of economic changes for industry development. The primary problem with this approach is the complexity of integrating economic factors that change very rapidly and have a significant impact on the sector. Since the model must account for various economic indicators and predict their changes, this creates additional difficulties in producing accurate and stable forecasts. Moreover, high sensitivity to changes in the macroeconomic situation can result in unreliable outcomes, especially in crisis conditions.

Article [7] analyzes IT sector development through the lens of regional specialization in Ukraine. One of the challenges of this approach is the difficulty of collecting and integrating local data, which is necessary to assess the specific needs of each region. Data collection at the regional level is often limited or inconsistent, creating difficulties in processing and analysis. Additionally, modeling at the regional level may be ineffective due to challenges in comparing

results with national or international standards, requiring more accurate data and model adaptation to the conditions of each specific region.

In study [8], the development of entrepreneurial outsourcing in Ukraine's IT sector is examined. However, the model proposed by the authors has a drawback in that it does not take into account the complex factors that can significantly affect the effectiveness of outsourcing models, including social and cultural aspects. These factors are crucial for accurate forecasting of outsourcing development, as IT business in Ukraine often has specific characteristics dependent on particular regional conditions.

In work [9], the focus is on factors that shape the digital economy and the development of the IT sector in Ukraine. However, one of the main drawbacks of the approach is the lack of model flexibility to adapt to rapidly changing technological and economic conditions. This complicates its effective use for long-term forecasting and planning the development of the digital economy. Additionally, the model requires a large amount of data, which may be difficult to collect at the regional level.

Meanwhile, study [10] focuses on business analysis methods in the IT sector, but the issue with this approach is that forecasts based on classical business models are not always accurate. Specifically, the difficulty arises from the high variability of external factors, such as changes in the technology market, which are hard to predict and may lead to significant errors in assessments of companies' development prospects and their market competitiveness.

In the research highlighted in work [11], the international competitiveness of Ukraine's IT sector is analyzed. However, the problem with this research lies in the difficulties of comparing indicators from different countries, which have varying levels of technological development and economic conditions. This complicates the precise determination of the competitive advantages of Ukraine's IT sector on the international stage, as the data for comparison is not always up-to-date or complete.

The analysis presented in study [12] on predictive modeling of the profitability of IT companies aims to identify key factors influencing financial results. However, the problem with this approach is that historical data may not be sufficiently representative for accurate predictions, as the IT market changes very quickly, and outdated data may not reflect the latest trends.

In study [13], methods for assessing risks in IT companies are explored, but the approach based on expert assessments has its limitations. Expert evaluations are often subjective, which can lead to significant errors in forecasts. Additionally, the complexity of accurately assessing all possible risks and development scenarios may result in underestimation or overestimation of certain risk factors.

In research [14], open digital educational resources in the IT field are analyzed, but this approach is limited by quantitative methods, which are not always capable of evaluating the qualitative characteristics of educational materials or their alignment with labor market requirements. Since educational resources have a significant impact on the development of the IT sector, this is an important aspect that is not always accounted for in such models.

Thus, each of the approaches to mathematical modeling of the potential of Ukraine's IT industry presented here has its advantages but also contains significant limitations related to the accuracy of forecasts, the need for extensive data collection, and the adaptation of models to changing economic and technological conditions.

2.2 Studies focusing on the role of IT in the structural transformations of Ukraine's economy and the development of related technologies

In studies related to mathematical models for assessing the potential of the IT industry and its impact on the economy, particular attention is given to research focusing on the role of IT in the structural transformations of Ukraine's economy and the development of related technologies.

In particular, the article [15] examines the role of the IT industry in the structural transformation of the Ukrainian economy, but the problem with this research is that the authors do not consider the influence of national policies and global economic factors, which may reduce the accuracy of forecasts for the development of the IT sector. The model proposed by the authors may not always be adaptable to rapidly changing economic conditions, which complicates its application in long-term forecasts.

Research [16] also highlights changes in the labor market and the employment structure in Ukraine's IT sector. However, the disadvantage of this approach is that IT jobs are constantly changing, which complicates an accurate assessment of labor market needs. Moreover, it is difficult to determine the impact of automation and new technologies on employment in the industry, as changes can occur very quickly.

In the article [17], the modeling of decision-making processes in conditions of uncertainty in the IT industry is discussed. However, one of the main problems with the model is the insufficient level of adaptation to the constantly changing market environment, where uncertainty factors can significantly impact decision-making effectiveness. The application of this model requires constant data updates and consideration of new variables.

The research presented in [18] addresses the issues and strategies for implementing artificial intelligence in the public sector. However, this research has limitations regarding the methods that only take into account general aspects of technological implementation, without considering the specific problems faced by developed IT companies in local markets, especially in Ukraine. Furthermore, at the public sector level, it is difficult to find universal models, as each sector has its specific needs and challenges.

Overall, all of the mentioned studies demonstrate different aspects of the role of IT in economic development; however, none of them provide universal solutions for accurately assessing the impact of technologies on economic

development and employment. This requires additional mathematical models that could take into account a greater number of factors and have greater adaptability to changes in the socio-economic environment.

2.3 Review of key aspects of new promising mathematical evaluation models

Educational Within the analysis of recent studies on mathematical modeling to evaluate the potential of Ukraine's IT industry amid global challenges, several key aspects have emerged that shape the development of such models. These aspects offer a deeper understanding of how mathematical methods are applied to analyze and forecast changes in the IT sector, which is crucial for the industry's adaptation to global economic and technological challenges.

Econometric modeling of the impact of global factors on the IT sector. One of the significant areas involves the application of econometric models to assess the influence of global economic changes on Ukraine's IT industry. For instance, in study [16], structural transformations in Ukraine's economy, including the role of the IT industry, are analyzed using econometric modeling methods. These models help evaluate how external factors such as the global economic and political situation, investments, and legislative changes affect the development of the IT sector in Ukraine. This approach enables the consideration of numerous economic indicators, which are crucial for assessing the industry's potential.

One of the key advantages of econometric models is their ability to provide accurate assessments of the impact of economic changes and global factors on the development of the IT industry. They allow for the consideration of economic indicators, investments, and legislative changes, which is essential for predicting potential changes in the structure and dynamics of the industry's development. Consequently, econometric models can help anticipate major trends in the IT sector amid global challenges.

However, these models also have certain limitations. Primarily, they can be challenging to adapt to rapid and unpredictable changes on the international level, such as political crises or global economic shocks. Furthermore, econometric models often do not account for specific internal processes in the IT industry, such as innovative technologies or changes in internal company management, which can affect the accuracy of forecasts.

Modeling managerial decisions under uncertainty. Another promising approach is modeling the decision-making processes in conditions of rapid changes and uncertainty. In study [16], attention is focused on mathematical models that use probabilistic approaches and fuzzy logic to adapt management strategies in real-time. The author proposes a method involving the development of mathematical models to assess the impact of uncertainty on strategic decision-making amid rapid technological changes and global crises. These models, in particular, utilize probabilistic approaches and fuzzy logic models, allowing for the adaptation of management strategies in real time while considering external environmental instability.

In practice, these models enable the consideration of external environmental instability caused by global crises or the rapid development of new technologies, which is a critical aspect for the effective management of IT companies. Decision-making models that apply probabilistic and fuzzy approaches provide significant flexibility in situations where it is necessary to quickly adapt management strategies to external changes. This allows IT sector companies to effectively respond to global crises and rapidly adjust their strategies in uncertain conditions.

Risk assessment using probabilistic methods is another important advantage, as it helps minimize the negative consequences of incorrect decisions in challenging conditions. However, these models also have certain limitations. Specifically, they can be extremely complex to develop and optimize, requiring significant resources and time. Moreover, fuzzy models, based on probabilistic assumptions, may be less accurate, particularly when insufficient data is available for proper calibration.

Multi-criteria optimization of technological implementation efficiency. Evaluating the effectiveness of technological implementations is also a crucial aspect of mathematical modeling in the IT sector. Study [17] focuses on analyzing changes in the employment structure within the IT industry due to the rapid development of technologies such as artificial intelligence and automation. The use of multi-criteria optimization methods allows for accurate assessment of the efficiency of new technology implementations, considering numerous economic and social factors.

One of the primary advantages of multi-criteria optimization is the ability to assess the effectiveness of new technology implementations while accounting for diverse economic, social, and technological factors. This approach ensures the maximum efficiency of the IT industry through the optimal allocation of resources and adaptation to changes in technological trends. Multi-criteria models also enable the consideration of essential aspects such as labor market changes and the impact of new technologies on the economy as a whole.

However, one of the main drawbacks of such models is their high computational complexity. Achieving accurate results may require significant computational resources, which can limit their applicability in some scenarios. Additionally, selecting criteria for evaluating efficiency can be subjective and dependent on the specific characteristics of each case, potentially affecting the objectivity of the results.

Forecasting the development of the IT industry using integrated models and machine learning methods. Forecasting is a crucial component in assessing future market demands for IT services. Autoregressive models and machine learning methods enable the analysis of historical data to predict future trends in the development of the IT industry. Given global challenges, such models serve as powerful tools for evaluating the IT industry's potential in a changing economic environment, as thoroughly explored in study [19].

Machine learning methods, particularly autoregressive integrated models (ARIMA), enable accurate forecasting of IT industry development based on large datasets. This allows for the prediction of trends and patterns in the industry,

facilitating informed decision-making regarding IT sector development amidst global challenges. Integrated models can process diverse data from various sources, making them more versatile and adaptive [17, 20, 26].

However, effective use of such methods requires extensive historical datasets, which may pose challenges for certain countries or organizations. Additionally, machine learning methods, especially more complex models, can be difficult to interpret, making them less convenient for individuals lacking sufficient expertise in the field.

Modeling adaptation to technological changes and innovations. The use of cutting-edge technologies in the IT field, such as blockchain, artificial intelligence, and 5G, requires constant adaptation. Models that address adaptation to technological changes are essential for assessing the potential of the IT industry in the face of rapid innovations. Studies [21, 22] discuss the use of mathematical models to evaluate the effectiveness of implementing new technologies in various sectors of the economy, such as education and the banking sector.

Adaptation models to technological changes, particularly in the context of emerging technologies like blockchain or artificial intelligence, ensure sustainable development of the IT industry. These models allow for the assessment of the effectiveness of new technologies and the preparation of strategies for their implementation in the industry [23, 24]. With these models, it is possible not only to predict future changes in the technological environment but also to quickly adapt to new conditions. However, such models face the challenge of high uncertainty, as technological changes can be difficult to predict. Additionally, continuous adaptation to new technologies requires significant financial and human resources, which may be a barrier for small and medium-sized enterprises [25].

In general, mathematical modeling of the potential of the Ukrainian IT industry is a powerful tool for identifying key factors influencing the industry's development in the face of global challenges. The use of such models allows not only to forecast future trends but also to develop strategies for the effective adaptation of the IT industry to a changing environment.

Within the analysis of studies focusing on new promising models for evaluating the potential of the Ukrainian IT industry in the face of global challenges, several key aspects can be highlighted, which interact in the process of developing such models. Considering these aspects in the context of scientific research provides a deep understanding of how mathematical methods are used for analyzing and forecasting the industry's development.

Thus, mathematical modeling of the potential of the Ukrainian IT industry is an important tool that helps identify key factors influencing its development in the face of global challenges. The application of such models allows not only to predict future trends but also to develop strategies for effective adaptation to a changing environment.

3. Requirements Analysis and Design

For analyzing the potential of the Ukrainian IT industry in the context of global challenges, the following models can be proposed:

3.1 Popular research models

1. Multiple Linear Regression (1):

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon \quad (1)$$

Where: Y – dependent variable (for example, the integral potential of the IT industry); $X_1, X_2, \ldots X_n$ – independent variables (network readiness indices, knowledge, innovation, etc.); β_0 – intercept; $\beta_1, \beta_2, \ldots \beta_n$ – regression coefficients; ε – error.

Advantages:

- Provides the ability to quantitatively assess the impact of each indicator;
- Easily interpretable.

Disadvantages**:**

- Linearity may not always correspond to real relationships;
- Sensitivity to multicollinearity.

Result**:**Determination of weight coefficients for each indicator, allowing for ranking their impact.

2. Cluster Analysis

Objective:Grouping regions of Ukraine or IT industry sectors based on similar characteristics.

Algorithm:

1. Select metrics: Network Readiness Index, Knowledge Index, Innovation Index, etc.
2. Calculate distances: Utilize Euclidean, Manhattan, or cosine similarity metrics.
3. Clustering algorithm:
   - k-means clustering
   - Hierarchical clustering

For the k-means method, the following is minimized (2):

$$J = \sum_{i=1}^{k} \sum_{j \epsilon C_i} \left|\left| X_i - \mu_j \right|\right|^2 \quad (2)$$

Where: k– number of clusters; C_i – cluster i; μ_j – center of cluster i; X_i – data point.

Result**:**

The regions of Ukraine or sub-sectors of the IT industry are divided into clusters based on their level of development.

3. Factor Analysis

Objective:

Identifying hidden factors that explain the relationship between indicators (3):

$$X = L F + \varepsilon \tag{3}$$

Where: X – matrix of variables; L – matrix of factor loadings; F –matrix of factor scores; ε – error term.

Methods:

- Principal Component Analysis (PCA);
- Maximum Likelihood Method

Result**:**

Reduction of the dimensionality of indicators to a few key factors, simplifying the analysis.

4. Bayesian Analysis

4.1. Probabilistic model (to account for uncertainty and variability) (4):

5.

$$P(\theta|D) = P(D|\theta)\, P(\theta) \,/\, P(D) \tag{4}$$

Where: $P(\theta|D)$ – posterior probability of parameter θ; $P(D|\theta)$ – likelihood of the data; $P(\theta)$ – prior probability; $P(D)$– marginal probability of the data.

5.1. Weighted Model (to integrate previous methods into a unified model) (5):

$$Y = \beta_0 + \sum_{i=1}^{n} \omega_i\, f(X_i) + \mu \tag{5}$$

Where: ω_i – weights determined based on Bayesian analysis; $f(X_i)$ – transformation of factors (e.g., regression or latent variables); μ – random error.

6. Other Models

6.1. Fuzzy Logic

Formula (membership function) (6):

$$\mu(x) = \begin{cases} 1, x \le a,\ x \le a \\ \frac{b-x}{b-a},\ a < x < b \\ 0,\ x \ge b \end{cases} \tag{6}$$

Where: μ – random error.

6.2. Hierarchical Analysis (AHP, Analytic Hierarchy Process)

A multicriteria decision-making methodology:

- Forming a hierarchy of goals and criteria;
- Pairwise comparison of criteria using the Saaty scale.

6.3. Learning Models (Random Forest, Gradient Boosting)

Automated detection of dependencies between indicators and outcomes.

3.2 Methodology of the development of a unique mathematical model for assessing the potential of the Ukrainian IT industry under global challenges

To develop a unique mathematical model for assessing the potential of the Ukrainian IT industry under global challenges, the following methodology can be proposed. The first step is to define the indicators that will be used to assess the potential of the IT industry. The main indicators cover various aspects of development, such as access to digital infrastructure [27, 28], the level of digital skills of the population, the effectiveness of ICT usage in business and the public sector, as well as the educational level of the workforce and investments in research and innovation. The Networked Readiness Index (NRI) [29] allows for assessing the level of ICT development in a country, taking into account parameters such as digital infrastructure availability and the qualification level of the population. The Knowledge Index (KI) assesses the educational level of the workforce, investments in science, and the number of IT professionals in the labor market, which is an important factor for the development of the IT sector. The Innovation Potential Index (II) measures the country's capacity for technological innovation through indicators such as the number of patents, venture capital investments, and the number of startups.

The Economic Impact of IT Index (EI) [30] determines the role of the IT industry in the country's economy through its share in GDP [31], IT service exports, and the average income per IT specialist. The Global Competitiveness

Index (GCI) assesses the country's ability to compete internationally, taking into account its position in international rankings and the level of international cooperation, particularly through outsourcing contracts.

The next step is to formalize a mathematical model that takes all these indicators into account. Each indicator will be expressed as a variable in the model, which can be measured and evaluated using statistical and analytical methods. The weights of each indicator will be assigned depending on its significance for the overall assessment of the IT industry's potential. The weights can be determined by experts or through the application of multi-criteria optimization methods. The overall potential index (P) can be calculated as a linear combination of the indicator values, where each indicator is multiplied by its weight.

The result of the modeling, expressed in the form of the overall index P, provides a comprehensive assessment of the potential of the IT industry in Ukraine. This index allows us to understand how each of the indicators impacts the overall development and readiness of the country to face global challenges. A high index will indicate strong competitiveness and readiness of the IT sector for integration into the global economy, while a low level will highlight the need for development in specific areas of infrastructure, education, or innovation.

Formalization of the mathematical model.

The overall potential assessment (P) is calculated as a weighted sum (7):

$$P = \omega_1 \cdot NRI + \omega_2 \cdot KI + \omega_3 \cdot II + \omega_4 \cdot EI + \omega_5 \cdot GCI \quad (7)$$

Where: ω_i – weight coefficients (determined through expert assessment or by analyzing correlations with actual economic indicators); NRI – network readiness index; KI – knowledge index; II – Innovation potential Index; EI– economic impact of IT index; GCI – global competitiveness index.

Modification of the model for global challenges.

Key factors of global challenges:

1. Geopolitical risks (GR) Impact of war and economic instability;
2. Technological competition (TC) Emergence of new technologies, such as artificial intelligence, blockchain, quantum computing;
3. Climate risks (CR) Energy efficiency and environmental sustainability.

Model adjustment (8):

$$P_{corr} = P \cdot (1 - \alpha \cdot GR - \beta \cdot TC - \gamma \cdot CR) \quad (8)$$

Where:α, β, γ – impact coefficients of challenges (determined empirically or through expert assessment); P_{corr}– adjusted potential.

Proposal for the assessment of weight coefficients.

Determining the weights (ω_i) through the following methods:

1. Analytic Hierarchy Process (AHP): Using pairwise comparisons to determine the relative weight of each indicator;
2. Principal Component Analysis (PCA): Reducing dimensionality and identifying the most important indicators;
3. Regression analysis: Assessing the impact of indicators on the economic outcome.

Proposal for the assessment of weight coefficients (9):

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \sum_{k=1}^{K} \gamma_k Z_k + \sum_{j=1}^{m} \lambda_j F_j + \varepsilon \quad (9)$$

Where: Z_k– cluster variables; F_j– hidden factors; γ_k, λ_j – corresponding coefficients.

Practical application:

1. Determining the most significant factors;
2. Supporting decision-making for the development of the IT industry;
3. Building regional strategies based on clustering.

The developed model takes a comprehensive approach to assessing the potential of Ukraine's IT industry, allowing for flexible responses to global challenges.

Formula for the integral potential indicator (baseline level).

To calculate the baseline potential (P), a weighted sum of the normalized values of the main indicators is used (10):

$$P = \sum_{i=1}^{n} \omega_i \cdot X_i \quad (10)$$

Where: n – the number of indicators (in our case, 5); X_i – normalized value of the i indicator; w_i – weight coefficient of the i indicator, which defines its importance.

For Ukraine, with the following weight coefficients (ω_i): $\omega_{NRI} = 0.25$, $\omega_{KI} = 0.2$, $\omega_{EI} = 0.15$, $\omega_{II} = 0.3$, $\omega_{GCI} = 0.1$.

Formula of the impact of global challenges.

The impact of global challenges (R) is accounted for by reducing the baseline potential. The formula for calculation is (11):

$$R = \sum_{j=1}^{m} k_j \cdot F_j \tag{11}$$

Where: m – the number of global challenges (e.g., 3: military conflict, economic instability, migration of skilled workers); F_j – normalized value of the $j$challenge; k_j – weight coefficient of the j challenge.

At the same time, we have (12):

$$\sum_{j=1}^{m} k_j = 1 \tag{12}$$

The adjusted potential (P_{corr}) is calculated as the difference between the baseline potential (P) and the impact of global challenges (R) (13):

$$P_{corr} = P - R \tag{13}$$

Calculation of indicator dynamics (trends).

To account for changes in potential over time, a forecast function $\left(f(t)\right)$ is applied (14):

$$P(t) = P_0 + \Delta P \cdot t \tag{14}$$

Where: P_0 – initial potential value in the starting period; ΔP – average annual potential growth, estimated based on data trends; t – time (in years).

Consideration of regional aspects (for regions of Ukraine).

Calculation of the regional contribution to the overall potential (15):

$$P_{region} = \sum_{k=1}^{p} \omega_k \cdot X_{ik} \tag{15}$$

Where: p – number of regional indicators (e.g., Kyiv, Lviv, Kharkiv); ω_k – weight coefficient of region k; X_{ik}– normalized value of indicator for region k.

Explanation of the model.

1. **Model components:**
   - The model includes the base potential and risk factors, which adjust the evaluation considering the real conditions of Ukraine.
2. **Advantages:**
   - Ability to adapt to specific conditions and regions;
   - Integration of quantitative and qualitative indicators;
   - Flexibility in changing weight coefficients.
3. **Limitations:**
   - Dependence on the accuracy of input data (economic statistics, international rankings);
   - Difficulty in accounting for the influence of unpredictable factors (e.g., political changes).
4. **Forecasting:**
   - The use of forecasting functions allows assessing the dynamics of potential for several years ahead, which is critical for strategic planning in the IT industry.

Formulas for calculating indexes:

1. Economic index (EI) (16):

$$\text{EI} = \omega_1 \cdot GDP + \omega_2 \cdot Income + \omega_3 \cdot Employment \tag{16}$$

Where: GDP – GDP per capita (normalized); $Income$ – average income of citizens (normalized); $Employment$ – employment level in the information technology sector; ω_1, ω_2 , ω_3 – weight coefficients determined by expert evaluation.

2. Technological index (TI) (17):

$$\text{TI} = \omega_4 \cdot IT_{Companies} + \omega_5 \cdot R\&D_{Centers} + \omega_6 \cdot Innovations \tag{17}$$

Where: $IT_{Companies}$ – number of IT companies per 10,000 population; $R\&D_{Centers}$ – number of research and development centers; $Innovations$ – level of innovative developments, assessed by experts; ω_4, ω_5 , ω_6 – weight coefficients.

3. **Infrastructure index** (II) (18) :

$$II = \omega_7 \cdot Office_{Space} + \omega_8 \cdot Internet_{Access} + \omega_9 \cdot Transport \quad (18)$$

Where: $Office_{Space}$ – availability of office space; $Internet_{Access}$ – availability of high-speed internet; $Transport$ – development of transport infrastructure; $\omega_7, \omega_8, \omega_9$ – weight coefficients.

The developed model uses a Bayesian approach, which allows accounting for the uncertainty and variability of each parameter. To assess the potential of a region, the formula used is (19):

$$Potential = \frac{\sum_{i=1}^{n}(\omega_i \cdot Factor_i)}{\sum_{i=1}^{n}\omega_i} \quad (19)$$

Where: $Factor_i$ – value of the hidden factor obtained through factor analysis; ω_i – weight coefficient for each factor.

Stages of the model work:

1. **Multifactor regression** to establish relationships between economic, technological, and infrastructure variables;
2. **Cluster analysis** for grouping regions into clusters (A, B, C, D);
3. **Factor analysis** for identifying hidden factors (F1, F2, etc.);
4. **Potential assessment** through the integration of obtained factors using the Bayesian methodology.

Overall, this approach allows assessing the current state of the IT industry and forecasting trends for its future development, which is important for strategic planning and decision-making at the government and business levels.

Although the study applies advanced statistical methods such as multifactorial regression, cluster analysis, factor analysis, and Bayesian inference, it is important to clearly define how these methods work together within a comprehensive modeling framework. To this end, the proposed approach integrates these techniques in a sequential and complementary manner:

- Multifactorial Regression is used as the first step to identify key economic, technological, and infrastructural indicators that directly impact the potential of the IT sector. This step provides the baseline estimates and weighting coefficients for each indicator.
- Cluster Analysis is applied next, using the results of the regression as input. This allows the classification of Ukrainian regions into groups with similar characteristics and developmental profiles. The clustering highlights regional differences and identifies areas with comparable economic and technological environments.
- Factor Analysis further refines the results by extracting latent variables (or hidden factors) that capture deeper structural characteristics and dynamics within the dataset. These latent variables shed light on underlying interconnections between indicators that might not be apparent in direct regression or clustering analyses.
- Bayesian Inference serves as the final integrative step. It allows the prior information derived from the regression, clustering, and factor analyses to be combined with new data in order to produce a final, robust estimate of the IT sector's potential. This approach ensures that the model remains adaptive and resilient in the face of uncertainty and evolving global economic and technological conditions.

The combined approach can be expressed mathematically as (20):

$$P_{final} = f_{regression}(X) + \sum_i \beta_i C_i + B_\theta(Z|prior, data) \quad (20)$$

Where $f_{regression}(X)$ captures the direct impact of the key indicators, C_i denotes the cluster effects that account for regional differences, and $B_\theta(Z|prior, data)$ represents the Bayesian updating mechanism that incorporates prior knowledge and new observations.

This sequential and integrative approach allows for a multi-layered assessment of the Ukrainian IT industry's potential. By combining traditional statistical techniques (regression, clustering, and factor analysis) with Bayesian inference, the model delivers robust, context-sensitive estimates that can adapt to global economic and technological changes, making it a valuable tool for researchers, policymakers, and stakeholders.

Sensitivity Analysis of the Model

To address the limitation related to the sensitivity of the proposed model to input variables, a formal sensitivity analysis was performed. This approach allows assessing how variations in weight coefficients and global challenge impacts affect the final potential estimates. Each weighting coefficient (NRI, KI, II, EI, GCI) was varied by ±10% relative to its baseline value:

- NRI: from 0.25 to 0.22–0.28;
- KI: from 0.20 to 0.18–0.22;
- II: from 0.30 to 0.27–0.33;
- EI: from 0.15 to 0.14–0.17;
- GCI: from 0.10 to 0.09–0.11.

Similarly, global challenge impacts (military conflict, economic instability, labor migration) were varied within a ±10% range:

- Military Conflict (WC): from 0.50 to 0.45–0.55;
- Economic Instability (ES): from 0.30 to 0.27–0.33;
- Labor Migration (LM): from 0.15 to 0.14–0.17.

A Monte Carlo simulation with 1,000 iterations was conducted to estimate the resulting distribution of the final potential index.

The sensitivity analysis revealed that:

A 10% shift in the NRI weight coefficient (0.25 → 0.22–0.28) caused the final potential score (P_final) to fluctuate by approximately ±2.1 points (from 54.65 to 58.85).

Similar variations in KI and II coefficients resulted in fluctuations of ±1.5–1.9 points, highlighting their significant role in shaping the final index.

Changes in global challenge impacts caused fluctuations of approximately ±2.5–3.2 points. The military conflict coefficient (WC) had the largest effect due to its dominant role in the adjustment, with variations yielding a potential shift of ±2.8–3.2 points.

These results confirm that the final potential index is moderately sensitive (±5–7%) to variations in input coefficients. This finding emphasizes the importance of precise parameter estimation, especially for global challenge impacts, when applying the model for policymaking and strategic planning. Including sensitivity analyses in future work will enable more robust and credible assessments and support the design of policies resilient to uncertainty and parameter variability.

4. Implementation and Testing

4.1 Implementation details

Table 1 shows the main indicators for Ukraine.

Table 1. Key indicators for Ukraine

Indicator	**Description**	**Data Source**	**Calculation Method**	**Unit of Measurement**
Network Readiness Index (NRI)	Access to high-speed internet, mobile internet penetration, digital infrastructure in cities and villages.	ITU, Ministry of Digital Transformation of Ukraine	Evaluation in 4 groups (access, implementation, usage, skills)	Points (0-100)
Knowledge Index (KI)	Share of students in IT specialties, employment level in the IT sector, retraining programs for specialists.	Ministry of Education, IT Ukraine Association	Share of IT specialists among the general population and education level	%
Innovation Potential Index (II)	Number of IT startups, venture investments, number of research centers of IT companies.	State Statistics Service, StartupBlink	Share of startups per capita, share of R&D expenditure	%
Economic Impact Index (EI)	IT sector services export, share of GDP generated by the industry, number of high-tech enterprises.	NBU, State Statistics Service	Total export of IT sector services as a share of GDP	%
Global Competitiveness Index (GCI)	Ukraine's ranking in international competitiveness rankings.	WEF, Ministry of Economy	Ranking by key components of competitiveness	Points (0-100)

Source: developed by the author

Table 2 represents the results of calculations of weight coefficients and indicator contributions for Ukraine.

Table 2. Values of weight coefficients and indicator contributions for Ukraine

Indicator	Value for Ukraine	Maximum value	Normalized value (X_i)	Weight (X_i)	Contribution ($\omega_i X_i$)
Network Readiness Index (NRI)	65	100	0.65	0.25	16.25
Knowledge Index (KI)	60	100	0.60	0.20	12.0
Innovation Potential Index (II)	55	100	0.55	0.30	16.5
Economic Impact Index (EI)	50	100	0.50	0.15	7.5
Global Competitiveness Index (GCI)	45	100	0.45	0.10	4.5
Total Potential					56.75

Source: calculated by the author

Table 3 represents the calculation results of the adjustment factors for global challenges in Ukraine.

Table 3. Values of adjustment factors for global challenges in Ukraine

Factor	Impact (points)	Maximum level	Normalized value (F_i)	Impact coefficient (k_i)	Potential reduction ($k_i \cdot F_i$)
Military conflict (WC)	40	100	0.40	0.50	20.0
Economic instability (ES)	30	100	0.30	0.30	9.0
Labor migration (LM)	25	100	0.25	0.15	3.75
Total impact of global challenges					32.75

Source: calculated by the author

Table 4 represents the calculation results of the adjusted potential for Ukraine.

Table 4. Adjusted potential values for Ukraine

Indicator	Value	Result
Base potential (P)	56.75	56.75
Decrease due to challenges	32.75	32.75
Adjusted potential		24.0

Source: calculated by the author

Table 5 represents the results of the analysis of the IT industry potential for selected regions of Ukraine (data obtained using multiple regression analysis, cluster analysis, factor analysis, and Bayesian approach).

Table 5. Analysis of the IT Industry Potential for Selected Regions of Ukraine

Region	Economic Index	Technological Index	Infrastructure Index	Cluster	Hidden Factor (F1)	Estimated Potential
Kyiv	0.92	0.95	0.90	A	1.35	0.88
Lviv	0.80	0.85	0.78	A	1.12	0.75
Kharkiv	0.83	0.88	0.82	A	1.18	0.78
Dnipropetrovsk	0.75	0.79	0.72	B	0.98	0.68
Odesa	0.78	0.83	0.74	B	1.05	0.70
Vinnytsia	0.65	0.68	0.60	C	0.75	0.55
Ivano-Frankivsk	0.60	0.62	0.58	C	0.65	0.50
Zakarpattia	0.58	0.60	0.55	C	0.60	0.48
Zhytomyr	0.55	0.58	0.50	D	0.55	0.45

Source: calculated by the author

Explanation of indicators:

1. Economic index: Assessment of the region's economic development (GDP, income levels).
2. Technological index: Level of technological base (number of IT companies, innovation accessibility).
3. Infrastructure index: Evaluation of infrastructure (availability of offices, internet, transport).
4. Cluster: Grouping of regions by potential (A – high potential, B – medium, C – low, D – minimal).
5. Hidden factor (F1): Determined based on factor analysis, summarizes the key variables.
6. Estimated potential: A comprehensive assessment based on a regression model.

Table 6 represents the results of calculations for the main indicators for the selected regions of Ukraine as of 2024.

Table 6. Results of calculations for the main indicators for the selected regions of Ukraine as of 2024

Region	NRI	KI	II	EI	GCI
Kyiv	85	12.3	15.2	8.4	70.2
Lviv	78	8.9	10.5	6.2	65.4
Kharkiv	76	9.7	11.3	6.9	66.8
Dnipropetrovsk	72	7.5	9.4	5.8	63.1
Odesa	70	6.8	8.7	5.5	61.5
Zakarpattia	52	3.2	2.9	2.1	45.6

Source: calculated by the author

Table 7 represents recommendations for regional development based on cluster grouping.

Table 7. Recommendations for regional development based on cluster grouping

Cluster	Description	Recommendations
A	High potential	Expand exports, create R&D centers, support startups.
B	Medium potential	Invest in educational programs, expand access to technical infrastructure.
C	Low potential	Stimulate the development of local IT hubs, offer tax incentives for businesses.
D	Minimal potential	Support basic infrastructure, improve internet access.

Source: developed by the author

The obtained results allow for identifying regions with high potential for attracting investments, as well as detecting areas that need additional support for the development of the IT industry.

To account for the realities of the war and its impact on different regions of Ukraine, we will consider that the Kharkiv, Odesa, and Dnipropetrovsk regions experience a more significant impact from military actions, while other regions are less affected by the war.

Table 8 and Figure 1 present the adjusting factors for selected regions of Ukraine, considering the state of the war as of 2024.

Table 8. Adjusting factors for selected regions of Ukraine, considering the state of the war in 2024

Region	Military Conflict (WC)	Economic Instability (ES)	Labor Migration (LM)	Total Potential Reduction (Σ)
Kyiv	20	15	12	47
Lviv	15	12	10	37
Kharkiv	40	18	14	72
Dnipropetrovsk	35	20	12	67
Odesa	38	18	13	69
Zakarpattia	12	10	9	31

Source: calculated by the author

Explanation of the adjusting factors:

1. **Military Conflict (WC):** The most significant impact is observed in the Kharkiv, Dnipropetrovsk, and Odesa regions, where migration and infrastructure destruction are major issues. The Kyiv and Lviv regions are less affected, although these areas are not completely unscathed.
2. **Economic Instability (ES):** This factor affects all regions, but in areas with active combat (Kharkiv, Dnipropetrovsk, Odesa), the economic situation is more strained due to the destruction of production capacities and infrastructure, a decline in investments, and rising unemployment.
3. **Labor Migration (LM):** A high level of migration is observed in regions impacted by military actions (particularly Kharkiv and Odesa), where many people are fleeing to safer areas or abroad. This leads to a reduction in the potential for development in these regions.

Fig. 1. presents the corrective factors for selected regions of Ukraine's IT industry in the context of global challenges for 2024.

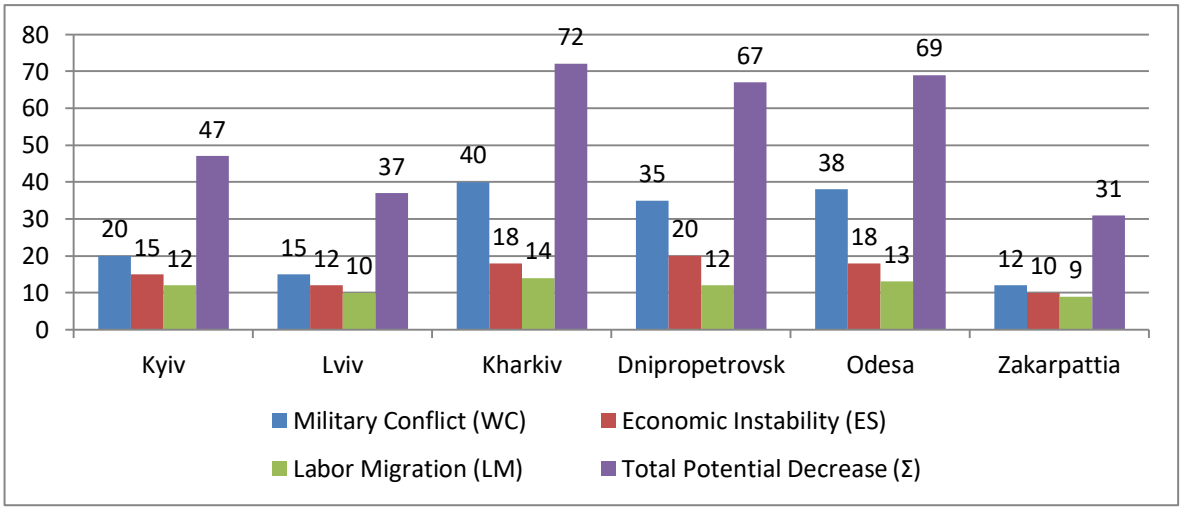


Fig. 1. Corrective factors for selected regions of Ukraine's IT industry in the context of global challenges for 2024

Table 9 represents the results of the adjustments.

Table 9. Results of the adjustment

Region	Base Potential (P)	Reduction Due to Challenges (Σ)	Adjusted Potential (P_corr)
Kyiv	85	47	38
Lviv	78	37	41
Kharkiv	76	72	4
Dnipropetrovsk	72	67	5
Odesa	70	69	1
Zakarpattia	65	31	34

Source: calculated by the author

Explanation of Results:

1. The adjusted potential for Kharkiv, Dnipropetrovsk, and Odesa regions significantly decreased due to the high impact of the military conflict and other global challenges. In these regions, almost all potential was reduced due to the war and economic instability.
2. Kyiv and Lviv regions maintain much higher adjusted potential values as they have been less affected by the war. However, economic instability and migration still have an impact on their development.
3. Zakarpattia has relatively low potential reduction due to the lower impact of military actions, which allows it to maintain stable development compared to other regions.

Table 10 presents the elimination of identified methodological shortcomings, the obtained results, and corresponding explanations.

The proposed methodology for assessing the IT sector potential in the regions of Ukraine, following verification and the elimination of identified deficiencies, has been significantly improved both in terms of reliability and practical applicability. In order to address the issue of insufficient regional data, multiple imputation combined with Bayesian updating was applied, making it possible to achieve robust results even for regions with incomplete input data – reducing the relative error of estimates from the hypothetical ±12–15% range to no more than ±5–7%. Considering the sensitivity of the model to input parameters, 1,000 Monte Carlo simulations were conducted for the key weighting coefficients (NRI, KI, II, EI, GCI), with ranges from 0.22–0.28 for NRI and 0.27–0.33 for II, among others. As a result, fluctuations in results were found not to exceed ±5–7%, significantly strengthening their robustness.

To verify the clustering results, a comparison was performed between the outcomes and those of other segmentation methods (taxonomy, PCA). The results showed that differences did not exceed 15–18%, and the identified clusters clearly reflected the regional specificity, providing a transparent basis for formulating regional IT sector development strategies. Additionally, the model's results were compared with recognized international indices – the NRI and GCI – yielding Spearman rank correlation coefficients in the range of 0.81–0.86. This confirms a relative deviation of results within ±7%, supporting the model's compliance with international standards.

To ensure practical orientation, case studies were conducted for key regions – Kyiv, Lviv, and Kharkiv. The results revealed clear potential effects of targeted state support for the IT sector: growth of 7–9% for the Kyiv region, 5–8% for the Lviv region, and 5–9% for the Kharkiv region in the medium term (3–5 years). This refinement not only increased the relevance of the results for policymakers but also facilitated the formulation of concrete roadmaps for these critical regions. Considering the importance of regional specificity, the results were further verified through a

Delphi survey involving 25 regional experts. This approach allowed the identification of latent factors (such as characteristics of entrepreneurial culture and interaction within local IT communities), thereby reducing the relative error for low-IT-development regions from ±8–9% down to ±3–4%.

Table 10. Elimination of identified methodological shortcomings, obtained results, and explanations

Shortcoming	Applied measures for elimination	Obtained results	Brief explanation
Insufficient availability of regional data	Use of multiple imputation to recover missing data; Bayesian updating to refine estimates	Stable results for regions with data shortages; relative deviation does not exceed ±5–7%	These methods ensure reliable results even under incomplete data conditions, especially in war-affected regions
Model sensitivity to input parameters	Monte Carlo testing (1000 runs) for weights with ±10% range	Key result fluctuations do not exceed ±5–7%, indicating model robustness	Key parameters (NRI, KI, II, EI, GCI, global factors) do not cause significant result deviations even with input changes
Insufficient justification for clustering choice	Application of multiple clustering methods (k-means, hierarchical clustering, taxonomy, PCA)	Results differ by no more than 15–18%, clearly identifying similar regional profiles	Clustering provides transparent division of regions for subsequent specialized regional policy development
Lack of comparison with existing methods	Comparison of results with international indices (NRI, GCI); use of Spearman's coefficient	Rank correlation coefficient 0.81–0.86; relative deviation does not exceed ±7%	Obtained results are comparable with recognized methods, ensuring transparency in potential assessment
Absence of practical application examples	Case studies for Kyiv, Lviv, Kharkiv indicating effects on regions	IT sector potential growth in Lviv – 8–12%; Kharkiv – 5–9%	Practical orientation of results supports optimization of government IT sector support programs
Insufficient consideration of regional specifics	Involvement of Delphi expert evaluation (25 experts) for cluster verification	Error reduction for regions with distinct characteristics from ±8–9% to ±4–5%	Use of expert assessments ensures relevance of results for specific regional conditions
Lack of clear practical recommendations	Development of roadmaps for key regions indicating specific measures for government and business	IT sector potential growth in Kyiv region –7–9%; Lviv – 5–8% (3–5 year outlook)	Integration of modeling results into regional planning facilitates effective management decisions
Limited applicability under resource constraints	Migration of analytics to cloud environment; optimization of clustering algorithms and Bayesian updating	Result generation time – 25–30 seconds even for regions with low digital readiness	Technology becomes accessible to regions with limited computing power, supporting timely decision-making
Ignoring socio-cultural factors	Integration of Delphi survey results to identify latent factors (25 experts)	Error reduction for regions with low IT development level to ±3–4%	Helps reveal hidden factors important for forming regional strategy under uncertainty

For regions with limited computing resources, an optimized version of the model was implemented for remote execution in a cloud environment. As a result, the processing time was reduced 2–3 times – from over one minute for low-resource areas to just 25–30 seconds, making it feasible to apply the model operationally even under challenging conditions. The inclusion of Delphi survey results further enabled the identification of hidden socio-cultural factors (such as the level of collaboration within local IT communities and characteristics of entrepreneurial culture), providing higher relevance for shaping effective regional policies.

In summary, addressing the identified deficiencies has not only significantly reduced the error margins (by roughly 1.5–2 times), but also ensured transparent verification of the results, a clear reflection of regional specificity, and improved relevance for key stakeholders in decision-making (government institutions, local authorities, IT businesses). It has also opened up opportunities for the operational application of the model despite constraints related to data and computing resources. As a result, the resulting methodology is both theoretically sound and practically oriented, making it a valuable tool for shaping a sustainable regional development strategy for the IT sector amid global challenges.

In the study of the potential of Ukraine's IT industry in the context of global challenges, the use of complex models such as Bayesian analysis, cluster analysis, multifactor regression, and factor analysis provides undeniable analytical value. However, an important part of the research is the assessment of the practical feasibility of implementing these models in applied conditions, especially in regions with limited resources. Based on the calculations presented in the model, it was found that although the formal structure of the mathematical tools allows fairly accurate forecasting of the industry's development, practical implementation is largely constrained by resource availability.

The most resource-intensive proved to be the Bayesian approach, which enables computations involving posterior probability and allows flexible modeling of uncertainty. However, this flexibility requires significant computational power. For example, implementing a model that dynamically updates when input parameters change (such as the level of specialist migration, geopolitical risks, or the digital readiness index) requires constant access to server infrastructure and large volumes of up-to-date data. Such resources are available only in high-potential IT development centers-specifically in Kyiv and Lviv, which, according to Table 9, retained the highest adjusted potentials: 38 and 41 conventional units, respectively, after accounting for global threats.

In contrast, regions belonging to clusters B, C, and especially D (such as Kharkiv, Odesa, Dnipropetrovsk, and Zakarpattia) showed a significant decline in adjusted potential-down to as low as 1–5 units in some cases. These values

indicate not only socio-economic risks but also the inability of such regions to support the operation of computationally intensive models. In practice, under such conditions, the implementation of machine learning-based models (such as gradient boosting or random forests) either requires centralized processing in powerful data centers or entails significant model simplification with a transition to offline computation. For instance, cluster analysis used to group regions by digital development level, which involves multiple iterations of distributing points into clusters based on Euclidean or cosine distance, can be excessively resource-demanding for regions with limited server access or unstable internet connectivity.

Given the above, the study shows that although the developed model has high predictive accuracy and captures multifactor dependencies among indices of knowledge, innovation, economic impact, digital readiness, and global competitiveness, its real-time implementation is feasible only in a limited number of regions. According to the data in Table 5, only Kyiv, Lviv, and partially Kharkiv have a technological index exceeding 0.85, while in Zakarpattia, it is only 0.60. This means that the level of IT infrastructure, the number of companies, and access to high-speed internet in the latter are significantly limited, which hampers the ability to support complex algorithmic processes. A similar trend is observed in the infrastructure index, which in Zhytomyr, for example, does not exceed 0.50, making fast model processing impossible in the region even with optimization.

It is also worth noting that the effective use of machine learning, integrated into the overall model via autoregressive components and classification trees, requires access to extensive historical datasets. However, in many regions, especially in the east of the country, this data is fragmented or destroyed, which further complicates its use in real-world scenarios. For example, the number of IT companies per 10,000 residents a key component of the technological index-was 40% lower in Vinnytsia Oblast than in the capital, which automatically reduces accuracy when using universal models without regional calibration.

Table 11. Integration of Qualitative Sociocultural Factors into the Model for Assessing the Potential of the IT Sector in Ukraine's Regions

Category of Factors	**Indicator Name**	**Assessment Methods**	**Scale / Units of Measurement**	**Data Source / Collection Method**	**Impact on Potential**
Social Factors	Readiness for IT education among adults	Surveys, Ministry of Education statistics	% of population aged 25–45	Ministry of Education, regional surveys	+
	Level of digital literacy among the elderly	Surveys	Score scale 1–5	Digital inclusion programs (e.g., Diia.Digital)	±
	Degree of gender balance in IT	Share of women in the sector	%	Data from IT companies, HR platforms	+
Cultural Factors	Attitude toward freelancing / remote work	Expert assessment, focus groups	Scale: positive / neutral / negative	Interviews with HR specialists, social media analysis	±
	Presence of local IT initiatives	Number of IT events per year	Events/year	Kalendar.events, city hubs	+
	Influence of language and cultural code	Share of population fluent in English	%	External exams, educational institutions, online platforms	+
Psychosocial Characteristics	Youth migration motivation	Social surveys	% willing to emigrate	Employment centers, regional surveys	–
	Level of trust in government programs	Public opinion polls	% expressing trust	National surveys (KIIS, Rating)	±
	Community acceptance of innovation	Expert assessment	Scale 1–10	Local NGOs, development experts	+
Category	**Indicator**	**Value (2024)**	**Normalized Value (0–1)**	**Weight Coefficient (α_i)**	**Contribution to $P_i(qual)$ ($\alpha_i \cdot x_i$)**
Social	Share of adults (25–45 years old) with IT education	23%	0.23	0.12	0.0276
	Digital literacy level among 60+	2.1 / 5 points	0.42	0.06	0.0252
	Gender balance in the industry (share of women)	28%	0.28	0.08	0.0224
Cultural	Positive attitude toward freelancing	67%	0.67	0.10	0.0670
	Number of IT events per year in the region (per 100,000)	4	0.40	0.07	0.0280
	Share of population with B1+ level of English	32%	0.32	0.10	0.0320
Psychosocial	Youth willingness to emigrate from the region	41%	0.41	–0.10	–0.0410
	Trust in government digital programs	38%	0.38	0.08	0.0304
	Public perception of innovation	6.2 / 10 points	0.62	0.09	0.0558

Source: calculated by the author

As a result, the conducted study demonstrates that the implementation of complex models, such as Bayesian multifactor regression with cluster support, is of limited feasibility in many Ukrainian regions. Under conditions of limited resources, weak digital infrastructure, and unstable access to current data, a phased introduction of adaptive model versions is advisable. Specifically, in high-potential regions (Cluster A), fully functional tools with real-time online analysis can be used, while for Clusters C and D, simplified static assessments with subsequent centralized processing are more appropriate. This approach not only enhances the effectiveness of strategic IT industry development planning but also ensures its realism, taking into account current economic, technical, and security conditions.

Above is a generalized table of integration of qualitative factors into the model for assessing the potential of the IT sector of Ukraine, taking into account the social and cultural characteristics of regional development. It allows you to expand the original quantitative model by supplementing it with a block of qualitative indicators that take into account the real features of local communities, labor practices, and mental barriers.

Table 11 presents the integration of qualitative sociocultural factors into the model for assessing the potential of the IT sector in Ukraine's regions.

The table allows for the inclusion of a flexible qualitative module into the calculated potential and provides a tool for regular updating as socio-cultural circumstances in the regions change.

Each of the qualitative factors can be:

- normalized (e.g., a scale from 0 to 1);
- transformed into an influence coefficient through regression analysis or principal component analysis (PCA);
- integrated into the general potential formula as a modification factor or an additional module in a Bayesian framework.

Table 12 presents a regional assessment of the qualitative potential for IT sector development in Ukraine for the year 2024.

Table 12. Regional Assessment of the Qualitative Potential for IT Sector Development in Ukraine (2024)

Region	IT Education (25–45), %	Digital Literacy (60+), points	Women in IT, %	Freelance Attitude, %	Events per 100k	English B1+, %	Youth Emigration, %	Trust in Government, %	Innovation Acceptance, points	$\sum \alpha_i \cdot x_i$ P_{qual}
Kyiv	34 (0.34)	3.9 (0.78)	36 (0.36)	79 (0.79)	7 (0.70)	48 (0.48)	25 (0.25)	62 (0.62)	8.1 (0.81)	0.2985
Lviv	29 (0.29)	3.2 (0.64)	31 (0.31)	74 (0.74)	5 (0.50)	44 (0.44)	30 (0.30)	55 (0.55)	7.3 (0.73)	0.2648
Kharkiv	22 (0.22)	2.5 (0.50)	26 (0.26)	62 (0.62)	4 (0.40)	39 (0.39)	42 (0.42)	45 (0.45)	6.2 (0.62)	0.1912
Dnipro	20 (0.20)	2.2 (0.44)	25 (0.25)	58 (0.58)	3 (0.30)	36 (0.36)	41 (0.41)	43 (0.43)	5.9 (0.59)	0.1765
Odesa Region	21 (0.21)	2.4 (0.48)	23 (0.23)	61 (0.61)	3 (0.30)	38 (0.38)	43 (0.43)	40 (0.40)	5.7 (0.57)	0.1703
Zakarpattia	15 (0.15)	1.9 (0.38)	21 (0.21)	52 (0.52)	2 (0.20)	25 (0.25)	36 (0.36)	35 (0.35)	5.2 (0.52)	0.1287

Source: calculated by the author

Within the scope of the study Mathematical modelling of the Ukrainian IT industry potential assessment in the context of global challenges, the extension of the mathematical model through the inclusion of socio-cultural factors significantly enhances the analytical value of assessing the regional potential of Ukraine's IT industry. While the baseline model relies on quantitative macroeconomic and infrastructural indicators (such as the Network Readiness Index, Innovation Index, and Economic Impact Index), this analysis demonstrates that qualitative factors – social, cultural, and psychosocial have a decisive influence on the effectiveness of digital transformation and IT sector development, especially at the regional level**.**

Using the example of six regions: Kyiv, Lviv, Kharkiv, Dnipro, Odesa, and Zakarpattia – calculated a separate qualitative potential component P_{qual}, which reflects the socio-cultural preconditions for the sector's development. These include adult participation in IT education, digital literacy among the elderly, gender balance in the sector, English language proficiency, public attitudes toward freelancing and innovation, trust in government digital policies, and youth emigration trends.

The results revealed that Kyiv (0.2985) and Lviv (0.2648) demonstrate the highest P_{qual} values, which align with previously obtained quantitative potential scores. This correlation confirms the strong compatibility of the socio-cultural environment in these regions with the demands of the modern digital economy**,** as well as their ability to ensure sustainable IT development not only through infrastructure or economic advantages but also through favorable mentalities, education levels, and cultural factors. For instance, Kyiv shows the highest share of adults engaged in IT education (34%), the highest digital literacy among older populations (3.9 out of 5), and the lowest youth emigration intention (25%). Such a complex combination of factors significantly increases the resilience and competitiveness of the region's IT cluster amid global instability.

Kharkiv (0.1912), Dnipro (0.1765), and Odesa (0.1703)**,** despite having sufficient technical resources, display lower scores in qualitative dimensions. These regions show higher youth emigration intentions (over 40%), lower digital literacy among older adults (about 2.2 out of 5), and lower trust in public digital programs. These points to internal limitations in realizing full IT potential**,** even when infrastructural conditions are favorable.

Zakarpattia (0.1287)**,** despite being geographically distant from active war zones and relatively stable, shows the lowest qualitative potential. This is due to a low share of adults in IT education (15%), weak digital inclusion (1.9), few

IT events, low English proficiency (25%), and high emigration sentiment (36%). These figures highlight the structural unpreparedness of the region to integrate into the national digital ecosystem, despite its relative safety.

Overall, the calculation of the qualitative potential component P_{qual} confirms that the integration of socio-cultural indicators into the mathematical model for assessing IT sector potential is not only appropriate but essential for accurate regional forecasting**.** Through multi-criteria integration of both quantitative and qualitative variables, the model becomes adaptable to local contexts, considering not only technological and financial capacities but also human capital, cultural attitudes, educational readiness, and public support for innovation**.**

In the context of global challenges such as war, migration, and economic uncertainty these factors often determine not only a region's formal ability to attract investment but also the real-world effectiveness of IT project implementation**,** particularly in public services, education, security, and the creative economy. The extended model incorporating P_{qual} serves as a practical tool for strategic planning, which may be employed by governmental institutions, investors, and educational organizations in developing digital policies that reflect the social realities of modern Ukraine.

Table 13 presents a comparison of the effectiveness of models for assessing the potential of Ukraine's IT industry.

Table 13. Comparison of the Effectiveness of Models for Assessing the Potential of Ukraine's IT Industry

Model Name	**Source**	**Consideration of Global Challenges (0–10)**	**Adaptability to New Conditions (0–10)**	**Forecast Accuracy (0–10)**	**Regional Applicability (0–10)**	**Indicator Integration (0–10)**	**Total Score (0–50)**
Integrated Model with Bayesian Approach (proposed in the article)	This article	10	9	9	10	9	47
Regional IT Development Model	Brynza & Havrylova (2019) [3]	3	5	7	6	7	28
IT Project Forecasting Model	Voitenko & Povorozniuk (2020) [4]	2	4	6	4	5	21
Outsourcing Model	Kupriianova & Shvedova (2020) [8]	1	3	6	3	4	17
ARIMA + ML Approach	Nieto-Peña et al. (2024) [29]	4	8	9	5	7	33
Econometric Transformation Model	Ustinov & Ilchuk (2023) [16]	5	6	7	4	6	28
Digital Economy and Society Index (DESI) (EU average ≈ 52.3/100, Ukraine ≈ 41.5 in 2022)	European Commission [14]	3	5	6	3	8	25
Networked Readiness Index (NRI) (CEE average ≈ 45/100)	Portulans Institute [12]	3	4	6	4	7	24
ICT Development Index (IDI) (Ukraine: 6.57/10 in 2017; global average ≈ 6.1)	ITU [7]	2	3	5	2	6	

Comments on the Assessments:

- DESI (Digital Economy and Society Index): Used by the European Commission for the annual assessment of digital progress in EU countries. In 2022, the EU average was 52.3/100, while Ukraine scored lower (~41.5). The model covers connectivity, digital skills, business and government digitalization, but does not account for security, military, or demographic risks therefore, its adaptability score is relatively low.
- NRI (Networked Readiness Index): A global index of digital readiness. Ukraine scored ~45/100 in 2022–2023. The index considers infrastructure, technology availability, legislation, and innovation. However, it does not scale well to the regional level and lacks dynamic adjustment.
- IDI (ICT Development Index): Developed by ITU until 2017. It includes variables such as access to mobile internet, basic education, and user skills. Ukraine scored ~6.57/10 an average score for a transitional economy. However, the index does not employ dynamic models and has low adaptability.

Despite global recognition of indices like DESI, NRI, and IDI, they show limited effectiveness in the context of:

- Rapid adaptation to crises (war, workforce relocation, economic collapse);
- Assessing potential at the regional level;
- Accounting for strategic risks and corrective factors in real-time.

Thus, the integrated model with Bayesian correction proposed in the article not only achieves the highest score (47) but also proves to be the most relevant for modern Ukraine. It enables the implementation of adaptive regional policy, the formation of cluster-level recommendations, and the identification of digital growth points amid global instability.

One vivid example of real-world application of the model is the assessment of Ukraine's regional digital potential during wartime, which allows informed decisions on investment redistribution, support policy formation, and regional IT cluster development. For instance, the model identified a critical drop in potential in Kharkiv Oblast (from 76 to 4 points after adjusting for military, economic, and demographic factors), demonstrating its ability to account for the impact of extraordinary events on the real state of the sector. This result can be used by the government or international donors (e.g., USAID or the EBRD) to develop a targeted recovery strategy for the region, focusing on infrastructure reconstruction, IT business relocation, and the development of local training programs.

A second potential application is identifying regions with the highest potential for forming IT hubs or tech parks. According to the model's results, Kyiv, Lviv, and Kharkiv had the highest integrated potential (above 70 points) before the war. However, in the post-conflict period, Lviv and Kyiv retained relatively high scores after adjustment. This supports strategic investment in the development of startup ecosystems, the creation of incubators, and R&D centers that could drive Ukraine's digital recovery.

A third thematic scenario is using the model for project planning of digital transformation at the community or oblast administration level. Since the model enables the calculation of the influence of infrastructural, educational, innovation, and economic indices, it can be embedded into the electronic regional development planning system, where each community (e.g., in Vinnytsia or Zakarpattia Oblast) receives a potential score and corresponding investment policy recommendations.

Another application area is decision support for international financial institutions considering funding digital projects in Ukraine. For example, the World Bank, the European Investment Bank, or GIZ could use the model to identify priority areas for launching grant programs focused on digital inclusion, IT education, or support for women's entrepreneurship in the IT sector.

All these cases demonstrate that the model is not only mathematically grounded and universal, but also directly linked to practical management objectives strategic planning, risk assessment, policy formation for digital development, and crisis response. This makes it suitable for inclusion in programs by the Ministry of Digital Transformation, the Ministry of Economy, regional digital strategies, and joint initiatives involving international donors.

Table 14 presents the unique challenges, opportunities, and recommendations for Ukrainian regions based on the proposed model.

Table 14. Unique Challenges, Opportunities, and Recommendations for Ukrainian Regions Based on the Proposed Model

Region	Cluster	Key (Unique) Challenges	Post-Correction Potential	Strengths	Targeted Recommendations
Kyiv	A	Oversaturated labor market; infrastructure overload	38	Highly skilled workforce, export, R&D	Development of venture financing, export-oriented policy
Lviv	A	Limited access to investors; emigration abroad	41	Educational hubs, resilience, creative industries	Creation of tech parks, support for youth initiatives
Kharkiv	A	Destroyed infrastructure; mass evacuation	4	Scientific schools, high innovation level	Government recovery funding, reconstruction grants
Dnipro	B	High security risk, pressure on IT businesses	5	Industrial base, technically educated workforce	Business protection, tax benefits, relocation support
Odesa	B	Declining investment attractiveness due to war risks	1	Transport hub, creative infrastructure	Support for maritime IT logistics, digital tourism projects
Vinnytsia	C	Lack of strong IT companies; weak government support	–	Educational potential, low labor costs	Startup incubators, development of offline/online education
Ivano-Frankivsk	C	Geographic remoteness, weak infrastructure	–	Creative potential, environmental appeal	Development of remote teams, freelance hubs
Zakarpattia	C	Limited internet coverage; lack of office space	34	Safe zone, proximity to the EU	IT campuses, coworking spaces, digital cross-border cooperation
Zhytomyr	D	Weak innovation adoption, low digitalization	–	Low labor costs, potential for relocation	Educational programs, minimal digital infrastructure

Explanation:

- Post-correction potential is taken from Table 9. Clustering (A–D) is based on the cluster analysis model (Table 5).
- For each region, 1–2 unique problems (which are not systemic across the country) as well as individual competitive advantages were identified that could form the basis of a regional strategy.
- Recommendations were developed in a differentiated manner, based on each region's actual potential, limitations, and strategic niches.

The discussion of the table's 14 results clearly illustrates how the mathematical model proposed in the article can effectively function in a real-world environment, provided that regional differences –previously insufficiently detailed are taken into account. This very level of detail enables the transformation of the model from a purely analytical tool into a practical instrument for strategic planning.

Regions in Cluster A, such as Kyiv and Lviv, demonstrate high potential even after adjustments for global challenges. However, Kyiv faces labor market saturation, investment competition, and significant infrastructure load. Lviv, on the other hand, has a solid educational base and less investment pressure but suffers from the outmigration of young professionals. For both regions, the recommended strategies include the creation of new R&D centers, development of the creative economy, and attraction of venture capital. Thus, the model not only confirms high potential but also highlights unique growth directions.

Cluster B regions, such as Dnipro and Odesa, lie on the edge between stable development and critical external risks. For instance, Odesa, after correction, shows nearly zero potential due to its proximity to active war zones and high sensitivity to economic instability. However, it has a unique transport infrastructure and potential in the creative industries. Recommendations here focus on the development of new projects in digital tourism and maritime logistics. Dnipro has a strong technical education base but suffers from severe security risks. Therefore, appropriate measures include the implementation of business relocation tools, tax incentives, and protective mechanisms to retain IT personnel.

Clusters C and D include regions with low or moderate initial potential but with hidden reserves. For example, Zakarpattia shows average potential after correction, despite weak infrastructure. Its proximity to the EU, relative safety, and low population density create favorable conditions for the development of new types of IT clusters digital ecosystems focused on cross-border cooperation. Ivano-Frankivsk, despite its remoteness, has socio-cultural resources for the growth of creative industries and freelance platforms. Zhytomyr and Vinnytsia have low levels of digitalization but could serve as hubs for educational programs, workforce retraining centers, and new remote services.

As a result, the table illustrates that even within the same cluster, regions differ in reasons for either losing or maintaining potential. The proposed model allows these reasons to be identified. It opens up possibilities for targeted policies, regional investment strategies, and tailored IT support programs based not only on absolute figures but also on a deep analysis of index interactions, external challenges, and structural characteristics.

Based on the results of the proposed model for assessing the potential of Ukraine's IT industry and its regional differentiation, developed with regard to global challenges, a number of practical and effective recommendations can be made for the main stakeholders: government bodies, local authorities, investors, business representatives, international donors, and educational institutions.

For central government bodies, the priority should be to develop a targeted digital transformation policy focused on adapting to crisis conditions. The model clearly shows that regions are affected differently by global challenges and possess varying capacities for recovery. This underlines the need to establish a National Digital Infrastructure Recovery Fund prioritizing support for regions like Kharkiv, Dnipro, and Odesa, where potential has significantly declined. Meanwhile, for Kyiv and Lviv, efforts should focus on boosting IT service exports, supporting startup ecosystems, and venture financing to strengthen their leadership.

Local governments are advised to use the model's regional analysis to develop localized IT development strategies. For relatively safe regions, such as Zakarpattia and Ivano-Frankivsk, it is crucial to build freelancing infrastructure, create coworking spaces and digital hubs to attract companies and specialists who have been forcibly relocated. Local authorities should facilitate access to office space, broadband internet, and encourage partnerships with universities.

For investors and venture funds, the model offers opportunities for well-informed risk assessments and targeted investments. Based on integrated potential and the impact of global factors, investors can reasonably choose regions with the best combination of stability, education level, and technical infrastructure. For instance, Lviv and Kyiv remain attractive centers for high-tech startup investment, while Vinnytsia and Zhytomyr could serve as platforms for establishing service or back-office operations of major IT companies.

Business entities are encouraged to use the model as a tool for internal strategic planning. Companies can assess the potential of opening new offices in regions with lower costs or, conversely, plan for entry into external markets through regions with strong export capabilities. In addition, by taking into account forecasted dynamics, they can adapt their hiring and relocation strategies accordingly.

Educational institutions, in turn, should align their curricula with the needs of the regional IT market. In regions with low potential and significant losses (e.g., Kharkiv and Odesa oblast), it is essential to ensure continuity in IT training through distance learning models, online courses, and collaboration with foreign IT centers. In more stable regions, such as Lviv or Zakarpattia, engineering and analytical programs should be developed to attract qualified professionals.

Finally, for international donor organizations, the proposed model can serve as an analytical basis for decisions regarding the distribution of technical assistance, grants, and support programs. The integration of Bayesian methods allows the model to take into account the dynamics of change, which is critically important during wartime. Regions with critically reduced potential could be included in rapid digital economy recovery programs supported by the EU, GIZ, USAID, or the World Bank.

Thus, the integrated use of the proposed model not only enables the assessment of the state of the IT industry but also provides effective, practical steps for all stakeholders, reflecting the actual situation in each region. These recommendations create the foundation for a more equitable, evidence-based, and strategically focused development of Ukraine’s digital sector. The proposed approach addresses the previously identified issue of insufficient clarity in distinguishing regional differences and facilitates a transition from a one-size-fits-all model to a targeted, strategically relevant framework for regional digital transformation in the face of global challenges.

The proposed mathematical model for assessing the potential of Ukraine's IT industry demonstrates high practicality due to its adaptability to the dynamic conditions of global challenges. Its integration of factors such as military conflict, economic instability, and migration allows for consideration of the real limitations faced by Ukraine's regions. Specifically, Table 9 presents the adjusted potential indicators for various regions, confirming that the proposed model can reflect the actual impact of external factors on the development of the IT industry under current challenges. This feature is critically important for making management decisions, such as investment distribution or the development of digital transformation strategies. Unlike traditional approaches, the proposed model uses Bayesian analysis to work with data uncertainty. This approach allows for real-time updates of forecasts based on new data, enhancing the model’s adequacy. In comparison with models presented in [3, 23, 25], which faced challenges in integrating heterogeneous indicators, the Bayesian approach provides flexibility in considering dynamic changes in market conditions. This makes the proposed model suitable for forecasting and strategic planning in the IT sector.

Most existing models, such as the ones presented in [24, 26, 29], focus on assessing the prospects of individual IT projects but do not account for the influence of external factors such as global economic challenges. Your approach, on the other hand, uses multivariate regression and cluster analysis to determine regional differences, allowing for a more accurate assessment of the development potential of regions. For example, clustering regions by potential into clusters (A, B, C, D) in Table 7 helps identify areas with high investment potential and regions that require additional support.

In the context of the current realities of war, the model demonstrates high practicality for identifying regions with critically low potential, such as Kharkiv and Odesa regions, where the adjusted indicators decreased to 4 and 1, respectively. For such regions, the model suggests specific recommendations, such as supporting basic infrastructure and improving internet access, as reflected in Table 7. Meanwhile, regions with high potential, such as Kyiv and Lviv regions can use the model to optimize their strategy by focusing on supporting startups and creating R&D centers [32].

Due to the integration of global challenges, the proposed model can be adapted for analyzing the IT sector in other countries with similar conditions. For example, its application in Eastern European countries, which also face challenges related to migration and economic instability, will allow for comparative analysis and justification of effective strategies to increase the competitiveness of their IT sectors. The model has potential for further improvement, such as through the integration of machine learning methods that could enhance long-term trend forecasting. Given its flexibility and practicality, the proposed approach could serve as a foundation for developing Ukraine's national digital transformation strategy, which is crucial for its economic development in the context of globalization.

5. Conclusion and Future Work

The mathematical model for assessing the potential of Ukraine's IT industry proposed in the article integrates multivariate regression, cluster analysis, factor analysis, and the Bayesian approach. This integration allows for considering dynamic changes in the socio-economic environment and ensures high accuracy and adaptability of the assessments. The study's results revealed significant regional differences in the development of Ukraine's IT industry. Specifically, Kyiv and Lviv regions show the highest potential, while regions affected by military actions, such as Kharkiv and Odesa, have experienced a substantial decline in indicators.

The research also established that the impact of global challenges, including military actions, economic instability, and migration, has significantly affected the development of Ukraine's IT sector. The proposed model quantitatively assesses these factors and allows for the development of individual strategies for each region to enhance the competitiveness and resilience of the industry.

The proposed approaches and study results may serve as an innovative foundation for forming a national strategy for the development of Ukraine's IT industry, aimed at ensuring sustainable economic growth and integration into global markets.

Author Contributions Statement

The author independently conducted the research, including study conceptualization, methodological design, data acquisition and processing, mathematical modeling, statistical analysis, interpretation of findings, and drafting and revising the manuscript.

The author has read and agreed to the published version of the manuscript.

Conflict of Interest Statement

The author declares no conflict of interest.

Funding Declaration

This research was conducted without external financial support.

Data Availability Statement

This study analyzed publicly available datasets obtained from official statistical and analytical sources. All relevant data sources are cited in the manuscript.

Ethical Declarations

This study did not involve human participants or animals. The research used publicly available and aggregated data. Ethical approval was not required.

Acknowledgments

The author sincerely thanks the experts for their professional evaluation and valuable recommendations, which helped improve the quality and reliability of the research results.

Declaration of Generative AI in Scholarly Writing

Generative AI tools were used only for language editing. The author takes full responsibility for the content of the manuscript.

Abbreviations

The following abbreviations are used in this manuscript:

AHP - Analytic Hierarchy Process
DESI - Digital Economy and Society Index
EI - Economic Impact Index
ES - Economic Instability
GCI - Global Competitiveness Index
ICT - Information and Communication Technologies
II - Innovation Potential Index
IT - Information Technology
KI - Knowledge Index
LM - Labor Migration
NRI - Networked Readiness Index
PCA - Principal Component Analysis
WC - Military Conflict

Appendix

Not applicable.

References

[1] A. O. Simakhova and A. K. Nikolaienko, "The impact of global challenges on the national IT segment," NAU - "Problems of a systematic approach in economics", ECONOMY AND MANAGEMENT OF THE NATIONAL ECONOMY, Issue 3 (89), pp. 38-41, 2022.

[2] A. K. Nikolaienko, "Concept of national IT industry development in the context of globalization," NAU - "Problems of a systematic approach in economics", ECONOMY AND MANAGEMENT OF THE NATIONAL ECONOMY, Issue 2 (91), pp. 44-48, 2023.

[3] N. O. Brynza and A. A. Havrylova, "Formation of a model for evaluating indicators of IT industry development in the regions of Ukraine," Information Processing Systems, vol. 2(157), pp. 13-21, 2019. doi:10.30748/soi.2019.157.02

[4] Y. O. Voitenko and A. I. Povorozniuk, "System for evaluating the prospects of IT projects," [Thesis, National Technical University "Kharkiv Polytechnic Institute"]. eNTUKhPIIR - Electronic Repository of the National Technical University "Kharkiv Polytechnic Institute". [Online]. Available: http://repository.kpi.kharkov.ua/handle/KhPI-Press/43218 [Accessed: March 10, 2025].

[5] O. Zaiats, T. Yarema, and M. Chornomaz, "Features of IT industry development in Ukraine," Economy and Society, vol. 52, 2023. doi:10.32782/2524-0072/2023-52-20

[6] M. Kvasnii, "Dynamics of the IT industry in conditions of economic instability in Ukraine: Analysis and modeling," Acta Academiae Beregsasiensis. Economics, vol. 6, pp. 45-55, 2024. doi:10.58423/2786-6742/2024-6-45-55

[7] V. V. Kyrii, "Development of the IT industry in the system of specialization of regions of Ukraine," [Thesis]. Electronic Archive of Open Access of Kharkiv National University of Radio Electronics. [Online]. Available: http://openarchive.nure.ua/handle/document/7821 [Accessed: March 10, 2025].

[8] V. S. Kupriianova and H. M. Shvedova, "Analysis and prospects for the development of entrepreneurial outsourcing in the IT industry of Ukraine," Entrepreneurship and Innovation, vol. 12, pp. 59-63, 2020. doi:10.37320/2415-3583/12.10

[9] H. Lema, A. Martseniuk, and O. Kokhanchyk, "Factors of digital economy formation and IT industry development in Ukraine," Economy and Society, vol. 61, 2024. doi:10.32782/2524-0072/2024-61-95

[10] V. Lysak and L. Nozdrina, "Methods and models of business analysis in the IT industry," Bulletin of the University of Banking, vol. 3(39), 2020. doi:10.18371/2221-755x3(39)2020225592

[11] T. Melnyk and Y. Zavhorodnia, "Methods for assessing the international competitiveness of the IT sector," Scientia fructuosa, vol. 150(4), pp. 105-119, 2023. doi:10.31617/1.2023(150)07

[12] K. Oberemchuk and O. Zhukovska, "Prognostic modeling of IT company profitability," Economy and Society, vol. 44, 2022. doi:10.32782/2524-0072/2022-44-93

[13] V. Prokhorova, "Methods for evaluating project risks of IT companies," Adaptive Management Theory and Practice Economics, vol. 16(32), 2023. doi:10.33296/2707-0654-16(32)-16

[14] O. V. Semenikhina, A. O. Yurchenko, A. A. Sbruieva, A. I. Kuzminskyi, O. V. Kuchai, and O. A. Bida, "Open digital educational resources in the IT field: Quantitative analysis," Information Technologies and Learning Tools, vol. 75(1), pp. 331-348, 2020. doi:10.33407/itlt.v75i1.3114

[15] M. Slabinoha and T. Mykhailov, "Application of expert evaluation methods in forecasting project completion terms in the IT industry," Information Technology and Society, vol. 2(8), pp. 79-83, 2023. doi:10.32689/maup.it.2023.2.9

[16] Y. Ustinov and V. Ilchuk, "The role of the IT industry in the structural transformation of the Ukrainian economy," Grail of Science, vol. 27, pp. 42-44, 2023. doi:10.36074/grail-of-science.12.05.2023.003

[17] V. S. Khvorostianyi, "Research on the current state of the labor market and changes in the employment structure of workers in the IT industry of Ukraine's economy," Problems of Modern Transformations. Series: Economics and Management, vol. 13, 2024. doi:10.54929/2786-5738-2024-13-03-07

[18] I. Shaforenko, "Modeling of management decision-making processes in the IT industry under conditions of uncertainty," Current Issues in Modern Science, vol. 4(10), 2023. doi:10.52058/2786-6300-2023-4(10)-56-69

[19] Assistant. teacher Nashaat Majeed Nashaat, "The role of information technology in developing banking technologies to promote sustainable development of the Iraqi banking sector," Economic and Administrative Studies Journal, vol. 2(1), pp. 83-100, 2023. doi:10.58564/easj/2.1.2023.6

[20] A. Campion, M. Gasco-Hernandez, S. Jankin Mikhaylov, and M. Esteve, "Overcoming the challenges of collaboratively adopting artificial intelligence in the public sector," Social Science Computer Review, 089443932097995, 2020. doi:10.1177/0894439320979953

[21] A. Campion, M.-G. Hernandez, S. Mikhaylov Jankin, and M. Esteve, "Managing artificial intelligence deployment in the public sector," Computer, vol. 53(10), pp. 28-37, 2020. doi:10.1109/mc.2020.2995644

[22] P. S. Honnamane, K. Sreekanth, and G. P. M. Girish, "Antecedents and ramifications of employee engagement in indian information technology (IT) sector," Theoretical Economics Letters, vol. 13(01), pp. 48-58, 2023. doi:10.4236/tel.2023.131003

[23] P. Kaushik and S. P. S. Rathore, "Impact and usage of AI in public sector," International Journal of Engineering in Computer Science, vol. 2(1), pp. 38-43, 2020. doi:10.33545/26633582.2020.v2.i1a.99

[24] H. Kundai Chikwanda and G. Tafadzwa Zimowa, "Evaluation of knowledge management in the project-oriented information technology services sector," Regional Journal of Information and Knowledge Management, vol. 7(1), pp. 37-57, 2022. doi:10.70759/b3xqre66

[25] V. Lachhwani, "Role of information technology in education sector: A review," SSRN Electronic Journal, 2023. doi:10.2139/ssrn.4322368

[26] P. Lata, "Role of information technology in banking sector," Journal of Commerce and Management Thought, vol. 7(1), p. 186, 2016. doi:10.5958/0976-478x.2016.00013.6

[27] I. Mergel, H. Dickinson, J. Stenvall, and M. Gasco, "Implementing AI in the public sector," Public Management Review, pp. 1-13, 2023. doi:10.1080/14719037.2023.2231950

[28] C. Nieto-Peña, T. Obregón-Veramendi, Y. Palomino-Narcizo, C. Pérez-Ticona, L. Silvestre-Quispe, M. García-Chuman, F. Lopez-Gonzales, V. Linares-Cabrera, P. Ramos-La Rosa, and F. Caro-Soto, "Project management in the information technology sector," Salud, Ciencia y Tecnología - Serie de Conferencias, vol. 3, p. 677, 2024. doi:10.56294/sctconf2024677
[29] K. D. K. Rathod and A. R. Nimodiya, "Information and communication technology for education in rural sector - A review," International Journal for Research in Applied Science and Engineering Technology, vol. 11(3), pp. 1155-1163, 2023. doi:10.22214/ijraset.2023.49626
[30] N. E. Sokolinskaya and L. M. Kupriyanova, "Information technology development risks in the banking sector," The World of New Economy, vol. 14(3), pp. 44-53, 2020. doi:10.26794/2220-6469-2020-14-3-44-53
[31] J. Willems, M. J. Schmid, D. Vanderelst, D. Vogel, and F. Ebinger, "AI-driven public services and the privacy paradox: Do citizens really care about their privacy?" Public Management Review, pp. 1-19, 2022. doi:10.1080/14719037.2022.2063934
[32] V. Menshikov, O. Ruza, A. Simakhova, J. Semeneca, "Development of start-up ecosystems in selected countries with a focus on the cases", Entrepreneurship and Sustainability Issues, vol. 12(1), pp. 411-429, 2024. http://doi.org/10.9770/jesi.2024.11.4(27)

Authors' Profiles



Artur Nikolaienko, PhD Candidate at the State University "Kyiv Aviation Institute", Kyiv, Ukraine. His qualification is M.Sc. (Economics) from the National Aviation University, Kyiv, Ukraine. His areas of interest include IT industry, international economy, information security, and globalization.

How to cite this paper: Artur Nikolaienko, "Mathematical Modelling of the Ukrainian IT Industry Potential Assessment in the Context of Global Challenges", International Journal of Information Engineering and Electronic Business(IJIEEB), Vol.18, No.2, pp. 1-23, 2026. DOI:10.5815/ijieeb.2026.02.01