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Matrix for Selecting Methods of Forecasting Regional Socio-Economic Development: An Adaptive Taxonomy for Managerial Decision-Making

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ABSTRACT

The **purpose** of this study is to develop a matrix for selecting methods for forecasting the socio-economic development of regions. The **scientific novelty** of the research lies in the classification of existing approaches used to address this issue, the identification of their advantages and limitations, the specification of required data and resources, the consideration of uncertainty factors and forecast-specific tasks, and the determination of the planning horizon. The study employs such **methods** like a systems approach, as well as comparative and retrospective analyses. The **findings**, obtained through a review of publications on regional socio-economic development forecasting over the past twenty years, may be useful both to the academic community and to decision-makers involved in related policy and management processes.

Keywords: socio-economic development of regions; forecasting methods; selection matrix; adaptive taxonomy

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INTRODUCTION

In conditions of uncertainty associated with geopolitical conflicts, sanctions pressure, economic crises, and social challenges, the ability of regions to ensure sustainable socio-economic development directly depends on the quality of managerial decisions based on diverse forecasts and development scenarios. It is important to note that in the present study, the term "region" (due to the broadness of this concept) is used as a general designation for administrative-territorial entities — constituent entities of the Russian Federation. Methods for forecasting regional socio-economic development are constantly being updated and transformed, which creates significant barriers to their practical implementation due to fragmentation and the lack of a unified integrated approach. Moreover, some approaches remain purely theoretical due to their impracticality caused by resource constraints in regions, the unavailability or complexity of obtaining analytical data, and other factors.

In this regard, there is a need for a comprehensive analysis of existing methods for forecasting regional socio-economic development, their classification in order to determine their applicability in practice, taking into account available data and resource potential.

The adaptability of the proposed taxonomy lies not only in the classification of these methods, but also in their subsequent linkage to specific managerial contexts through a developed selection matrix. This enables the decision-maker (DM) to understand under which conditions a method will be most effective in terms of resources, planning horizon, and level of uncertainty.

It should be noted that forecasting of regional socio-economic development has undergone a significant transformation over the past two decades — from the use of linear extrapolation models to the application of complex adaptive systems, which may be attributed to three main factors: the development of digitalisation, the accumulation of experience in overcoming crisis situations, and a shift in the management paradigm.

In the 2000s, classical econometric methods based on regression analysis of data predominated. Their theoretical foundation was laid in the works of J. Box and G. Jenkins [1], who established the methodology of time series analysis; P. Schwartz [2], the founder of scenario planning; O. Helmer and N. Dalkey [3], who applied the Delphi method; and J. Forrester [4], whose works are based on system dynamics and simulation modelling.

The effectiveness of classical methods under stable conditions (where forecast error did not exceed 5–7%) was demonstrated in the works of A.P. Yanukyan [5] and V.Z. Petrosyants [6]; however, the 2008 financial crisis revealed their key limitation, namely the inability to account for significant changes in data structure.

A turning point in the development of methods for forecasting regional socio-economic development occurred in the 2010s with the spread of digitalisation and simulation tools. For example, in the study by O.I. Babina [7], it was shown that regional "digital twins" make it possible to test scenarios in real time, take into account nonlinear relationships among more than fifty parameters, and visualise the consequences of decisions.

The COVID-19 pandemic became a catalyst for the integration of artificial intelligence (AI) into the solution of this problem. For instance, the results of neural network models by A.R. Dmitrieva [8], which have the unique ability to process heterogeneous data (from environmental indicators to population mobility), proved significantly more accurate than demographic forecasts obtained via regression analysis. At the same time, the role of the scenario approach, considered in particular by A.V. Voloshin [9], has increased.

EVOLUTION AND CLASSIFICATION OF METHODS FOR FORECASTING THE SOCIO-ECONOMIC DEVELOPMENT OF REGIONS

The contemporary paradigm of forecasting regional socio-economic development is characterised by: the hybridisation of methods (for example, the simultaneous use of artificial in-

Fig. 1. **Classification of Methods for Forecasting the Socio-Economic Development of Regions**

Source: compiled by the author based on the theoretical analysis of the works by Russian and international scholars, published over the past 20 years.

telligence capabilities, scenario approaches, and macroeconomic tools); their adaptability through feedback mechanisms; and a focus on uncertainty as a constant of development. At the same time, it is important to note that, due to the diversity and complexity of methods, their tools are not always applicable in practice because of various constraints (lack of data, as well as regional resource limitations [financial, human, material, time, etc.]). In addition, each region has its own specific features, and it is precisely its needs that should be taken into account when selecting a method for managerial decision-making. For these purposes, it is first necessary to classify existing approaches to forecasting regional socio-economic development, identifying their limitations and advantages (*Fig. 1*).

The data in *Fig. 1* reflect the diversity and fragmentation of existing methods, which can be grouped according to forecasting horizons: short-term (1–3 years) — focused on operational indicators of regional development (unemployment, inflation, demographic indicators, etc.); medium-term (3–7 years) — primarily focused on strategic planning and development programmes; long-term (over 7 years), where elements of scenario modelling are used.

The following trends in the evolution of methods for forecasting regional socio-economic development can be identified:

- a shift towards hybrid models that take into account a wide range of parameters and tools;
- increasing adaptability of methods and the incorporation of mechanisms for forecast adjustment;
- emphasis on uncertainty and sudden risks (for example, sanctions, pandemics, geopolitics, etc.);
- integration of ESG criteria, i.e. consideration of environmental indicators and parameters of regional development (*Fig. 2*).

At the same time, all analysed approaches (regardless of the evolution of their development) have a number of advantages and disadvantages (*Table 1*).

The data presented in *Table 1* are further explained below.

1. Econometric and regression methods.

Advantages:

- High accuracy under stable conditions means that the method produces minimal error in the absence of structural changes in the economy and when historical patterns remain stable;
- Transparency of calculations is ensured by the interpretability of the coefficients used in forecasting, which makes it possible to justify managerial decisions;
- Statistical verification enables the practical testing of existing theoretical assumptions using statistical methods.

Disadvantages:

- Require extensive historical data — robust regression models typically require statistical information covering 15 years or more, which is not

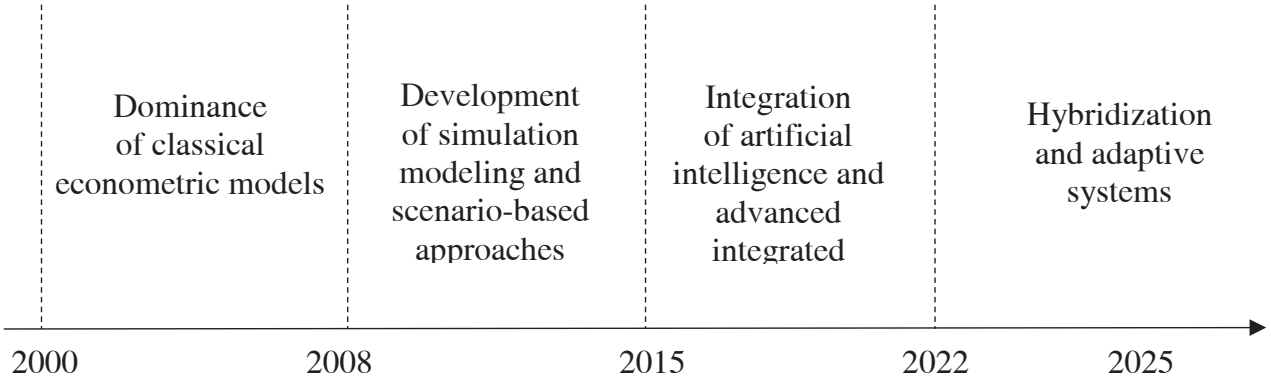

Fig. 2. **Evolution of Methods for Forecasting the Socio-Economic Development of Regions**

Source: compiled by the author.

available, for example, for newly formed regions of the Russian Federation or in cases where calculation methodologies have changed;

• Do not account for nonlinear shocks — the models fail to predict crises, as they are based on linear extrapolation;

• Risk of multicollinearity is explained by strong correlations between variables (for example, investment and GRP), which may distort forecasting results.

2. Scenario forecasting methods.

Advantages:

• Consideration of uncertainty allows assessment of the consequences of unpredictable events (sanctions, crises) through the construction of alternative scenarios;

• Flexibility of strategic planning is explained by the active use of planning documents, which facilitates the adaptation of forecasts to changing development priorities;

• Visual clarity is achieved through graphs and other visualisation tools.

Disadvantages:

• Subjectivity of scenarios arises from the fact that the selection of scenario variants always depends on experts' individual judgments, reducing the objectivity of forecasts;

• Labour-intensive development is associated with the need to account for a large number of parameters and to incorporate qualitative assessments from multiple experts, etc.;

• Difficulty of quantitative assessment is determined by the largely subjective nature of assigning probabilities to scenarios in the absence of statistical justification.

3. Simulation modelling methods.

Advantages:

• Testing managerial decisions enables the application of developed forecasts without real-world costs;

• Accounting for complex interdependencies in system dynamics makes it possible to model feedback loops;

• Result visualisation makes forecasts more understandable, including for non-specialists.

Disadvantages:

• High data requirements — the application of this method requires several dozen indicators (with time-series dynamics) for at least 10 years;

• Computational intensity is explained by the first limitation;

• Calibration complexity — an error in weighting relationships between indicators may increase forecast error by up to 25%.

4. Artificial intelligence and neural network methods.

Advantages:

• High accuracy is driven by the ability of neural networks and AI to simultaneously analyse interdependencies among dozens of factors;

• Adaptability to new data is explained by the capacity of neural networks and AI for retraining;

• Forecast automation is ensured by the ability to generate results without manual calculations or adjustments.

Disadvantages:

• "Black box" nature is determined by the specifics of neural networks and AI, as internal processes are not transparent to users, which complicates the interpretation of decision-making processes;

• Risk of overfitting is a known issue in the application of neural networks and AI. It occurs when the model learns training data too well during machine learning and loses its ability to generalise new information;

• High computational requirements are necessary to ensure stable operation of neural networks and AI.

5. Integrated methods.

Advantages:

• Holistic perspective is typically formed through the use of composite indicators that include various aspects of regional development;

• Comparability across regions enables ranking and the development of specialised rating systems (e.g., welfare, competitiveness, quality of life, etc.).

Disadvantages:

• Subjectivity of weighting coefficients due to the use of expert methods for their determination;

• Limited practical applicability due to the inability to adapt certain tools used for one region to forecasting in another.

6. Expert-analytical methods.

Advantages:

• Consideration of non-formalised factors, i.e. those belonging to the category of "qualitative" variables;

• Low data requirements are explained by the widespread use of qualitative information that does not require full statistical analysis.

Disadvantages:

• Subjectivity of assessments of development prospects based on expert judgement, as well as their potential dispersion;

• Dependence on expert competence (the lower the qualification level, the higher the probability of forecasting errors);

• Limited scalability of assessments across multiple regions, due to their qualitative nature.

7. Trend-statistical methods.

Advantages:

• Simplicity of implementation using standard tools that do not require additional costs (e.g., Excel);

• No need for specialised software or programming skills;

• Clarity of results due to the use of graphs and other visualisation tools.

Disadvantages:

• Inapplicability under structural breaks (due to reliance mainly on linear extrapolation in forecasting);

Table 1

Comparative Characteristics of the Advantages and Limitation of Methods for Forecasting the Socio-Economic Development of Regions

Method	Advantages	Disadvantages
Econometric and regression methods	- high accuracy under stable conditions; - transparency of calculations; - statistical verification	- require extensive historical data; - do not account for nonlinear shocks (crises); - risk of multicollinearity
Scenario forecasting methods	- account for uncertainty; - flexibility of strategic planning; - visual clarity	- subjectivity of scenarios; - labour-intensive development; - difficulty in quantifying probabilities
Simulation modelling methods	- testing managerial decisions; - accounting for complex interdependencies; - result visualisation	- high data requirements; - computationally intensive; - model calibration complexity
Artificial intelligence and neural network methods	- high accuracy in complex relationships; - adaptability to new data; - automation of forecasting	- "black box" nature, interpretability issues; - risk of overfitting; - require significant computational resources
Integrated methods	- holistic assessment of development; - interregional comparability	- subjectivity of weighting coefficients; - limited practical applicability
Expert-analytical methods	- consideration of non-formalised factors; - low data requirements	- subjectivity of assessments; - dependence on expert competence; - low reproducibility and scalability
Trend-statistical methods	- simplicity of implementation; - minimal resource requirements; - clarity of results	- inapplicability under structural breaks; - low long-term accuracy; - neglect of qualitative factors

Source: compiled by the author.

Table 2

Matrix for Selecting Methods of Forecasting Regional Socio-Economic Development

Criterion	Methods						
	Econometric and regression	Scenario forecasting	Simulation modelling	Artificial intelligence and neural network	Integrated	Expert-analytical	Trend-statistical
Data							
Rich (>15 years)	●	○	●	●	●	○	○
Moderate (10–15 years)	●	●	○	○	●	●	●
Limited (<10 years)	⊘	●	⊘	⊘	○	●	●
Planning horizon							
Short-term (1–3 years)	●	○	○	●	⊘	○	●
Medium-term (3–7 years)	●	●	●	●	●	●	○
Long-term (>7 years)	○	●	●	○	●	●	⊘
Uncertainty							
Low	●	⊘	○	●	○	⊘	●
Medium	●	●	●	●	●	●	○
High	⊘	●	●	○	○	●	⊘
Resources							
Limited	⊘	○	⊘	⊘	⊘	●	●
Sufficient	●	●	●	●	●	○	○
Special tasks							
Testing decisions	⊘	○	●	○	⊘	⊘	⊘
Balance assessment	⊘	⊘	⊘	⊘	●	○	⊘
Interregional comparison	●	⊘	⊘	⊘	●	⊘	⊘

Source: compiled by the author.

Notes: ● — use of the method/methods is recommended; ○ — use of the method/methods is conditionally recommended; ⊘ — use of the method/methods is not recommended.

• Low long-term accuracy (resulting from the first limitation);

• Neglect of qualitative factors, as forecasting is primarily based on statistical data and trend construction.

ADAPTIVE TAXONOMY FOR MANAGERIAL DECISION-MAKING IN THE SELECTION OF METHODS FOR FORECASTING THE SOCIO-ECONOMIC DEVELOPMENT OF REGIONS

In the context of this study, adaptive taxonomy is understood as a classification system of forecasting methods that enables flexible adjustment of the selection process to changing regional conditions and managerial tasks. Taking into account the advantages and disadvantages of the methods described above, it should be noted that forecasting effectiveness critically depends on the degree of alignment between the method and the specific characteristics of the region, the availability of necessary data and resources for their processing, as well as the planning horizon, the presence of uncertainty, and the specific objectives embedded in the forecast. Based on *Table 1*, a decision matrix for selecting forecasting methods is constructed to support their identification and effective practical application (*Table 2*).

The logic for assigning values ("recommended", "conditionally recommended", and "not recommended") to each cell of the matrix is as follows.

Data criterion. Methods that directly depend on large volumes of retrospective information (econometric, AI-based, and simulation methods) are not recommended under conditions of data scarcity. Conversely, when data requirements are less strict (expert-based, trend-statistical methods), such methods are classified as "recommended" under the same conditions.

Planning horizon criterion. Long-term methods (scenario-based, simulation methods) are classified as "recommended", whereas short-term methods (trend-based methods) are marked as "not recommended" for such horizons.

Uncertainty criterion. Methods designed for uncertain environments (scenario-based, expert-based methods) are marked as "not recommended" under conditions of high uncertainty. Deterministic methods (econometric, trend-based methods) are also classified as "not recommended" under these conditions.

Resource criterion. Resource-intensive methods (AI-based, simulation methods) are not recommended under conditions of limited resources.

Special-task criterion. Recommendations are based on the method's ability to solve a specific task (for example, simulation modelling is recommended for testing managerial decisions).

Depending on the specific situation in a given region, combinations of methods can be constructed on the basis of the obtained matrix. The step-by-step procedure for its application by the decision-maker (DM) is as follows:

1. Diagnosis of forecasting parameters. The DM assesses the current situation in the region according to all matrix criteria: volume and quality of data, planning horizon, level of uncertainty, available resources, and specific tasks.

2. Selection of the core method. At the intersection of the identified parameters in the matrix, corresponding recommendations are found. Methods marked with ● form the core for constructing the forecast.

3. Formation of a hybrid approach. The DM analyses the possibility of combining methods. For example, under high uncertainty (● for scenario methods) and availability of large datasets (○ for AI), it is possible to create a hybrid model in which AI calculates quantitative parameters for each qualitative scenario.

4. Verification of the selection. The final choice of method must be checked for compliance with resource constraints and the specific characteristics of the region.

The presented matrix demonstrates that, for example, scenario methods are the most universal under contemporary conditions of un-

certainty, while neural network-based methods provide maximum accuracy when Big Data is available. For regions with data scarcity, expert-analytical approaches are recommended, supported by enhanced result verification, whereas for stable environments, econometric and regression methods are more appropriate.

CONCLUSIONS

The diversity of methods for forecasting the socio-economic development of regions can be divided into the following groups: econometric and regression methods; scenario forecasting methods; simulation modelling methods; methods using artificial intelligence and neural networks; integrated methods; expert-analytical methods; and trend-statistical methods. Over time, this classification may be subject to adjustment.

For the effective application of the listed methods, it is important to take into account specific criteria, namely: the characteristics of the region, the set of required data and resources for their processing, the planning horizon, the presence of uncertainty elements, and the specific tasks embedded in the forecast.

Thus, the developed matrix is a reliable analytical tool. Its practical application will serve as a basis for optimising managerial decision-making in the field of forecasting regional socio-economic development.

The theoretical contribution of the study lies in the development of an adaptive taxonomy of forecasting methods that integrates a classification dimension with managerial selection criteria. The practical value of the work consists in the creation of a decision-making tool — a selection matrix that provides the decision-maker (DM) with a structured and transparent algorithm for choosing a forecasting method adapted to the specific conditions of a region.

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