Logistics Management Automation of Interregional Cooperation based on the Digitalization of the Territorial Potential Integrated Assessment

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ABSTRACT

The article proposes and verifies a step-by-step software-algorithmic methodology for the integrated assessment of regional potentials, aimed at supporting intra- and interregional logistics management decisions in conditions of limited resources and high combinatorial complexity of spatial interactions. The methodology is based on a system of twenty potentials types, formed due to the initial private indicators. It includes a number of following conceptual innovations: formalized identification of neighboring entities that form «the first circle of proximity» as a separate calculation contour; a shift in weights towards controlled (regulated) indicators using a shift coefficient of 0.9; a two-level model of connections with separated endogenous and exogenous influences and with the given coefficients for key and auxiliary development; a combined quantitative and qualitative selection of project combinations through the use of morphological synthesis and a PEST/SWOT-like matrix of expert assessment. The following methods were used in the research: the method of system analysis, the population density-corrected standardization, the enumeration of feasible combinations, and the multi-criteria optimization with budget constraints. The software implementation in the form of the analytical and calculation module (SIACM) automates the collection, standardization, and calculation of endogenous and exogenous estimates, generates top potential combinations, and creates interactive matrices for expert validation of the results. The module functionality is illustrated on the example of the Orenburg Region. The research findings confirm the reproducibility and transparency of the computational procedure; they enable to identify the «development dominants» of regions and «limiting spheres» as well as they prove the practical applicability of the developed program for government agencies and project offices in Russia when working with aggregated open data in local information systems to manage logistics of interregional cooperation.

General Terms

Algorithms, technologies, information support.

Keywords

Logistics management, regional potential, information support, combinatorial interactions, digitalization.

1. INTRODUCTION

Regional systems are complex, multilayered structures, where each unit operates according to its own rules and is simultaneously influenced by internal and external factors. Within the terms of information environment complexity, statistical and analytical data growing, and the need to quickly process large data sets, the automated method that ensures a holistic, reproducible, and algorithmically robust assessment of regional potential are viewed as required.

It must be operational for diagnosing the current state of the system and generating manageable modernization scenarios as well as selecting optimal combinations of parameters for cooperative interactions between territories, the final characteristic is especially important for the decision makers (DM) [1]. Therefore, the task of formalizing, structuring, and automated processing of indicators that adequately reflect various types of regional potential becomes the basis for constructing algorithmically-proved decisions.

The relevance of this study is substantiated by several interrelated factors. First, existing methods of interregional analysis and assessment often rely on incomplete, incomparable, or poorly structured indicator sets, that reduce the accuracy of ranking and complicate their automated processing, verification, and comparison [2]. Secondly, modern regional systems function as open networks of interacting elements, where the dynamics of one node influences the parameters of neighboring systems. Therefore, formalization of spatial and intersystem connections with subsequent software integration of these connections into computational models is required. Any subject of Russia cannot be considered in isolation from the overall structure of national space, as its development is closely linked to the status of neighbouring territories [3]. Forming a unified but heterogeneous system of connections, the interdependence between regions is manifested in the exchange of resources, capital movement, data flows, scientific and technical cooperation, migration and infrastructure interactions, [4]. Thirdly, the lack of a standardized and formalized methodology for comprehensive assessment hinders the creation of software solutions for the targeted selection of indicators combinations, and prevents the automated selection of alternatives and coordination of project scenarios [5].

The aim of this study is to develop and verify a digital product to implement a step-by-step methodology for the integrated assessment of regional potentials, based on structured partial indicators, the «first circle of proximity» spatial connections, as well as mechanisms for automated ranking, combinatorial enumeration and selection of optimal parameters combinations for making project decisions.

The practical significance of the methodology under discussion is in its ability to transform disparate data into a reproducible software-analytical procedure for decision-making, suitable for information systems, project modules and analytical platforms.

The software implementation of algorithms, presented in the form of the calculation and analytical module (SIACM), removes technical barriers related to the volume of calculations, the construction of mutual influence matrices, the processing of multidimensional data arrays, and the enumeration of combinatorial options. Furthermore, the module provides a user-friendly interface for expert adjustment of results, setting selection criteria, and comparing alternatives. Automation enables the rapid generation of TOP parameter combinations, the formation of summary matrices for expert input, and the performance of multi-criteria morphological synthesis of design alternatives with consideration to specified constraints.

The expected effect from automating the methodology is primarily computational and organizational in nature. The automation provides for the objectivity of system ranking; identifies dominant and limiting parameters. It improves the intersystem interactions quality through clearly formalized connections and supports the adoption of balanced design decisions through the use of formalized criteria for selecting and ranking alternatives. It also ensures transparency, reproducibility, and verifiability of analytics, thus reducing the risk of results subjective distortion during data processing and scenario construction.

Thus, the developed methodology, implemented in a digital product, forms a comprehensive, reproducible, and applied software-algorithmic toolkit to assess the system potential and support intra-and intersystem management decision-making in conditions of limited resources, high combinatorial complexity, and the significance of spatial interactions.

2. MATERIALS

To ensure the reliability, reproducibility, and availability of source data for the software-based calculation of regional potential, specific indicators from open sources were used as the information base, primarily from official statistical collections and comparable structured data sets from the integrated municipal information system (IMIS). This approach enables to rely on standardized, verifiable, and publicly available data operational for machine processing, automated verification, and subsequent inclusion in the software calculation module.

The initial set of indicators was formed on the basis of a theoretical analysis focusing on the specifics of 20 types of regional potential as well as the requirements for subsequent calculation algorithms. This resulted in an array of 62 indicators that ensure sufficient completeness, stability, and reliability of the regional system description within the framework of the methodology software implementation [6].

Three groups of indicators are identified in the methodology:

– o_i – a general indicator reflecting the efficiency degree of a particular area (type of regional potential), where i is the type number;

– u_x – a specific (conditional) indicator reflecting the conditions of existing and functioning of a particular regional area, where x is the number of a conditional indicator;

– r_y – a specific (adjustable) indicator that characterizes the degree of initial conditions effectiveness, where y is the number of an adjustable indicator.

A unique characteristic feature of the developed algorithm, which substantiates the importance of the methodology, is the introduction and software implementation of the «first circle of proximity» concept as a separate algorithmic module that takes into account the spatial environment of the target region when calculating and interpreting results. Thus, the software algorithm considers not only the parameters of the region itself – investment attractiveness, quality of life, and other indicators, – but also similar parameters of adjacent territories, determining its real position within the spatial system of interconnections.

3. METHODS

Based on the identified types of potentials, the identified patterns of inequality, and the identified shortcomings of existing methods, a modified, proprietary methodology for the integrated assessment of regional potential was developed, focusing on software implementation, automation of calculations, and algorithmization of the data processing procedure (Table 1).

According to one selected combination, a matrix, built on the logic of PEST- and SWOT- analysis, is filled in for the expert generation of features, intersections and conflicts of the selected combinations.

The matrix of mutual influences as a stage of «qualitative» analysis of the selected combinations relies on a systems approach to regional development and the algorithmic logic of processing the relationships between parameters. The regional system is regarded as a network of interconnected potentials, where the final effect of integration is determined by the nature of their interactions rather than by the sum of individual increases [7].

The matrix is a synthesized tool, where PEST defines the content axes in the form of a potential type, and SWOT defines the analytical framework for the assessment in the form of a potential significance type [8]. This enables, firstly, to avoid the abstract nature of PEST and SWOT, replacing them with specific potentials, and secondly, to preserve their value in explaining how exactly selected combinations of potentials can be formalized, compared, and transformed into strategic activity (Fig. 1).

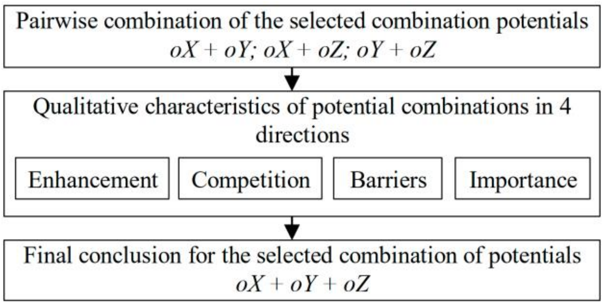

Fig. 1. The matrix of qualitative inter-potential connections characteristics. Scheme of its operation.

Table 1. Step-by-step algorithm for assessing regional potentials and their functional characteristics

Methodology Step	Explanation	Formula
I. Data Collection.	Data collection on selected indicators for all regions of Russia. Information is grouped into tables.	
II. Identification of neighbouring regions (minimum 3).	The first circle of proximity enables us to focus on areas in which the region has more obvious advantages and disadvantages.	
III. Calculation of the population density coefficient.	The logarithmic smoothing method enables to correctly account the population density, eliminating extreme distortions when comparing indicators between subjects of the Russian Federation with different settlement conditions and ensuring more stable standardization algorithm operation.	$\alpha_j = 1 - \left\lvert 1 - (0{,}5 + 0{,}5 \times \frac{\ln(\rho_j) - \ln(\rho_{min})}{\ln(\rho_{max}) - \ln(\rho_{min})} \right\rvert$, (1) where ρ_j is the population density for region j, ρ_{max} is the maximum population density among all regions, and ρ_{min} is the minimum population density among all regions.
IV. Standardization of indicators.	Standardization makes it possible to avoid distortions in the results, since indicators with higher numerical values should not automatically have a greater influence only due to their absolute value.	$r(u_x)_{yj}^{n} = \frac{r(u_x)_{yJ} - r(u_x)_{ymin}}{r(u_x)_{ymax} - r(u_x)_{ymin}} \times \alpha_j,$ (2) where x, y are the indicator numbers (from 1 to 62), α_j is the population density correction coefficient (with the relative value of the original indicator = 1), j is the number of the calculated region (from 1 to 82), $r(u_x)_{ymax}$ is the maximum value of this indicator among the regions of the first circle of proximity, $r(u_x)_{ymin}$ is the minimum value of this indicator among the regions of the first circle of proximity, $r(u_x)_{yJ}$ is the value of this indicator for the region under consideration.
V. Calculation of the potentials` independent part.	The coefficient of 0.9 is introduced to moderate the influence of conditional, poorly controlled factors, preserving their significance, but shifting calculations to indicators that can be improved by management and programmatically implemented impacts.	$o_{ij} = \frac{\sum_{i=1} r_{yj}^{n} + \sum_{i=1} u_{xj}^{n} \times 0{,}9}{m},$ (3) where m is the number of partial indicators, i is the type number (from 1 to 20 according to the potential type number).
VI. Calculation of potentials, taking into account their connections.	The coefficients α and β are defined to reflect the greater significance of key relationships that fundamentally shape potential, thereby prioritizing structure-forming factors in the regional potential calculation algorithm. Dependent variables have two types of assessment: endogenous (o_{ij}), based on individual indicators without taking into account the influence of connectability, and exogenous (o'_{ij}), with taking the influence into account. This approach ensures a comprehensive calculation and at the same time eliminates the problem of duplicating information.	$o'_{ij} = \frac{o_{ij} + \frac{\sum o_{kj}}{k} \times \alpha + \frac{\sum o_{vj}}{v} \times \beta}{1 + \alpha + \beta},$ (4) where k is the number of the associated key development potential (from 1 to 20), α is the key development coefficient (= 0.7), v is the number of the associated auxiliary development potential (from 1 to 20), β is the auxiliary development coefficient (= 0.3).
VII. Determining the boundaries of the potentials` significance and the level of regional development.	«Development Dominant» – $o_i \geq \bar{o} + 0{,}8\sigma_o$; «Stable Sphere» – $\bar{o} + 0{,}8\sigma_o > o_i > \bar{o} - 0{,}8\sigma_o$; «Limiting Sphere» – $o_i \leq \bar{o} - 0{,}8\sigma_o$.	
VIII.a Calculation of the effect for each potential at the intra-regional level.	The goal of these stages is to identify the most effective combinations of potentials, which interaction is expected to have the greatest positive impact on the socio-economic development of the region. For the economic dimension, $\delta_{эк} = 2$ is adopted. For the natural resource dimension, $\delta_{пр} = 1.5$ is adopted. For the social dimension, $\delta_{соц} = 1$ is adopted. The indicator of interregional inter-potential effect Δ_q^{mr} aggregates the mechanisms of innovation diffusion, convergence and spillover effects which accelerate economic growth and can be used as an acceleration coefficient when forecasting the dynamics of relevant sphere development in the host region.	$\Delta_i^{ef} = \delta_i \times o_i,$ (5) where δ_i is the coefficient of relative importance of the direction
VIII.b Summation of the the selected combination effects at the intra-regional level.		$E_{comb} = \sum_{i \in S_{comb}} \Delta_i^{ef},$ (6) where S_{comb} is the set of potentials covered by direct and adjacent influences.
IX.a Calculation of the effect for each potential at the interregional level.		$\Delta_q^{mr} = \frac{o_q^B}{o_q^A},$ (7) where o_q^B is the value of the «development dominant» potential q in region B, o_q^A is the value of the potential q in region A.
IX.b Summation of the selected combination effects at the interregional level.		$E(i, \{q_e\}) = \Delta_i^{ef} + \sum_{e=1} \Delta_{q_e}^{mr},$ (8) where q_e is the growth potential in neighbouring regions.
X. Calculation and expert selection of the optimal combination through matrices of qualitative inter-potential connections` characteristics.		

This set of aspects to characterize the inter-potential connections correlates with the logic of the SWOT matrix and is sufficient for a complete comprehensive analysis of the combination.

Thus, the proposed algorithm transforms complex network information into a set of formalized operational questions and makes the identification of emergent properties more accessible. This, in turn, enables the transition from the analytical level to the level of algorithmic solution design, making the process more transparent and reproducible.

Systematic collection, standardization, and subsequent aggregation of a large set of specific indicators by type of a potential provide an objective picture of the structure, its current state, and dynamics. Formalized procedures for standardization, calculation of endogenous and exogenous assessed values as well as the computation of dynamic indicators eliminate subjective shifts when comparing regions and create a single, representative data set for decision-making.

The established potential classification rules form transparent criteria for identifying «development dominants» in regions and vulnerable areas. This makes it possible not only to establish a set of priorities but also to rank them within limited resources, select strategy types, and calculate expected cumulative effects based on the formalized matrix of inter-potential connections. The formalized rules for transmitting results into qualitative matrices simplifies the task of converting analytics into project assignments, which increases the applied value of the research while preparing territorial development programs. Normalized indicators and final values are easily integrated into the monitoring and visualization system, paving the way for regular reassessment of effects and adaptive adjustment of strategies. The practical feasibility of the methodology is confirmed by the fact that the calculation set covers a significant portion of the country's regions. It is the combination of comprehensive coverage and the transparency of the algorithms that makes the proposed modification of the methodology suitable for systemic integration into the software and analytical framework for developing cooperative relationships in addressing issues of territorial strategic development.

The second important aspect of this methodology's modification is the inclusion of a substantiated mechanism for selecting optimal projects corresponding to a given combination of potentials. This stage is particularly important at the interregional level, when the process of co-financing involves multiple stakeholders and requires a combinatorial comparison of alternative solutions. For this purpose, it is proposed to use methods of combinatorial-morphological analysis and synthesis of rational systems, which is effectively applicable to solving problems of functional cost analysis and forecasting [7, 9, 10]. In this case, it is assumed that the system under study is improved simultaneously for several or all functions and for each function there is more than one implementation alternative, which makes the problem naturally algorithmic.

Each alternative A_{ij} in the morphological table has an estimated benefit (achieved efficiency) and an implementation cost assessment, expressed in monetary units, i.e., each $A_{ij} \in \{B_{ij}; И_{ij}\}$, where B_{ij}, $И_{ij}$ are the monetary values of the benefits and costs. The search for rational solution options is based on the benefit maximization and cost minimization.

The required costs C for a combination are calculated as the simple sum of the selected alternatives costs, while the budgetary feasibility condition is preserved as $C \leq R$, where R is the available budget. Fs represent individual selected areas. Thus, a morphological table with the alternatives assessment according to the criteria of benefits (B) (or efficiency (E)) and costs (C) (Table 2) can be presented.

Table 2. Morphological table with alternatives assessment

Functional subsystem	**Criterion**	**Alternative**			
F_1	A	A_{11}	A_{12}	…	A_{1y}
	$B(Э)$	B_{11}	B_{12}	…	B_{1y}
	C	C_{11}	C_{12}	…	C_{1y}
…	…				
F_x	A	A_{x1}	A_{x2}	…	A_{xy}
	$B(Э)$	B_{x1}	B_{12}	…	B_{xy}
	C	C_{x1}	C_{12}	…	C_{xy}

This approach enables to consider the multifaceted nature of projects, where a single performance indicator is insufficient. If necessary, it is possible to calculate several objectively relevant indicators and create ranked lists for each indicator. This approach enables a comprehensive assessment at the pre-project stage and ensures coordinated selection and comparison of alternatives.

4. RESULT AND DISCUSSION

Despite its methodological comprehensiveness, it must be acknowledged that the proposed calculation procedure is labor-intensive and technically complex. Standardizing a large array of indicators, taking into account neighbouring regional groups and settlement patterns, creating and verifying a matrix of inter-potential relationships, modeling the two-level effect propagation, and sorting out permissible combinations require significant computational resources and strict adherence to algorithmic rules. Therefore, a digital product was developed to automate all calculation stages and relieve analysts of the routine workload (Figure 2).

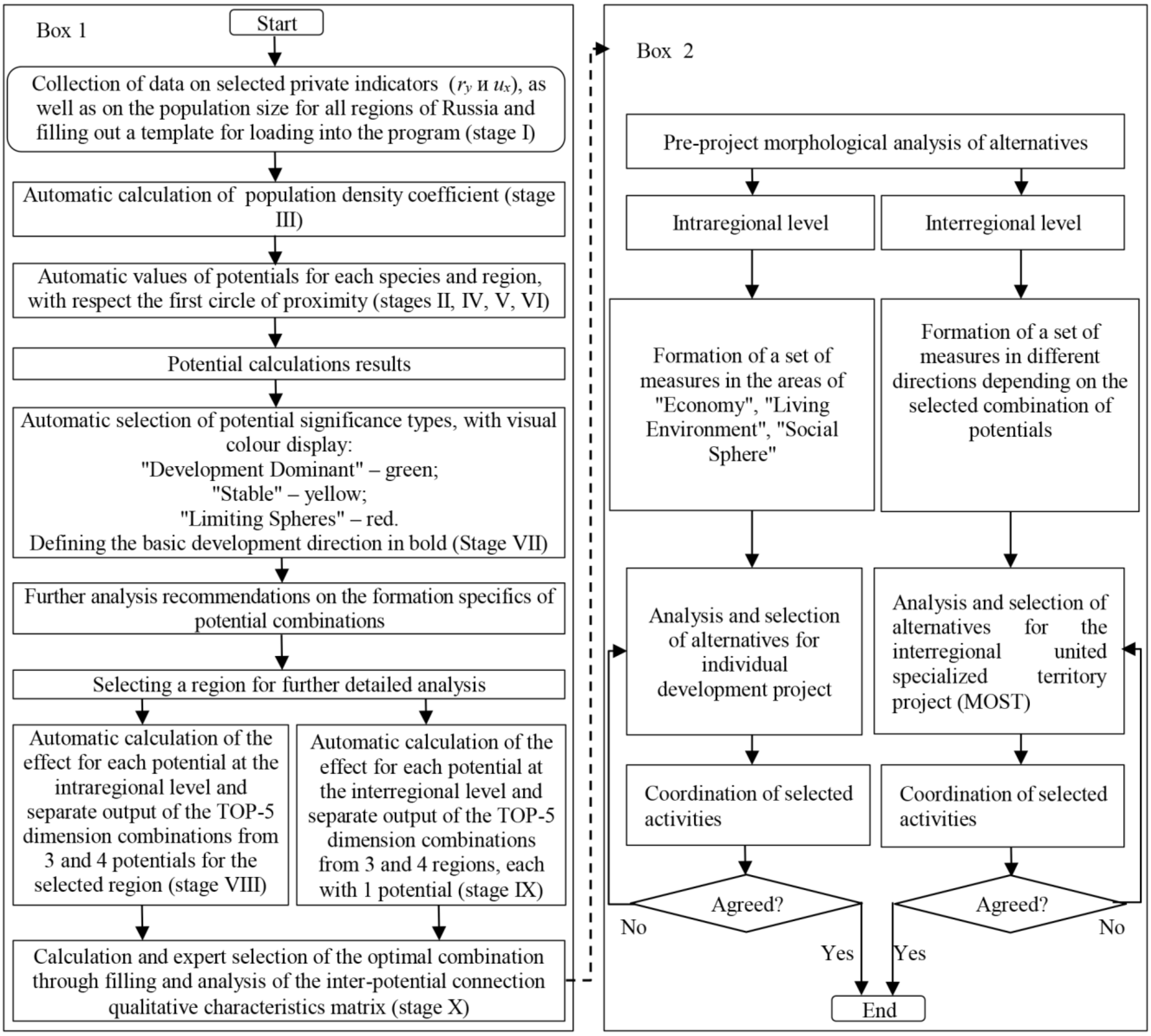

Fig. 2. Functioning of the logistics management program for interregional integration development

The program presents a multifunctional calculation and analytical module consisting of two interconnected blocks, developed to form an integrated assessment of regional potential in order to support management decision-making on territorial development at the intra- and interregional levels (Fig. 3).

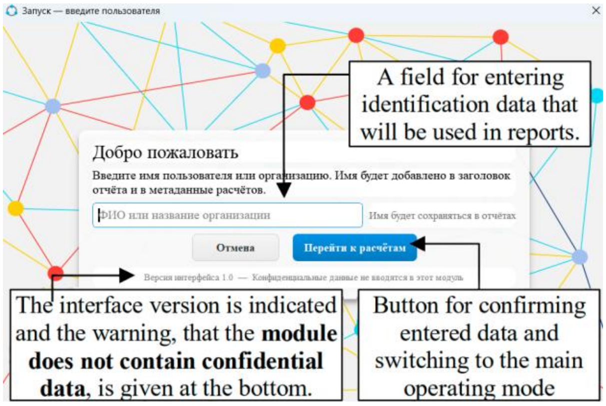

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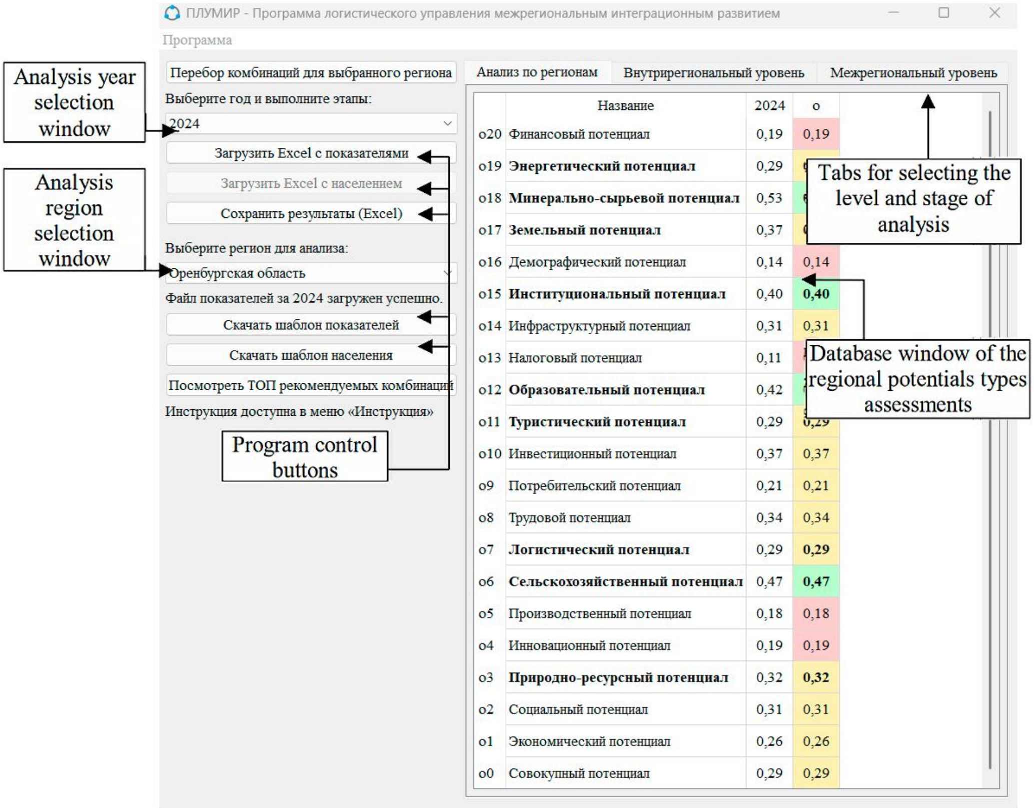
Fig. 3. SIACM launch window

The first block implements several sequential stages described in Table 1. First of all, it provides the import of statistical indicators from MS Excel as well as their processing and standardization within a circle of neighbouring regions considering population density. It also calculates endogenous and exogenous types of potentials (Fig. 4).

Next, the automated sorting out of permissible potentials combinations as well as the output of the TOP-5 values for the expected cumulative effect considering the chain of inter-potential connections is carried out.

The final stage of the first block consists of interactive matrices inference (PEST/SWOT-like) for an expert to fill in characteristics reflecting the qualitative effects of connections combinations in accordance with the TOP-5.

The expert group then confirms or adjusts the proposed combinations, selects relevant areas, and populates the qualitative analysis matrix, taking into account the local context and management constraints. This approach is substantiated by the fact that automation ensures the accuracy and speed of calculations, while expert validation complements the local institutional and political-organizational nuances that algorithms cannot formally count.



ПЛУМИР - Программа логистического управления межрегиональным интеграционным развитием

Выберите год и выполните этапы: 2024

Выберите регион для анализа: Оренбургская область

Файл показателей за 2024 загружен успешно.

Инструкция доступна в меню «Инструкция»

	Название	2024	о
о20	Финансовый потенциал	0,19	0,19
о19	**Энергетический потенциал**	0,29	
о18	**Минерально-сырьевой потенциал**	0,53	
о17	**Земельный потенциал**	0,37	
о16	Демографический потенциал	0,14	0,14
о15	**Институциональный потенциал**	0,40	**0,40**
о14	Инфраструктурный потенциал	0,31	0,31
о13	Налоговый потенциал	0,11	
о12	**Образовательный потенциал**	0,42	
о11	**Туристический потенциал**	0,29	**0,29**
о10	Инвестиционный потенциал	0,37	0,37
о9	Потребительский потенциал	0,21	0,21
о8	Трудовой потенциал	0,34	0,34
о7	**Логистический потенциал**	0,29	**0,29**
о6	**Сельскохозяйственный потенциал**	0,47	**0,47**
о5	Производственный потенциал	0,18	0,18
о4	Инновационный потенциал	0,19	0,19
о3	**Природно-ресурсный потенциал**	0,32	**0,32**
о2	Социальный потенциал	0,31	0,31
о1	Экономический потенциал	0,26	0,26
о0	Совокупный потенциал	0,29	0,29

Fig. 4. The SIACM window with potential assessments on the example of Orenburg region

The second block implements a morphological analysis of alternatives, enabling the formation and comparison of project activities sets according to selected potentials based on expected efficiencies and costs within budget constraints. This block enables to do the morphological analysis of alternatives based on pre-calculated benefits and cost indicators for each alternative at the intra- and interregional levels, following the principle described previously. Report tables can be exported to Excel at any stage.

The program is made up for representatives of regional government bodies, relevant ministries, project offices, and business analysts. However, to move from theoretical and methodological substantiation for practical application, an expert-level evaluation of the developed methodology is necessary. Therefore, it would be advisable to engage specialists in the area of regional development, resource management, and strategic planning to conduct the evaluation. The data obtained will be a key step in validating the proposed approach and will constitute the ground for its subsequent refinement and implementation in strategic planning practices at the regional level.

Two representatives of the scientific area (economists in regional economy), a representative of the regional executive authorities (an employee of the Ministry of Economic Development of the Orenburg Region) and two economists from professional-oriented organizations were invited into the expert group as the representatives of decision-makers. The following criteria are offered: information content, practicality (realistic implementation), versatility, accuracy (reliability of results), transparency (openness of calculations), and ease of use. The experience in the area of scientific and methodological developments analysis proves the practicality of these criteria [11]. Each expert assigned a score for each criterion on a point scale (from 1 to 10, where 10 is the best) (Table 3).

The key step is to check the consistency of expert opinions. At this stage, the Kendall concordance coefficient (*W*) was calculated. For 5 experts ($c = 5$) and m criteria, the ranks are summed for each criterion (Rb is the sum of the ranks of the b-th criterion) and calculated [12]:

$$W = \frac{12\sum_{b=1}^{a}(R_b - \bar{R})^2}{c^2(a^3 - a)} \approx 0{,}704, \tag{9}$$

Where $\bar{R} = \frac{1}{a}\sum_b R_b$ is the average sum of ranks. This indicator reflects the degree of agreement between the assessments: $W = 1$ represents complete unanimity, $W = 0$ represents complete disagreement. Scientific literature recommends considering an assessment satisfactory when $W \approx 0.4$-0.5, and high when $W >$ 0.7-0.8. In our case, $W \approx 0.704$.

According to the results of expert evaluation, the methodology receives high scores for information content, versatility, and accuracy, confirming its scientific and practical value. The lowest score has got «ease of use», but the digital product's automated calculations redeems this shortcoming and reduces the complexity of the methodology.

The Kendall Concordance Coefficient of 0.704 indicates a relatively high degree of agreement among expert opinions. Consequently, the proposed methodology enjoys a high level of acceptance and approval among the professional expert community, which serves as an important ground for its further application, adaptation, and possible implementation in strategic planning at the regional level.

Thus, the methodology, combined with the automation program, provides a comprehensive solution for identifying growth opportunities within Russia's regional system.

Table 3. Expert evaluation of the methodology conducted in 2025

Expert/Criterion	Informativeness	Practicality	Universalism	Accuracy	Transparency	Ease of Use
Expert 1	9	6	9	8	7	4
Expert 2	8	7	8	7	8	5
Expert 3	9	6	9	8	6	3
Expert 4	7	5	9	6	7	5
Expert 5	8	4	7	9	8	5
Average grade	8.2	5.6	8.4	7.6	7.2	4.4

To demonstrate the practical outcome of the first computational block, the methodology was applied to Orenburg Oblast using reference points for 2020, 2022, and 2024. The values presented are exogenous estimates for 20 types of potential, obtained after standardization within the boundaries of the first proximity circle and adjustment for population density. Each value falls within an interval from 0 to 1. Comparing the three time slices makes it possible to separate stable structural characteristics of the region from short-term fluctuations and to trace how the “development dominants” and “constraining spheres” are redistributed (Table 4).

Table 4. Calculation of indicators for Orenburg Oblast for 2020–2024

Type of potential	2020	2022	2024
Financial potential o_{20}	0,26	0,22	0,19
Energy potential o_{19}	0,29	0,28	0,29
Mineral and raw material potentia o_{18}	0,53	0,53	0,53
Land potentialo_{17}	0,24	0,22	0,37
Demographic potential o_{16}	0,22	0,23	0,14
Institutional potential o_{15}	0,37	0,84	0,40
Infrastructure potential o_{14}	0,35	0,31	0,31
Tax potential o_{13}	0,13	0,10	0,11
Educational potential o_{12}	0,42	0,42	0,42
Tourism potential o_{11}	0,25	0,25	0,29
Investment potential o_{10}	0,43	0,50	0,37
Consumer potential o_{9}	0,11	0,22	0,21
Labor potential o_{8}	0,20	0,16	0,34
Logistics potential o_{7}	0,26	0,24	0,29
Agricultural potential o_{6}	0,44	0,44	0,47
Industrial potential o_{5}	0,27	0,18	0,18
Innovation potential o_{4}	0,21	0,25	0,19
Natural resource potential o_{3}	0,30	0,31	0,32
Social potential o_{2}	0,26	0,34	0,31
Economic potential o_{1}	0,25	0,24	0,26
Aggregate potentia o_{0}	0,30	0,34	0,29

With an aggregate value of 0.29 in 2024, the table delineates a stable structural profile of the region. The development dominants include mineral and raw material potential (0.53), agricultural potential (0.47), educational potential (0.42), and institutional potential (0.40), whereas demographic (0.14), tax (0.11), industrial (0.18), financial (0.19), and innovation (0.19) potentials fall among the constraining spheres. This combination reflects a resource-agrarian profile of the economy, in which a strong resource base is not fully converted into economic outcomes.

A comparison of the three time slices divides the potentials into structurally stable and unstable ones. The mineral and raw material potential and the educational potential remain unchanged throughout the entire interval, while the demographic, industrial, and financial potentials show a consistent decline, and the labor potential (from 0.20 to 0.34) and land potential (from 0.24 to 0.37) increase markedly.

The fact that the same initial data, when processed by the module, yield a similar structure confirms the reproducibility and transparency of the computational procedure asserted above. In this regard, the table serves not only as an illustration of steps V and VII, but also as evidence that formalized rules replace expert intuition at the calculation stage and leave the expert group with nothing but the interpretation of an already verifiable numerical result.

Based on the obtained potential estimates, the software module iterated through all possible combinations and calculated the expected effect for each using the formulas of the combinatorial stage. The five combinations with the highest effect values at the intraregional level are presented in Table 5.

Table 5. Ranking of combinations by the magnitude of the expected effect at the intraregional level

Combination	Expected effect
Financial potential; Mineral and raw material potential; Investment potential; Agricultural potential	2,86
Mineral and raw material potential; Investment potential; Agricultural potential; Innovation potential	2,85
Mineral and raw material potential; Investment potential; Agricultural potential; Industrial potential	2,84
Financial potential; Mineral and raw material potential; Labor potential; Agricultural potential	2,80
Mineral and raw material potential; Labor potential; Agricultural potential; Innovation potential	2,80

All 5 combinations are built around a stable core of "mineral and raw material – agricultural potential," to which investment, financial, labor, innovation, and industrial potentials are added, with the spread of the effect between the first and fifth positions being minimal (2.86–2.80), indicating not a single best solution, but a group of similarly effective alternatives. The TOP-5 serves as input data for subsequent stages – filling the matrix of qualitative inter-potential linkages and morphological selection of projects within the budget constraint.

5. CONCLUSION

The developed program can be considered as an element of a logistics management digital twin for regional development. Logistics management in this context is the management of the distribution of financial, material, and other resource flows based on information processing and the automation of the alternative management solutions selection for territorial development, as well as the formation of cooperative ties between regions.

The visual displays a tabular arrangement of specially collected and classified data, as well as color-coded highlighting of the most significant determinants of regional development after processing, using the proprietary methodology. The search for combinatorial solutions is based on the mathematical tools of the morphological analysis and synthesis method for comparing and processing expert opinions to find optimal combinations. The expansion includes the presentation of data dynamics in the form of graphs, the integration of built-in algorithms with artificial intelligence algorithms to automate the extraction of data sets from information bases, and the implementation of automated control using a digital assistant.

The digital product doesn't replace the expert component, but it frees analysts and experts from routine calculations and ensures reproducibility and transparency of calculations, leaving the key functions of interpretation and decision-making to a decision maker. After the user has uploaded the selected indicators and their values, the system recommends a combination based on numerical criteria, generates a list of priority combinations, and calculates their numerical effects.

Particular attention is paid to information and economic security. The program uses aggregated statistical data available in open sources. However, the program itself only processes manually uploaded data. The system does not process personal data and, if necessary, can be deployed on a local secure network, completely eliminating data transfer to external services. This architecture minimizes the risk of confidential information leakage and complies with national economic security requirements, while allowing authorized bodies to reproduce calculations and verify decisions.

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