SCENARIO MODELING OF ECONOMIC GROWTH BASED ON INDICATIVE PLANNING

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Abstract. This paper considers a multilevel indicative planning model for target indicators in the "World–Country–Industries–Resources–Projects" system. The proposed simulation model implements scenario planning. The problem of analyzing and forecasting the country's target indicators, using the example of Gross Domestic Product at Purchasing Power Parity (GDP at PPP), is formulated for individual industries. The growth rates of individual industries' GDP and Gross Value Added (GVA) necessary for implementing the target scenario are estimated. Specific efficiency indicators for financial and human resources are determined: labor productivity and capital intensity. The investment in fixed assets and human resources necessary for implementing the target scenario are estimated. As demonstrated, implementing the target scenario of GVA growth requires measures to accelerate labor productivity growth, and the most important industries in this context are identified. The study is based on initial data provided by the World Bank and the Federal State Statistics Service of the Russian Federation.

Keywords: modeling, forecasting, targeting, indicative planning, management, large-scale systems, system dynamics.

INTRODUCTION

Under capitalism, an economy faces the challenge of growth and development stimulated by credit interest. Gross Domestic Product (GDP) is a quantitative measure of an entire economy according to the System of National Accounts (SNA).

Consider Task 1 set in the Russian President's Address to the Federal Assembly: "Take measures ensuring that by 2030 the Russian Federation will become one of the four largest economies in the world in terms of Gross Domestic Product calculated at Purchasing Power Parity" (PPP) [1, 2].

Information on the current rank of the Russian Federation by GDP at PPP is provided in Section 4.

Previously, Russia has already succeeded in accelerated growth. In 2003, Vladimir Putin set the task of doubling the country's GDP in 10 years. It required a *Compound Annual Growth Rate* (CAGR) of 7.2% and was implemented from 2000 to 2008 [3]. On the one hand, it was "growth from zero," after the collapse of the Russian economy in the 1990s [4]. On the other hand, it was necessary to provide conditions for such growth. In the 2000s, the key contribution to GDP growth as the total GVA of industries was made by the following industries (Table 1): wholesale and retail trade (PJSC Gazprom is a gas trading organization according to OKVED codes), construction, financial activities, and real estate activities. There were also industries with almost zero growth in that period: agriculture, forestry and fishing; electricity, gas, steam, and air conditioning supply; education; and healthcare.

However, the large-scale economic crisis of 2008–2009 and the COVID restrictions of 2020–2021 have noticeably slowed down the growth of the global and Russian economy.

There exist GDP and GDP at PPP. The latter considers the real purchasing power of national currencies in local markets and their exchange rates. Which indicator is preferable? This question has no universal answer as the criterion depends on the situation under study.

Table 1

The GVA of industries by OKVED at constant prices of 2008

Industry	The GVA of industries in 2002, bln. RUB	The GVA of industries in 2008, bln. RUB	Absolute increase in 2002–2008, bln. RUB	CAGR in 2002–2008, %
Gross domestic product at market prices, including:	27 312	41 277	11 972	7.13%
Construction	1152	2225	927	11.60%
Wholesale and retail trade	3740	7138	2900	11.37%
Financial activities	438	1538	973	23.30%
Real estate activities	2423	3959	1469	8.53%

In low-income countries, goods and services tend to be cheaper than in high-income ones. With this international price differential being neglected, one may underestimate the purchasing power of the population in developing and emerging countries and, consequently, the welfare of society. Therefore, GDP at PPP is commonly used to measure the welfare of society.

The main problem is the difficulty of measuring GDP at PPP compared to GDP at current prices. Calculating GDP at PPP requires extensive statistical work, and new price comparisons become available only after a significant delay. In the periods between survey dates, it is necessary to estimate the PPP coefficient, which may cause measurement errors.

Exports and imports in international calculations indirectly affect purchasing power and are included in GDP at PPP. The share of imports and exports in the Russian economy can be estimated by the ratio of the value of exports to revenue for the full range of organizations, or by the share of imports to costs. The volume of Russia's exports constituted 425.1 billion USD in 2023 [5] and 592.5 billion USD in 2022 with a revenue of 324 321 billion RUB for all types of qualification groups [6]. Hence, in the revenue of all Russian organizations in 2022, the share of exports (592.5 billion USD at an average daily RUB/USD exchange rate of 68.35) was

$$D_{\exp,2022} = \frac{40.5 \text{ trillion RUB}}{324.3 \text{ trillion RUB}} = 12.5\,\%$$

With such a share of exports in the total revenue of the country's organizations, the purchasing power estimated at PPP seems more reasonable. GDP at PPP was considered in many publications related to the real development of countries [7, 8].

The share of exports in budget revenues is significantly higher due to the export of oil and gas products and a higher share of taxes, including mineral extraction tax (MET).

This paper considers the development of the country as a large-scale system in terms of GDP at PPP based on the trajectory approach of the system optimization model. The model under consideration serves as an indicative planning tool for assessing the prospects of economic growth and the need for significant amounts of resources.

In this (possibly multipart) study, Task 1 will be solved in several stages:

Subtask 1.1. Determining the required growth rate of the entire economy;

Subtask 1.2: Determining the required growth rate of the economy by industries.

Subtask 1.3. Determining the resource demands to ensure the growth rate of the economy by industries.

Subtask 1.4: Determining the sufficiency of resources to ensure the growth rate of the economy by industries.

Subtask 1.5 Management: determining the parameter values for effective resource management.

1. LITERATURE REVIEW

At the moment there is no unambiguous definition of indicative planning. Within this paper, we will adopt the following definition: indicative state planning is represented as the process of forming a system of indicators and, on their basis, the development of economic state measures for economic processes to achieve the target indicators [9].

O. Smirnova considered indicative planning models with adaptation to national conditions [10, 11]. The challenges of indicative planning and shortcomings of the systemic scientific-methodological approach in this field were shown. For indicative planning, the author recommended forming a system of indicators and, on their basis, developing a complex of measures to achieve the targets. Mathematical modeling methods and balance calculations can be used as tools to analyze resource provision. This approach allows developing a system of measures and management decisions.

F. Pashchenko with colleagues presented a complex of indicative planning models, including those applied to regional development [12–14]. Khabarovskii krai was studied as an example.

The traditional macroeconomic two-factor Cobb – Douglas model describes the development of a production factor Q depending on two main resources: labor and capital [15]:

$$Q = F\, L^{\alpha}\, K^{\beta},$$

where F denotes the total productivity of these factors; L and K are labor and capital; finally, α and β are the labor and capital elasticities, respectively.

Scenario analysis using cognitive maps is one simple but effective method preceding the planning of indicators. The cognitive approach allows identifying a subset of indicators with significant links (relations). Cognitive maps of regional development with the identification of growth opportunities were considered by I. Chernov et al. [16]. The construction of cognitive maps with the identification of vulnerabilities was discussed in [17].

Z. Avdeeva with colleagues described the application of cognitive maps for time series forecasting [18]. A cognitive maps-based approach to assessing the achievability of development targets with many active subjects was proposed in [19]. In addition, some promising applications of such problems were highlighted: decision validity analysis, problem resolution, and coalition formation for interested parties.

A. Zakharova, A. Podvesovskii, et al. considered examples of building strategic management scenarios for weakly structured socio-economic systems using fuzzy cognitive maps [20, 21]. Also, note the joint usability of visual analytics and the cognitive approach [22, 23]. Visual analytics serves for conducting the preliminary (exploratory) analysis of indicator-related data and forming the primary structure of scenarios based on resulting hypotheses. Cognitive modeling is intended to clarify and verify scenarios and perform their dynamic modeling.

Scenario approaches to indicative planning on the example of the EAEU development were presented by F. Ereshko with colleagues [24]. Simulation models were used to implement scenarios.

A. Tsvirkun et al. discussed development tools for a high-tech industry [25]: sliding planning and budgeting, the program-targeted approach, *Computable General Equilibrium* (CGE) models, and *Social Accounting Matrices* (SAM, the balances of income and expenditures of the main economic agents in a base year). As was emphasized, many models are not provided with initial data, which significantly restricts their applicability.

The industry's indicators of development (on the example of manufacturing) were considered by N. Obrosova and A. Shananin [26] using *the Constant Elasticity of Substitution* (CES) function as a model. Many research works involve the CES function with two resources: $B_1 = K$ (capital) and $B_2 = L$ (labor). In general, the CES function with n inputs (resources) has the form

$$Q = F\left(\sum_{i=1}^{n} w_i B_i^r\right)^{\frac{1}{r}},$$

where Q is production output; F is the total productivity of the factors; w_i is the share of input I ($\Sigma w_i = 1$); B_i is the quantity of factor i (resource); finally, r is the substitution parameter.

V. Varnavskii studied medium-term trends in the development of the global economy and identified the following growth drivers [27]: globalization, information and communication technologies (computer), opening China to the world, labor and productivity, and the compliance of institutions with global standards. The first three drivers were analyzed in detail.

V. Glushkov [28, 29] and V. Mikhalevich [30] considered the model of system optimization. The basic idea is to improve all system parameters to achieve targets.

The trajectory approach of the system optimization model was analyzed by V. Irikov, V. Burkov, and V. Trenev [31]. This line of research remained underdeveloped due to the transition of the Russian economy to market relations. In the 1990s, financing was the main scarce resource; other resources became redundant or at least not scarce. Under the substitutability of resources with a financial equivalent, the system optimization model was reduced to a single-resource optimization problem. At present, the development of an economy requires the explicit consideration of limiting resources, especially under the existing constraints in international trade.

The application of the system optimization model for developing the country's energy industry was studied in [32], with investment, human resources, metal, and equipment as the main resources. V. Irikov considered the application of the system optimization model to industrial and regional development [33, 34]. The following possibilities to increase the degree of achievement of a target point λ^* were analyzed in the system optimization model:

– utilizing an additional resource; note that additional non-limiting resources will not affect λ^* (will be redundant) unless an additional limiting resource is allocated;

– exchanging resources: increasing a scarce resource at the expense of a non-deficient (non-limiting) one;

– improving efficiency by changing technologies; this possibility is described by a change (reduction) of specific consumption rates;

– changing the target point (the ideal point).

The logic of the trajectory approach of the system optimization model agrees with clause 6 of Federal Law dated June 28, 2014, no. 172-FZ “On Strategic Planning in the Russian Federation” [35]. According to this clause, the principle of effectiveness and efficiency of strategic planning means that the choice of ways and methods for achieving the targets of socioeconomic development and ensuring the national security of the Russian Federation should be based on the need to achieve given results with the least resource costs in accordance with strategic planning documents elaborated within planning and programming.

A management system for innovative development as a tool for increasing the pace of Russia’s withdrawal from the crisis was considered in [36].

2. MATHEMATICAL PROBLEM STATEMENT

The GDP growth problem is described by the criterion

$$\Delta GDP \to \max. \tag{1}$$

The control parameters are the growth rates of the lower-level indicators. For GDP, these are the growth rates of GVA by industries; for GVA, the growth rates of value added by enterprises.

GDP is formed by the sum of GVA by industries. For the sake of simplification, we omit the subscript of periods (years) t in the GDP estimation formula:

$$GDP = \sum_j VA_j + VA_0,\ j = 1,\dots,\ J,$$

where VA denotes the gross value added; j is the industry subscript; finally, VA_0 is the net taxes on products (for Russia, about 10% of GDP).

The value added of an industry and the output of individual enterprises are related by

$$VA_j = \sum_i VA_{ji}, \tag{2}$$

where VA_{ji} is the value added of individual enterprise i operating in industry j.

The value added of industry j can be described by the dynamic dependence

$$VA_j(t) = VA_j(t-1)(1 + r_{VA,j}(t)),$$

where $r_{VA,j}$ is the growth rate of the industry’s value added.

The growth rate of each industry can be divided into two components:

– an inertial growth rate, according to the statistics of previous years;

– a change in the growth rate due to management.

Let the inertial one be the compound annual growth rate (CAGR) g obtained from the equation

$$VA_j(t) = VA_j(t-\tau)(1 + g_j(t))^{\tau}.$$

where

$$g_j(t) = \left(VA_j(t) / VA_j(t-\tau)\right)^{(1/\tau)} - 1$$

is the growth rate of the value added of industry j and τ is a data analysis period.

Generally speaking, the rate $g_j(t)$ depends on the period τ and can be written as $g_j(t, \tau)$. In this paper, however, we carry out calculations under a constant value of τ to avoid overparameterized formulas.

In addition, we introduce a control action, i.e., the growth rate change $u_j(t)$. Then

$$r_{VA,j}(t) = (1 + g_j(t))(1 + u_j(t)) - 1,$$

where $r_{VA,j}$ is the growth rate of the value added of industry j under the control action.

Considering $t = 0$ as the period with the latest factual data, GDP can be expressed through the period T as the total GVA of all industries:

$$GDP(T) = \sum_j VA_j(T) + VA_0(T),$$

$$GDP(T) = \sum_j VA_j(0) \prod_{t=1}^{T} (1 + g_j(t))(1 + u_j(t)) + VA_0(T).$$

Problem (1) is reduced to increasing the growth rates of individual industries (see Subtask 1.2 in the Introduction):

$$(1 + g_j(t))(1 + u_j(t)) \to \max,\ j = 1,\dots, J,$$

subject to the constraints

$$\mathbf{A}(t)\mathbf{VA}(t) \le \mathbf{B}^{\text{av}}(t),$$

where $\mathbf{A}$ is the specific resource consumption matrix; $\mathbf{VA}(t)$ is the GVA vector of industries; finally, $\mathbf{B}^{\text{av}}$ is the resource availability vector.

The difficulty in applying formula (2) is the absence of information on the value added of an individual enterprise. Therefore, we consider the following relationship between the value added and revenue of enterprises:

$$VA_j = k_{VA,j} R_j + \varepsilon_j,$$

where R stands for revenue; k_{VA} is the coefficient of value added in revenue; ε is an error.

The value of $k_{VA,j}$ can be determined using regressions based on factual data of past periods. Thus, due to the difficulty (impossibility) of obtaining information on the value added of individual enterprises, it is possible to find instead the average coefficients of value added in revenue by industry (under the assumption that within a particular industry, the coefficients of value added of individual enterprises lie in some neighborhood of the average coefficient of this industry). In other words,

$$VA_j = \sum_i VA_{ji} = \sum_i k_{VA,ji} R_{ji} = k_{VA,j} R_j + \varepsilon_j .$$

The total revenue of an industry is the sum of the revenues of all its individual enterprises:

$$R_j = \sum_i R_{ji}, \; j = 1,\ldots,J ,$$

where enterprise i operates in industry j and J is the number of industries.

Considering $t = 0$ as the period with the latest factual data, we represent GDP through the relationship between the gross value added of industries and the revenues of enterprises:

$$GDP(T) = \sum_j \left\{ R_j(0) k_{VA,j} \prod_{t=1}^{T} (1 + g_j(t))(1 + u_j(t)) \right\} + VA_0(T).$$

Thus, we have a multilevel system; see Fig. 1. The upper level is the aggregate indicator (the country's GDP); the next level corresponds to the types of activity with decomposition by industries; enterprises and development projects are located below them.

3. THE RESOURCE MODEL

We separate several resource constraints essential for solving this problem:

B1. Investment.

B2. Human resources.

B3. Energy resources.

B4. Key raw materials and supplies.

B5. Land.

The list of resources can be enlarged. This paper considers resources B_1 (investment in fixed assets) and B_2 (human resources); the corresponding calculations are provided.

The amount of net investment in fixed assets is given by

$$Inv_{FA,j} = FA_{j,t} - FA_{j,t-1},$$

where Inv_{FA} denotes net investment in fixed assets and FA is fixed assets. ("Net" means accounting for the use of current period's depreciation in the purchase of fixed assets.)

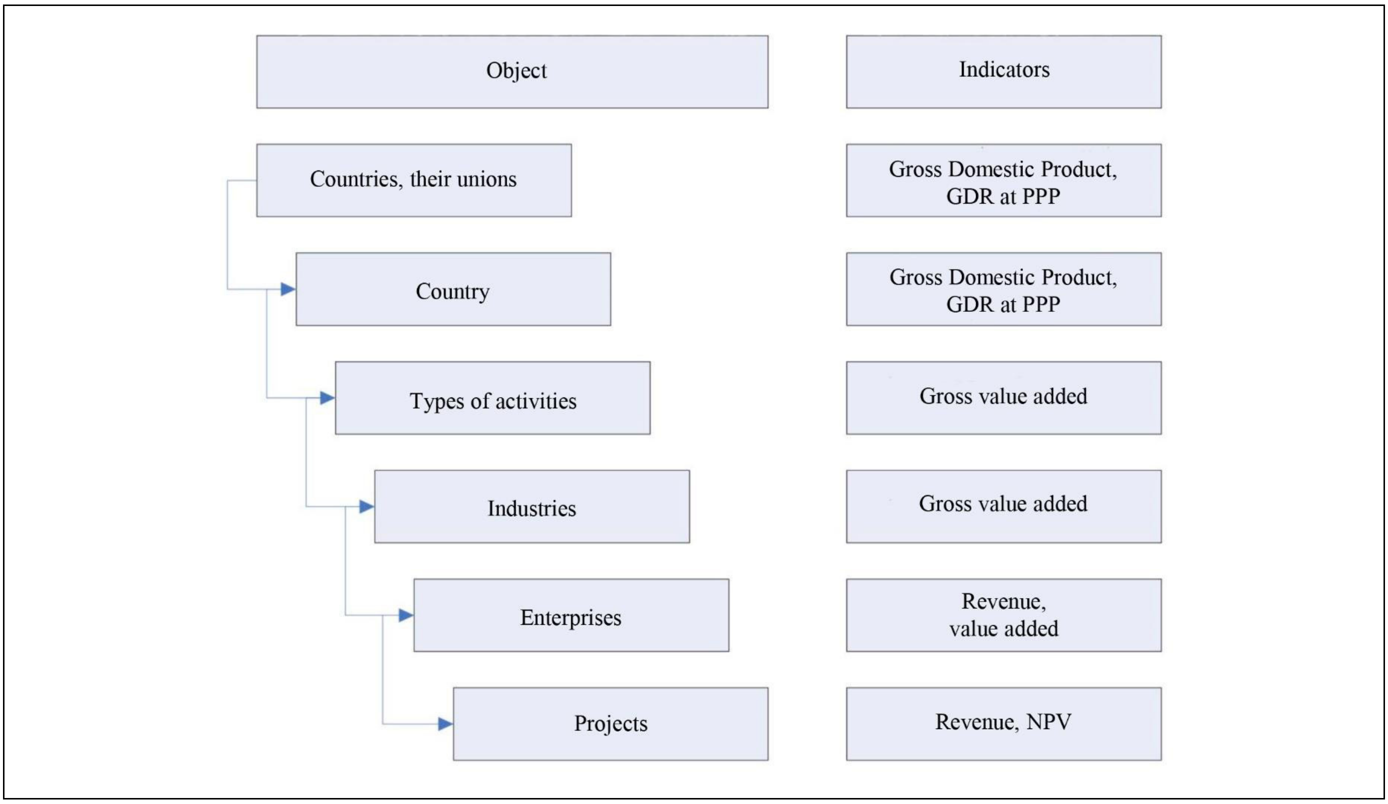

Fig. 1. The "country-industry-enterprise-project" multilevel system.

However, in addition to investment in fixed assets, investment in current assets is necessary, especially at the growth stages of the enterprise's revenues to provide inventories for continuous production in advance. Then the total investment is defined as

$$Inv_{ji} = IC_{ji,t} - IC_{ji,t-1},$$

where *IC* is invested capital. The amount of invested capital is given by assets less accounts payable:

$$IC_j = A_j - CL_j = FA_j + CA_j - CL_j,$$
$$Eq_j = FA_j + CA_j - CL_j - D_j = IC_j - D_j,$$

with *A* denoting assets; *Eq*, equity capital; *CA*, current assets; *CL*, current liabilities; *D*, long-term liabilities.

Specific capital investment in the growth of value added is an efficiency indicator relating the growth of value added and investment:

$$a_{1,j} = IC_j / GVA_j,$$

where GVA_j means the gross value added of industry *j*.

At the enterprise level, it is possible to use an additional coefficient of specific capital investment in revenue growth:

$$\bar{a}_{1,j} = IC_j / R_j$$
$$= (IC_j / GVA_j) \times (GVA_j / R_j) = a_{1,j} \times k_{VA,j}.$$

The demand for human resources is given by labor productivity in terms of value added:

$$a_{2,j} = B_{2,j} / GVA_j.$$

At the enterprise level, it is possible to use an additional coefficient of labor productivity in terms of revenue:

$$\bar{a}_{2,j} = B_{2,j} / R_j$$
$$= (B_{2,j} / GVA_j) \times (GVA_j / R_j) = a_{2,j} \times k_{VA,j}.$$

4. INITIAL DATA

By the time of writing this paper, different sources have presented slightly varying data regarding the quantitative measurement of GDP at PPP and the initial ranking of countries based on this indicator.

According to www.worldeconomics.com [37], China, USA, and India ranked 1st, 2nd, and 3rd, respectively, by the estimated GDP at PPP in 2023, with a large gap from the other countries; Japan, Russia, Indonesia, and Germany were sequentially assigned ranks 4–7. As noted, the authors reestimate the indicators due to *informal economic activity* and insufficient (or possibly distorted) official statistical data for the countries. Also, GDP dynamics were forecasted for 2025–2030 based on average annual growth rates for the previous decade.

The data provided by the World Bank (see the "GDP, PPP (current international $" indicator) [38] from 1990 to 2022 differ from one version to another. In the version dated March 28, 2024, Russia ranked 6th in 2022 with a GDP at PPP of 5082 billion USD (Table 2). In the version dated May 30, 2024, Russia was assigned rank 4 in the same year (a GDP PPP of 5988 billion USD). The data variation was 17.8% due to the change in the PPP coefficient from $K_{PPP,0a}$ = 0.4409 to $K_{PPP,0b}$ = 0.3742. In Table 2, CAGR includes inflation.

In this paper, the basic estimates for the growth of industries and additional resources demanded to achieve the global average growth rate of the economy change insignificantly due to the adjustment of the PPP coefficient K_{PPP}.

For Russia, the initial GVA data by the types of activity and industries are provided by the Federal State Statistics Service of the Russian Federation (Rosstat) [39].

Table 2

The GDP at PPP of some countries according to the World Bank data

Rank in 2022	Country	GDP at PPP in 2000, bln. USD	GDP at PPP in 2012, bln. USD	GDP at PPP in 2022, bln. USD	CAGR in 2012–2022, %
World		49 258	100 816	171 531	5.46%
1	China	3683	15 213	31 773	7.64%
2	USA	10 251	16 254	25 440	4.58%
3	India	2212	6163	12 998	7.75%
4	Russian Federation	1001	3480	5988	5.58%
5	Japan	3461	4800	5862	2.02%
6	Germany	2236	3487	5582	4.82%
7	Brazil	1582	2992	4120	3.25%
8	Indonesia	1002	2408	3980	5.15%

5. THE MODEL AND CALCULATIONS

5.1. At the Country Level

What should be the additional growth acceleration of country 1 (Russia) to outperform another country (with no. 2)? By simple transformations of GDP growth formulas for countries 1 and 2, we establish that for $GDP_{1,T} \geq GDP_{2,T}$, where

$$GDP_{1,T} = GDP_{1,0}\,(1+g_1)^T(1+u_1)^T,$$
$$GDP_{2,T} = GDP_{2,0}\,(1+g_2)^T(1+u_2)^T, \qquad (3)$$

it is necessary that

$$u_1 \geq (1+u_2)\left(\frac{GDP_{1,0}}{GDP_{2,0}}\right)^{-1/T}\left(\frac{1+g_1}{1+g_2}\right)^{-1} - 1, \qquad (4)$$

where g stands for CAGR; u_1 and u_2 are the control actions for the growth rate g of countries 1 and 2, respectively; T specifies the period of analysis.

Calculations based on the World Bank data of March 28, 2024, using formulas (3) and (4) show that the additional acceleration of average annual growth of country 1 (Russia) is u_1^{tar} = 2.12% with u_2 = 0% from 2023 to 2030. For the solution of this problem, the difference between the CAGR values of the compared countries is crucial, not the growth acceleration of an individual country.

Russia's national GDP growth targets until 2030 are "ensuring the growth rate of the country's gross domestic product above the world average while maintaining macroeconomic stability" [40]. According to the authors' calculations based on the World Bank data [41], the growth rate of the world economy amounted to 2.76% for the period 2011–2022.

For this period, the average annual growth of CAGR of gross domestic product at constant prices was 1.01%; the growth of GVA at constant prices, 1.24% (the inertial scenario data). The difference in GDP and GVA growth is the decrease in net taxes on products.

In this paper, we will not analyze taxes on products, noting however that "these are taxes proportional to the quantity or value of goods and services produced, sold, or imported by residents. They include value added tax, excise taxes, export duties, and taxes on imported goods and services." [42].

The additional GDP growth u_1^{tar} = 2.12% will be treated as an input parameter for decomposing the growth rates by the types of activity and industries, both to achieve the global average growth rate of the economy (the target indicator) and to solve Task 1 (growth in terms of GDP at PPP).

5.2. At the Level of the Types of Activity and Industries

Rosstat provides information on 54 industries in accordance with the OKVED-2 classifier [43]. The industries are assigned a combination of a section letter (from A to T) and a number (from 1 to 99). In some cases, industries are enlarged: J (62–63) "Computer software development, consulting services in this field and other related services; activities in the field of information technology" is the sum of industries J 62 "Computer software development, consulting services in this field and other related services" and J 63 "Activities in the field of information technology."

Figure 2 highlights some industries with large growth (more than 100 billion RUB) at constant prices in 2021 and an average growth rate of more than 1.5% per year. (From this point onwards, they are called major.)

Let us separate some industries with the highest absolute GVA growth and high growth rate:

- Section K "Financial and insurance activities";
- Section L "Real estate activities";
- J (62–63) "Computer software development, consulting services in this field and other related services; activities in the field of information technology";
- C 25 "Manufacturing of finished metal products, except machinery and equipment";
- C 20 "Manufacturing of chemicals and chemical products";
- C 21 "Manufacturing of drugs and materials used for medical purposes";
- R 93 "Activities in the field of sports, recreation and entertainment";
- M 71 "Activities in the field of architecture and engineering design; technical testing, research, and analysis."

Note that all major growth industries can be categorized as smart industries: these are complex manufacturing or management.

6. GROWTH FORECAST SCENARIOS

We consider several growth scenarios:

- inertial growth by industries with the growth rate corresponding to the past periods;
- accelerated growth by the same value for each industry (all industries will accelerate equally);
- accelerated growth with an increment proportional to the growth in the previous period.

For this study, such scenarios illustrate possible structural shifts by industry. Many factors in each industry can affect the development process, deviating it from the inertial scenario: external impacts, exchange rate fluctuations, export–import opportunities, technological innovations, etc.

The results of the accelerated growth scenario of different industries are shown in Fig. 3 and Table 3. For clarity, we have grouped the industries by size (the major ones are with a GVA growth of more than 100 billion RUB for 2011–2022) and by growth rate (high rate—above 2%, low rate—from 1 to 2%, and no growth—below 1%). According to the chart, the key growth of the total GVA is provided by the major industries with high growth rates. In the calculations of this scenario, the control action (the additional growth of an industry) is assumed to be proportional to the inertial growth on the factual interval. The industries without growth and with small growth insignificantly contribute to the increase of the total GVA (and, hence, GDP). Accelerated growth is ensured by industries with fast growth. In the tables, the types of activities with codes from M to S are not presented due to the limited scope of this paper, and the types of activities have abbreviated names.

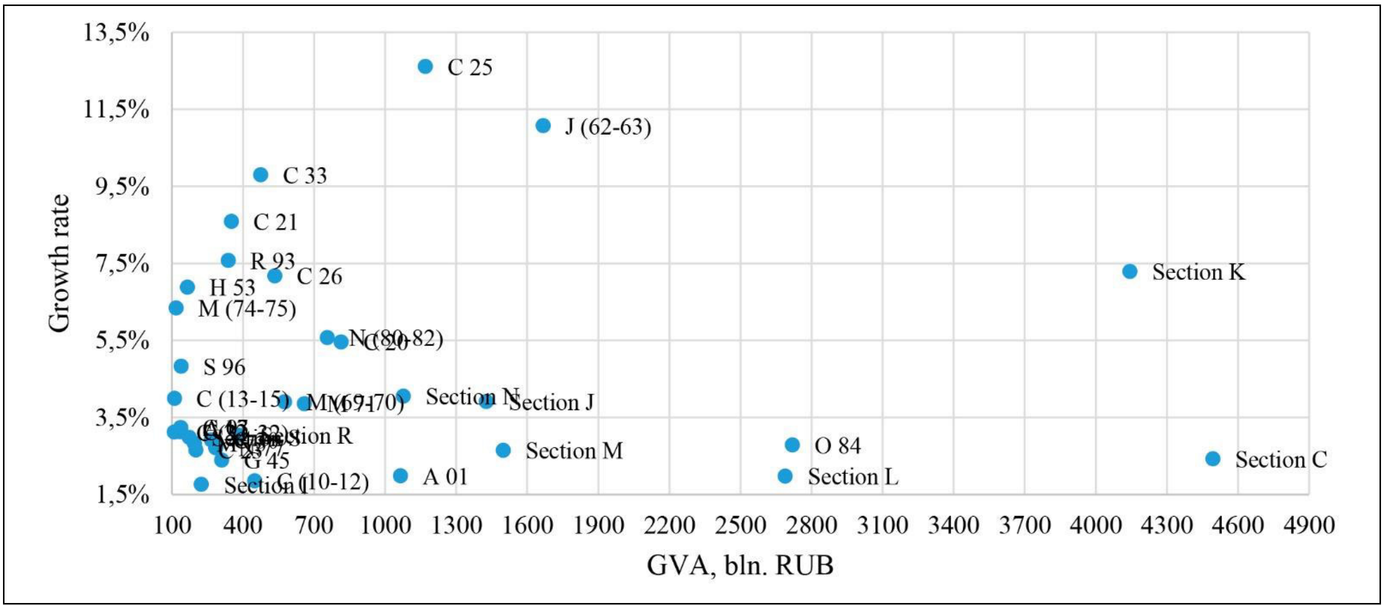

Fig. 2. The growth rate and increment of GVA at constant prices for some industries.

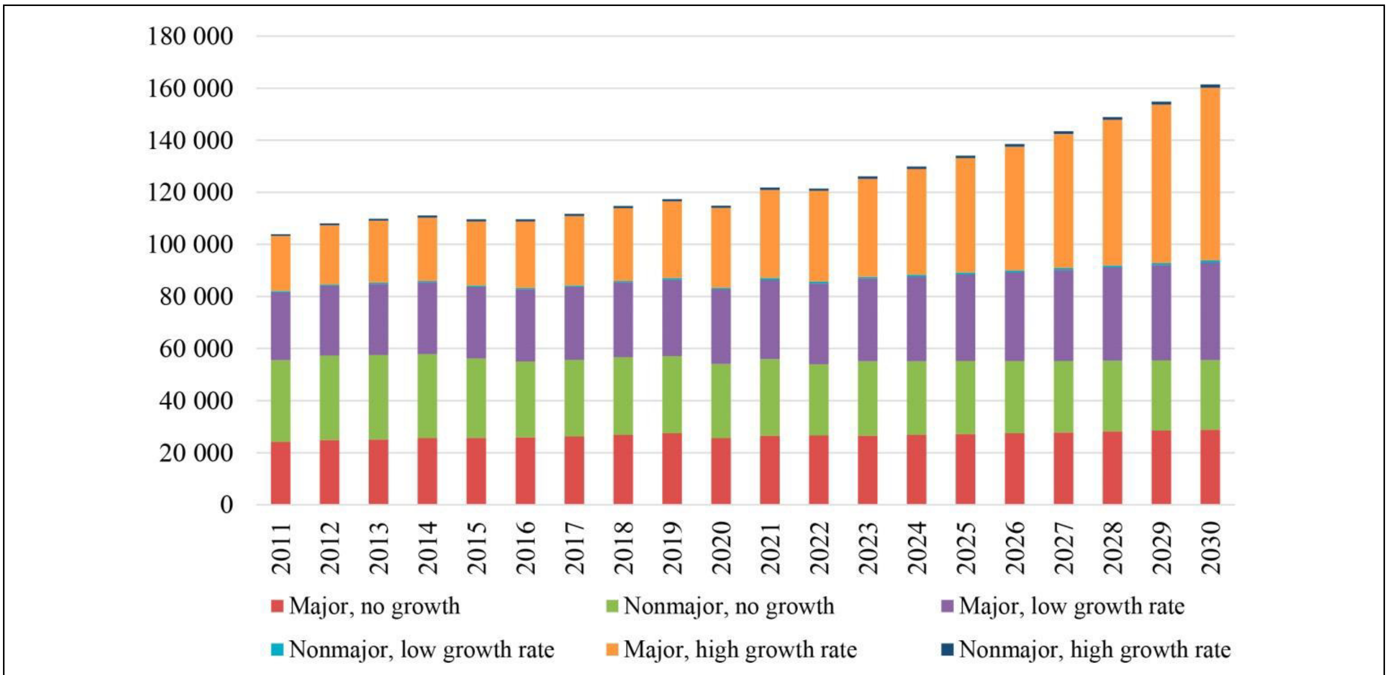

Fig. 3. The GVA accelerated growth scenario by growth groups (at 2021 prices, bln. RUB).

Table 3

PPP at GDP growth estimate corresponding to the accelerated growth scenario, at constant 2021 prices

Code	Industry	Indicator		
		2022, bln. RUB	2030, bln. RUB	Group
Gross Domestic Product at constant prices		134 081	173 604	Overall
Gross Value Added at constant prices		121 436	161 391	Overall
A	Agriculture, forestry and fishing	5720	7001	Sum
B	Mining and quarrying	16 201	17 213	Major, no growth
C	Manufacturing	16 783	27 043	Sum
D	Electricity, gas, steam and air conditioning supply	2984	3003	Nonmajor, no growth
E	Water collection, treatment and supply	591	586	Sum
F	Construction	6240	7424	Major, low growth rate
G	Wholesale and retail trade	14 121	14 264	Sum
H	Transportation and storage	7617	8664	Sum
I	Accommodation and food service activities	1078	1412	Major, low growth rate
J	Information and communication	3518	8179	Sum
K	Financial and insurance activities	6687	14 747	Major, high growth rate
L	Real estate activities	12 719	15 597	Major, low growth rate

Manufacturing industries (C 27 “Manufacturing of electrical equipment,” C 28 “Manufacturing of machinery and equipment not included in other groups,” C 29 “Manufacturing of motor vehicles, trailers and semi-trailers”), as well as Section D “Electricity, gas, steam and air conditioning supply,” Section H “Transportation and storage,” Section I “Accommodation and food service activities,” J 61 “Telecommunications activities,” M 72 “Scientific research and development,” and P 85 “Education,” belong to the “nonmajor, no growth” group. These are important industries, often related to infrastructure. Due to insufficiently fast growth in the past decade, their role has nevertheless diminished significantly compared to the almost self-sufficient economy of the Soviet Union; or (like telecommunications/mobile communications) they stopped growing after a jump. Education provides the foundation for eliminating the bottleneck in human resources and labor productivity. In this paper, we will not revise the accelerated growth scenario with a proportional distribution of growth rates. However, the importance of these industries for the country’s development strategies should be outlined to explore more realistic growth scenarios of the Russian economy with a significant degree of autonomy.

As an example, we take the target scenario on GVA change for agriculture, forestry and fishing (Section A of OKVED-2; see the *Y* axis in Fig. 4) and information and communication (Section J of OKVED-2; see the *X* axis in Fig. 4). These industries were chosen for the chart due to their different growth rates in the past, so their dynamics will also differ in the target scenario. Circles indicate the factual data for 2011–2023 whereas crosses the forecasted data in the target scenario for 2024–2030.

Figure 4 shows the resource constraints for the two industries in 2030 and the following resources:

- investment in fixed assets B_1 (green square);
- human resources B_2 (red triangle).

The resource constraints in Fig. 4 were calculated as the product of the GVA estimate for the inertial scenario and specific resources (in terms of human resources and investment) for the final period under study (year 2030). The specific coefficients for human resources (labor productivity by value added, $a_{2,j}$) were estimated under the inertial scenario considering the increase in labor productivity.

According to Fig. 4, the target growth of industries will not be achievable with the current amount of resources in the inertial scenario of specific expenditures (resource utilization technologies). It is required to allocate additional resources and/or significantly increase the efficiency of resource utilization (change the matrix **A**, which includes specific investment and labor productivity).

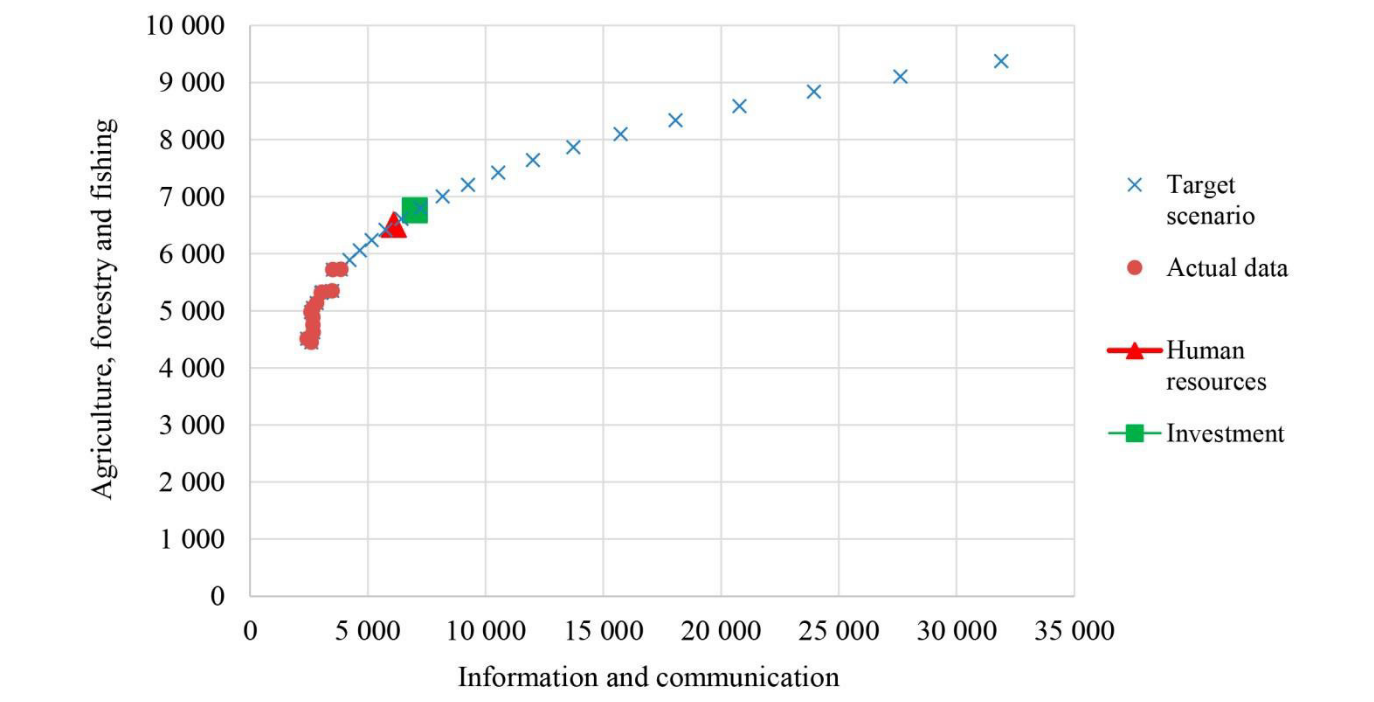

Fig. 4. The factual and target scenario of GVA change, bln. RUB.

An implicit assumption for resources can be formulated as follows: a resource is substitutable across industries. For investment, this assumption seems reasonable; for human resources with different qualifications in different specialties, it can be met under considerable efforts to train and retrain employees.

7. CALCULATIONS OF RESOURCE DEMANDS

Rosstat defines investment in fixed assets as "the aggregate of expenditures aimed at construction and reconstruction (including expansion and modernization) of facilities that increase their initial value; the acquisition of machinery, equipment, vehicles, production and household equipment subject to accounting in the order established for the accounting of investment in non-current assets; investment in intellectual property (since 2013); cultivated biological resources" [44].

Rosstat also distinguishes investment in nonproductive non-financial assets. In the period 2013–2023, this indicator ranged from 1.0 to 2.3% of the total investment in non-financial assets. It is not considered in this paper.

Investment in fixed assets includes the following groups [45]: investment in buildings (except residential) and constructions, residential buildings and premises, land improvement, machinery, equipment, vehicles, intellectual property objects, and other investment in fixed assets.

Note that Rosstat separately provides information on investment in current assets as part of the investment indicator. In this paper, investment in current assets is not considered.

Analysis of GVA and investment by industries should provide information on average specific investment in GVA growth and then information on possible industry priorities.

In a practical interpretation, accumulated investment forms the initial cost of fixed assets (buildings and structures, equipment), which serves for the manufacture of products. Precisely the completed construction with the commissioning of fixed assets makes it possible to manufacture products. We have conducted additional studies on the relationship between GVA by industries and investment in fixed assets and also between GVA by industries and accumulated investment in fixed assets. (The studies go beyond the scope of this paper.) According to the analysis results, there exists a strong dependence of investment in fixed assets and average annual accumulated investment on GVA; for the sake of simplification, annual investment in fixed assets is used in this paper.

Based on the Rosstat data (Table 4), there are capital-intensive industries (electricity, gas, steam and air conditioning supply; water collection, treatment and supply; transportation and storage) and non-capital-intensive industries (wholesale and retail trade; accommodation and food service activities; financial and insurance activities; public administration).

Table 4

Specific resource coefficients in 2023 at 2021 prices

Code	Industry	Indicator					
		GVA in 2023, bln. RUB	CAGR, %	Total investment in fixed assets in 2023, bln. RUB	$a_{1,j}$ (investment, RUB/GVA, RUB)	Estimated labor productivity by VA in 2023, thousand RUB/employee	$a_{2,j}$ estimated labor intensity (employment/GVA) in 2023, employees/mln. RUB
Total		126 088	1.65%	27 432.3	0.218	1737	0.576
A	Agriculture, forestry and fishing	5723.6	1.85%	1238.7	0.216	1347	0.742
B	Mining and quarrying	15 869.0	0.82%	4161.8	0.262	13 467	0.074
C	Manufacturing	17 937.2	2.24%	4051.7	0.226	1719	0.582
D	Electricity, gas, steam and air conditioning supply	2985.2	0.06%	1493.9	0.500	1946	0.514
E	Water collection, treatment and supply	573.3	0.05%	343.1	0.598	861	1.161
F	Construction	6649.4	1.11%	1214.1	0.183	962	1.040
G	Wholesale and retail trade	15 047.2	-0.55%	877.6	0.058	1056	0.947
H	Transportation and storage	7857.8	0.75%	4484.7	0.571	1302	0.768
I	Accommodation and food service activities	1185.0	1.76%	174.7	0.147	577	1.733
J	Information and communication	3861.3	3.61%	1019.4	0.264	2244	0.446
K	Financial and insurance activities	7266.5	7.29%	882.7	0.121	5749	0.174
L	Real estate activities	12 814.7	1.98%	3319.0	0.259	7039	0.142

The data on the average annual employment by the types of economic activity since 2017 are provided by Rosstat [46]. The human resources to ensure growth can be estimated using the average labor productivity by industries.

Based on the order [47], let us calculate the specific consumption indicators $a_{2,j}$ of the resource B_2 (labor). The values of the parameters $a_{2,j}$ will be inverse to labor productivity. For example, $a_{2,\mathrm{B}}$ = 1/13 467 thousand RUB/employee for industry j = B (mining and quarrying) and $a_{2,\mathrm{J}}$ = 1/577 thousand RUB/employee for industry j = I (accommodation and food service activities).

We emphasize the significant distinction in the values of parameters for different types of activities. Activities with high labor intensity (low labor productivity) are: water collection, treatment and supply; accommodation and food service activities; education. Activities with low labor intensity (high labor productivity) include: mining and quarrying; financial and insurance activities; real estate activities.

Table 4 shows some input data for the calculation: initial data, growth, and the specific coefficients for resources B_1 (investment) and B_2 (human resources).

Table 5 presents the estimated investment in fixed assets demanded for the target and inertial growth scenarios (see Subtask 1.3 in the Introduction). Note a small difference in the estimated demand for total investment in fixed assets in the inertial and target scenarios.

Next, Table 6 contains the estimated demand for human resources by the types of activities. This estimate is based on the target scenario of GVA and labor productivity by industries:

$$B_{2,j}(t) = GVA_j(t)\, a_{2,j}(t),$$
$$a_{2,j}(t) = a_{2,j}(t-1)(1+g_{a_{2,j}}),$$

where $B_{2,j}$ is employment by industries; GVA_j is the GVA of industry j; $a_{2,j}$ is the specific labor intensity of industry j; $g_{a_{2,j}}$ is the labor productivity growth rate; j denotes the industry subscript; finally, t stands for the time instant.

Table 5

Estimated investment in fixed assets demanded for the target growth scenario at 2021 prices, bln. RUB

Code	Industry	Indicator			
		In 2024, target scenario	In 2030, target scenario	Total, target scenario, in 2024-2030	Total, inertial scenario, in 2024-2030
Demanded investment in fixed assets, total		28 289.4	33 391.0	215 090	208 692
A	Agriculture, forestry and fishing	1271.5	1500.1	9682	9394
B	Mining and quarrying	4226.8	4638.8	31 011	30 099
C	Manufacturing	4321.9	5489.8	34 077	33 051
D	Electricity, gas, steam and air conditioning supply	1505.8	1579.7	10 797	10 482
E	Water collection, treatment and supply	346.4	365.9	2492	2419
F	Construction	1236.7	1380.9	9154	8884
G	Wholesale and retail trade	878.9	890.0	6189	6010
H	Transportation and storage	4547.7	4955.0	33 240	32 264
I	Accommodation and food service activities	179.1	207.9	1353	1312
J	Information and communication	1090.0	1550.4	9093	8815
K	Financial and insurance activities	954.1	1521.2	8535	8269
L	Real estate activities	3409.9	4009.5	25 921	25 150

Table 6

Estimated employee demand, thousand people

Code	Industry	In 2022	In 2023, estimate	In 2024, target scenario	In 2030, target scenario	Growth, 2023–2030
Employee deficiency		-	-	400	4829	-
Total, inertial scenario		71 217	71 066	70 985	70 738	0.995
Total, target scenario		71 156	71 066	71 386	75 549	1.097
A	Agriculture, forestry and fishing	4466	4353	4274	3846	0.884
B	Mining and quarrying	1195	1209	1237	1419	1.174
C	Manufacturing	10 003	9970	10 120	12 015	1.205
D	Electricity, gas, steam and air conditioning supply	1560	1546	1523	1390	0.899
E	Water collection, treatment and supply	706	698	686	617	0.883
F	Construction	6552	6600	6586	6506	0.986
G	Wholesale and retail trade	13 251	13 165	13 006	12 159	0.924
H	Transportation and storage	5751	5859	6008	7028	1.200
I	Accommodation and food service activities	1862	1905	1933	2115	1.111
J	Information and communication	1619	1656	1745	2680	1.619
K	Financial and insurance activities	1303	1280	1267	1191	0.930
L	Real estate activities	1856	1841	1847	1880	1.021

The inertial forecast of employment shows a slight increase in $B_2^{\text{iner}}(t)$ by 2030. According to the estimated demand for human resources in the target scenario ($B_{2,j}^{\text{tar}}(t)$), the shortage of employees by 2030 will reach about 4.8 million people (see Subtask 1.4 in the Introduction). The industries with large expected shortages of employees are: manufacturing; wholesale and retail trade; information and communication; public administration.

CONCLUSIONS

This paper has been devoted to the analysis and forecasting of the country's target indicators. A multilevel indicative planning model has been proposed to solve the problem.

The country's rank by GDP at PPP has been selected as the indicator. For individual industries, the demanded growth of GDP and gross value added, as well as the required resources (investment in fixed assets and human resources) have been estimated based on the World Bank and Rosstat initial data.

The main finding is that the target scenario of GVA growth cannot be implemented under the inertial scenario of labor intensity (labor productivity) change. Of the resources considered, employees will be an obstacle to achieving the targets.

Measures are needed to accelerate labor productivity growth, especially in information and communication, manufacturing, wholesale and retail trade, and public administration (see Subtask 1.5 in the Introduction).

The model allows considering scenarios of changes in target settings, resource constraints, and changes in resource utilization efficiency.

The indicative planning results of the target growth of the Russian economy refer only to the two-level economic system: the country as a whole and industries. Analysis at the level of enterprises and projects will be the subject of subsequent research.

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