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ORIGINAL PAPER

ANALYSIS OF STUDENT NUMBER DYNAMICS AT DIFFERENT LEVELS OF THE RUSSIA EDUCATION SYSTEM

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Abstract. The article defines the problems of the modern Russian education system and identifies priority areas in the development of educational services using the methods of statistical, mathematical, economic analysis, as well as methods for predicting market conditions. The study highlights the need to create a sustainable environment in the field of educational services. New approaches are proposed to improve the quality of services in the education system of Russia in order to ensure the progressive development of the entire national economy. In order to improve the education system, the features of interpreting the key points in terms of the time of formation and reflection of key indicators in the education system were identified, as well as the features of human capital production cycles. In the course of the study, a retrospective analysis of the number of students in the field of primary and secondary education, secondary vocational education in full-time, part-time and extra-mural forms of education, higher education in full-time, part-time, extra-mural forms of education was carried out. The features of the non-linear development of the education system and the estimated indicators are identified, indicating the hidden nature of the transition period difficulties, which can create significant problems in the medium term. At the same time, based on the results of calculations of the growing number of students in educational institutions, new directions for the development of education have been identified. According to the coefficients, funding for each form of education was determined in the amount of cost (in thousand rubles) equal to the modulus of the trend coefficient and the second-order time indicator. In order to improve the training of highly qualified specialists at the levels of secondary vocational and higher education, it is proposed to create an education support fund, which, in combination with external factors, will be able to create favorable conditions for qualitative and quantitative changes in relation to the student population. At the same time, the formation of an education sector that is accessible to a significantly larger number of citizens (compared to the actual one) remains the most important task, considering the possibility of modeling and adjusting the number of consumers of educational services.
Keywords: structure of students, trend analysis of education, sustainable development of the sectoral structure, financing of education, economics of educational services, education system, levels of the education system

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ОРИГИНАЛЬНАЯ СТАТЬЯ

АНАЛИЗ ДИНАМИКИ ЧИСЛЕННОСТИ ОБУЧАЮЩИХСЯ НА РАЗНЫХ УРОВНЯХ СИСТЕМЫ ОБРАЗОВАНИЯ РОССИИ

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Аннотация. В статье определены проблемы современной российской системы образования и выявлены приоритетные направления в развитии образовательных услуг с применением методов статистического, математического, экономического анализа, а также методов прогнозирования конъюнктуры рынка. Исследование подчеркивает необходимость формирования устойчивой среды в сфере образовательных услуг. Предложены новые подходы к повышению качества услуг системы образования России с целью обеспечения поступательного развития всей национальной экономики. В целях совершенствования системы образования выявлены особенности интерпретации ключевых точек по времени формирования и отражения ключевых показателей в системе образования, а также определены особенности циклов производства человеческого капитала. В ходе исследования проведен ретроспективный анализ численности обучающихся в сфере начального и среднего образования, среднего профессионального образования по очной, очно-заочной и заочной формам обучения, высшего образования по очной, очно-заочной, заочной формам обучения. Выявлены особенности нелинейного развития системы образования и оценочные показатели с указанием на скрытый характер трудностей переходного периода, которые могут создать существенные проблемы в среднесрочной перспективе. При этом на основе результатов расчетов растущей численности обучающихся в образовательных учреждениях выявлены новые направления развития образования. Согласно коэффициентам, определено финансирование для каждой формы обучения в размере стоимости (в тыс. руб.), равном модулю трендового коэффициента и временного показателя второго порядка. С целью улучшения подготовки высококвалифицированных специалистов уровней среднего профессионального и высшего образования предложено создание фонда поддержки образования, который в совокупности внешних факторов сможет создать благоприятные условия для качественных и количественных изменений в отношении обучаемого контингента. При этом важнейшей задачей остается формирование сферы образования, доступной для значительно большего числа граждан (по сравнению с фактическим) с учетом возможности моделирования и корректировки численности потребителей образовательных услуг.
Ключевые слова: структура обучающихся, трендовый анализ образования, устойчивое развитие отраслевой структуры, финансирование образования, экономика образовательных услуг, система образования, уровни системы образования

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Introduction

Improving the state policy in the field of education is the most important direction in the development of the social sphere, which, among other things, ensures the reproduction of labour resources in the sectoral complexes of the national economy. The education system retains its system-forming significance and forms a socially significant product, increasing the quality and volume of human capital. The sphere of educational services accompanies people throughout their lives, shaping their personalities not only through the impact of acquired knowledge and competencies, but also through qualitative changes in the educational process; and the degree of influence of human capital on the economic growth rates of high-tech industries and other enterprises has been widely recognized in recent decades [1].

According to S.A. Kovalenko, domestic researchers identify a number of approaches to the direction of education development [2]. On the one hand, there is the liberalization of the market and the reduction of mandatory requirements for its participants; on the other hand, strengthening control by state authorities, as well as their active influence on the market, up to the abolition of the sector of private educational services or reducing its participation to a minimum. The development of the Russian education market is currently in line with the global educational trends and adequately overcomes the barriers in comparability of the approaches of the specialist and the Bologna system [3].

At the beginning of the 20th century, the Russian education system was formed as a system for the distribution of priority sectors using human capital. It was focused on the most favourable development of the real sector of the economy through the continuous consumption of educational services and other socially useful activities. The formation of high-quality training after completing the studies compensated for the loss of time in the process of educational activities and adapted specialists to the conditions of production. The creation of an environment in which the entire population has access to knowledge, and the participation in it of various social groups wishing to participate in it, is considered as one of the most important state tasks. The active participation of employees in the educational process, despite significant cultural and value differences, is considered a positive factor that brings specialists closer to the working environment. The formation of adequate reflection, general cultural competence and the acceptance of students with different mental, psychic and physical abilities should follow the path of accepting participants “as they are”. Segregation methods have been actively used throughout history and worldwide. In order to spend funds more efficiently, they restrict access to markets, significantly reduce the level of well-being, determine the formation of an educational substyle and create a shadow market for knowledge consumption with frustration and protest personality development.

A necessary condition for the process of industrial reproduction is the achievement of a state of sustainable development of the education system. On the other hand, the training of highly qualified specialists is associated with the uninterrupted provision of educational services and the formation of a uniform change in the number of students in order to meet the needs of manufacturers and optimize the financial burden of educational institutions. The main objectives of the education sustainable development, according to the draft document “Key directions for the development of Russian education to achieve the goals and objectives of sustainable development in the education system until 2035”, are [4]:

- formation and development of the need to improve the level of education;
- changing the nature of education in terms of uncertainty, high speed of change and digitalization of the socio-economic environment;
- changes in educational technologies aimed at individualization of educational trajectories;
- ensuring the growth of education’s contribution to positive social change for an individual;
- support for children from socially vulnerable families and those who are lagging behind in mastering educational programs;
- assistance to children from migrant families in mastering the language and educational programs of the host country;
- meeting the individual educational needs of students and their families.

The goals and objectives of sustainable development in the field of education, implemented within the framework of the national “Education” project, are closely related to the priority areas of economic development of the Russian Federation. However, it is necessary to take national and religious characteristics into account, as well as those characteristics that apply to all Russian regions, while ensuring respect for national strategies and priorities [3].

In a global economy, the goal of improving the education system can be defined as a global wish list, with each government setting its own national goals. Guided by global aspirations, but considering national circumstances, each state decides how to ensure that these global goals are taken into account in the form of aspirations in the process of national planning of various activities and strategies. In the Russian Federation, certain strategic directions for the development of education are defined, as set out in the Decree of the President of the Russian Federation No. 204 “On the national goals and strategic objectives of the development of the Russian Federation for the period up to 2024” dated 07.05.2018 and the “Education” national project. In Russia, the project of National System of Indicators for Achieving Sustainable Development Goals (SDGs) was prepared by a group of experts led by the Federal State Statistics Service (Rosstat) and is currently under discussion; the authors of the project consider a set of indicators proposed by Rosstat as national indicators for achieving SDG-4 (“Quality Education”) [5].

The study presents an analysis of the current and potential supply and demand in the Russian market of educational services, as well as market development trends in the context of the formation of a sustainable socio-economic development of the country. To determine the potential demand in the market of educational services, it is necessary to solve the following tasks:

1) identify trends in the development of an industry product (students);
2) identify trends and forms of education in the field of educational services;
3) propose the necessary measures for the sustainable development of the sectors of the Russian economy.

The study used data from the Rosstat portal (“Education” section), the Ministry of Education of the Russian Federation, the Ministry of Science and Higher Education of the Russian Federation, executive authorities in the form of collections of processed primary information. In addition, from 2022 to the present, in cooperation with the above state authorities and the National Research University Higher School of Economics, the results of a study on certain areas of education development in Russia have been published in the form of the annual

publication “Education in Numbers”.

When constructing series of homogeneous statistical materials for higher education, in accordance with the recommendations of Rosstat, “external studies” and “extra-mural form of education” are combined. For primary and secondary education, there is no need to separate the forms of education, because the number of students in alternative to full-time forms of education is infinitely small. In addition, students who are under investigation, convicted and serving sentences, as well as students outside their subordinate educational institutions were excluded from the study. The research methodology is a combination of statistical, mathematical and economic analysis.

The data for the study were obtained from open data sources for the period 2005-2022 and grouped by forms and levels of education, then a trend analysis was carried out in order to identify the main pat-terns in the development of indicators.

The first and second derivatives are analyzed to determine the critical points in the direction of students’ development for each of the indicators. The first derivative with a zero resulting indicator deter-mines the presence of critical points and their number, the value of the independent indicator (time fac-tor) obtained in this case forms the time interval of the event on the basis of trend analysis; to form a dependent indicator, the value of x is substituted into the original trend equation. The second derivative is necessary to determine the nature of the point: if its value is greater than 0, then this is the maximum of the function, if it is less than 0, then this is the minimum of the function, if it is 0, then this is the inflection point of the function.

The peculiarity of accounting in the education system is associated with linking data to the beginning of the school year (September 1 of each year), in connection with which the dates of events are shifted four months ago, without taking the number of days in a month into account (*Table 1*). Since the academic year begins in September and the formation of the indicator of the number of students occurs precisely during this period, it would be incorrect to use January, the middle of the academic year, as the initial month.

Table 1 / Таблица 1

Accounting for Changes in the Month of Determining the Critical Point of Development of the Indicator of the Sphere of Education, shares / Учет изменения месяца определения критической точки развития показателя сферы образования, долей

Month when considering the indicator from January 1 of the x-th year / Месяц при учете показателя с 1 января *x*-ого года	Month when considering the indicator from September 1 of the (x-1)-th year / Месяц при учете показателя с 1 сентября *(x-1)*-ого года	Lower limit of the interval, inclusive / Нижняя граница интервала, включительно	The upper limit of the interval, not including / Верхняя граница интервала, не включая
January	January	0	0.083333
February	February	0.083333	0.166667
March	March	0.166667	0.25
April	April	0.25	0.333333
May	May	0.333333	0.416667
June	June	0.416667	0.5
July	July	0.5	0.583333
August	August	0.583333	0.666667
September	September	0.666667	0.75
October	October	0.75	0.833333
November	November	0.833333	0.916667
December	December	0.916667	1

Source: compiled by the author / *Источник:* рассчитано автором

The value of x is considered applicable for the period up to 2038 due to the likelihood of a change in both technological patterns and value orientations (principles) of the development of the education system.

Results and Discussion

As a result of data processing regarding the forms of education, the following trend equations were obtained with determination coefficients describing the nature of the temporary change in the number of students as the main consumers of the educational services industry in Russia (1.1-1.7) [5]:

$$Y1 = 19{,}074x^2 - 70{,}608x + 13024R^2 = 0.78040 \quad (1.1)$$

$$Y2 = 8{,}7841x^2 - 122{,}85x + 1989{,}1R^2 = 0.7804 \quad (1.2)$$

$$Y3 = 0{,}2119x^2 - 3{,}9848x + 66{,}851R^2 = 0.7804 \quad (1.3)$$

$$Y4 = 1{,}4758x^2 - 38{,}448x + 644{,}16R^2 = 0.7804 \quad (1.4)$$

$$Y5 = 3{,}9219x^2 - 131{,}19x + 3494{,}4R^2 = 0.7804 \quad (1.5)$$

$$Y6 = 0{,}979x^2 - 26{,}949x + 348{,}35R^2 = 0.7804 \quad (1.6)$$

$$Y7 = 0{,}6484x^2 - 28{,}9x^2 + 255{,}64x + 2195{,}2R^2 = 0.7804 \quad (1.7)$$

where: Y1 the number of students in primary and secondary education institutions (thousand people); Y2 – the number of full-time students in institutions of secondary vocational education (thousand people); Y3 – the number of students in institutions of secondary vocational education in full-time and part-time education (thousand people); Y4 – the number of students in institutions of secondary vocational education in extra-mural form of education (thousand people); Y5 – the number of full-time students in institutions of higher education (thousand people); Y6 – the number of students in institutions of higher education in part-time and extra-mural forms of education (thousand people); Y7 – the number of students in institutions of higher education in extra-mural form of education (thousand people); X is a time indicator of the dynamics of the number of students (in September 2004 x=0), years.

The resulting trends are polynomial in nature, indicating the formation of the direction of the forms of students and the dynamism of the change in the contingent of schoolchildren and students. Based on the shown equations, which have a high level of non-linearity, a conclusion was made about the continuous development of forms of educational activity. This is due to the development of education in dynamic periods and the transfer of established trends in all periods. In the calculations, the value of the variable x was used since 2004 in connection with the formation of a system for accounting for educational activities according to world standards.

The results of the study show that the current trends are transitive and, in combination with negative linearity, determine the hidden problems of Russia’s sustainable socio-economic development. The predictive indicators that appear in the future are currently latent due to the high acceleration created by the non-linear coefficient but require further research. The determination coefficients determined during the study indicate the stochastic nature of the development of trends with an error level from 1.98% to 21.96%, which indicates significant differences in the scientific predictability of the phenomenon. The most predictable level of education is full-time students in higher education institutions and the least reliable trend is in secondary education institutions (with an error rate of less than 22%). The low reliability of trends is due to the presence of significant fluctuations in the number of students and the combination of “extra-mural form of education” with “external studies”. The transitional state is determined by the changes inherent in the change of the economic system – from a planned economy to a market one. Given the dynamics, it is important to constantly monitor and evaluate the performance of

students, including using the methods of mathematical analysis of the cycle of homogeneous human capital production within the framework of educational activities (table 2).

Table 2 / Таблица 2

Mathematical Analysis of Trends in the Dynamics of the Number of Students by Forms of Education in the Russian Federation / Математический анализ трендов динамики численности обучающихся по формам обучения в Российской Федерации

Indicator / Показатель	The first derivative of the equation with Yi = 0 / Первая производная уравнения со значением Yi = 0	X	The second derivative of the equation / Вторая производная уравнения	Y" when x / Y" при x	Y when x, thou-sand people / Y при x, тыс. чел.	Indicator development status (key points) / Состояние развития показателя (ключевые точки)
Primary and secondary education						
	38.148x-70.608=0	1.851	38.148	38.148	12958.656	crisis July 2006
Secondary vocational education						
Full-time	17.5682x-122.85=0	6.993	17.5682	17.5682	1559.57	crisis August 2011
Part-time	0.4238x-3.9848=0	9.403	0.4238	0.4238	48.117	crisis January 2014
Extra-mural and external studies until 2012	2.9516x-38.448=0	13.026	2.9516	2.9516	393.745	crisis September 2017
Higher education						
Full-time	7.8438x-131.19=0	16.725	7.8438	7.8438	2397.302	crisis May 2021
Part-time	1.958x-26.949=0	13.764	1.958	1.958	162.893	crisis June 2018
Extra-mural and external studies until 2013	$1.9452x^2$-57.8x+255.64=0	5.407 24.308	3.8904x-57.8	-36.766 36.766	645.927 2835.033	peak January 2010 crisis December 2028

Source: compiled by the author / *Источник:* рассчитано автором

The results of the analysis of the obtained digital data on the development of the educational services market show that the current growth trends in the education market with high dynamics will continue in the near future, with the exception of the extra-mural form of higher education, which shows a non-linear declining trend until December 2028. Since the pilot projects of the education system is implemented until 2024, the determination of real opportunities for implementing the results of the study is possible only by 2029, when the first specialists will be received and the first graduation of students of extra-mural courses will be formed. The dynamics of the ongoing crisis in the education system has a wave character and the sequence of its transition from the lower levels of education to the higher ones, which determines the importance of the integrated development and reform of educational activities. According to the analysis, the change in the trend in basic education, which is the foundation and resource for the development of all other levels, began in July 2006, when the average monthly number of students was minimal for the entire period of the existence of modern Russia (12958656 people) [6]. After the change in trend, secondary education reacted with a significant time lag: first, full-time education (5 years 1 month), then part-time (7 years 5 months) and extra-mural (11 years 2 months), which indicates that the main positive changes are concentrated in the basic part of education. At the same time, their extremely slow transition to the senior classes of education was determined. In higher education, this trend shifts for an even longer period of time, creating a significant gap between the dynamics of the consumption of educational services: full-time (15 years 10 months), part-time (11 years 11 months). A special situation has arisen with extra-mural form of education, where demand grew until January 2010, which most likely indicates a re-profiling of the existing workforce. From January 2020 to December 2028, with an error level of 11.48%, there is a decrease in the predicted value of the number of students due to the formation of a stable structure of productive forces and the stabilization of the socio-economic situation in Russia. Measures of targeted social assistance and support for socially vulnerable students have a significant impact on the development of the education system. According to forecast data, full stabilization and growth in the number of students in the Russian education system is expected from 2029. It is expected that this will lead to significant and positive changes in the structure of the education system, both direct (transition from the Leibniz concept of education to Kant's educational paradigm) and indirect (the formation of innovative means of forming, storing and transferring information).

Conclusion

On the basis of this study, some conclusions can be drawn about the state of the educational services market and the measures necessary to maintain or adjust the existing structures of the Russian education system. The dynamics of the development of educational services, forming a non-linear, constantly accelerating nature, has a hidden depressive direction of development, which should be taken into account when monitoring the transition to new or improved forms of education:

1) adjustment of the values of potential consumers of services;
2) prevention of exceeding this value by creating a targeted subsidy equal to the coefficient x of the linear part of the function and creating an artificial overheating of the education market through interest-free targeted educational loans.

The dynamic development of the educational services market in a general direction is consistent in nature, which makes it possible to predict negative trends in advance and take measures to prevent them. The practical application of the results of the study is to create an educational fund (following the example of the developed countries of the world) to finance innovative areas of education development by bringing the coefficient of the cost of each form of education (thousand rubles) to the trend coefficient of the second-order time indicator. The goal of creating an affordable cost is to ensure the availability of paid education in higher education. According to a study by R. Saner [7] and taking the current situation in Russia into account, reforming the domestic education system will require the investment of significant financial and human resources in the next 10-20 years. To solve the problems that have accumulated in the Russian education system, it is necessary to create

institutions to support students. The Education Support Fund is a social regulator in the education system, which contributes to ensuring the availability of educational services for lowincome categories of the population. The formation of a support fund, along with other factors, can ensure favourable changes in the number of students and form an educational sphere accessible to a much larger number of citizens. In this case, it will be possible to model and adjust the number of consumers of educational services.

The need to form a sustainable structure of the national economy requires not only the creation of conditions for the stable development of an industry product, but also the determination of strategic key indicators that determine its behavior. This is due to the fact that without this model, the consequences associated with a normative and unpredictable change in the number of consumers are likely, which determines the complexity of calculating the load on educational resources used in the educational services sector. Issues related to the improvement of the education system are covered in the work of V.V. Basheva and co-authors: “Currently, schools still have a second shift and in some regions of Russia there is a third shift, which does not contribute to ensuring the availability of quality general education. The obsolescence of buildings and premises of educational organizations is one of the obstacles to fulfill the requirements of equal access to quality education” [8, 9]. In conclusion, summarizing the above-mentioned aspects of the study, it can be noted that the solution to the problem of improving the quality of education is associated with the formation of the conditions necessary for a sustainable environment in education, including the formation of financial accessibility of the learning process.

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