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PROSPECTS OF LEAN TECHNOLOGIES IN EDUCATION: MOVING TOWARDS STABILITY IN TERMS OF SOCIAL AND ECONOMIC CHANGE

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Abstract. This research focuses on summarizing statistical data on the total number of students enrolled in Bachelor, Specialist, and Master programs from 2005 to 2021. As a result, a general decrease in the number of students is determined. This trend can be associated with such factors as changes in demography, society, economy, and educational policies. The authors suggest introducing lean technologies into the learning process as a means to increase the number of people involved in education. The evident recent stabilization indicates possible changes in education, highlighting the importance of further research. The integration of lean practices in higher education not only responds to current challenges but also creates conditions for sustainable development of the educational system in the long run.

Keywords: student population, economic factors, dynamics of decline, lean technologies, demography

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ПЕРСПЕКТИВЫ ВНЕДРЕНИЯ БЕРЕЖЛИВЫХ ТЕХНОЛОГИЙ В ПРОЦЕСС ОБУЧЕНИЯ: ПУТЬ СТАБИЛИЗАЦИИ В УСЛОВИЯХ СОЦИАЛЬНО-ЭКОНОМИЧЕСКИХ ИЗМЕНЕНИЙ

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Аннотация. Настоящее исследование представляет собой анализ обобщеных статистических данных, отражающих совокупную численность студентов, обучающихся по программам бакалавриата, специалитета, магистратуры с 2005 по 2021 год. Определён общий тренд снижения численности студентов, который может быть связан с такими факторами как изменения в демографии, социально-экономической и образовательной политике. Предложены варианты внедрения в процесс обучения бережливых технологий с целью повышения количества привлекаемых к образованию людей. Эффект стабилизации, проявляющейся в последние годы данного временного ряда, свидетельствует о возможных переменах в образовательной сфере, подчеркивая важность дальнейших исследований в рассматриваемой области. Интеграция бережливых практик в высшее образование не только отвечает на текущие вызовы, но и создает условия для устойчивого развития образовательной системы в долгосрочной перспективе.

Ключевые слова: численность студентов, экономические факторы, динамика снижения, бережливые технологии, демография

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Introduction

In recent decades, education systems have had to face rapid economic, scientific, and technological changes, which required the adaptation of learning processes to new conditions (Fedotova, 2020; Gergalo, 2016; Krasnova, 2015). Lean technologies, which have proven their effectiveness in industry and other sectors, have become especially important in the context of limited funding, high-quality requirements, and the growing need for individualized approach in learning. Lean technologies are able to reduce costs, minimize wastage, and ensure more efficient resource use. According to research, implementing these methods can reduce the costs of administrative and training processes, allowing funds to be reallocated to innovative training programs and increasing student satisfaction overall.

Lean production methods in the form of Lean and Six Sigma systems are widely used in companies and daily prove their effectiveness in boosting productivity and quality. At the same time, the application of these methods in education is relatively new and, therefore, has great potential for optimization.

Materials and Methods

This research invites the methods of collection and analysis of information, comparison and description. The information base of the study is represented by a wide range of publications on innovative technologies in the energy supply, food industry and agriculture. The tabular method was used to present the results of the study.

Results and Discussion

Analyzing the indicator of change in the number of students in Russia in the period from 2005 to 2021, it is possible to identify some statistical regularities (Krasnova, 2015).

Table 1. Indicator of change in the number of students in Russia (2005-2021) (based on the Rosstat data)

Year	The number of students enrolled in Bachelor, Specialist and Master degree programs (total, mln.)	t
2005	7.065	1
2006	7.301	2
2007	7.461	3
2008	7.513	4
2009	7.419	5
2010	7.065	6
2011	6.49	7
2012	6.075	8
2013	5.647	9
2014	5.209	10
2015	4.767	11
2016	4.4	12
2017	4.246	13
2018	4.162	14
2019	4.068	15
2020	4.049	16
2021	4.044	17
Average	5.70	

As we can see from the table the beginning of the period (2008-2021) is marked by a decreasing trend in the total number of students; absolute and relative growth became negative. Primarily, it may have resulted from the demographic changes. According to Rosstat, the birth rate in the country decreased from 1.61 million children in 2008 to 1.46 million in 2021, which could lead to a decrease in the number of potential students and, thus affect the total number of university students.

The economic factors could have turned out to be another fundamental prerequisite. According to the report of the Ministry of Labor and Social Protection of the Russian Federation, the unemployment rate in the country fluctuated between 5.5% in 2008 and 5.8% in 2021. Logically enough, it contributed to the rising unemployment and instability of the labor market, which could have influenced the family's decision whether now is the right time for higher education.

And yet another factor is changes in the education system. Introduction of new standards and requirements, as well as optimization of educational programs could have created additional barriers for applicants (Bogdanova, 2018; Alekseeva, 2022).

Growth rates are mostly negative from 2009 to 2015. Figure 1 graphically represents this trend.

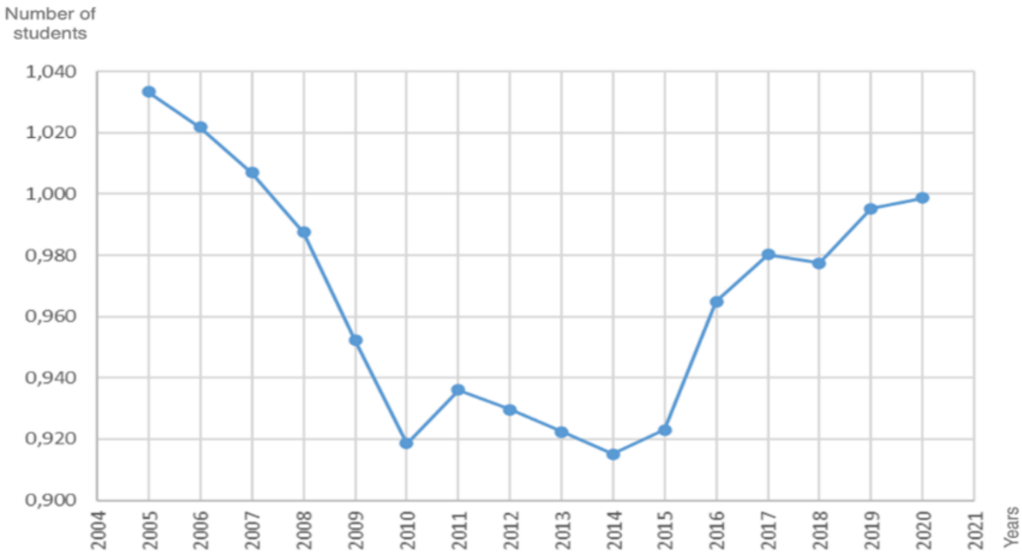

Fig. 1. Chain growth rates (designed by the authors).

Starting from 2009, we can observe a negative impact of external factors, which is reflected in negative values of Kc (chain growth rates) and Kb (base growth rates) (Table 2).

Table 2. Indicators of changes: 2005-2010 (based on the Rosstat data)

Year	Yt, Number of students enrolled in Bachelor, Specialist and Master programs (total, mln.)	APRc	APRb	TRc	TRb	Kc	Kb	TPRc	TPRb	A1
2005	7.065	-	-	-	-	-	-	-	-	-
2006	7.301	0.24	0.24	103.34	103.34	1.033	1.033	3.34	3.34	0.07
2007	7.461	0.16	0.40	102.19	105.61	1.022	1.056	2.19	5.61	0.07
2008	7.513	0.05	0.45	100.70	106.34	1.007	1.063	0.70	6.34	0.07
2009	7.419	-0.09	0.35	98.75	105.01	0.987	1.050	-1.25	5.01	0.08
2010	7.065	-0.35	0.00	95.23	100.00	0.952	1.000	-4.77	0.00	0.07
2011	6.49	-0.58	-0.58	91.86	91.86	0.919	0.919	-8.14	-8.14	0.07
2012	6.075	-0.42	-0.99	93.61	85.99	0.936	0.860	-6.39	-14.01	0.06
2013	5.647	-0.43	-1.42	92.95	79.93	0.930	0.799	-7.05	-20.07	0.06
2014	5.209	-0.44	-1.86	92.24	73.73	0.922	0.737	-7.76	-26.27	0.06
2015	4.767	-0.44	-2.30	91.51	67.47	0.915	0.675	-8.49	-32.53	0.05
2016	4.4	-0.37	-2.67	92.30	62.28	0.923	0.623	-7.70	-37.72	0.05
2017	4.246	-0.15	-2.82	96.50	60.10	0.965	0.601	-3.50	-39.90	0.04
2018	4.162	-0.08	-2.90	98.02	58.91	0.980	0.589	-1.98	-41.09	0.04
2019	4.068	-0.09	-3.00	97.74	57.58	0.977	0.576	-2.26	-42.42	0.04
2020	4.049	-0.02	-3.02	99.53	57.31	0.995	0.573	-0.47	-42.69	0.04
2021	4.044	-0.01	-3.02	99.88	57.24	0.999	0.572	-0.12	-42.76	0.04
Average	5.705	-3.02				0.572				
		-019				0.966		-0.034		

The first observation from the table is a steady decline in the number of students from 2008 to 2021, which is reflected in the negative values of APRc and APRb. A particularly sharp decrease is witnessed in 2011 and is confirmed by the negative values of APRc (absolute chain growth), APRb (absolute base growth), TRc (chain growth rate), and TRb (base growth rate), indicating the presence of a negative trend.

Subsequently, from 2010 to 2015, the oppsite trend becomes apparent, Kc and Kb become positive, indicating a change in the direction of the influence of external factors on student enrollment. This coefficient reflects the change in the number of students compared to the previous year in percentage terms. Positive values of Kc indicate an increase in the number of students, while negative values indicate a decrease. It is important to note that Kc decreases over time, which may be interpreted as a slowdown in the rate of change in the number of students (Figure 1).

Thus, positive values of Kc at the beginning of the period represent an active growth of the population, while closer to the end of the period, when Kc becomes closer to zero or negative, we can assume the onset of saturation or even a decrease in the population.

In the following years, from 2015 to 2021, Kc and Kb remain positive, emphasizing the stable positive impact of external factors on the level of student population at the university (Kuprina, 2016; Kupriyanova, 2012; Savelyeva, 2005; Bukharina, 2023).

Kb compares the current year with the base year (2005). Positive values of Kb before 2010 indicate an increase in student population compared to 2005. Negative values after 2010 indicate a decrease in the number of students in relation to the base year. It is important to note that closer to 2021, Kb values get closer to zero, which may represent the achievement of a new level stabilization within the education system itself (Chuks, 2022; Moe, 2021).

Joint analysis of Kc and Kb allows interpreting the dynamics of changes in the number of students much better. For example, if Kc is positive but Kb is negative, a temporary increase may take place, however, not leading to a sustainable increase in enrollment. A decrease in both coefficients may shape the grounds for concerns. (Figure 2).

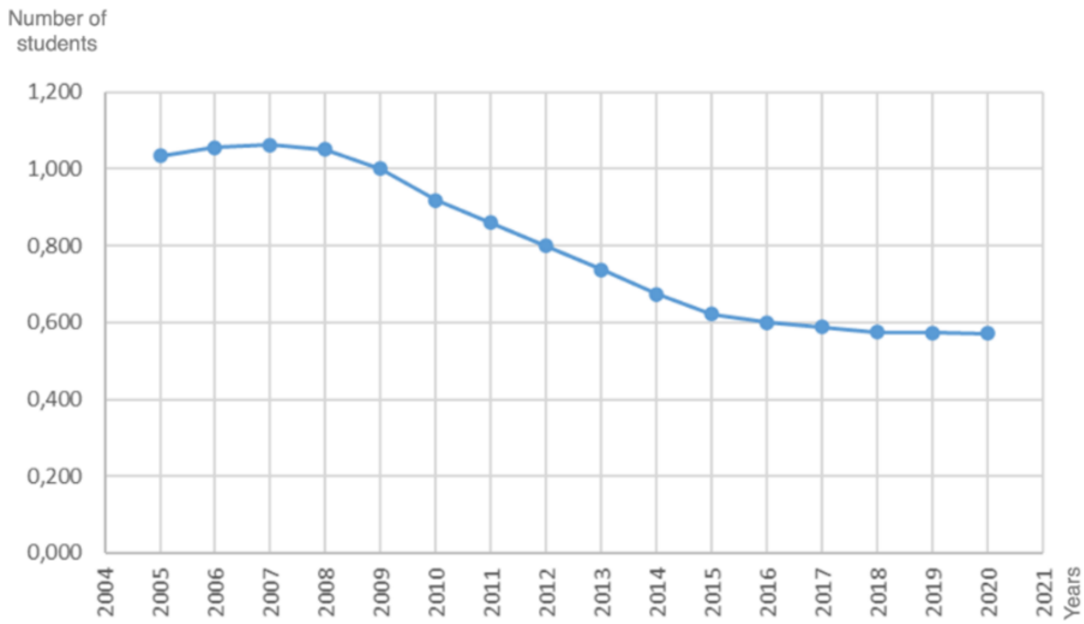

Fig. 2. Growth coefficients (designed by the authors).

The growth of Kc and Kb in the first half of the timeline may be explained by the economic development, since this period saw an increase in economic activity and improvement of the socio-economic situation in the country. GDP growth, higher incomes, and lower unemployment rates created favourable conditions for higher education; demographic changes (a temporary increase in the birth rate led to an increase in the number of young people in the following years, and subsequent number of students enrolled in universities. Another significant matter of the given time was the expansion of educational opportunities, including state support programs, infrastructure improvement, expansion of the university network, and optimization of study programs. A decrease in these coefficients in the second half of the period may indicate saturation or changes in the education policy.

Summarizing the trends mentioned above it is possible to derive the following:

– 2005-2010 – relative stability in the number of students, with a slight decrease in 2010;

– 2011-2014 –visible and rapid decline in student enrollment, reaching almost a 19% annual decline;

– 2015-2017 – continued decline in student numbers, however with a lighter decrease of a 7% annual;

– 2018-2021 – relative stabilization of the student population.

In 2000, about 1.567 million newborns were registered in Russia, but by 2010 this figure had fallen to 1.218 million, indicating a decline in the birth rate of about 22% (Brykin, 2020). The decline in the number of students in the early 2010s could be related to the demographic decline (Rupietta, 2021).

Economic challenges, especially during the 2011-2014 crisis, could have affected the accessibility of education as well as students' intension to continue their studies. During the crisis, Russia faced with an increase in inflation, a reduction of currency reserves, and a slowdown of economic growth, which led to the deterioration of the financial situation of the population. Students and their families had to deal with rising prices for goods and services, as well as growing unemployment and declining incomes (in 2010, 25.000 rubles; 2014 it fell to about 23.000 rubles, on average) (Dillinger, 2022).

Stabilization in the late 2010s may indicate the adoption of measures to adapt to demographic and economic changes, possibly with improved education conditions and financial support (Yu, 2022; Gruchmann, 2020).

In order to achieve high accuracy and minimize the impact of random fluctuations on the results, the authors employed the polynomial moving averages. This approach allows mitigating irregular oscillations and highlight the underlying trend. What is more, the application of polynomial moving averages as a filtering method helps eliminating short-term spikes that may distort data interpretation. Instead, it becomes possible to focus on long-term trends, which is particularly important for economic or managerial analysis.

As can be seen from the Table, the moving average method helped smoothing out short-term fluctuations and reveal the overall trend. The number of students has been decreasing over time, which may indicate long-term changes in the education system. The use of 5- and 7-term moving averages helped reducing the impact of random fluctuations and emphasizing more stable trends. Moving averages with 5- and 7-term components, by displaying averaged values, contribute to a better visualization of the overall stability of the trend in student population dynamics. These findings should be considered within the context of general trends in the higher education system, accounting for potential factors influencing student enrollment in Russia. The analysis of moving averages enhances the perception of student population dynamics by providing average values and highlighting more stable trends in the data.

Table 3. Implementation of the moving average method (designed by the authors)

Year	Number of students enrolled in bachelor's, specialist, and master's programs, total, million people	MA5	MA7
2005	7.065	-	-
2006	7.301	-	-
2007	7.461	7.352	-
2008	7.513	7.352	7.188
2009	7.419	7.190	7.046
2010	7.065	6.912	6.810
2011	6.49	6.539	6.488
2012	6.075	6.097	6.096
2013	5.647	5.638	5.665
2014	5.209	5.220	5.262
2015	4.767	4.854	4.929
2016	4.4	4.557	4.643
2017	4.246	4.329	4.414
2018	4.162	4.185	4.248
2019	4.068	4.114	-
2020	4.049	-	-
2021	4.044	-	-

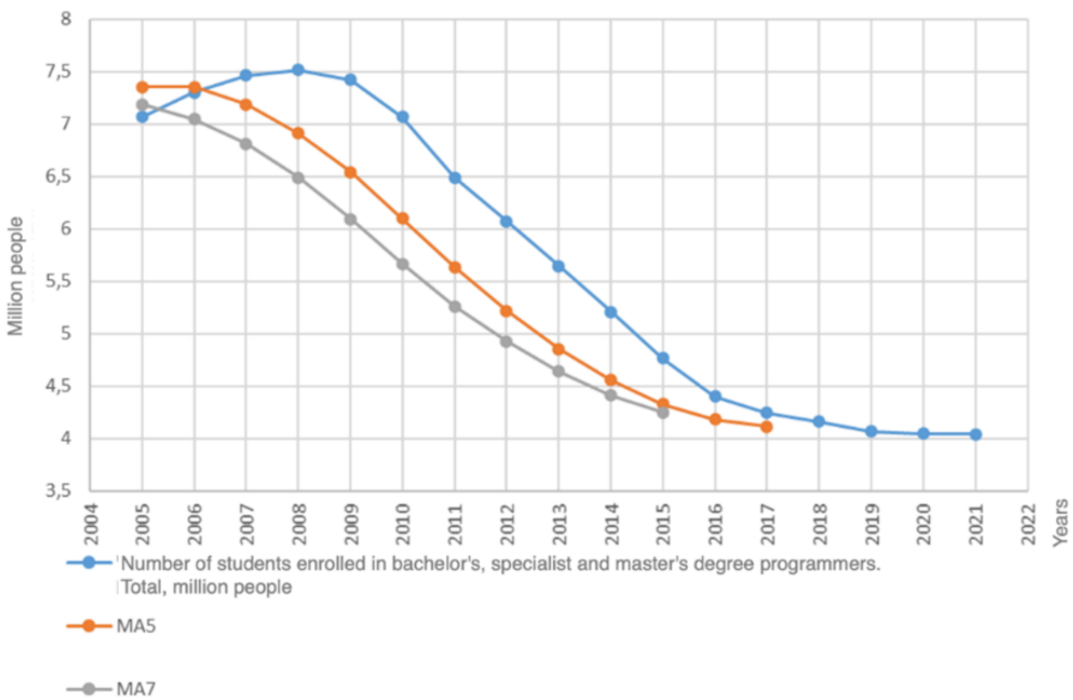

Fig. 2. Graphical representation of the original data overlaid with data obtained using the moving average method (designed by the authors).

A graphical display of the original data overlaid with the data obtained using the moving average method (Figure 3) provides a clearer representation of the difference in accuracy. In the moving average graph, periods can be identified in the point where the moving averages shift direction. These points may indicate potential changes in the dynamics of student population trends.

Conclusion

Currently, the government of the Russian Federation is taking measures to increase the number of available state-funded positions. According to the Ministry of Science and Higher Education of the Russian Federation, in 2021, the number of state-funded students in Russian universities increased by 5.4% compared to the previous year (Przybył ek, 2021). In addition, the government allocates significant funds to the development of educational infrastructure, including the construction of new and modernization of existing educational premises. In 2021 alone, more than 1000 new higher education facilities were built (Ansheles, 2020; Alami, 2022).

The introduction of lean technologies into education will significantly improve the scale of attracting and retaining new students. Analysis of trends over the last few years shows the number of learners remains stable at the level of 85-90%. Lean technologies shape a more flexible and learner-centred environment, making the learning process more engaging and adaptable to changing conditions.

An example of successful application of lean technologies in the education sector is the introduction of lean methods in STEM education in the United States. A study conducted by the Lean Enterprise Institute in 2022 showed that educational institutions that implemented lean principles were able to reduce the time spent on administrative processes by an average of 20-30%, increasing the focus on learning. By streamlining the processes of preparing and revising assignments, as well as reducing non-core teacher load, the average performance of STEM classes increased from 85% to 95%, while teachers' time spent on organizational activities was reduced by 15% (Wahl, 2022).

A key aspect of the application of lean technology is the reduction of non-core operations and the optimization of teaching resources. For example, schools and colleges that have implemented Just-In-Time have been able to reduce the costs of purchasing and refurbishing teaching equipment by 10 percent. This accomplishement enabled them to plan the needs and requirements more accurately, thus ensuring that students have access to up-to-date equipment and materials without overstocking. Another example of success is represented by the approach to continuous improvement through regular surveys among students and lecturers on the quality of the educational process.

To implement these improvements, it is important to develop and implement the concept of continuous improvement with the support of staff and management, which means engaging all employees in the process of optimization and reallocation of resources. Studies in other industries have shown that similar approaches (e.g., Kaizen) can improve performance by an average of 10-15% and can be adapted to the education sector.

In addition, methods of process visualization and standardization, such as value stream mapping or VSM, can be used to identify and eliminate bottlenecks in an organization.

Analyzing the student population in the context of the above mentioned factors emphasizes the importance of systematic research, considering the long- and short-term impact of different factors on student dynamics. Subsequent research could aim to better interpret the dynamics and reasons of fluctuations in the student numbers, as well as to identify tools to improve the overall performance of universities.

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