

Theoretical and Methodological Approaches to Analysis and Forecasting of the Labour Market within the Framework of Sustainable Development

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Abstract. The escalating risk of precarious employment underscores the necessity to examine the impact of digitalization of the labour market on sustainable economic development. The precarization of employment may result in diminished performance metrics for the achievement of decent work goals. The study is aimed at the development of a theoretical approach in order to supplement sustainable development indicators with the characteristics of vacancies in the labour market in the context of its digitalization. Official statistical data, as well as online information sources for the period 2013-2023, summarized with the help of Big Data and AI technologies serve as the empirical basis of the study. A forecasting model for demand metrics of the labour market was chosen on the basis of evidence from the labour market in Minsk. The XGBoost model demonstrated superior results compared to other time series models. The results of October 2023 - October 2024 forecasting of the number of vacancies in Minsk are given in the article. The results are received after the predictive model of gradient boosting was adjusted. The predictive model of gradient boosting was trained using actual data. Further research to improve the quality of forecasts will focus on the following: optimization of the model of gradient boosting using deep learning; identification of additional features and factors that influence appearance of new vacancies in the regions of Belarus.

1 Introduction

Today, issues of sustainable development have become a priority task. However, within the ternary of sustainable development components (economic, social, and environmental aspects), priority is mainly given to the environmentalization of social and economic development. At another point, the labour market is that part of the social and economic system where all aspects of sustainable development are interwoven. However, there is little theoretical and methodological research dedicated to the analysis and forecasting of the labour market from a sustainable development perspective. Nevertheless, an analysis of current labour market trends reveals that the aggravation of employment and

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unemployment problems results in violations of sustainable development in their various manifestations: increasing number of working poor; a deterioration in the status of employees under non-standard employment conditions; and precarization. Digitization of the economy and the labour market intensifies these processes.

The study is aimed at the development of a theoretical approach in order to supplement sustainable development indicators with the characteristics of vacancies in the labour market in the context of its digitalization.

2 Materials and methods

Data on the development of the labour market in Belarus, generated by a combination of data received from the survey of households on employment issues and the author's database of vacancies and resumes which are posted on online vacancy portals in Belarus, serve as the empirical basis of the study. The use of such an advanced database will facilitate a comprehensive characterization of the labour market, and supplement it with a number of indicators which national statistics does not consider (e.g., the structure of vacancies in terms of occupations and skills, their seasonality, employment conditions, etc.). However, these indicators exist in the labour market in the age of digitalization and affect the country's sustainable growth.

Processing and systematizing of information and analytical material were carried out with help of ARIMA and SARIMA predictive models, exponential smoothing, XGBoost models, Random Forest algorithm and linear regression, applying methods of economic-and-statistical analysis, machine learning, and scraping.

3 Results and Discussion

3.1 Sustainable development and the labour market: theoretical aspects of coordinating directions for analysis and forecasting

The ILO principles of Decent work serve as the methodological foundation for the alliance between the labour market and sustainable development [1]. The outcome document of the United Nations Conference on Sustainable Development (Rio de Janeiro, 2012) outlines the pivotal role of decent work in achieving sustainable development goals [1]. However, the conception of sustainable development has subsequently shifted towards environmentalization exclusively. The terms "green economy" and "green jobs" have been introduced in economic literature, however there is insufficient methodology to operationalize them and determine their quantity. On the one hand, the green economy is associated with the economy that employs "environmentally friendly technologies" [1], which is rather a simplified approach, as it limits the number of green jobs to environmentally friendly industries alone. On the other hand, the green economy is defined as "the economy that results in the increase of wellbeing and ensures equity, while reducing risks to the environment and preventing its depletion" [2, p. 16]. Such a definition is fairly extensive for the green economy can be considered as the development goal of any economy; and it does not help to clearly identify parameters and the number of green jobs.

Thus, the multitude of approaches to the definition of the green economy prevents from determining criteria to identify and count green jobs. Sustainable growth appears to be a broader term than environmentalization and green economy development; its relation to the labour market goes beyond identifying green jobs. From the perspective of the labour market, sustainable growth implies increasing performance, wages, ensuring social security to employees, aligning the education system with needs of the labour market (i.e. ensuring

that quantity and quality of professional training meets the labour market needs; the quality and quantity is measured in the number of employees and their skills). Digitalization of the economy greatly affects the sustainability of social and economic development. However, in terms of sustainable development, this area remains understudied. The impact of digitalisation of the economy on demand in the labour market is analysed in a number of studies [3-6]; it is manifested in the following: emergence of new professions; partial or complete disappearance of existing professions; changes in tasks; alterations in working conditions; rapid development of new digital and hybrid skills, necessitating continuous training, retraining and advanced learning.

Expansion in the age range of the economically active population, due to the possibility of employment of persons older and younger than working age, displays the impact of digitalisation of the economy on supply in the labour market. It is further evidenced by increased mobility of labour resources, changes in the personnel training system, combination of work activities with training (including online training). Increasing labour mobility and virtualization of traditional labour relations pose risks to the principles of decent work and lead to employment precarization. Digital transformation of the economy and surge in demand for new skills create a gap between the demand for skills and their supply in the labour market, which leads to the risk of structural unemployment.

The consequences of this transformation include growing shortage of workers, engineers, and domain IT experts; uneven sectoral and regional allocation of labour force; high labour turnover; and partial loss of working population in the labour market. In the context of digitalisation, the labour market is shifting towards limitations in the supply rather than the demand for labour. It results in persistent shortage of skills and qualifications as the education system is lagging behind in responding to the demand of the labour market. Consolidated efforts of employers, government and education institutions to anticipate and meet the need for skills for the digital economy among the economically active population are required to ensure sustainable development.

Thus, the following processes endanger sustainable development of the social and economic systems: growing skill mismatch due to rapidly updating requirements to jobs and competencies; increasing labour mobility and expansion of non-standard forms of employment, which are inadequately integrated into the current model of social policy. Such articulation of the issue is especially relevant for the Republic of Belarus, since the digitalisation of the economy requires directions of the labour market development to be specified. These directions will help to create and maintain effective employment in the economy, enter and compete in the global labour market successfully while securing social stability in the country.

The aforementioned conditions lead to the following conclusions:

- In the terms of sustainable development, the labour market involves not only creation of green jobs but also ensuring growth in workers' performance, wages and social security.
- The role of the labour market has its national features in every country, which depends on the level of national development and the structure of economy.
- Digitalization introduces adjustments to the sustainable development, adding risks of precarization. It underscores the need to study the impact of digitalization of the labour market on sustainable economic development.
- The rapid emergence of new skills and their growing discrepancy pose a global challenge for achieving the goals of the decent work and sustainable development.
- In order to understand the real-time processes on the labour market during the digitalisation, it is necessary to supplement the labour market analysis and forecast made on the basis of the official statistics with the analysis of data collected from online sources [8].

3.2 Analysis and forecasting of the labour market within the framework of sustainable development

The National platform of Belarus features reports produced according to the Sustainable Development Goals. The labour market dynamics is reflected in the 8th Sustainable Development Goal (SDG 8) – "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" [9]. The dynamics of decent work indicators (Table 1) reveals that in Belarus, on the one hand, the employment is growing while the unemployment is falling. On the other hand, the labour market retains certain negative trends such as growth of informal employment, a high level of youth unemployment, and a low rate of workers' performance. Consequently, a quarter of the employed in the country's economy can be classified as the working poor, which collectively impedes the sustainable development.

Table 1. Dynamics of major indicators of decent work in Belarus, 2016-2022. [9]

Indicator	2016	2017	2018	2019	2020	2021	2022
Employment (15 - 74 years old), %	66.7	67.2	67.5	67.7	67.5	67.3	67.7
Unemployment (15-74 years old), %	5.8	5.6	4.8	4.2	4.0	3.9	3.6
The proportion of young people at the age of 15–24 who neither study nor work to the total population of this age group, %	8.2	7.3	6.3	6.9	6.8	5.5	5.1
Informal employment (15 - 74 years old), %	7.4	8.3	8.2	8.0	8.6	8.8	8.3
Youth unemployment (15-24 years old), %	10.7	9.3	10.7	10.2	12.0	10.5	10.3
The proportion of employees with low wages (lower than 2/3 of the median wage) to the total number of employees, %	23.9	23.8	23.7	23.8	23.3	23.2	22.5
The proportion of the employed (15-74 years old), working extra hours (over 48 hours a week) to the total number of the employed, %	2.3	2.7	3.0	2.0	1.8	1.8	1.5
Workforce productivity in GDP per an employed person, thousand BYN	21.5	24.3	28.2	31.1	34.7	41.3	45.4
Growth rate of workforce productivity, %	99.5	103.7	103.5	101.5	99.6	103.2	96.8

Following the in-depth analysis of the labour market, it can be concluded that despite the positive trends of certain indicators, the employment efficiency in Belarus is decreasing. This situation arises partly due to insufficient focus on current trends in the labour market

and national features during the analysis. Thus, a high level of employment, for example, is attributed to the population’s involvement in economic activity, regardless the economy’s actual capacity to create effective jobs. The growth of informal employment necessitates an analysis of its structure. However, the data on the progress assessment in the field of decent work lack information on vacancies. The analysis of the number of vacancies in the country relies on data provided by the National Bank of Vacancies, which is arranged on the portal of the Ministry of Labour and Social Protection by administrative order and, hence, contains the inflated number of vacancies. A number of jobs offering low wages, which are economically unnecessary, remain vacant for extended periods. Such incomplete statistics on vacancies hinder the assessment of the real demand for labour in the economy. In many countries of the world, the analysis and forecast of the current trends on the labour market utilize data collected from online sources, which supplement conventional databases (official and administrative statistics) in terms of detailed assessment of vacancies and resumes [8, 10, 11]. A number of experts acknowledge the need to develop harmonized approaches and terminology at the national and international levels [1]. In the Republic of Belarus, just a few research projects have started the work in this direction [8].

The recent decade’s analysis of vacancies within regions of Belarus helps to study the trend dynamics and seasonality in the emergence of new jobs. Also, it assists in selecting models for compiling forecast values of the demand on the labour market, which will eventually help provide reasonable recommendations to applicants, employers, labour market researchers, and the educational system.

The research database generated with the use of scraping [12] included 15 million vacancies posted on online job search platforms in Belarus from 2013 to 2023. Figure 1 shows the data on the number of vacant jobs in Minsk and regions of Belarus for the period from 01.01.2013 to 30.06.2022. A description of the vacancies is given in Table 2.

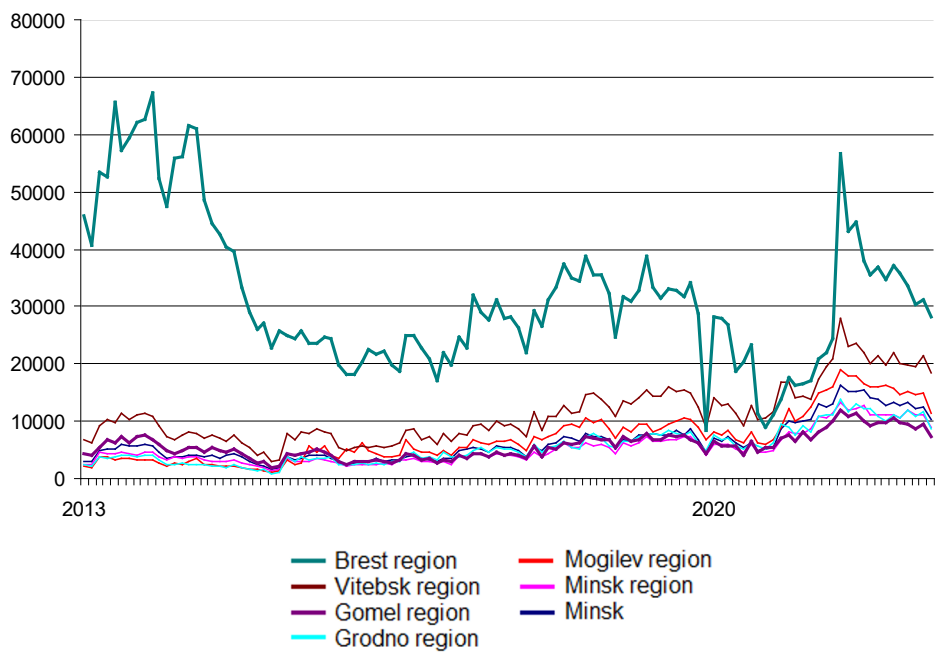


Fig. 1 The number of vacant jobs in Minsk and regions of Belarus for the period from 01.01.2013 to 30.06.2022.

Table 2. The descriptive analysis of data on vacancies in Minsk and regions of Belarus for the period from 01.01.2013 to 30.06.2022.

Region	Value, thousand of vacancies				
	average number of vacant jobs	median number of vacant jobs	minimum number of vacant jobs	maximum number of vacant jobs	standard deviation
Brest Region	6,320	5,303	1,720	16,249	3,465
Vitebsk Region	5,293	4,403	1,299	13,365	2,900
Gomel Region	7,152	6,263	1,090	19,043	4,437

The analysis of data on vacancies in Minsk and regions of Belarus for the period from 01.01.2013 to 30.06.2022 reveals the following:

- Minsk offers the largest number of vacant jobs (3,629,897 vacancies recorded from 2013 to the first half of 2022).
- Among all other regions, Mogilev Region is characterized by the fewest number of vacant jobs (652,225 vacancies in the same period).
- The greatest variety of vacancies is found in Minsk and Minsk Region, which is indicated by high values of standard deviation (5,115 vacancies in Minsk Region and 13,025 vacancies in Minsk).
- Mogilev Region shows the greatest stability in the number of vacancies (the region has a minimum standard deviation of 2,202 vacancies).
- Minsk and Minsk Region have the maximum demand for labour, for their median values are 10,152 and 29,027 vacancies, respectively.

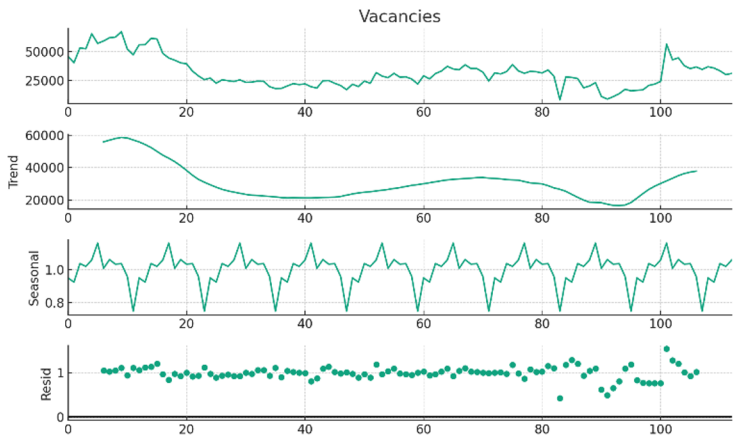


Fig. 2. Decomposition of the time series on the number of vacant jobs in Minsk and regions of Belarus for the period from 01.01.2013 to 30.06.2022.

Decomposition of the time series (Figure 2) reveals that the data features seasonality, and some trend can be discerned. The analysis of trends and seasonality is essential when adapting to rapidly changing economic and technological environment. It helps businesses optimize their processes of recruitment and human resource development; it facilitates more effective allocation of resources, strategic planning and development of government policies in the field of employment and education. Table 3 illustrates the analysis of trends and seasonality in the emergence of vacant jobs across regions of Belarus.

Table 3. The analysis of trends and seasonality in the emergence of vacant jobs across regions of Belarus.

Region	Indicator					
	Max gain		Max drop		Trend	Seasonality
	metrics, vacancies	month, year	metrics, vacancies	month, year		
Brest Region	+3,356	October 2020	-2,334	June 2022	growth till 2019, then slight decline and stabilization	seasonality with the maximum number of vacancies at the end of the year and with the minimum number in the mid year
Vitebsk Region	+2,115	March 2021	-2,290		gradual growth with slight fluctuations	peak of emergence of vacant jobs occurs at the end of a year
Gomel Region	+3,310	November 2020	-3,537		sharp growth till 2019, then slight decline	seasonal fluctuations are weak, with the peak at the end of the year
Grodno Region	+3,337	October 2020	-2,962		steady growth with slight fluctuations	strong seasonal fluctuations with peaks at the beginning and end of a year
Mogilev Region	+2,330	June 2020	-2,063		moderate growth with sporadic fluctuations	peak of emergence of vacant jobs occurs at the end of a year
Minsk Region	+7,134	June 2021	-4,852	July 2021	remarkable growth, especially after 2018	prominent seasonality with the maximum number of vacancies at the end of spring and beginning of summer
Minsk	+32,218	June 2021	-20,431	December 2019	significant growth, especially after 2017	remarkable seasonal fluctuations, with the high number of vacancies at the end of spring and end of a year

The analysis of trends and seasonality in the emergence of vacant jobs across regions of Belarus reveals the following:

- All the regions exhibit seasonal fluctuations in the emergence of vacant jobs.
- There is a growth of vacancies in all the regions; although, its intensiveness varies (the highest intensiveness is observed in Minsk, while the lowest one is in Vitebsk Region).

- The peaks in the emergence of vacant jobs occur at the end of the year; Minsk and Minsk Region also experience peaks at the end of spring and beginning of summer, making it optimal time for job search in Belarus.
- There was a drop in the number of vacancies in June, October and November 2020 (in Mogilev Region, Brest Region, Grodno Region, and Gomel Region respectively), as well as in March and June 2021 (Vitebsk and Minsk Regions, and Minsk respectively).
- There is moderate growth in the number of vacancies in all the regions except Minsk. Minsk stands out due to significant growth, which can be attributed to higher demand for workforce in the capital city.
- Minsk has the highest peaks (+32,218 vacancies) and drops (-20,431 vacancies), which indicates the greatest fluctuations of the labour market in the capital city and reflects its high buoyancy.
- In all the regions, there are seasonal fluctuations in emergence of vacant jobs.
- In most regions, peak of emergence of vacant jobs occurs at the end of a year. It may be caused by the beginning of new projects or an increase of workload in certain industries.

The research on the number of vacant jobs, trends and seasonality can be used in the following activities: in-depth analysis the labour market dynamics; planning business strategies for companies and employees' career paths; development of personnel policies and job search plans across regions of Belarus.

Forecast of the emergence of vacant jobs by regions contributes to more accurate planning of labour resources and economic development for each region. It helps organizations and government institutions adapt to future market needs, minimize unemployment and optimize investment strategies. This approach ensures a balance between labour supply and demand, contributing to the sustainable social and economic development across the regions. A forecasting model was selected based on the evidence from the labour market in Minsk, which is the largest and most dynamic market in Belarus (Table 4).

Table 4. Results of demand development forecasts for the Minsk labour market made with the use of ARIMA and SARIMA predictive models, exponential smoothing, XGBoost, Random forest, linear regression, and machine learning for the period of 01.07.2022г. – 01.06.2023 г.

Indicator	Predictive model					
Forecast period	ARIMA, thousand of vacancies	SARIM A, thousand of vacancies	simple exponential smoothing	XGBoost	Random Forest	linear regression
July, 2022	8,952	9,284	13,261	23,733	22,624	18,182
August, 2022	8,939	6,492	13,573	16,847		18,375
September, 2022	8,939	6,212	13,556	35,802		18,569
October, 2022		5,662	11,972	35,677		18,762
November, 2022		513	10,055	33,806		18,956
December, 2022		5633	12,239	34,522		19,149
January, 2023		5,449	11,520	35,579		19,343
February, 2023		6,292	13,085	34,604		19,536
March, 2023		4,799	12,975	35,173		19,730
April, 2023		5,945	13,718	38,069		19,924
May, 2023		10,441	13,891	34,598		20,117

June, 2023		1386	12,168	34,094		20,311
Forecast errors						
Mean absolute error (MAE)	24,076.49	27,315.19	20,887.03	7,011.44	27,818.6	72,485.7
Mean square error (MSE)	642,265,545.37	797,697,071.70	478,836,667.64	106,283,506.52	233,356,357,372.4	6,932,554,065.5
coefficient of determination (R2)	-7.57	-9.65	-5.39	0.23	-1,507.6	-43.8

The XGBoost model has demonstrated superior results compared to those produced by other time series models. The forecast error has significantly declined and amounted to 7,011.44; with the coefficient of determination achieving a positive value (0.23).

Updated data for the period from 01.07.2022 to 01.06.2023, collected from the website of the state employment service and online job search platforms, were used in conjunction with a retrained model of gradient boosting to adjust the predictive model. This adjustment enabled further prediction of the number of vacancies in Minsk for the period from October 2023 to October 2024. Forecast data for the Minsk labour market in the period form October 2023 to October 2024 are shown in Table 5.

Table 5. Forecast made by XGBoost model for the Minsk labour market in the period from October 2023 to October 2024.

Indicator	2023			2024									
	October	November	December	January	February	March	April	May	June	July	August	September	October
Forecast number of vacancies	23,716	24,446	24,796	55,810	26,392	27,490	32,237	28,578	24,031	31,549	27,343	29,490	24,161

Forecast values generated by XGBoost model for the Minsk labour market in the period from October 2023 to October 2024 exhibit a vivid trend and seasonality, mirroring the statistics from 2013 to 2023.

Further research aimed at improving forecast quality will focus on the following: optimization of the model of gradient boosting; exploration of potential applications of deep learning models; identification of additional features specific to certain regions of Belarus; and factors that influence the emergence of new vacancies.

3.3 Conceptual approach to the arrangement of monitoring and forecasting of the labour market in Belarus within the framework of sustainable development

According to experts, social dialogue currently plays a vital role in developing an integrated approach to the analysis and forecasting of the labour market [3]. This, in turn, requires coordination and cooperation of government authorities and non-government organizations in the process of providing informational support for sustainable development. The analysis of foreign experience reveals that social dialogue can be facilitated through Labour Market Information and Anticipation System [13] or via the network of the National and sectoral observatories of the labour market [3]. The following actions are necessary to arrange monitoring of the labour market in Belarus within the framework of sustainable development:

- Making agreements with portals and linking informational resources related to the labour market within the Labour Market Information System of the Ministry of Labour and

Social Protection of the Republic of Belarus. This will contribute CV data to the National Bank of Vacancies (according to a specified template) and lead to the creation and development of a Labour Market Information System that should be integrated with the National Bank of Vacancies and CVs.

- Development of a web-laboratory for the labour market and a network of sectoral observatories for the labour market that utilize SMART-statistics to classify and process data on vacancies and CVs with the help of AI.

- Arrangement of results exchanges; provision of products and services to the users who are interested in them; organization of seminars and training events.

The conceptual model for the labour market analysis and anticipation in terms of sustainable development is capable of combining several databases, such as Internet data, data obtained from labour force surveys, demographic statistics, etc. The model can also process and organize these data using unified classifiers, visualize the processing results and share them with all the decision-makers.

4 Conclusion

The increased risk of precarious employment underscores the need to study the impact of digitalization of the labour market on sustainable economic development. Precarization of employment may result in diminished performance metrics for the social aspect of sustainable development. In the terms of sustainable development, the labour market involves not only the creation of green jobs but also ensuring growth in workers' performance, wages and social security. The rapid emergence of new skills and their growing discrepancy pose a global challenge for achieving the goals of decent work and sustainable development. The role of the labour market has its national features in every country, which depends on the level of national development and the structure of economy. In order to understand real-time processes in the labour market during digitalisation, it is necessary to use the labour market analysis and forecasting based on the official statistics and data from online sources. These data should be processed with the use of Big Data and AI technologies.

The dynamics of decent work indicators reveals that in Belarus, on the one hand, employment is growing while unemployment is falling. On the other hand, the labour market retains certain negative tendencies such as growth in informal employment, a high level of youth unemployment, and a low rate of workers' performance, etc.

The 2013-2023 analysis of vacancies posted on online job search platforms across the regions of Belarus was conducted with the use of a database of 15 million vacancies which was compiled with the help of scraping. The analysis helped to study the trend dynamics and seasonality in the emergence of new jobs. Also, it was used to formulate reasonable recommendations for applicants, employers, labour market researchers, and for the educational system.

A model for demand anticipation in the labour market was selected based on the evidence from the labour market in Minsk, which is the largest and most dynamic market in Belarus. The XGBoost model has shown superior results compared to those produced by other time series models. The forecast error amounted to 7,011.44 (which is significantly lower than other models); with the coefficient of determination amounting to 0.23. The article unveils the results of further forecast of vacancies in Minsk for the period from October 2023 to October 2024. These results were produced after the adjustment of the predictive model of gradient boosting. The predictive model of gradient boosting was retrained using new actual data (collected from the website of the state employment service and online job search platforms during the period from 01.07.2022 to 01.06.2023).

Further research aimed at improving the quality of forecasts will focus on the following: optimization of the model of gradient boosting; exploration of potential applications of deep learning models; identification of additional features specific to regions of Belarus, and factors that influence the emergence of new vacancies.

Thus, the labour market analysis and forecasting within the framework of sustainable development, based on artificial intelligence and Big Data technologies, will mitigate the negative consequences of digitalization of the labour market and ensure timely coordination of labour supply and demand across the regions of Belarus. It will help to improve metrics of decent work indicators and contribute to achieving sustainable development goals.

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