Risk-balanced assessment of labour resources in the sustainable development system of regions in the digital economy

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Abstract. The paper explores the issue of risk-balanced development of the region workforce in the conditions of digitalization. The research purpose is to assess the impact of risks related to workforce and population employment on the region's economic development in the digital economy. The risk impact assessment is carried out based on the method developed by the authors for studying the degree of balance between factors which affect the region workforce. This helps identify disparities in the development of regions. The methods of modeling, decomposition for developing the risk assessment algorithm, online survey and content analysis were applied. An algorithm is developed for a balanced assessment of risks arising as a result of region workforce and employment changes under the influence of digital technologies. Article provides guidelines for assessing the skill-related, technological (innovation), socio-economic risk, risk of virtual labour migration, and also for determining their threat level for the region's economy. The research results can be used for planning and forecasting the development of a region in terms of availability and employment of labour resources. The implementation of the findings enables to substantiate the activities aimed at reducing economic losses of a region caused by the labour market asymmetric development, transformation of employment in the conditions of digitalization and virtual workforce migration. This will contribute to the sustainable development of territories.

1 Introduction

The economy digitalization has an increasing impact on labour resources. New digital technologies require the development of corresponding skills and competencies, and the globalization of the virtual economic environment changes the nature of employment, leading to new forms and ways of using labour resources. However, the digitalization processes go faster than staff training for working in new conditions. Therefore, labour resources can be considered limited in the regional economic ecosystem. This gives reason to explore them as part of the green economy. This concept implies sustainable growth through balanced development and risk minimization, which can be used for managing workforce.

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The change of the technological paradigm from industrial to digital led not only to positive transformations in the field of labour. The economy of the country and its regions faced new problems:

- Growing unemployment among certain professional groups due to automation and robotics, with a simultaneous lack of personnel with the necessary digital skills and competencies. The development of platform work has given rise to a new type of unemployment, namely platform unemployment. It is caused by a temporary lack of orders for people whose source of income is digital labour platforms [1,2] and exclusion of people, employed on nontraditional (flexible) basis [3], from the coverage of public social protection system [4, 5]. People employed on flexible terms are not usually conscious of the need to make voluntary pension and medical contributions [6]. This creates a deficit of funds accumulated by the funds of the social protection system for citizens. However, the failure of the working generation to make pension contributions violates the main principle of the current pension insurance system, founded by Otto von Bismarck, namely intergenerational solidarity, when "each successive generation feeds the previous one". This causes disparities in forming and distributing the pension system funds and, in the long term, requires developing fundamentally different approaches to building this system.

- Virtual migration development [7] raises concerns of socio-economic disparities between the recipient regions and donor regions of virtual labour resources. The recipient region receives economic benefits from attracting virtual workforce if the price of the created product, which is a part of the gross regional product, is higher than the cost of paying virtual migrants. Virtual migrants spend their income mainly in the region of their residence, which, apparently, benefits the donor region of labour resources [8]. However, the constant granting of workforce can be risky for the region in terms of increased economic disparities. The reasons for this are as follows. When attracting virtual labour migrants, recipient areas get additional advantages compared to physical labour migration, since they do not bear social expenses associated with providing the region with skilled workforce (pre-school, school and higher education, medical care, costs of ensuring public order and other indicators of quality of life). These costs are borne by the donor regions of virtual labour resources, which can lead to economic disparities between the regions.

The described problems create imbalances in the development of regions due to the asymmetric development of the labour market and the spread of flexible forms of employment. We can outline the following contradictions in the field of labour and employment caused by the economy digitalization:

- Skill-related - a combination of a shortage of workers in occupations that require professional digital skills and competencies (specialists in machine learning and artificial intelligence, robotics, human-machine interaction, etc.) and an excess of employees in disappearing occupations (assemblers and factory workers, accountants, translators, etc.) [9, 10].

- Migration-related - unbalanced inflow and outflow of virtual workforce in the region.

- Innovative (technological) - a future imbalance of labour resources in a particular region, expected after the introduction of large investment and innovation projects or the diffusion of new technologies, which will either require additional workforce or, more likely in the context of digitalization, help reduce the use of human labour [10, 11].

- Socio-economic - imbalance in income and expenses of funds involved in the system of social support and protection of the population (disparities at the state level), imbalance in income and expenses of regional budgets.

We suggest considering these disproportions as risks that require special balanced measures to coordinate the processes of formation and distribution of labour resources in regions. Such risks will pose a threat to the region's economy when the imbalance begins to cause noticeable negative consequences [12]. The study hypothesizes that a risk-balanced

assessment of the region's labour resources and employment will ensure its sustainable socio-economic and innovative development. It differs from other methods of assessing the region's workforce by focusing on identifying imbalances between the demand and supply of labour resources, workforce structure and staffing needs of a region, virtual labour emigration and immigration.

The research purpose is to explore the possibility of a balanced assessment of the region's labour resources and the accompanying risks in the context of the development of the digital economy and flexible forms of employment. The research objectives include the following:

• Developing a methodological framework for risk-balanced assessment of the region's labour resources in the conditions of digitalization,

• Developing an algorithm for identifying and assessing risks caused by the imbalances in the labour and employment market development,

• Testing the research results on the example of the Rostov region.

The article's structure is as follows: the "Materials and Methods" section describes our approach to studying disparities in the development of the region's workforce, the "Results" section presents the results of identifying disproportions and assessing risks, the "Discussion" section is dedicated to discussing the situation in the labour market of a specific region. The "Conclusion" section sums up the main findings and provides ideas for future research.

2 Materials and Methods

The study is based on the balance approach, which underlies the traditional balance model of labour resources. It is recommended for the harmonious management of risks affecting the formation and distribution of labour resources, as well as employment in the context of the economy digitalization. We propose a method for assessing imbalances in the development of the region's labour resources in the conditions of digitalization, which create risks of economic losses. The method is based on the traditional balance model of labour resources, which is adjusted considering new opportunities for attracting and distributing workforce in the digital economy. It helps justify the need for managing risks caused by the asymmetric development of the labour and employment market.

The initial data for constructing a traditional balance model of labour resources are data from demographic statistics, migration registration and sample statistical surveys of the population on the employment of persons beyond working age.

Our method requires additional data:

• Distribution of labour resources by employment forms,

• Demand and supply of workforce in the labour market,

• Investment projects implemented in the region, strategic plans for the development of large enterprises and sectors, expected bankruptcies of large companies,

• Online surveys, surveys of business executives to determine the scale of virtual migration,

• Information about freelancers, voluntary pension contributions of freelancers, voluntary health insurance of freelancers.

The developed method considers the following employment forms:

• Traditional, involving a long-term or indefinite employment contract, regulation of working conditions. The traditional form also includes remote work, when an employee performs work remotely under flexible working hours, while maintaining other attributes of traditional employment (employment contract, social benefits, long-term employment relationship),

• Platform employment, which involves a civil contract between three parties (employee, client and online platform), flexible working time, mostly short-term employment,

• Freelancing. Its fundamental difference from platform employment is the bilateral nature of the labour relations (employee, client). The work comes not from the digital platform, but from the employee's personal connections and other search methods that help bypass digital platform intermediaries during the job search.

All other modern forms of employment described in [13] are seen as variations of these three forms.

The method for assessing imbalances in the development of the region's labour resources in the conditions of digitalization involves the following algorithm:

- Collecting initial data.
- Drawing up a traditional balance of labour resources in the region.
- Adjusting a traditional balance of labour resources in the region:

• the resource part is adjusted to account for the balance of virtual migration,

• the distribution part is adjusted to account for the number of persons whose employment became possible due to flexible forms of employment. The traditional balance model considered them as the economically inactive population (persons on child-care leave, housewives, people with disabilities, seniors, teenagers).

- Distributing employees by forms of employment (in addition to the traditional distribution by types of economic activity).
- Assessing the balance of parameters which create disparities in the region's development (skill-related, virtual migration-related, innovation (technological), socio-economic) and are considered as corresponding risks.
- Determining acceptable limits of imbalance of parameters, which create risks in the region's development.
- Evaluating the significance of risks by comparing the results of assessing the balance of the factors causing them with the acceptable limits of imbalance (Figure 1, Table 1).
- Assessing the economic losses of the region by significant types of risk (Table 2).

Based on the risk assessment results, measures should be developed to manage risks that threaten the sustainable economic development of the region. Such activities should be aimed at balancing the parameters, the difference between which determines the risk.

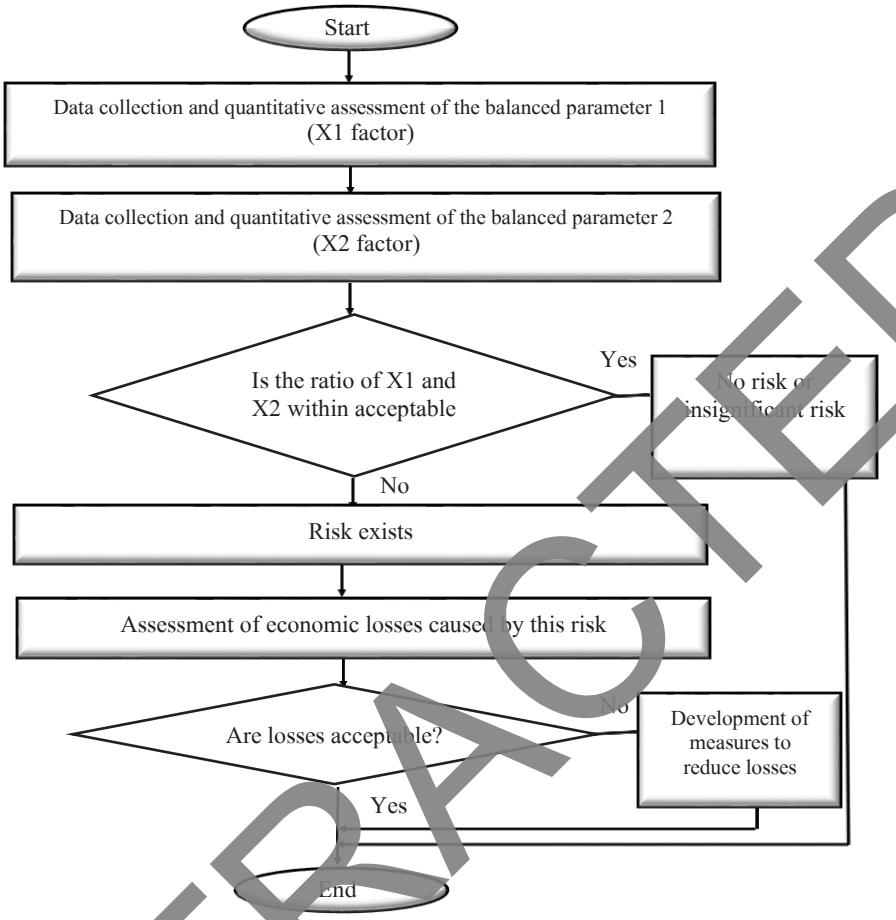

Fig. 1. Algorithm for a balanced assessment of risks associated with digitalization and affecting the region's workforce and employment, *Source: own elaboration.*

Table 1. Balanced parameters of risks associated with digitalization and affecting the region's labour resources, *Source: own elaboration.*

Types of risk	Compared (balanced) parameters		The comparison result	The aim of balancing
	Parameter 1	Parameter 2		
Skill-related	Demand (D) for labour of specific qualifications: number of vacancies by profession (or group of professions)	Supply (S) of labour of specific qualifications (number of unemployed people with the necessary skills)	If D > S then labour shortage is observed If D < S then unemployment is observed	To ensure an acceptable (minimum) level of deficit or unemployment
Innovation	Current labour demand (distribution of employees by types of economic activity)	Future labour demand (distribution of employees by types of economic activity, considering the	Labour shortage or unemployment by types of economic activity	To ensure an acceptable (minimum) level of labour shortage or unemployment

		implemented projects and technology development)		by types of economic activity
Virtual migration-related	Virtual emigration VE	Virtual immigration VI	Balance of virtual migration	VI > VE
Socio-economic	Number of self-employed and digital platform workers not registered as individual entrepreneurs (SPE)	Number of self-employed and digital platform workers not registered as individual entrepreneurs voluntarily paying insurance fees for pensions and health care (SPE_C)	The share of people in precarious employment voluntarily paying insurance fees for pensions and health care	SPE_C / SPE →1

Table 2. Assessment of risks related to digitalization and affecting the region's labour and employment, *Source: own elaboration.*

Types of risk	Source	Risk assessment	Characteristics
Skill-related	Excess of the acceptable share of unemployed people with relevant skills in the total number of unemployed people by profession	The probable excess number of unemployed people with relevant skills in the total number of unemployed people by profession, multiplied by the average unemployment benefit or by the region's unit costs to eliminate unemployment	The region's expenses on unemployment benefits and retraining for new professions
Innovation	Deviation between the prospective and current number of employees by types of economic activity	Probable shortage of labour with the required skills by types of economic activity, multiplied by GRP per capita	Loss of regional GRP due to the shortage of people with the required skills
Virtual migration-related	Negative balance of virtual migration	Negative balance of virtual migration multiplied by the excess of GRP per capita over the average income of intellectual emigrants	Loss of regional GRP due to outflow of virtual intellectual workers
Socio-economic	Reluctance of people in precarious employment to make voluntary pension and health care contributions	The number of people in precarious employment, who do not make voluntary insurance contributions for pensions and health care, multiplied by the region's average per capita spending on social support and protection	Additional spending of the region and state extra-budgetary funds for social support and protection of citizens

The developed method involves the use of morphological analysis, statistical analysis, commonly accepted methods of data collection and comparative analysis (surveys, interviews, method of analogies, content analysis, expert analysis). The method is developed

based on the use of the modeling method and decomposition method for drawing up a risk assessment algorithm.

3 Results

Table 3 shows the traditional and adjusted balance of labour resources of the Rostov region according to 2022 data. It is drawn up based on the data from the Ministry of Labour and Social Development of the Rostov region (https://mintrud.donland.ru/activity/18135/), statistical authorities (https://61.rosstat.gov.ru/folder/29049), research on platform employment(https://www.csr.ru/upload/iblock/66e/cz42mhivcz4efvjua99s0r3nipqbgl3e.pdf) and the survey conducted by the authors.

Table 3. The traditional and adjusted balance of labour resources of the Rostov region, thousands of people (short form), *Source: own elaboration.*

Indicator	Traditional	Adjusted
Resource part		
Number of labour forces	2,595.6	2,603.2
including:		
working age population	2,389.7	2,389.7
balance of cross-regional and international labour migration	36.5	36.5
balance of virtual labour migration	-	-10.3
number of employed people over working age	164.2	180.6
number of employed people under 16 years of age	5.2	6.7
Balance	2,595.6	2,603.2
Distribution part		
Economically active population (workforce), total	2,093.1	2,175.1
including:		
- annual average number of employed persons	2,017.2	2,017.2
- platform workers	-	89.60
- unemployed (registered)	75.9	68.30
Number of students of working age who do not combine work with education	196.6	196.6
Number of other working age population not employed in the economy	305.9	231.5
Balance	2,595.6	2,603.2

The risk assessment is shown in Table 4.

Table 4. Assessment of risks related to digitalization and affecting the labour resources of the Rostov region, *Source: own elaboration.*

Types of risk	Compared parameters (X)		The comparison result	Acceptable imbalance limits	Economic assessment of the region's losses
	X1	X2			
Skill-related (a risk assessment example for "Java developer" job	40 jobs available	20 CVs	Labour shortage (imbalance amounts to 40.8%)	10%	Costs of training programmers is 1.5 million rubles

according to the HeadHunter portal data)					
Innovation (an example for the type of activity "transport and storage")	107.62 thousand people	108.12 thousand people	Shortage amounts to 0.5 thousand people (0.5% imbalance)	3%	Not assessed as the risk is not significant
Virtual migration-related	15.4 thousand people	5.1 thousand people	-10.3 thousand people	0 and above	no losses
Socio-economic	271 thousand people	157.19 thousand people	58% do not pay voluntary fees to the pension fund	10% or less	23.01 thousand rubles for providing a minimum pension

4 Discussion

The adjustment of labour resources to account for new employment opportunities led to the increase in their number in the Rostov region by 0.2% due to virtual labour migration and by 3.9% due to platform employment and the opportunity to work for those who were not seen as part of the economically active population. The employment rate of the population of the Rostov region in 2022 was 58.7%. Taking into account the growth of virtual employment, this indicator could amount to 61%.

The assessment of skill-related risk using the example of the in-demand profession "Java developer" revealed a strong supply shortage in the regional labour market. Potential region losses are related to the need to train those willing to obtain this profession. This risk can be assessed for other professions in a similar way. This will help identify asymmetries in the labour market and take measures to adjust state-funded educational programs along with regional programs for training, retraining, and advanced training of personnel.

Technological (innovation) risk is determined considering the development prospects of the Rostov region. Information about ongoing investment and innovation projects in the region is posted on the official portal of the Government of the Rostov Region[1]. Currently, high-tech projects involving automation, digitalization and robotics of production are not being implemented in the region. We conclude that the technological risk of labour shortage in terms of innovations and introduction of new digital technologies poses no threat to the region in the next 1-3 years.

There is no risk of virtual migration, since GRP per capita of the region, amounting to 556.6 thousand rubles in 2022, is less than the average income of platform workers, which is determined based on the study[3], other studies and calculated as an average of 572.8 thousand rubles a year. The difference, multiplied by the balance of virtual migration, produced a negative value of 166.86 thousand rubles. Conclusion is drawn that the negative balance of virtual migration does not directly result in economic losses in the region, since the income of virtual migrants exceeds GRP per capita. So, there is no risk of virtual migration, however, additional research is needed on the implicit losses of the region related to the socio-economic burden due to the residence of virtual labour migrants in the region.

The socio-economic risk is the highest in terms of potential economic losses in the region, since according to the research[3], only 42% of people who do not have a permanent job ("employed on flexible terms") make voluntary contributions to the pension fund, which causes a pension system deficit, calculated based on the minimum pension in the region.

Thus, the following risks are significant for the Rostov region:

- skill-related, caused by the imbalance of current supply and demand in the labour market for jobs requiring professional digital skills and competencies,

- socio-economic, caused by the reluctance of people employed on flexible terms to make voluntary contributions to the public system of social, health and pension insurance. At the national level, this leads to a pension fund deficit, and at the regional level this might cause social discontent, economic disparities and limited access to health care for those employed on flexible terms.

The research is consistent with the opinion of D. Wadley [14] about the need for profound planning based on the precautionary principle. A .G. Ross, P. G. McGregor and J. K. Swales [15] highlight the negative impact of technological changes on employment in the short-to-medium term, which may require government intervention. The study [16] raises concerns about taxation of digital nomads. The paper [5] emphasizes the need for additional social protection in the platform economy. Thus, based on the research results, we suggest that the authorities of the Rostov region should address the identified potential problems in the region's economy development.

5 Conclusion

The study identified potential sources of economic losses in the Rostov region caused by the transformation of the labour and employment market under the influence of the development of digital technologies. The threat is posed by a skill-related imbalance of the labour market, expressed in a shortage of highly-trained personnel with digital skills. This will hinder the realization of the region's potential in using new technologies. Moreover, the region's leadership should pay attention to the risk of increasing socio-economic disparities in the future among the population employed on traditional and flexible terms. The research results can be used by regional authorities when drawing up plans and forecasts for the region's development. This will ensure sustainable and well-balanced development of the region in the conditions of digitalization, accompanied by the transformation of labour resources along with the development of new forms of employment.

We believe that the further development of platform employment will contribute to increased virtual migration and the inextricably linked cross-regional and international migration of added value produced in the region's economy. This may increase the digital economic inequality between regions. Since this problem is just beginning to get close consideration from the academic community, we assume that it has broad prospects for further research.

Acknowledgments

The research is supported by the Russian Science Foundation grant funding No. 24-28-00848, https://rscf.ru/project/24-28-00848/.

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