The Modernization of Current Methods and Technologies for Risk Assessment, Modeling and Forecasting

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Abstract. Theoretical and scientific-methodical approaches to the definition and quantitative risk assessment were systematized. The main advantages and disadvantages of using mathematical and statistical methods of modeling and risk forecasting were analyzed. The advantages of using recursive models of Path-analysis were justified and the results of their approbation for estimation and forecasting of social risks of labor sphere according to the inertial scenario of development of national economy are introduced. The influence of digital transformations on the formation of risks was determined. The concept of the European System of Social Indicators (ESSI) was taken into account in the development of a methodology for identification of indices of the socio-economic vulnerability of the entire population and the employed one. The peculiarities of indirect assessment of the manifestation of social risks were disclosed.

1. Introduction.
The problem of increasing of the global and national challenges is determined by the spread of risks and dangers that negatively affect the living conditions of population, the natural environment and create the obstacles for the further progressive world development. As a consequence, national economies are in urgent need of a qualitative and accurate assessment of these risks with the further modeling of the consequences of their manifestation and the development of scenario forecasts that determine the choice of management decisions. The modern social risks have a high variability, they are characterized by rapid and unpredictable changes in the safe environment. There is a growing need for the development of methodologies for the assessment that allow to make adjustments and to have comparable and accurate data in the end.

2. Analysis of recent research and publications.
The subject of social risk research is popular and quite developed among the scientists. It is researched as an independent scientific direction, as well as a subsystem in more generalized social systems. Such
a division is conditional, because simultaneously the same types of social risks can have an independent manifestation and be the result of transformations in the economic, environmental, digital, industrial and other spheres.

Social risks are common to all spheres of life, both society as a whole and the individual. Based on the results of scientific research, the separate classifications of social risks according to different criteria for their determination have been developed. In the context of the possibility of social protection of the population, risks are determined as a measure of the impact of the events that limit economic independence and social welfare of the person [1, 2, 3]. Social risks include those that cause loss or decline of regular income on the assumption of unemployment, disease, old age, childbirth, child care, death of a breadwinner, total or partial disability and others. They are defined by the Law of Ukraine "On Compulsory State Social Insurance" [4]. Non-traditional social risks are regulated by the Law of Ukraine "About Social Services" [5]. The main ones are loneliness, orphanhood, poverty, homelessness, caregiving, assist in housing maintenance, and so on.

The social risks to the criterion of the social security include those associated with the loss of health and life, loss of employment, especially for a long period of time, capacity for work and livelihood, economic and social vulnerability, social isolation, poverty and social exclusion, etc. [6, 7, 8].

The approach generalizes the given criteria for determining social risks, according to which they are considered as risks of social status [9]. In this regard, dangers and menaces limit the economic independence, social welfare and are accompanied by the negative changes and deterioration of social status. In turn, the social status is determined by a set of social and labor, economic, legal and other parameters that are typical for society as a whole, certain social groups or individual, which provides the ability to identify types of risks by their content or subjectivity. These can be risks of human development [6, 10], unemployment [11], informal [12] or vulnerable [13] employment and other types.

With a wide range of researches of certain types of social risks, a number of unresolved issues remain, which are primarily related to the development of methodological and methodical approaches to quantifying assessment, modeling and forecasting of integrated indicators of social risks and their consequences.

3. The research objective.
The objective of the work is to analyze the theoretical and scientific-methodical results of scientific research and propose the development of a methodology for social risk assessment based on the concept of Path-analysis.

4. Presentation of the main material.
Social risks are mostly characterized by uncertainty and multimodal of manifestations depending on changes in factors and conditions for establishing. Uncertainty usually arises in the presence of a large number of dimensions of social risks and upon condition that some qualitative characteristics are unclear and "vague" by nature. On the other hand, the objective possibilities of risk are due to the probabilistic nature of the impact of many natural, political, economic, social and technological processes, the variety of material, social and socio-psychological relations in which the subjects of social life are entered.

Each type of risk has a quantitative and qualitative characteristic, that make it necessary to take into account not only their types, but also the internal components and possible consequences of the manifestation. The structure of the qualitative approach defines the areas, spheres, factors, determinants and conditions of development of social risks, their meaningful identification and structuring, intensity of manifestation and possible socio-economic consequences.

The quantitative assessment provides an opportunity to measure certain parameters of social risks, in particular, the probabilities of realization and consequences of the manifestation.

The quantitative approach is based on the probabilities of formalization, development of an algorithm for the formation and manifestation of risks, the choice of methods for risk assessment, their modeling and forecasting for a certain period of prejudices.
The main methodological approaches to risk assessment in modern risk methodology are a set of formal and analytical algorithms that provide an opportunity to assess the probability of manifestation or realization of an undesirable event or phenomenon, i.e. risk in its generic term, and the losses caused by it. With a certain conditionality, all approaches to the quantitative risk assessment can be divided into four groups:

- probabilistic one provides the ability to determine the functions of the distribution of probabilities of risk to assess the risks using the appropriate characteristics of the allocation, but does not take into account the factors and changes of influence;
- the model one is based on the construction of probabilistic models and provides the ability to take into account factors and determinants of influencing the formation of risks;
- index one is a quantitative assessment of risks based on the development of integrated indicators on a set of factor features of their formation or manifestation;
- the expert one is based on the obtaining of the qualitative and quantitative risk assessment by the collation of expert views of specialists, while the assessments are mostly subjective and depend on the professional level of experts.

Based on the given approaches, all methods of social risk assessment can be combined into the three main groups: statistical and mathematical-statistical, methods of expert assessment and forecasting, methods of integrated and rating assessment.

Among the methods the most common are mathematical and statistical, which are based on the use of a specific mathematical and statistical apparatus: probability theory, mathematical statistics, mathematical and statistical modeling, the theory of fuzzy set and others.

The risk assessment is a statistical assessment of parameters, characteristics, dependencies that are included directly in the model. In probabilistic models, the assessment of the possibility of an undesirable event is related to the determination of probabilities, and the amount of damage caused by the manifestation of risk is considered as a function of their distribution. When assessing social risks, these theoretical characteristics are defined as statistical frequencies of the corresponding risk, and the amount of damage depends on the content of the risk itself and can be measured in physical, labor or value units. Mathematical and statistical methods provide an opportunity to assess the potential opportunity for losses based on statistical information for previous periods and to determine the limits of their distribution.

The statistical methods are based on determining the empirical (actual) frequencies of the manifestation of a particular type of social risk. They are quite easy to use, but to build the distribution series to determine the necessary statistical characteristics, in particular, the indicators of variation as the main risk assessments, it is necessary to have the quite large arrays of statistical information over a long period of time.

The use of probabilistic and statistical methods, in particular methods of probability theory and mathematical statistics, in some cases makes it possible to supplement the statistical information with theoretical hypotheses and analysis of supporting data. Under these conditions, the conformity of the empirical distribution to the theoretical laws according to certain criteria for assessment of the necessary risk parameters is checked.

A generalization of the two approaches is the use of methods of mathematical and mathematical-statistical modeling for quantitative risk assessment, modeling and forecasting. They are based on the use of models and algorithms of game theory in the development of scenario approaches, scoring models, the use of trend models for predictive assessments of the characteristics of risk determination and others.

Among the modern methods of diagnosis and risk forecasting, in particular, to assess the risk of unemployment among the employed population, the use of scoring models is proposed, which is based on the tools of predictive analysis [11, p. 95-112; 14, 15], notably, mathematical and statistical methods: methods of regression analysis, a tree of classification, neural networks. Based on them, the dependences of the dichotomous variable (employment-unemployment) on a number of independent factors (age, sex, level of education, profession, etc.) that affect the possibility of risk of this type are
determined. Possibilities of the thorough and detailed assessment of risk probabilities with determination of a specific halo of its formation, which is an objective achievement of this approach, are significantly restricted by the need to have the large arrays of statistical information over a long period of time, which are absent nowadays.

The group of mathematical and statistical methods includes the approaches to the quantitative assessment of social risks, which are based on the European System of Social Indicators (ESSI) [16]. According to the basic concept of the system, the measurement of processes should be carried out in the coordinates of identity, inequality, consolidation and conflict and be based on the use of the most common databases and results of national researches. The developed and tested approaches for the social risk assessment using the basic requirements and concepts of the ESSI make it possible to assess the changes in levels of economic and social vulnerability in the context of the manifestation or implementation of a particular type of social risk: the risks of unprotected employment due to unemployment, underemployment or informal employment, the risks of income and livelihoods loss, the risks of social exclusion and others [13; 15; 17].

The algorithm for determining social risks in the field of social and labor relations or risks of vulnerability \( I_{vul,SLR} \) provides the full identification of the main components of their formation and quantitative assessment by the following ratios:

\[
I_{vul,SLR} = \sum^n_{i=1} \prod^n_{i=1} K_i^n
\]

where \( K_i \) - a subindex for each \( i \)-ed type of risk;

\[
K_i = \frac{X_{i1,t}}{X_{i1,t-1}} \cdot \frac{X_{i2,t}}{X_{i2,t-1}} \cdots \frac{X_{in_i,t}}{X_{in_i,t-1}}
\]

\( n_i \) - value of the \( n_i \) indicator of measurement of the \( i \)-ed subindex for \( t \) and \((t - 1)\) periods; \( n_i \) - the number of indicators for determining the \( i \)-ed subindex; \( W_i \) - weighting coefficients of the \( i \)-ed index, which can be defined as the proportion of the population covered by the corresponding risk.

In the system of social and labor relations, it is possible to consider such types of risks that cause a certain level of vulnerability.

- risks of employment vulnerability \((K_1)\):

\[
K_1 = \frac{R_t}{R_{t-1}} \cdot \frac{Q_t}{Q_{t-1}} \cdot \frac{S_t}{S_{t-1}} \cdot \frac{N_t}{N_{t-1}} \cdot \frac{L_t}{L_{t-1}} \cdot \frac{q_t}{q_{t-1}} \cdot \frac{d_t}{d_{t-1}}
\]

where \( R_t, R_{t-1} \) – the unemployment rate, accordingly, in the \( t \)-ed and \((t-1)\)-ed periods; \( Q_t, Q_{t-1} \) – the level of part-time employment; \( S_t, S_{t-1} \) – the level of informal employment; \( N_t, N_{t-1} \) – the proportion of the employed population whose wages are counted within the minimum; \( L_t, L_{t-1} \) – the level of vulnerable platform employment; \( q_t, q_{t-1} \) – the level of vulnerable employment of migrant workers; \( d_t, d_{t-1} \) – the level of precarity of the employed population.

In the structure of social risks, a special place is occupied by risks associated with social exclusion, social isolation of a person, or social rejection \((K_2)\):

\[
K_2 = \frac{m_t}{n_{t-1}} \cdot \frac{k_t}{k_{t-1}} \cdot \frac{v_t}{v_{t-1}} \cdot \frac{m_{t-1}}{m_{t-1}} \cdot \frac{r_t}{r_{t-1}} \cdot \frac{b_t}{b_{t-1}} \cdot \frac{p_t}{p_{t-1}} \cdot \frac{f_t}{f_{t-1}}
\]

\(^1\) Under the conditions, if the indicators are disincentives of the level of vulnerability, then to ensure a direct impact, they are included as the reciprocal.
where $n_t$, $n_{t-1}$ – the level of trust in society; $k_t$, $k_{t-1}$ – index of social well-being; $v_t$, $v_{t-1}$ – the proportion of people who believe that most people do not believe in anything; $m_t$, $m_{t-1}$ – the level of personal security (on the street, in public places); $r_t$, $r_{t-1}$ – the level of distribution of material deprivation among the capable population; $b_t$, $b_{t-1}$ – change of employment guarantees; $p_t$, $p_{t-1}$ – the level of satisfaction with their position in society;

$f_t$, $f_{t-1}$ – the proportion of people who believe that there is a lack of suitable work and the opportunity to work at full capacity.

The index of vulnerability due to the manifestation of social risks is calculated as follows:

$$I_{vul} = \sqrt{K_1^{w_1} K_2^{w_2}}$$

This approach makes it possible to identify the main trends in the levels of vulnerability for certain periods of time with full identification of the main factors of such change for the scientific basis of management decisions and does not require a large amount of statistical information. Based on this approach, it is not directly the levels of social risks that are assessed, but their socio-economic consequences and losses.

The development of methodology of risk assessment using mathematical and statistical methods can be considered the concept of Path-analysis [18, 19, 20, 21, 22], which begins with the identification of individual types of social risks, in this case, the labor risks. On the basis of the qualitative analysis of their content, the causal relationships between factors, determinants and conditions of formation and manifestation, as well as the socio-economic consequences of the implementation of risks are determined. Based on these connections, a recursive model is developed, which graphically reproduces all the identified connections.

The conceptual model of the recursive type, which reflects the causal links of the formation of social risks in the labor sphere under the condition of digitalization of the economy is presented in Figure 1.

It contains the following components:

- as external or exogenous factors that determine the main conditions for the formation of risks, two main ones are selected: $R_1$ – the parameters of the economic development strategy according to the inertial ($R_{11}$) and target ($R_{12}$) scenario. $R_2$ is the probability of digitalization of the economy both by inertial ($R_{21}$) and accelerated ($R_{22}$) options;

- as internal factors that determine the main manifestations of risks in the labor sphere are the following: the level of economic activity of the population ($x_1$); the level of employment ($x_2$); the proportion of persons over 60 years of age in the total labor force ($x_3$); unemployment rate ($x_4$); the proportion of dismissed workers due to digitalization ($x_5$).

The consequences of changes in the level of employment are determined by the following indicators: informal employment ($y_1$); underemployment ($y_2$); platform employment ($y_3$); vulnerability in terms of platform employment ($y_4$); the proportion of employees who are not covered by collective contracts ($y_5$).

The system of risks in the labor sphere includes: the risks of job loss or unemployment ($z_1$); the risks of vulnerable employment ($z_2$); the risks of precarious employment ($z_3$); the risks of out-migration ($z_4$).
Figure 1. The recursive model of formation of socio-economic risks in the labor sphere under the condition of digitalization of the economy [21].

In the structure of the model, the path-coefficients $P(x_i, x_j)$ are calculated on the basis of special mathematical and statistical algorithms, which provide the ability to determine the probability of realization or manifestation of a particular type of social risk [18, 19; 20] while $P(x_i, x_j)$ assesses the probability of realization of the $x_i$ element of the models under the condition of manifestation of the $x_j$ factor or determinant.

Based on the casual links of the developed recursive model, structural equations are determined to assess the probability of realization of a particular type of risk:

- probability of dismissal or risks of unemployment $P(z_1)$:
  $$P(z_1) = P_{R_1,R_1} \cdot P_{X_1,R_1} \cdot P_{X_2,X_1} \cdot P_{Z_1,X_2} + P_{X_3,R_2} \cdot P_{Z_1,X_3};$$

- probability of economic vulnerability of employment or risks of economic insecurity $P(z_2)$:
  $$P(z_2) = P_{R_1,R_1} \cdot P_{X_1,R_1} \cdot P_{Y_1,X_2} \cdot P_{Z_2,Y_1} + P_{R_1,R_1} \cdot P_{X_2,X_1} \cdot P_{Y_2,Y_2} \cdot P_{Z_2,Y_2} +$$
  $$+ P_{R_1,R_1} \cdot P_{X_3,X_1} \cdot P_{Y_3,X_2} \cdot P_{Z_2,X_3} + P_{R_1,R_1} \cdot P_{X_3,X_1} \cdot P_{Y_4,X_2} \cdot P_{Z_2,Y_4} + P_{R_1,R_1} \cdot P_{X_3,X_1} \cdot P_{Y_5,X_2} \cdot P_{Z_2,Y_5} =$$
  $$= P_{R_1,R_1} \cdot P_{X_1,R_1} \cdot P_{X_2,X_1} \cdot P_{Y_1,X_2} \cdot P_{Z_2,Y_1} + P_{Y_2,X_2} \cdot P_{Z_2,Y_2} + P_{Y_3,X_2} \cdot P_{Z_2,Y_3} \cdot P_{Z_2,Y_4} +$$
  $$+ P_{Y_3,X_2} \cdot P_{Z_2,Y_5} = P_{Z_2,Y_1} + P_{Z_2,Y_2} + P_{Z_2,Y_3} + P_{Z_2,Y_4} + P_{Z_2,Y_5};$$

- probability of risks of precarity of employment $P(z_3)$:
  $$P(z_3) = P_{Z_3,Z_1} + P_{Z_3,Z_2};$$

- probability of risk of out-migration of economically active population $P(z_4)$:
  $$P(z_4) = P_{R_1,R_1} \cdot P_{X_1,R_1} \cdot P_{Z_4,X_1};$$

The identified recursive model for assessing the social risks of the social and labor sphere according to the inertial scenario of Ukraine’s economic development and its digitalization is shown in Fig. 2, and the initial indicators for calculating the probabilities are presented in the table.
Figure 2. The recursive model of formation of social and economic risks of labor sphere according to the inertial scenario of development and digitalization of economy.

The probabilities of risk manifestation according to the given structural equations will be as follows:
- risks of unemployment
  \[ P(z_1) = 0.9 \cdot 0.613 \cdot 0.913 \cdot 0.074 + 0.9 \cdot 0.293 = 0.301; \]

Table 1. The main statistical frequencies for determining risks in the labor sphere according to the model of Path-analysis for 2025\textsuperscript{a} [21]

| Indicators | Symbols | Level (statistics) |
|------------|---------|-------------------|
| A proportion of EAR (economic activity rate) in the entire population at the age of 15-70 | \( X_1 \) | 0.613 |
| A proportion of the employed population at the age of 15-70 in EAR | \( X_2 \) | 0.913 |
| A proportion of the population at the age of 60 and 60+ | \( X_3 \) | 0.178 |
| A proportion of the dismissed population | \( X_4 \) | 0.074 |
| A proportion of the dismissed population as a result of the digitalization | \( X_5 \) | 0.293 |
| Informal employment | \( Y_1 \) | 0.224 |
| Underemployment | \( Y_2 \) | 0.04 |
| Platform employment | \( Y_3 \) | 0.07 |
| The vulnerability in the contexts of the platform employment | \( Y_4 \) | 0.58 |
| Not covered by the collective labor contracts | \( Y_5 \) | 0.222 |

Calculated following the model:
- The risks of unemployment
  \[ P(z_1) = 0.301 \]
- The risks of vulnerable employment
  \[ P(z_2) = 0.2642 \]
- The risks of the precarious employment
  \[ P(z_3) = 0.5652 \]
- The risks of out-migration of the population
  \[ P(z_4) = 0.1374 \]

\textsuperscript{a} Calculated by the authors as follows:
- the number of economically active and employed population is calculated on the basis of forecast assessments of the population of the relevant age group.
- the level of economic activity and employment is defined as their average annual values for 2017-2018 for certain sex and age groups.
- risks of vulnerable employment:
  \[ P(z_2) = 0.9 \cdot 0.613 \cdot 0.913 \cdot (0.224 + 0.04 + (0.07 \cdot 0.58) + 0.222) = 0.2642 \]
- risks of the precarious population related to the labor force:

\[ P(z_3) = 0.301 + 0.2642 = 0.5652; \]

- risks of labor out-migration:

\[ P(z_4) = 0.9 \times 0.613 \times 0.249 = 0.1374. \]

Based on the forecasted number of the workforce and taking into account the identified probabilities of risk, it can be calculated the number of people in this contingent, among which there may be manifestations of risks or contingent that may get under the risk. Thus, the number of workers who may lose their jobs if the risk of unemployment is realized will be almost 4970 million people \((16511.6 \times 0.307)\). Therefore, under the implementation of the inertial scenario of economic development with the simultaneous introduction of certain processes of digitalization, unemployment may cover a third, i.e. the unemployment rate may reach 30.1%, which is 3.4 times more than in 2018. The contingent of precarious workers will reach 9.33 million people – without taking into account the seasonal employment and employees whose wages are counted within the minimum or below its level.

The economic vulnerability of the employed population is determined by the levels of part-time, informal employment, the vulnerability under platform employment and the proportion of workers who are not covered by collective labor contracts. It is estimated that almost every four one of the labor forces or one in three of the entire population at the age of 15-70 falls under the category of "economic vulnerability", and their total number can reach 4362.4 thousand people or 28.9% of the employed at the age of 15-70.

The probability of the risk of out-migration of population among the labor force will be 0.1374, i.e. 2268.7 thousand people of the labor force can annually take part in labor emigration under certain conditions. According to the inertial scenario, the country will lose about 2.27 million people at the age of 15-70, in addition to the contingent that has already left to earn money outside the country.

According to the calculations, more than 70% of the contingent of "labor force" \((0.5652 + 0.1374 = 0.7026)\), which is about 11.6 million people are subject to only four identified employment risks provided the maintaining of the inertial nature of economic development and the implementation of individual elements of digitization.

Based on the given models of Path-analysis, with regard to the lack of objective information, it is quite difficult to determine the probability of manifestation of both individual components of certain risks and directly the risks of a certain type. Consequently, there are no indicators of seasonal employment in the structure of the risk of precarious employment and the proportion of employees who are counted a salary within the minimum of subsistence level and below. Additionally, it is quite problematic to assess the probability of the risk of intergenerational gap and social rejection according to the concept of Path-analysis. However, as time goes on, the assessments of the probability of each type of risk can be adjusted and clarified, which will allow a more objective determination of the possibility of realizing a particular type of risk of social and labor relations.

5. Conclusions.

The main problems of assessment, forecasting and management of social risks are determined by their multicriteria and weak level of structuring. On the one hand, this is due to a large number of factors that affect the processes of activation and the intensity of their manifestation. On the other hand, the complexity of formalization is associated with a relatively low level of identification and study of the links between the factors, the lack of a formalized description of the process of formation and manifestation of social risks and parameters of such manifestations.

The use of Path-analysis models provides an opportunity to develop scenario approaches to risk assessment in the contexts of changes of external and internal factors and factors of influence. The models of formation and manifestation of social risks are open, they allow without changing the basic concept to additionally include (or exclude) in their structure new factors, determinants and conditions of risk formation or new types of risks, if they arise, without changing the basic concept. The generalized conceptual model of assessment of probabilities of manifestation of social risks can be supplemented by
allocation of separate kinds and differentiations on the separate social groups among which their realization or display is possible.

The advantage of Path-analysis models is the possibility to use expert reasonable and reliable information according to certain criteria when assessing the Path-coefficients, if the models are used for prediction and forecasting.

The scientific and methodological value of this approach may be found in its universality and possibilities of use even when changing the initial indicators. On the other hand, the manifestations of those types of social risks that are currently unknown or may occur as the implementation of certain digitization processes can be included in the model to determine the causal relationships and probabilities of manifestation without violating the basic concept of the model.

The use of indices of socio-economic vulnerability for the quantitative assessment of social risks provides an opportunity to identify and analyze trends in individual components of the formation and manifestation of risks, their impact on changing levels of vulnerability for scientific basis and development of management mechanisms.

The necessity to improve the existing methods of social risk assessment and development of new approaches is primarily due to the need to create a risk management system that includes their identification, control, monitoring, selection of effective regulators to reduce a negative impact to a certain safe (acceptable) level or even to elimination and substantiation of necessary management decisions, which will be implemented in strategic and program documents of national, regional and global levels.

References

[1] Boyarchuk T V 2006 The formation of the system of assessment and the regulation of social protection of the population (Lviv: NASU, Institute of Regional Studies) p 195

[2] Topyshko N P 2010 The application of the theory of fuzzy sets in the assessment of the level of social protection of the population Financial system of Ukraine 13 467-480

[3] Topyshko N P The social risks and the problem of assessment of the level of social protection based on the theory of fuzzy sets. – [Electronic Resource]. – Available from: https://eprints oa.edu.ua/2282/1/topishkonp1_06092013.pdf

[4] The Law of Ukraine “On Compulsory State Social Insurance” of January 18, 2001 № 2240-III. – [Electronic Resource]. – Available from: https://zakon rada.gov.ua/laws/anot/2240-14

[5] The Law of Ukraine “On Social Services” of 19.06.2003 № 966-IV. – [Electronic Resource]. – Available from: https://zakon rada.gov.ua/laws/anot/966-15

[6] Human development in Ukraine: the minimization of social risks 2010 ed E.M. Libanova (Kyiv: Institute of Demography and Social Research named after M.V. Ptuha of the NASU, State Statistics Committee of Ukraine) p 496

[7] Novikova O F The assessment of social risks in the regions of Ukraine as a basis for making management decisions to overcome them. Retrieved from http://old.niss.gov.ua/Monitor/Juli08/08.htm

[8] Sydorchuk O G 2018 Social security: state regulation and organizational and economic support (Lviv: LRIPA NAPA) p 492

[9] Sharin V I 2013 Social risks as a threat to social status and protection from them Philosophy and Sociology 6 (50) 118-124

[10] Makarova O V 2018 The methodological approaches to the identification and assessment of human development risks Demography and social economy 2 (33) 103-116

[11] Ukrainian labor market: imperatives and opportunities for change 2018 ed I L Petrova and V V Blyznuk (Kyiv: NAS of Ukraine, Institute of Economics and Forecasting of NAS of Ukraine) p 356 – [Electronic Resource]. – Available from: http://ief org.ua./docs/mg/306.pdf

[12] Petrova I L 2016 Social risks of an informal employment in Ukraine Labor market and employment 4 29-34

[13] Novikova O and Shamileva L 2020 Evolution of Social and Economic insecurity risk for
employees during structural transformations in modern labor market Social and labor relations: Theory and Practice, 10 (1) 1-10

[14] Nadraga V I 2013 The assessment of social risks: the problem of choosing the methodology and tools Finance of Ukraine 12 70-77

[15] Nadraga V I 2015 Social risks: essence, analysis, possibilities of influence (Kyiv: NAS of Ukraine, Institute of Demography and Social Research named after Ptuha of NAS of Ukraine) p 329

[16] Saenko Y I 2004 Methodology and methods of determining the integrated social indicators. (Kyiv: Institute of Sociology of NAS of Ukraine) p 374

[17] Sydorchuk O G 2018 Methodical approaches to measuring economic vulnerability in the conditions of manifestation of social dangers Scientific Bulletin of the Uzhhorod national university. Series: International Economic Relations and the World Economy 18 Part 3 59-64

[18] Manhein D B and Rich R K 1997 Political science. Research methods: trans. in English (Moscow: The whole world) p 544

[19] Shamileva L L and Khandiy O O 2019, October 23-24 The concept of Path-analysis of risk identification in the field of social and labor relations in the digitalization of the economy. The scope of employment and incomes in the conditions of digitalization of economy: mechanisms of regulation, challenges and dominants of development: collection of abstracts of reports of the International scientific-practical conference (Kyiv: KNEU) pp 56-58

[20] Suimenko E I, Novikova O F, Shamileva L L and Pankova O V 2006 The concept of path-analysis as a model of forecasting of the social and labor conflicts Donetsk region in the mirror of economic sociology (Kyiv, Donetsk: Institute of Sociology of NAS of Ukraine, Institute of Industrial Economics of NAS of Ukraine) pp 276-314

[21] Novikova O F, Shamileva L L and Shastun A D 2020 The prospects for changes in the labor sphere in the digitalization of the economy by the inertial and target scenario of development of Ukraine Economic Bulletin of Donbass 2 (60) 187-200

[22] Sydorchuk O H and Pankova O V 2020. Formation and Ensuring Multi-Level System of Social Security of Ukraine in the Context of State Regulation Visnyk ekonomichnoi nauky Ukrainy 1 (38) 138-147 doi: https://doi.org/10.37405/1729-7206.2020.1(38).138-147