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RESERVES TO PREVENT WAGE DELAYS: A MONTE CARLO SIMULATION

Vitaliia Koibichuk
Candidate of Economy Sciences, Associate Professor, Head of the Department of Economic Cybernetics, Sumy State University, Sumy, Ukraine; e-mail: v.koibichuk@biem.sumdu.edu.ua
ORCID: 0000-0002-3540-7922
(Corresponding author)

Dariusz Krawczyk
Assistant Professor of the Department of Applied Social Sciences, Silesian University of Technology, Zabrze, Poland;
ORCID: 0000-0003-1823-0309

Serhii Drozd
PhD Student, Sumy State University, Sumy, Ukraine;
ORCID: 0000-0002-0716-3078

Bhola Khan
D.Sc. in Economics, Professor, MJP Rohilkhand University, Bareilly, India;
ORCID: 0000-0002-4479-2762

Tatyana Kostyshyna
D.Sc. in Economics, Professor, Head of the Department of HR Management, Labor Economics and Economic Theory, Poltava University of Economics and Trade, Poltava, Ukraine;
ORCID: 0000-0003-4776-5150

Zuzana Kubaščíková
Candidate of Economy Sciences, Associate Professor of the Department of Accounting and Auditing, University of Economics in Bratislava, Bratislava, Slovakia;
ORCID: 0000-0001-6739-1278

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ABSTRACT

Wage as a source of covering the basic needs of many households largely determines employee productivity, work enthusiasm, and creative activity. If an employee is dissatisfied with the remuneration or there are wage delays, then distrust in the employer increases, strikes are more likely, there is the risk of losing experienced and highly qualified employees, and the employer's reputation suffers, which can lead to significant economic losses for the enterprise. The article uses the Monte Carlo simulation method to determine the amount of reserves that should be formed by business entities representing different areas of economic activity to prevent possible accumulation of wage delays. Simulation modeling was performed for the following areas of economic activity: information and communication; financial and insurance activities; real estate activities; professional, scientific and technical activities; scientific research and development; and human health and social work activities. The modelling process considers simulated cases when wage delays are 10%, 20%, 25%, 50%, 75%, 100% of the total amount. The study was conducted on the example of Ukraine based on the statistical data of the National Bank of Ukraine. Since the war on the territory of Ukraine has significantly affected the functioning of all sectors of the Ukrainian economy, the research horizon is limited to before the full-scale invasion period: from February 2013 to February 2022. The analysis showed that in Ukraine, the largest delays in the payment of wages occur in the sectors financed from the state budget: professional, scientific and technical activities, scientific research and development, and human health and social work activities. This problem is particularly exacerbated by the total budget deficit during the war. Therefore, the results of simulation modelling for different scenarios presented in this paper can be used in planning the state budget and building state reserves.

Keywords: wage delays, wage, state budget, simulation, Monte Carlo, labour remuneration

JEL Classification: C15, C53, H61, H72

INTRODUCTION

Wages are the main source of income for many people who depend on them to cover their basic needs, such as food, shelter, medical care, and bills. Studies of motivational factors in terms of attracting and retaining a talented workforce show that salary is the most important extrinsic motivational factor (Brychko et al., 2023). According to the International Labor Organization (ILO), whose supreme governing body is the International Labor Conference, delayed or non-payment of wages is one of the main causes of labour disputes in the world (International Labor Organization, 2023).

The interactive analytical dashboard of the State Labor Service of Ukraine allows for tracking the dynamics of wage delays in Ukraine and analyzing their causes by type of economic activity, employment sector, ownership of enterprises, etc.

For example, the dynamics of wage delays for such economic activities as information and communication; financial and insurance activities; real estate activities, professional, scientific and technical activities; scientific research and development; human health and social work activities are shown in Figure 1.

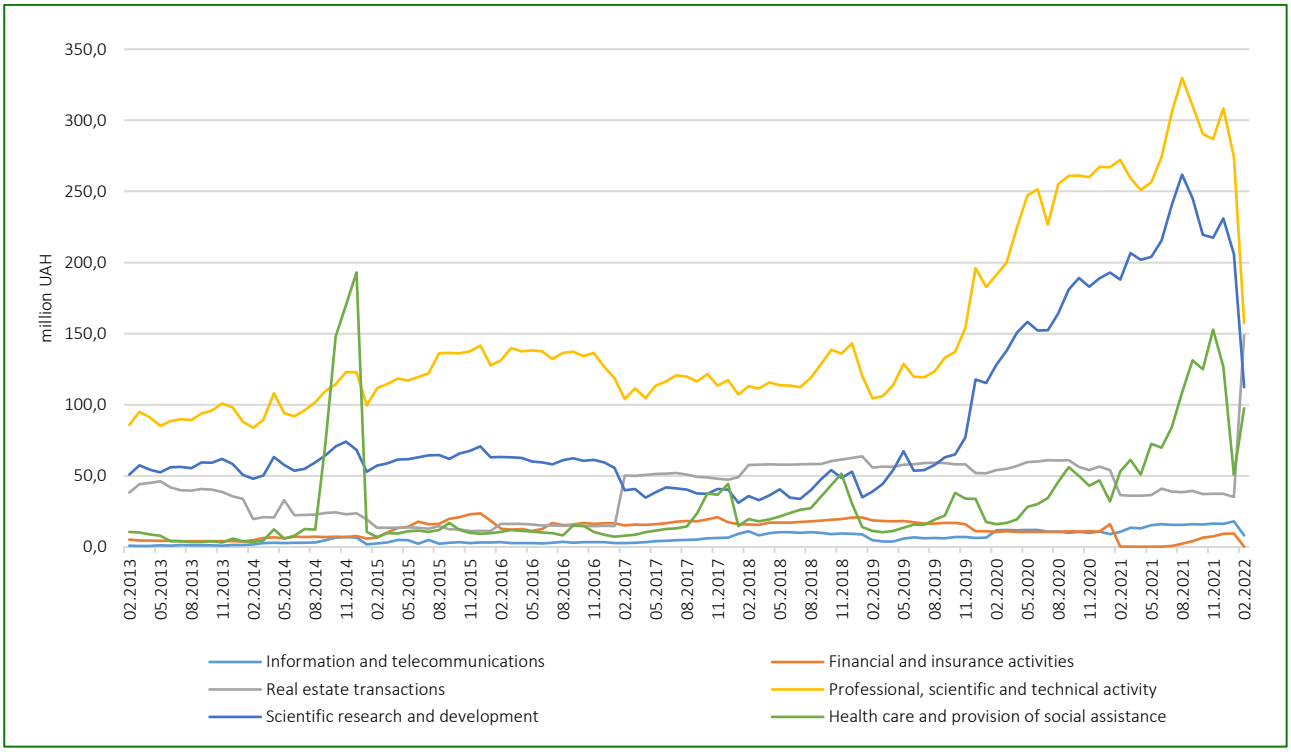

Figure 1. Graph of non-payment of wages in Ukraine in the pre-war period based on historical data for 2013–2022. *(Source: built by the authors using Microsoft Excel based on data from the National Bank of Ukraine, 2022)*

The data presented in Figure 1 is limited to February 2022, i.e., the pre-war period. As can be seen, for most of the analyzed types of economic activities, wage delays have grown over the years. This trend is sustainable only for companies operating in information and communication, and financial and insurance activities, though this does not eliminate the problem of delays as such.

Since the Russian invasion of Ukraine in 2022, wage delays at Ukrainian enterprises have increased, due to business cuts, reduced orders and late fulfilment of obligations by contractors, and reduced state capacity to provide guarantees and timely financing of state-owned enterprises (Table 1). Most of these factors are due, among other things, to the martial law imposed on the territory of Ukraine (Kuzior et al., 2022b).

Table 1. Causes of wage delays for active enterprises in Ukraine as of January 2, 2023. *(Source: State Labor Service of Ukraine)*

Cause of wage delays	Total amount of delays (UAH thousand)
Reduction of production volumes	13,101,000.00
No information provided	11,309,000.00
Decrease in orders for goods and services	10,600,000.00
Insufficient funding under the medical guarantee program from the National Health Service of Ukraine	5,616,000.00
Late (incomplete) payment by the customer for the work performed	878,000.00
There is no state order	521,000.00

To maintain the financial stability of enterprises during a difficult period of war, avoid social explosions and mass labour migration, and prevent a wave of massive bankruptcies that would be disastrous for a country at war, it is necessary to clearly understand the amount of reserves that should be formed in companies of various economic activity types to ensure timely payment of wages.

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LITERATURE REVIEW

Threats of late wage payments need to be considered in different contexts: both at the macro level, taking into account the cumulative social and economic consequences, and at the micro level, through the impact on the functioning of an individual company.

The macroeconomic risks of wage delays in economic entities, especially when they are massive or accumulate in a cascading manner, pose threats both to the financial stability of households (Didenko et al., 2020; Hara 2023), and also to the country's economic growth (Mursalov et al, 2023; Youcef 2023a; Zolkover et al., 2022). They can become catalysts for social stratification and inequality (Kuzior et al., 2022d; Court et al, 2023), and may also exacerbate the problem of social justice in society (Vasylieva et al., 2023; Tiutiunyk et al., 2022; Lyeonov et al., 2022).

At the micro level, wage delays pose a threat to motivation and productivity, as well as to employee turnover (Kuzior et al., 2023a; Prokopenko et al., 2023). If employees are dissatisfied with the remuneration level or there are wage delays, their productivity, work enthusiasm and creativity decrease (Rajan 2023; Youcef 2023b). At the same time, distrust in the employer increases, strikes are more likely, there is a risk of losing experienced and highly skilled workers, and the employer's reputation suffers, which can lead to significant economic losses for the enterprise (Fowler 2023; Zhuchenko et al. 2023; Wansi et al. 2023).

During unstable periods for the economy, staff losses due to dissatisfaction with the remuneration level or payment delays can become central (AL-Hashimi et al., 2023; Bekhouche et al., 2023; Bilan et al., 2023; Brychko et al., 2023; Kaya, 2023; Kuzior et al., 2022c). Oe et al., 2023, came to an interesting conclusion that manufacturing companies are more flexible in responding to labour demand fluctuations than non-manufacturing companies. This conclusion is based on a comparison of approaches to HR policies in manufacturing and non-manufacturing companies. The research is based on the HR Analysis in Companies 2023 survey conducted by Gi Group/Grafton Recruitment at the end of 2022. The survey covers 478 companies of various types in all regions of the Czech Republic.

The absence of wage delays is the key to building a favourable working environment (Mullens et al., 2023; Skrynnyk, 2023), ensuring a company's financial stability, and maintaining good relations between employers and employees, which is a crucial aspect of a stable and successful business (Benghebrid et al., 2023).

Employee attitudes toward employee evaluation systems are studied by Kuzior et al. (2022a) and Alieksieiev et al. (2023) based on various criteria: fairness, transparency, usefulness, and impact on motivation using a sociological survey. The results revealed ambiguous attitudes of employees towards evaluation systems: employees who believe that the evaluation system is fair are more motivated and productive; employees who believe that the evaluation system is transparent trust their management more; employees who receive constructive feedback are more satisfied with their work.

The relationship between wages and productivity was studied by Kuznyetsova et al., (2017) using 14 developed European countries as an example. The author's conclusions showed that higher wages increase productivity regardless of aggregate demand, wages have a constant and direct positive impact on productivity both at the country level and at the level of individual industries. Even with slow wage growth, this effect remains stable over time. In addition, it has been proven that higher wages stimulate innovation more effectively.

Wolf (2023) confirms the leading role played by salaries, bonuses, and other financial rewards in increasing employee motivation, engagement, business efficiency, and maintaining work-life balance.

The size of wages also impact greatly the formation of employee's financial behavior and self-efficacy, which Pozovna et al. (2023) consider through the prism of cognitive biases, Didenko et al. (2023) – through financial inclusion and financial literacy.

Malyarets et al., (2021) conducted a study to identify the determinants of wage delays among migrants, identify possible impacts on economic well-being, and develop subjective indicators of well-being.

AIMS AND OBJECTIVES

The purpose of the study is to determine (using the Monte Carlo simulation) the amount of reserves that should be formed by Ukrainian business entities in various areas of economic activity in order to prevent the possible accumulation of wage delays.

METHODS

In the modelling process, we will use macroeconomic indicators by type of economic activity for wage delays in Ukraine as of the first day of the month (UAH million) by the Ukrainian Classification of Economic Activities 2010 (NBU, 2022), that is aligned with the Statistical Classification of Economic Activities in the European Community (NACE).

The study uses historical wage delay data for the period from February 2013 to February 2022 for 6 economic activity types:

1. Information and Communication (K1);
2. Financial and Insurance Activities (K2);
3. Real Estate Activities (K3);
4. Professional, Scientific and Technical Activities (K4);
5. Scientific Research and Development (K5);
6. Human Health and Social Work Activities (K6).

To calculate the risk of wage non-payment, the Monte Carlo method was used, which, using statistical simulation modelling, allows obtaining high accuracy of the risk probable values. Its main advantages are:

- flexibility (can be used to evaluate various risk types based on modelling numerous uncertainties and variations in input parameters);
- versatility (can be used for risk assessment in various industries – finance, engineering, medicine, economics);
- inclusion of the heterogeneity of risks and their interconnectedness;
- easy modification of input indicators and their distributions to evaluate the impact of changes in conditions or risk factors, i.e., conducting a "what-if" analysis and identifying critical factors affecting risks.

Monte Carlo simulation is a computational method that uses a representative random sample to produce numerical results. The basic idea is to use randomness to solve problems that may be non-deterministic. The Monte Carlo method is mainly used in three classes of problems: optimization, numerical integration, and generating results based on a probability density function. Thus, the concept of the method is to generate large arrays of random numbers, which are then used to evaluate or simulate probabilistic phenomena (Kuzior et al., 2023b). The more random numbers used, the more accurate the results will be. This statement is based on the law of large numbers. It has been established that the arithmetic means of a random variable X, observed in a sufficiently large number of experiments, practically stops being a random variable and is a certain value that is considered to be the mathematical expectation M(X) of a random variable (e.g., average salary, average income). This property is called the stability of the mean.

The general scheme of the Monte Carlo method is based on the central limit theorem, which explains the normal distribution of most random phenomena (Tirnakly et al., 2021). Its meaning is as follows: if independent random variables

X_1, X_2, …, X_n have finite mathematical expectations $M(X)$ and variances $D(X)$, which are respectively equal to m_1, m_2, …, m_n and σ_1^2, σ_2^2, …, σ_n^2, and their number is large enough, with unlimited growth of n

$$\lim_{n\to\infty} \frac{\mu_1+\mu_2+\cdots+\mu_n}{\sqrt{(\sigma_1^2+\sigma_2^2+\cdots+\sigma_n^2)^3}} = 0, \quad (1)$$

where μ_1, μ_2, …, μ_n *is the third central moment, then the sum of random variables* X_1, X_2, …, X_n *is distributed with a sufficient degree of accuracy according to a normal distribution law with parameters* $m = m_1 + m_2 + \cdots + m_n$, $\sigma = \sigma_1^2 + \sigma_2^2 + \cdots + \sigma_n^2$.

The meaning of Theorem (1) is that the effect of any random variable term is small compared to the total effect of all these terms.

The risk of non-payment of wages was assessed using MS Excel software.

First, the input values are converted to the natural logarithm LN and the average value (AVG) and standard deviation (σ) are determined. This value is used to search for random variables of wage delays within the relevant type of economic activity by using the built-in function LOGNORM.INV. This function returns the inverse function of the integral lognormal distribution x, where $ln(x)$ has a normal distribution with parameters "mean" and "standard deviation".

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The lognormal distribution characterizes a random variable *X*, whose logarithm is distributed according to the normal distribution law with parameters m and σ. The density of the distribution of the variable $Z = \ln(X)$ is as follows:

$$f(z) = \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{(Z-m)^2}{2\sigma^2}} \quad (2)$$

where m is the mathematical expectation of Z, and σ^2 is the variance of Z.

Then the random variable $X = e^Z$ is distributed according to a lognormal distribution:

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} \cdot e^{-\frac{1}{2}\left(\frac{ln(x)-m^*}{\sigma^*}\right)^2}, 0 < x < +\infty \quad (3)$$

where

$$m^* = e^{m+\frac{\sigma^2}{2}} \quad (4)$$

$$\sigma^{2*} = e^{2m+\sigma^2}(e^{\sigma^2} - 1) \quad (5)$$

Next, a random number generator is created based on the data of the significance level, p-value (calculated by dividing the frequency of the delay occasions by the number of occasions) and the number of required generated values (value is user-defined) using the built-in MS Excel function BINOM.INV. This function returns the smallest value for which the integral binomial distribution is greater than or equal to the specified criterion value.

$$f_{bin}(k|n,p) = \binom{n}{k} p^k (1-p)^{n-k}, \quad (6)$$

where $\binom{n}{k}$ is the number of combinations for n choose k (combinations of n objects taken k at a time), the binominal coefficient, n is the number of trials, and p is the probability of success for each trial.

The binomial coefficient is calculated using the formula:

$$\binom{n}{k} = C_n^k = \frac{n!}{k!(n-k)!} \quad (7)$$

This is how it is determined if there was a failure to pay wages in the respective month or not. A fragment of a random event generator is shown in Table 2. Cells with a «-» symbol indicate a situation where the random event characterizing wage delay does not occur.

Table 2. A fragment of a random event generator. Note: K1 – Information and Communication; K2 – Financial and Insurance Activities; K3 – Real Estate Activities; K4 – Professional, Scientific and Technical Activities; K5 – Scientific Research and Development; K6 – Human Health and Social Work Activities. *(Source: built by the authors using a lognormal distribution of input data (6, 7))*

K1	K2	K3	K4	K5	K6
-	1	-	-	-	1
-	1	-	-	-	1
-	-	1	-	-	1
1	1	-	1	-	1
-	1	-	-	-	1

The next step is to determine the average losses (non-payment of wages) for all six types of activities. This is done by multiplying the data sets generated by the BINOM.INV and LOGNORM.INV functions and determining the maximum value of losses. In order to determine the reserves needed to cover possible wage delays in case of a risk situation, one need to use the built-in Percentile function. It flexibly allows changing the percentage of situations where there is a risk of wage non-payment. For example, the syntax "Percentile (Losses; 99,9%)" defines how much money you need to cover the debt in 99.9% of situations; "Losses" is the name of a range of 10000 average losses (wage non-payments).

RESULTS

A fragment of the input sample of historical data on wage delays is presented in Table 3.

Table 3. The amount of wage delays within the relevant type of economic activity in Ukraine, UAH million. Note: K1 – Information and Communication; K2 – Financial and Insurance Activities; K3 – Real Estate Activities; K4 – Professional, Scientific and Technical Activities; K5 – Scientific Research and Development; K6 – Human Health and Social Work Activities; AVG – average value of debt for the relevant type of economic activity, UAH million; Sum – total amount of debt for the relevant type of economic activity, UAH million. *(Source: built by the authors using NBU data, 2022)*

Month, year	K1	K2	K3	K4	K5	K6
February 2013	0.8	5.2	38.3	85.8	50.9	10.6
March 2013	0.8	4.4	44.1	95.0	57.3	10.1
April 2013	0.7	4.5	45.1	91.0	54.3	8.9
May 2013	1.1	4.3	46.2	85.1	52.5	7.9
June 2013	1.0	4.2	41.8	88.5	56.1	4.1
July 2013	1.4	4.0	40.0	89.8	56.2	4.2
August 2013	1.1	4.0	39.6	89.1	55.4	3.4
September 2013	1.2	4.0	40.7	93.9	59.4	3.5
October 2013	1.2	4.0	40.3	95.8	59.2	4.1
November 2013	0.9	4.1	38.8	101.0	61.9	3.1
December 2013	1.4	4.1	35.6	98.2	58.3	5.9
…	…	…	…	…	…	…
January 2021	9.0	16.0	54.0	267.0	193.0	32.0
February 2021	10.6	0.4	36.5	272.1	188.1	53.1
March 2021	13.5	0.2	36.0	259.2	206.6	61.3
April 2021	13.0	0.2	36.0	251.0	202.0	51.0
May 2021	15.3	0.2	36.5	256.4	203.9	72.4
June 2021	15.9	0.2	41.0	274.3	215.5	69.7
July 2021	15.7	0.7	39.0	305.6	240.5	84.1
August 2021	15.6	2.3	38.5	329.8	261.8	108.5
September 2021	15,9	4.1	39.4	310.2	245.1	131.3
October 2021	15.7	6.5	37.1	290.4	219.6	124.9
November 2021	16.5	7.5	37.4	286.9	217.6	152.9
December 2021	16.3	9.2	37.5	308.5	231.0	126.6
January 2022	18.0	9.5	35.2	274.3	205.9	50.8
February 2022	8.2	0.3	148.8	157.5	112.3	97.6
Sum	704.6	1301.5	4380.3	16,400.4	9371.2	3392.8
AVG	6.5	11.9	40.2	150.5	86.0	31.1

The calculation for each type of economic activity was performed for model cases with wage delays of 100%, 75%, 50%, 25%, 20%, and 10% of the total amount.

The parameters of the built Monte Carlo simulation model are presented in Table 4.

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Table 4. The parameters of the Monte Carlo simulation model. Note: trials binomial – the number of modelling iterations; p-value binomial – the level of significance (calculated by dividing the probability of delay occurrence by the number of iterations); input lognormal mean – the average values of logarithmic input historical indicators, UAH million; input lognormal st. dev – the calculated standard deviations of the lognormal distribution, UAH million. *(Calculated by the authors using MS Excel software based on NBU data, 2022.*

Risk:	K1	K2	K3	K4	K5	K6
Trials binomial	10,000	10,000	10,000	10,000	10,000	10,000
p value binomial	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Input lognormal mean	1.59	2.18	3.55	4.94	4.27	2.9321
Input lognormal st. dev.	0.80	1.07	0.58	0.37	0.58	0.9667

The results of the simulation for the model case when wage delays are 25% of the total amount are shown in Table 5.

Table 5. The results of the Monte Carlo simulation for the model case when wage delays are 25% of the total amount. Note: Count "Losses" – the number of cases; Maximum "Losses" – the maximum debt of wage non-payments, UAH million; Percentile 99.9 determines the amount of funds (UAH million) that will be enough to pay wages for 9990 cases out of 10,000. *(Calculated by the authors using MS Excel software based on NBU data, 2022)*

Monte Carlo Simulation Results of 25%	
Count "Losses"	10,000
Maximum "Losses",	1197.16
Percentile 99.9	736.67

Monte Carlo simulations for economic activities K1, K2, K3, K4, K5, and K6 showed that the maximum wage debt for the model case, when wage delay is 25% of the total amount, could reach UAH 1197.16 million. This is the cumulative debt for all six types of economic activity. The percentile value of 99.9 shows that with a probability of 0.999, the debt will not exceed UAH 736.67 million. That is, in 9990 cases out of 10,000, UAH 736.67 million will be enough to pay wages.

The simulation data for each indicator K1–K6 for the model case when wage delays are 25% of the total amount are shown in Table 6.

Table 6. Simulation data for economic activities K1–K6 for the model case when wage delays are 25% of the total amount. Note: K1 – Information and Communication; K2 – Financial and Insurance Activities; K3 – Real Estate Activities; K4 – Professional, Scientific and Technical Activities; K5 – Scientific Research and Development; K6 – Human Health and Social Work Activities. Percentile 99.9 determines the amount of funds (UAH million) that will be enough to pay wages for 9990 cases out of 10,000; Max – the maximum value of the debt, UAH million; AVG – the average value of debt, UAH million. *(Calculated by the authors using MS Excel software based on NBU data, 2022)*

	K1	K2	K3	K4	K5	K6
Percentile 99.9	60.5156	192.7078	167.1382	683.0222	530.5932	245.8756
Max	68.9895	442.6760	190.2175	834.2423	551.2362	258.1213
AVG	1.7182	4.0099	11.3936	40.64381	20.39361	7.391894

So, the 99.9th percentile determines how much money you need to have to cover your debts for 9990 situations.

The "Maximum Value" indicator defines the largest value of potential delays in the dataset, and the "Average Value" indicator shows the average value of delays for the relevant economic activity.

The difference between the 99.9th percentile and the maximum value can be used to identify outliers and potential problem areas. If the 99th percentile is higher than the maximum value, then there are outliers that have a significant impact on the mean, which in turn can lead to incorrect modelling results. In such circumstances, anomalous cases should be taken into account and the indicators that caused these outliers should be thoroughly examined.

For all six types of economic activity, the value of the 99.9th percentile is below the maximum, which indicates that the modelling was correct.

Similar calculations were made for model cases where wage delays are 10%, 20%, 50%, 75%, and 100% of the total amount (Tables 7–8).

Table 7. Simulation data for economic activities K1–K6 for model cases when wage delays are 10%, 20%, 50%, 75%, 100% of the total amount. Note: K1 – Information and Communication; K2 – Financial and Insurance Activities; K3 – Real Estate Activities; K4 – Professional, Scientific and Technical Activities; K5 – Scientific Research and Development; K6 – Human Health and Social Work Activities. Percentile 99.9 determines the amount of funds (UAH million) that will be enough to pay wages for 9990 cases out of 10,000; AVG_ model – average value of debt calculated by the model, UAH million; AVG_real – average value of debt as to statistical data for the February 2013 – February 2022 time period. *(Calculated by the authors using MS Excel software based on NBU data, 2022)*

10%	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
Percentile 99.9	15.7811	102.1495	131.6212	415.6810	272.0955	229.3258
Max	30.8164	234.7421	134.6531	518.9005	336.5755	249.3407
AVG	0.5312	1.43072	4.32628	15.01130	9.635096	3.499756
20%	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
Percentile 99.9	42.0504	176.2946	174.9519	453.8290	283.4725	295.9194
Max	76.6548	693.9817	226.1302	696.4128	354.0441	307.2431
AVG	1.5284	4.0184	8.5267	32.1552	14.8837	6.5038
50%	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
Percentile 99.9	66.8766	190.0480	318.5469	1037.5070	531.7454	215.0649
Max	110.7419	262.4425	525.0633	1151.3608	799.0092	275.3753
AVG	3.4090	7.9557	21.5010	78.6734	42.0227	13.7065
75%	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
Percentile 99.9	75.7885	366.7116	343.6763	928.2078	938.0118	298.3338
Max	97.5229	501.6813	348.0593	1313.7366	2064.2536	467.4844
AVG	5.1810	12.6946	30.5506	106.2799	70.2258	20.4894
100%	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
Percentile 99.9	76.9139	421.8532	473.1466	973.6442	956.3400	455.4009
Max	114.4238	562.0637	512.1492	1453.4064	1204.7092	487.2504
AVG_model	6.4901	15.6180	44.0566	150.4307	92.2794	28.8924
AVG_real	6.5	11.9	40.2	150.5	86.0	31.1

Table 8. Results of Monte Carlo simulation for the model cases when wage delays are 10%, 20%, 50%, 75%, 100% of the total amount. Note: Count "Losses" – the number of cases; Maximum "Losses" – the maximum debt of wage non-payments, UAH million; Percentile 99.9 determines the amount of funds (UAH million) that will be enough to pay wages for 9990 cases out of 10,000. *(Calculated by the authors using MS Excel software based on NBU data, 2022)*

Monte Carlo Simulation Results of 10%	
Count "Losses"	10,000
Maximum "Losses"	709.62
Percentile 99.9	479.52
Monte Carlo Simulation Results of 20%	
Count "Losses"	10,000
Maximum "Losses"	1108.94
Percentile 99.9	617.08
Monte Carlo Simulation Results of 50%	
Count "Losses"	10,000
Maximum "Losses"	2048.79
Percentile 99.9	1165.98
Monte Carlo Simulation Results of 75%	
Count "Losses"	10,000
Maximum "Losses"	2100.58
Percentile 99.9	1259.45
Monte Carlo Simulation Results of 100%	
Count "Losses"	10,000
Maximum "Losses"	2126.81
Percentile 99.9	1670.48

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The developed Monte Carlo simulation models (Tables 7 and 8) determine the optimal amount of funds that should be reserved to prevent wage delays in the considered economic activities.

Thus, the obtained results allowed us to determine with a high probability the optimal amount of funds that enterprises of specific economic activity types should hold in the reserve in order to avoid wage delays. The types of economic activity under consideration are information and communication; financial and insurance activities; real estate activities; professional, scientific and technical activities; scientific research and development; and human health and social work activities. This, in turn, will catalyze increasing labour productivity and efficiency.

DISCUSSION

The research methodology proposed in this paper differs from the considered and widely used methods of studying wage delays in that it uses the Monte Carlo approach to find the values of delays. Its uniqueness and peculiarity is the high accuracy of the results obtained since a large simulation sample (10,000 months in size, forecast for 833 years) is used in the process of risk assessment, which is based on the lognormal distribution of the input historical statistical data on wage non-payments in specific economic activities. The use of the Monte Carlo method allows for a more realistic and comprehensive analysis of the delay processes.

In addition, the approach outlined in this paper has a number of additional advantages:

1. Firstly, it is more accurate, as it is based on the statistical distribution of the generated sample and allows determining the probability of risk occurrence than other approaches to risk assessment (SWOT analysis, expert evaluation, scenario analysis, hierarchical risk assessment by degree of importance, ranking and comparison).
2. Secondly, it is more flexible, as it can be used to study different processes of risk situations (Djalilov et al. 2015; Zatonatskiy & Lieonov, 2024).
3. Thirdly, it is more efficient because it can be used to study a large array of possible outcomes in a short period of time.

CONCLUSIONS

Based on the results of the developed simulation model, which is based on the application of the Monte Carlo method, the maximum values of wage delays are obtained for model cases when the delays are 10%, 20%, 50%, 75%, 100% of the total amount. Simulation modelling was carried out for six types of economic activity: financial and insurance activities; professional, scientific and technical activities; information and communication; scientific research and development; real estate activities; and human health and social work activities. Calculations were made both for these types of economic activities together and separately for each type.

With the worst-case scenario of 100% wage delays, the generated model determines the maximum possible costs for all types of economic activity – UAH 2126.81 million, with UAH 1670.48 million to be reserved for 9990 cases of wage payments.

Monte Carlo simulation modelling at 100% probability of monthly delays showed that the average delays are quite close to the actual historical values during the considered period. Thus, the indicator (K1) has a real average value of UAH 6.5 million, while the modelled value was UAH 6.49 million. For the indicator (K2), the historical value is UAH 11.9 million, and the modelled value is UAH 15.61 million. The historical value of K3 is UAH 40.2 million, while the simulated value is UAH 44.05 million. The historical value of wage arrears for K4 is UAH 150.5 million, while the modelled value is UAH 150.43 million. The actual value of K5 is UAH 86.0 million, while the modelled value is UAH 92.27 million. The real value for K6 is UAH 31.1 million, and the simulated value is UAH 28.89 million. Therefore, the results of the simulation modelling are highly accurate and allow us to determine the probability of wage non-payments.

When considering each of the six types of economic activity separately, two stand out (K4 – professional, scientific and technical activities; and K5 – scientific research and development), as the average rate of wage delays in these types of economic activity is much higher than in the others.

The Percentile 99.9% indicators for K4 (973.6442) and K5 (956.3400) are relatively close to each other. The 99.9% Percentile indicators for K2 – financial and insurance activities (421.8532), K3 – real estate activities (473.1466), and K6 – human health and social work activities (455.4009) are relatively similar according to the results of the calculations. It

was also found that the maximum values in all six types of economic activity are significantly higher than the average values. This means that in each industry there are several extreme values of wage non-payments according to historical data in which the budget consolidation falls on October–December.

It is important to note that these are only projections, and the actual impact of a wage delay on spending may vary depending on a number of factors, such as the specific industries involved and the overall economic climate, public financing, and private investment. The model is based on a specific dataset and does not cover all economic activities.

Having indicators of possible delays for the whole group of activities and for the specific types, top managers and analysts can better prepare for the prevention of such situations and develop strategies and policies aimed at their avoidance.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

Conceptualization: *Vitaliia Koibichuk, Serhii Drozd*
Data curation: *Serhii Drozd, Bhola Khan, Tatyana Kostyshyna, Zuzana Kubaščíková*
Formal Analysis: *Dariusz Krawczyk*
Methodology: *Vitaliia Koibichuk, Tatyana Kostyshyna, Zuzana Kubaščíková*
Resources: *Vitaliia Koibichuk, Serhii Drozd, Bhola Khan, Zuzana Kubaščíková*
Supervision: *Tatyana Kostyshyna*
Validation: *Vitaliia Koibichuk, Dariusz Krawczyk, Bhola Khan, Zuzana Kubaščíková*
Investigation: *Bhola Khan*
Visualization: *Serhii Drozd*
Project administration: *Dariusz Krawczyk, Bhola Khan, Zuzana Kubaščíková*
Funding acquisition: *Dariusz Krawczyk, Tatyana Kostyshyna*
Writing – review & editing: *Bhola Khan*
Writing – original draft: *Vitaliia Koibichuk, Serhii Drozd, Bhola Khan*

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The Authors declare that there is no conflict of interest.

REFERENCES

1. AL-Hashimi, Y.N., AL-Toobi, J.S., & Ahmed, E.R. (2023). The Influence of Corporate Governance on Firm Performance During the COVID-19 Pandemic. *Financial Markets, Institutions and Risks, 7*(1), 109-122. https://doi.org/10.21272/fmir.7(1).109-122.2023
2. Alieksieiev, I., Węcławski, J., Kurylo, O., & Chaus, O. (2023). Family businesses in Ukraine and abroad: comparison of research areas. *Socio-Economic Relations in the Digital Society, 2*(48), 2-11. https://doi.org/10.55643/ser.2.48.2023.488
3. Bilan, Y., Tiutiunyk, I., Lyeonov, S., & Vasylieva, T. (2020). Shadow economy and economic development: A panel cointegration and causality analysis. *International Journal of Economic Policy in Emerging Economies, 13*(2), 173-193. https://doi.org/10.1504/IJEPEE.2020.107929
4. Bekhouche, F., & Boukhedimi, F. (2023). The Contribution of Employee Financial Participation to the Governance of the SME in Algeria. *Financial Markets, Institutions and Risks, 7*(4), 24-37. https://doi.org/10.61093/fmir.7(4).24-37.2023
5. Benghebrid, R., & Sahnouni, M. (2023). Telework: What is impact on the Algerian employee*? Socio-Economic Challenges, 7*(3), 55-62. https://doi.org/10.61093/sec.7(3).55-62.2023
6. Brychko, M., Bilan, Y., Lyeonov, S., & Streimikiene, D. (2023). Do changes in the business environment and sustainable development really matter for enhancing enterprise development? *Sustainable Development, 31*(2), 587-599. https://doi.org/doi:10.1002/sd.2410
7. Court, T. O. (2022). Demographic Characteristics and Job Satisfaction: The Mediation Role of Organisational Justice Perceptions in Public and Private Sector Health Organisations in Nigeria. *Health Economics and Management Review, 3*(4), 1-14. https://doi.org/10.21272/hem.2022.4-01

DOI: 10.55643/fcaptp.2.55.2024.4384

8. Didenko, I., Petrenko, K. & Pudlo, T. (2023). The role of financial literacy in ensuring financial inclusion of the population. *Financial Markets, Institutions and Risks, 7*(2), 72-79. https://doi.org/10.21272/fmir.7(2).72-79.2023

9. Djalilov, K., Lyeonov, S., & Buriak, A. (2015). Comparative studies of risk, concentration and efficiency in transition economies. *Risk Governance and Control: Financial Markets and Institutions, 5(4CONT1)*, 178-187. https://doi.org/10.22495/rgcv5i4c1art7

10. Didenko, I., Volik, K., Vasylieva, T., Lyeonov, S., & Antoniuk, N. (2020). Migration, environment, and country safety: Analysis of touchpoints. *Paper presented at the E3S Web of Conferences, 202.* https://doi.org/10.1051/e3sconf/202020203028

11. Fowler, D.S. (2023). Ethical Implications of Deceptive Earnings Management Practices. *Business Ethics and Leadership, 7*(3), 84-96. https://doi.org/10.61093/bel.7(3).84-96.2023

12. Mullens, D., & Shen, S. (2023). Sustainable and entrepreneurial: a path to performance improvements for family firms? *Socio-Economic Challenges, 7*(4), 54-65. https://doi.org/10.61093/sec.7(4).54-65.2023

13. Hara, M. (2023). Official Development Assistance and Middle-Income Trap in the Philippines: effects, challenges, and strategies. *Socio-Economic Challenges, 7*(2), 1-20. https://doi.org/10.21272/sec.7(2).1-20.2023

14. Kaya, H. D. (2023). The Impact of the 2008-2009 Global Crisis on Loan Applications and Access to Finance. *Financial Markets, Institutions and Risks, 7*(2), 12-17. https://doi.org/10.21272/fmir.7(2).12-17.2023

15. Kuzior, A., Koibichuk, V., Drozd, S., Grytsyshen, D., & Vasylieva, T. (2023a). Determinants of labor productivity in the USA. *Problems and Perspectives in Management, 21*(4), 724-739. https://doi.org/10.21511/ppm.21(4).2023.54

16. Kuzior, A., Kostenko, A., Sotnyk, I., Chortok, Y., Tuliakov, O., & Podmanicka, M. (2023b). Socioeconomic sustainability and the solidarity economy formation under the war conditions in Ukraine. *Financial and Credit Activity Problems of Theory and Practice, 5(52),* 256–267. https://doi.org/10.55643/fcaptp.5.52.2023.4132

17. Kuzior, A., Ober, J., & Karwot, J. (2022a). Employee Attitudes towards Employee Evaluation Systems in the Utility Sector: A Case Study of Sewage and Water Supply Ltd., Rybnik, Poland. *Sustainability, 14*(19), 12436. http://dx.doi.org/10.3390/su141912436

18. Kuzior, A., Krawczyk, D., Didenko, I., Sidelnyk, N., & Vasylieva, T. (2022b). Interaction between health insurance, household income, and public health financing in Ukraine. *Problems and Perspectives in Management, 20*(4), 436-450. https://doi.org/10.21511/ppm.20(4).2022.33

19. Kuzior, A., Didenko, I., Vorontsova, A., Lyeonov, S., & Brożek, P. (2022c). Managing educational determinants of financial inclusion as a key factor of sustainable development: logit-probit modeling. [Zarządzanie edukacyjnymi determinantami integracji finansowejjako kluczowego czynnika zrównoważonego rozwoju: modelowanie logit-probit] *Polish Journal of Management Studies, 26*(2), 265-279. https://doi.org/10.17512/pjms.2022.26.2.16

20. Kuzior, A., Arefieva, O., Kovalchuk, A., Brożek, P., & Tytykalo, V. (2022d). Strategic Guidelines for the Intellectualization of Human Capital in the Context of Innovative Transformation. *Sustainability, 14*(19), 11937. http://dx.doi.org/10.3390/su141911937

21. Kuzior, A., Postrzednik-Lotko, K. A., Smołka-Franke, B., & Sobotka, B. (2023b). Managing Competences of Generation Y and Z in the Opinion of the Management Staff in the Modern Business Services Sector. *Sustainability, 15*(7), 5741. http://dx.doi.org/10.3390/su15075741

22. Kuznyetsova, A., Misiats, N., Klishchuk, O. (2017). The equilibrium model of demand and supply at the Ukrainian Interbank Foreign Exchange Market: disclosure of problematic aspects. *Banks and Bank Systems, 12*(4), 31-43. https://doi.org/10.21511/bbs.12(4).2017.03

23. Lyeonov, S., Tiutiunyk, I, Vasekova, M., Dziubenko, O., & Samchyk, M. (2022). Tax, investment, institutional and social channels of economic shadowing: Challenges for macro-financial stability and good governance. *Public and Municipal Finance, 11*(1), 128-141. https://doi.org/10.21511/pmf.11(1).2022.11

24. Malyarets, L.M., Koibichuk, V.V., Zhukov, A.V., & Grynko, P.O. (2021). Diagnostics of Efficiency of an Enterprise's Export-import Activity. *Montenegrin Journal of Economics, 17*(1), 71-83. https://doi.org/10.14254/1800-5845/2021.17-1.5

25. Mursalov, M., Yarovenko, H., & Vasilyeva, T. (2023). Entrepreneurial Ecosystem and Digitalization: Relationship and Synergy of Development. In: Strielkowski, W. (eds) Leadership, Entrepreneurship and Sustainable Development Post COVID-19. NILBEC 2022. Springer Proceedings in Business and Economics. Springer, Cham. https://doi.org/10.1007/978-3-031-28131-0_9

26. National Bank of Ukraine. (2022). Wage delays. https://bank.gov.ua/ua/statistic/macro-indicators

27. Oe, H., & Yamaoka, Y. (2023). Organisational performance in the post-COVID era led by top leadership: Focus on the mediating effects of value co-creation mindset. *Health Economics and Management Review, 4*(3), 34-47. https://doi.org/10.61093/hem.2023.3-03

28. Prokopenko, O., Garafonova, O., & Zhosan, H. (2023). Digital tools in human resource management: how digitization affects personnel management. *Socio-Economic Relations in the Digital Society, 4*(50), 84-94. https://doi.org/10.55643/ser.4.50.2023.540

29. Pozovna, I., Hałuszko, K., & Polishchuk, A. (2023). Modelling structural relations between financial, social-economic and healthcare factors. *Health Economics and Management Review, 4(4),* 107-119. https://doi.org/10.61093/hem.2023.4-09

30. Rajan, D. (2023). Shift work, workload, and professionalism related motivators affecting job satisfaction: An empirical study among medical laboratory technicians. *Health Economics and Management Review, 4*(3), 1-21. https://doi.org/10.61093/hem.2023.3-01

31. Skrynnyk, O. (2023). Prediction of Convergent and Divergent Determinants of Organisational Development. *Business Ethics and Leadership, 7*(1), 74-81. https://doi.org/10.21272/bel.7(1).74-81.2023

32. Tiutiunyk, I. V., Zolkover, A. O., Lyeonov, S. V., & Ryabushka, L. B. (2022). The impact of economic shadowing on social development: challenges for macroeconomic stability. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 1*, 183-191. https://doi.org/10.33271/nvngu/2022-1/183

33. Vasylieva, T., Witczak-Smolnik, W., Tiutiunyk, I., & Filep, B. (2023). Social and economic determinants of quality of life: Case of European countries. *Economics and Sociology, 16*(4), 289-308. https://doi.org/10.14254/2071-789X.2023/16-4/14

34. Wansi, T., & Burrell, D. (2023). Financing Challenges of Cameroon's Small and Medium Enterprises (SMEs). *Financial Markets, Institutions and Risks, 7*(4), 88-104. https://doi.org/10.61093/fmir.7(4).88-104.2023

35. Wolf, M. (2023). Shared Leadership and Employee Satisfaction in China: A Multiple Correspondence Analysis of Gender and Education Aspects of Participative Leadership Models. *Business Ethics and Leadership, 7*(4), 37-45. https://doi.org/10.61093/bel.7(4).37-45.2023

36. Youcef, A. (2023a). The effect of quality of work life on creative behavior of professors at the Kasdi Merbah Ouargla university's Faculty of Applied Sciences. *Socio-Economic Challenges, 7*(4), 8-23. https://doi.org/10.61093/sec.7(4).8-23.2023

37. Youcef, A. (2023b). The Effect of Job Satisfaction on Work Accidents: Empirical Study in Algerian Electricity and Gas Company – Hassi Messaoud. *Business Ethics and Leadership, 7*(4), 1-13. https://doi.org/10.61093/bel.7(4).1-13.2023

38. Zatonatskiy, D., & Lieonov, S. (2024). Progressive practices of implementing public-private partnership projects in critical infrastructure. *Socio-Economic Relations in the Digital Society, 1*(51), 59-72. https://doi.org/10.55643/ser.1.51.2024.554

39. Zolkover, A., Tiutiunyk, I., Babenko, V., Melnychuk, M., Ivanchenkova, L., & Lagodiienko, N. (2022). The Quality of Tax Administration. *Macroeconomic Stability and Economic Growth: Assessment and Interaction, 20*. https://doi.org/10.55365/1923.x2022.20.76

40. Zhuchenko, S., Kubaščikova, Z., Samoilikova, A., Vasylieva, T., & D'yakonova, I (2023). Economic growth and housing spending within social protection: Correlation and causal study. *Public and Municipal Finance, 12*(1), 73-85. https://doi.org/10.21511/pmf.12(1).2023.07

Койбічук В., Кравчик Д., Дрозд С., Кхан Б., Костишина Т., Кубащикова З.

РЕЗЕРВИ ДЛЯ ЗАПОБІГАННЯ ЗАТРИМОК ЗАРОБІТНОЇ ПЛАТИ: ІМІТАЦІЙНЕ МОДЕЛЮВАННЯ ЗА ДОПОМОГОЮ МЕТОДУ МОНТЕ-КАРЛО

Зарплата як джерело покриття базових потреб багатьох домогосподарств у значній мірі визначає продуктивність роботи працівника, робочий ентузіазм і творчу активність. Якщо працівник не задоволений рівнем оплати праці або мають місце затримки виплати заробітної плати, то зростає недовіра до роботодавця, імовірність страйків, ризик втрати досвідчених та висококваліфікованих працівників, страждає репутація роботодавця, що може призвести до значних економічних втрат для підприємства. У дослідженні за допомогою методу імітаційного моделювання Монте-Карло визначено, у яких обсягах мають бути сформовані резерви суб'єктів господарювання, що представляють різні напрями економічної діяльності, для того щоб запобігти можливому накопиченню заборгованості на оплату праці працівників. Імітаційне моделювання здійснене для таких напрямів економічної діяльності як: інформація та телекомунікації; фінансова й страхова діяльність; операції з нерухомим майном, професійна, наукова й технічна діяльність; наукові дослідження та розробки; охорона здоров'я та надання соціальної допомоги. У процесі моделювання розглядаються модельні випадки, коли заборгованість із виплати зарплати становитиме 10%, 20%, 25%, 50%, 75%, 100% від загальної суми. Дослідження проведене на прикладі України на основі статистичних даних Національного банку України. Оскільки воєнні дії на території України суттєво вплинули на функціонування всіх галузей української економіки, горизонт дослідження обмежений довоєнним періодом: із лютого 2013 р. по лютий 2022 р. Аналіз засвідчив, що в Україні найбільші затримки виплат заробітної плати мають місце в галузях, що фінансуються з державного бюджету: професійна, наукова й технічна діяльність; наукові дослідження та розробки; охорона здоров'я та надання соціальної допомоги. Ця проблема особливо загострюється й унаслідок тотального дефіциту бюджету під час війни. Виходячи з цього, представлені в цій статті результати імітаційного моделювання для різних сценаріїв можуть бути використані при плануванні державного бюджету та формуванні державних резервів.

Ключові слова: заборгованість, заробітна плата, державний бюджет, імітаційна модель, Монте-Карло, оплата праці.

JEL Класифікація: C15, C53, H61, H72

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