Iryna Hryniuk[*]

MATHEMATICAL MODEL OF CURRENT CAPITAL'S OPTIMIZATION AND MANAGEMENT

A b s t r a c t: Current capital management is an important part of the enterprise management system. Determining the optimal value of its components allows more effectively using assets and investing resources. In order to determine the optimal value, it is necessary to determine the basic interdependence between these components. The process of optimization is based on the relationships and interactions between the components of current capital. The mathematical model of optimization of current capital components has been formed and proposed for the purpose of determining the optimal value of each of the components, which will enable the company to more effectively use available resources and production capacities and prevent inappropriate spending and investment of resources. This model is based on the Lotka–Volterra equations and represents a system of three differential equations that describe the interactions and interdependencies between the components of current capital, determining their optimal size, which ensures the continuity of economic activity, in the use of all production capacities of the enterprise and will help to prevent inefficient spending and investment in assets. The model is created in the process of PhD thesis writing.

K e y w o r d s: current capital, current capital components, stocks, accounts receivable, cash, optimization.

JEL: C21, C32

INTRODUCTION

Current capital is a totality of material assets and cash flows, both in their direct form and in the form of investments, which are in constant circulation in order to ensure the continuity of the production process and liquidity of the enterprise, changing its material form during one operating cycle (Гринюк, 2016).

In the process of economic activity can be identified three groups of current capital components, which have a significant impact on the financial position of the enterprise:

[*] Contact information: Iryna Hryniuk, Ivano-Frankivsk National Technical University of Oil and Gas, Institute of Economics and Management, Department of Accounting and Taxing, 15 Karpatska Street, Ukraine 76019, e-mail: ira.hryniuk@gmail.com

– stocks;
– cash, including current financial investments;
– account receivables.

In order for the increasing of the current capital management process' efficiency is important to find the optimal ratio of current capital components.

The process of optimization should be based on the main goal set by the managers of the enterprise as a component of current capital. Its essence is not to determinate the minimal or maximal size of the current capital components, which can afford to keep the company without creating threats for economic activity. Its main aim is to determinate the interconnections and interactions between current capital components and set such a value of each component which will help to ensure the continuation of enterprise's economic activity at the minimal level of costs associated with their formation and maintenance, and also related to the freezing of capital in these components, that means separately manoeuvring of each current capital component in the general management of its management. The essence of the optimization process will be in the formation of an adaptive mathematical model that could to satisfy the needs of enterprise's managers the informational support of the process of current capital components' management by the way of establishing such sizes of its components, which will guarantee the profit maximization while minimizing of costs, that is, setting of such parameters that will increase not only the efficiency of production but also the formation of the value of the enterprise and its image on the market.

Formulating the goal of the article. The main goal of the article is to develop the model for optimizing the current capital components' size based on the system approach.

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

Questions related to the development of models and mechanisms of current capital management are considered in the works of large numbers of economists. In particular S. Kuznetsov and I. Iricov (Кузнецов &Ириков, 2001) propose a mathematical model of the current capital movement as a dynamic change in flows and reserves of current assets, describing it as a classic Marx theory of Capital – Goods – Capital', scilicet in the form of a transformation from one form to another by the cyclic way. This model is fairly simple and does not take into account all interconnections with assets that have an impact on current capital. T. Chupilko and S. Chupilko (Чупілко & Чупілко, 2016) offers a dynamical economics-mathematical model for optimization the enterprise's income in the conditions of limited current capital, taking into account time-varying parameters, using numerical methods of simulation modelling. The model proposed by authors is multifactorial, its mathematical description is rather com-

plex and cumbersome, thus it is difficult for using and understanding. I. Shyn-dyruk (Шиндирук, 2012) in order to solve financial problems proposes to use an economic-mathematical model of finding the optimal set and ratio of sources and methods of financing the enterprise, by the mathematical formulation of the problem of optimization of capital structure by the criterion of its lowest value, which based on the minimization of the role of its target function. This model is based on a number of already developed and calculated indicators, which by their nature are subjective, and the results of this model cannot be considered reliable.

Current capital is a generalized category, which includes three components, and requires a systematic approach to the process of mathematical modelling taking into account the interactions between its components.

RESEARCH JUSTIFICATIONS

The team of authors, edited by N. Vlasova (Власова, 2014), argues that the optimization of current capital components is an "objective necessity" and "a priority direction". The economic dictionary edited by J. Zavadskyy defines the optimization as "the process of finding such system state, which provides the maximum or minimum of the values of some functions of the system (the choice of the best option from many possible" (Завадський, Осовська, & Юшкевич, 2006).

System-oriented management of current capital on the basis of optimization involves the study of patterns and interconnections between all components of current capital.

In order to study these relationships, it is necessary to study the effect on each component of the rest of the components. These relationships can be described as follows:

- stocks available at the enterprise are formed at the enterprise for the purpose of conducting economic activity, their size must be sufficient for normal production process and not create excess stocks that will be subject to ageing and spoilage. At the same time, the company's ability to provide the required level of inventories decreases with the prolonged growth of outstanding receivables and increases with an increase of cash that does not have a direct purpose for their spending;
- the amount of receivables that arose in the course of conducting business determines the size of the operating income of the enterprise and depends on the financial discipline of the enterprise, the size of available cash for a particular date, which should ensure the repayment of current liabilities and the amount of stocks that have been processed and sold in the reporting period, as well as, should not cause loss of solvency;

    –   the amount of money, guaranteeing the level of solvency and current liquidity of the enterprise, by providing at the enterprise the amount of money that will facilitate compliance with the payment calendar, namely the ability to repay its obligations, as well as decreasing with the need of the enterprise for the purchase of raw materials and the amount of outstanding receivables.

Such as described interconnections are characteristic of open economic systems and have a cyclic character, their description should be carried out using mathematical models.

A mathematical model is a description of a system using mathematical concepts and language. The process of developing a mathematical model is termed mathematical modeling ('Mathematical model', 2019).

The most widely used in various fields of science and technology, including economics, is the model independently formed by Alfred James in 1925 and Vito Volterra in 1926, the so-called Lotka-Volterra equations or the predator–prey equations. This model is a system of two a pair of first-order nonlinear differential equations, frequently used to describe the dynamics of biological systems in which two species interact, one as a predator and the other as prey ('Lotka–Volterra equations', 2019). The solution of this system is auto-oscillation. With the help of this system is possible to carry out a comprehensive assessment of the economic processes' dynamics and to forecast their behaviour in the future, subject to changing model parameters.

The relationships which was described above can be represented by the Lotka-Volterra equation as follows:

$$\begin{cases} x'(t) = k_1 x(t) - k_2 y(t) + k_3 z(t) \\ y'(t) = k_4 y(t) + k_5 x(t) + k_6 z(t) \\ z'(t) = k_7 z(t) - k_8 x(t) - k_9 y(t) \end{cases} \qquad (1)$$

where, $x'(t)$, $y'(t)$, $z'(t)$ - the need of stocks, accounts receivable and cash for the period; x, y, z - the amount of stocks, accounts receivable and cash respectively; k_1-k_9 - significance coefficients of the factors influence on the value of the indicator.

This model gives an opportunity to assess the level of interaction between the current capital components and provide the analysis in order to make effective management decisions.

It should be noted that this model is analogue and can be modified in accordance with the needs of a particular enterprise, its conditions of manufacturing or the object of management. In order to determine the effect of managing the value of one indicator on the value of another is expedient in this model to include the effect of the maximum and minimum permissible values of one or more components of current capital as a multiplier to the indicator being analysed, the

differences between the maximum or minimum allowable value and the actual value of the indicator.

Determining the maximum and minimum levels of values for current capital components has a significant impact on the process of system-oriented management:

– determination of the maximum allowable level of stokes will help to determine the optimal size of the order and the cost of their transportation and maintenance, prevent the emergence in the warehouse of surplus stocks that can be spoiled and become unfit for their processing;

– determination of the maximum allowable level of receivables will allow to establish the amount of receivables that an enterprise can account for on the balance sheet without loss of solvency and violation of normal financial discipline;

– determination of the maximum allowable level of cash will allow to optimize the amount of cash flows and make decisions about investments;

– determination of the minimum allowable level of reserves will ensure the continuity of the production process, prevent production failures in the emergencies, determining the optimal size of the order and the cost of their transportation and maintenance;

– determination of the minimum allowable level of receivables will characterize the minimum necessary level of operating income, which will provide the level of profit necessary for normal business activities;

– determination of the minimum allowable level of cash will determine the basic principles of the credit policy of the enterprise, facilitate the implementation of the company's financial obligations and determine the possibility of financial investment.

In order to obtain adequate data on the behaviour of current capital components in the future is advisable to determinate the affecting factors on them and the amount of the coefficients that they will be responsible for. Determination of these coefficients is carried out by means of expert estimations using the technique of ball assessments. Expert estimation methods are a way of forecasting and evaluating future results based on expert forecasts. The technique of ball assessments consists in the expert assessment of certain parameters in points or their distribution according to certain criteria, with subsequent assignment of points in the processing of data. The method of questioning was used to collect information on experts' assessment of the affecting factors. Respondents interviewed using the Google Forms product on the Google platform by sending a questionnaire to respondents' email addresses. To determine the amount of the importance of the affecting factors on the current capital components, is suggested using a scale from 0.1 to 0.9, where 0.1 represents the lowest level of influence, and 0.9 is the highest level. Also, experts are asked to determine the

parameter (stocks, accounts receivable, cash) by the method of ranking to the equation of which this factor has the highest impact.

The expert evaluation involved two groups of respondents whose practical skills, level of knowledge and competence are directly related to the subject of research:

  – employees of enterprises, whose professional duties are directly related to current capital or its components, and indirectly effect on them or expose to them (accounting staff, financial directors, managers of different levels);
  – scientists who provides their professional activity in educational and scientific institutions, whose scientific interests are related to current capital and its components.

In the process of collecting the information 150 questionnaires were sent out, 98 of which were processed and appropriated for analysis.

The estimation of the importance level of the affecting factors to the current capital components (coefficients k_1-k_9) was carried out in several stages with a series of indicators of consistency.

In first, the sum of the ranks (values) established by the respondents for each of the proposed factors was determined, which made it possible to identify nine factors with a maximum score. Then is necessary to determine the average level of consensus among respondents regarding the magnitude of the coefficients k_1-k_9. For this purpose the coefficient of correlation of the rank M. Kendall is used:

$$\tau = \frac{2 \cdot (P - Q)}{n \cdot (n - 1)} \tag{2}$$

where, P - number of agreed pairs; Q - number of uncoordinated pairs; n - number of factors.

The Kendall coefficient was performed using the online Math calculator ('Коэффициент ранговой корреляции Кендалла', n.d.). In order to check the value of this coefficient it is necessary to determine the critical point:

$$T = Z \cdot \sqrt{\frac{2 \cdot (2 \cdot n + 5)}{9 \cdot n \cdot (n - 1)}} \tag{3}$$

$$F(Z) = \frac{1 - \alpha}{2} \tag{4}$$

where, α – the level of significance.

It is advisable to set the level of significance at the value of 0.05. In this level of significance $F(Z)$ will be 0.475, that is $Z = 1.96$. Thus we obtain the following value of the critical point:

$$T = 1{,}96 \cdot \sqrt{\frac{2(2n+5)}{9n(n-1)}} = 1{,}96 \cdot \sqrt{\frac{2 \cdot (2 \cdot 9 + 5)}{9 \cdot 9 \cdot (9-1)}} = 0{,}009877$$

The assessment of the consistency of respondents' opinions is conducted based on the coefficient of concordance:

$$W = \frac{12}{m^2 \cdot (n^2 - n)} \cdot \sum_{j=1}^{n} \left[\sum_{i=1}^{m} x_y - \frac{m \cdot (n+1)}{2} \right]^2 \qquad (5)$$

where, m - number of experts; n - number of factors; i – experiment's number; j – factor's number; $\sum_{i=1}^{m} x_y$ - sum of factors' rank.

In order to check the level of significance of the coefficient of concordance, the value of the critical point is determined:

$$\chi_{\kappa}^2 = m \cdot q \cdot W = m \cdot (n-1) \cdot W \qquad (6)$$

where, q - the number of degrees of freedom.

The critical value of the Pearson coefficient $(\chi_{\bar{n}}^2)$ is determined on the basis of the significance level (a = 0.05) and the number of degrees of freedom (q = 9 - 1 = 8) and is in the Pearson tables. In our case it is 15.5.

The calculation of concordance coefficient was performed using the MathCad program. So, the highest factor is at number 8, the least significant is 3, m = 98, n = 9. So we get the magnitude of the multiplier

$$\frac{m \cdot (n+1)}{2} = \frac{98(9-1)}{2} = 392.$$

On the basis of the calculations the coefficient of concordance will have the following meaning:

$$W = \frac{12[(29-392)^2 + (47-392)^2 + \ldots + (18-392)^2]}{9604 \cdot (81-9)} = 0{,}724$$

Next we define the value of the critical point χ_{κ}^2:

$$\chi_{\kappa}^2 = m \cdot q \cdot W = 98 \cdot 8 \cdot 0{,}724 = 567{,}616$$

The coefficient of concordance is considered to be one that can be trusted, provided that $\chi_{\kappa}^2 > \chi_{\bar{n}}^2$, it means the conclusions made on its basis are reliable. As we can see, inequality is sustained, and it can be argued that the respondents' opinions are highly consistent and the data are reliable.

The value of the coefficients determined by the expert estimation method is given in table 1.

Table 1 – The value of the significance coefficients of the effecting factors accordance with the data obtained after questioning

Indicator	Parameter	Value of the parameter
1	2	3
Planning a delivery schedule	k_1	0,4
Increase in the maturity terms of accounts receivable	k_2	0,2
Accumulation of a significant amount of cash without making investment decisions	k_3	0,4
Ratio of outstanding receivables	k_4	0,4
Compliance the production schedule	k_5	0,1
Planning a billing calendar	k_6	0,2
Effective financial discipline	k_7	0,25
The accuracy of determining the optimal order size	k_8	0,3
Growth in the amount of outstanding receivables	k_9	0,15

Source: formed by the author on the basis of the Questionnaire Survey

Effecting factors of the maximum and minimum levels of current capital components on the processes of management and optimization should be introduced step-by-step into the system (1), which will enable to determine the most optimal model of the co-dependence between the components of current capital, on the basis of which it is possible to develop an optimal management system of current capital.

The factors influencing the maximum and minimum levels will be the factors that characterize these parameters:

– $(A-x(t))$ - impact of the maximum allowable level of stocks;
– $(B-y(t))$ - impact of the maximum allowable level of receivables;
– $(C-z(t))$ - impact of the maximum allowable level of cash;
– $(x(t)-D)$ - impact of the minimum allowable level of stocks;
– $(y(t)-E)$ - impact of the minimum allowable level of receivables;
– $(z(t)-F)$ - impact of the minimum allowable level of cash.

According to this condition, the parameters *A, B, C, D, E, F* will represent the maximum and minimum levels of stocks, receivables and cash respectively.

The excess of the indicators of cash and receivables to the maximum necessary for the company size allows the company to make decisions on financial and investment activities, to invest and receive additional profits. It is important to emphasize that the maximum allowable levels of accounts receivable and cash are not absolute indicators. They characterize the magnitude that allows an enterprise

to conduct operational activities and counteracts the threats that are associated with it. However, this does not mean that its excess will be negative for the enterprise. On the contrary, such a surplus will have positive effects for the enterprise: it will allow the opportunity for expansion and development for the enterprise. At the same time, their minimum level is a relatively absolute indicator that characterizes the minimum, below which an enterprise cannot afford to conduct business activity, keeping the basic indicators at the minimum level without significant losses and threats. As for stocks, the situation is slightly different. The minimum level of stocks characterizes the amount required by the company during the year to prevent downtime in production and the formation of minimum indicators of receivables and cash. However, their maximum level is not an absolutely relative magnitude. It shows the amount of inventory that may be based on the economic conditions and production capacity consumed and realized by the enterprise, and the amount of stocks that exceeds the maximum level can create discomforts associated with its storage, as well as be subjected to moral and physical ageing. As a result, they will be irrational costs for the enterprise.

In a further study by incorporating and excluding from the system (1) the factors (7), we obtain the schedules of the behaviour of these components, which will give an opportunity to evaluate their behaviour in the long-term period. Thus, the best optimization equation for all three components will be obtained, which will form the optimal structure of current capital. These simulations were performed using the MathCad.

$$\begin{cases} x'(t) = k_1 x(t) \cdot [\dots] - k_2 y(t) \cdot [\dots] + k_3 z(t) \cdot [\dots] \\ y'(t) = k_4 y(t) \cdot [\dots] + k_5 x(t) \cdot [\dots] + k_6 z(t) \cdot [\dots] \\ z'(t) = k_7 z(t) \cdot [\dots] - k_8 x(t) \cdot [\dots] - k_9 y(t) \cdot [\dots] \end{cases} \qquad (7)$$

In the course of the research it was found that the inclusion of the corresponding factors in only one of the equations is meaningless. Focusing only on one of the components will not help increase the efficiency of the management of current capital in general. Also, the inclusion of all the described factors in each of the equations will not help optimize the size of the working capital components and increase the efficiency of its management. Possible approach when factors are not taken into account at all. However, this option is possible only for the stable operation of the enterprise and the normal value of financial indicators.

As the data for analysis in the process of optimization are indicators of annual turnover (in debit), the most profitable for the company will be the following scenarios of the behaviour of working capital components:
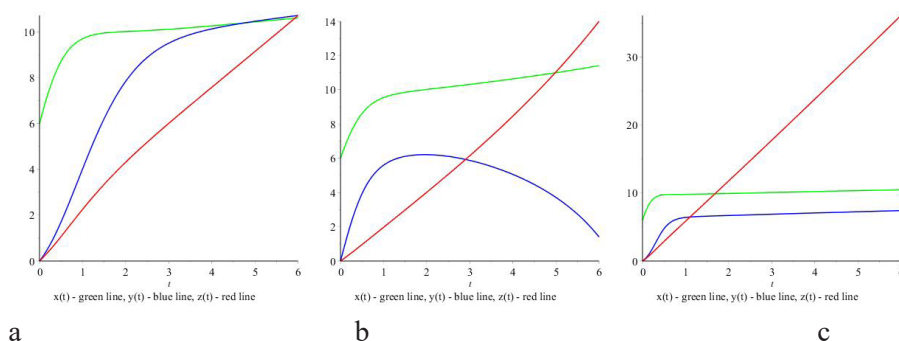
- simultaneously not rapid growth of all components of current capital, which testifies to the observance of a normal production process and the effectiveness of its activities;

    – a gradual increase in the amount of cash with respect to the initial parameters of stocks and receivables.

Other variants of the scenario of the current capital components' behaviour are possible. For example, the amount of cash and stocks will increase, and the amount of receivables will decrease. At first glance, this scenario has positive characteristics. However, a decrease in the turnover of receivables will indicate a decrease in sales when the value of purchased and processed stocks increases.

    At various combinations of parameters there are various graphs of the behaviour of current capital components (Fig. 1).

Figure 1 - Examples of possible variants of graphic display of various combinations of the model

$x(t)$ - green line, $y(t)$ - blue line, $z(t)$ - red line $x(t)$ - green line, $y(t)$ - blue line, $z(t)$ - red line $x(t)$ - green line, $y(t)$ - blue line, $z(t)$ - red line

    a   b   c

Source: formatted by the author using the MathCad software

    Through the method of checking options has been the gradual inclusion of factors in order to choose a strategy that will satisfy the management personnel with their results and will enable the size of the components of current capital at the optimal level, ensuring the continuity of economic activity, and will enable to assess future risks associated with current capital. In the process of optimization, studying the interrelationships and interactions of the current capital components among themselves, during the simulation, it was established that the indicators of the maximum and minimum allowable levels of components do not play a significant role in determining the optimal value of the turnover of cash and receivables. The main for this process will be the principle of continuity the activity. As any activity of the enterprise is oriented to the future and at the present time it is not taken into account the bankruptcy or liquidation of an enterprise in the normal course of business and in the normal production process, according to which the acquisition of stocks, their processing and posting of finished products are the main elements of the activity, and as well as its further realization for profit in the current reporting period. It is from the processes of ordering and selling will depend on the size of cash flows of the enterprise, as well as the amount of receivables. In the process of simulation, it has been established that the most

significant element in which the managers of the enterprise should be focused in the process of making decisions on current capital. It is the magnitude of stocks, taking into account their maximum permissible level. By analysing the graphics data obtained during the research the following basic model of optimization of current capital components has been formed:

$$\begin{cases} x'(t) = k_1 x(t) \cdot (A - x(t)) - k_2 y(t) + k_3 z(t) \\ \quad y'(t) = k_4 x(t) + k_5 y(t) + k_6 z(t) \\ \quad z'(t) = k_7 z(t) + k_8 x(t) - k_9 y(t) \end{cases} \quad (8)$$

Entering the initial data of enterprises in this model: the average value of annual demand in stocks, with the adjustment on their maximum allowable level, receivables and cash received graphs of the behaviour of current capital components and the predicted values of these components in the perspective of five years.

In the process of modelling, graphs of behaviour of current capital components have been obtained, which make it possible to assess the future performance of an enterprise. As can be seen from the established data, the indicators formed with this model correspond to the main criteria. The value of each of these indicators exceeds the minimum required level of each type of asset. Thus, all enterprises are capable of conducting further economic activity, increasing their profitability and liquidity. Also, these figures are within the set maximum permissible levels that may allow the holding of the enterprise. Talking about stocks, their projected volume is close enough to the maximum allowable level. It is the maximum allowable level that determines the need for an enterprise in all types of stocks within one year with the formation of their reserves, which will enable them to conduct continuous business activities and be risk-resistant. At the same time, exceeding the forecast indicators of accounts receivable indicates that the company can increase its profits without significant financial expenses. This aspect is very relevant for enterprises, which are subject to constant changes in political, social and economic conditions.

Objective remains the fact that the calculated forecast indicators are not definitive to which the enterprise will come in the future. These indicators enable enterprise personnel to assess all risks, all the benefits of certain investment decisions, concepts, strategies and models adopted in the enterprise, both in terms of current capital and other indicators with which this type of assets is closely related. Application of this model in practice will make it possible to reduce the costs associated with managing the components of current capital, the normalization of these components and the search for various strategies and concepts for their optimization.

All calculations and defined indicators are based on actual indicators of activity of enterprises. Approbation of the above model was conducted on the basis of financial reporting indicators of nine companies in the oil and gas industry (three

Ukrainian, three Russian and three Polish). Based on the data of tab. 2 it is possible to draw a conclusion on future performance indicators.

   Conduction the analysis of the calculated data, we see that if the enterprises comply with today's methods of management and credit policy, as well as the absence of any changes in them for a number of enterprises, there may be problems with solvency. Since the magnitude of the projected reserves is optimal and satisfies the needs of all enterprises meeting the conditions of production capacity, this aspect does not require additional adjustments. The two most problematic areas are: accounts receivable and cash. Accounts receivable, being the result of the sale of stocks, in the reporting period should objectively exceed the amount of stocks. Contrary to that, according to the classification of the current capital components to stocks included all kinds of raw materials, manufacturing and finished goods, in the process of optimizing taken into account only the value of consumed raw materials, components and other assets necessary for production. That is the size of optimized stocks is essentially close to the value of production cost of the enterprise's finished product. Thus, accounts receivable over a period should exceed the amount of these stocks, as it is appropriate to implement all manufactured products in the normal course of business. Since selling is carried out on post payment, the value of incoming cash flows is not always equal to the amount of current receivables. That this is the main element in the management of the enterprise: monitoring the timely collection of receivables and a sufficient amount of incoming cash flows to ensure that the minimum needs of the enterprise in cash.

Table 2 - Forecasted indicators of current capital components

Forcased period	Cash	Receivables	Stocks	Cash	Receivables	Stocks	Cash	Receivables	Stocks
	Enterprise 3 Ukr			Enterprise 2 Ukr			Enterprise 1 Ukr		
1	6 995 000	5 337 000	961 200	63 690 000	49 010 000	23 310 000	12 770 000	35 390 000	1 869 000
2	10 640 000	8 126 000	961 200	101 900 000	81 070 000	23 310 000	14 250 000	42 740 000	1 869 000
3	15 990 000	12 140 000	961 200	157 500 000	126 200 000	23 310 000	15 170 000	51 130 000	1 869 000
4	23 890 000	17 950 000	961 200	238 800 000	190 300 000	23 310 000	14 960 000	60 490 000	1 869 000
5	35 570 000	26 390 000	961 200	358 100 000	281 800 000	23 310 000	12 730 000	70 600 000	1 869 000
	Enterprise 3 Rus			Enterprise 2 Rus			Enterprise 1 Rus		
1	4 325 000	6 631 000	546 100	3 217 000	3 752 000	259 600	7 979 000	10 970 000	5 648 000
2	5 883 000	8 620 000	546 100	4 564 000	5 064 000	259 600	12 740 000	16 650 000	5 648 000
3	8 016 000	11 200 000	546 100	6 490 000	6 853 000	259 700	19 330 000	24 100 000	5 648 000
4	10 960 000	14 580 000	546 100	9 260 000	9 317 000	259 700	28 540 000	33 970 000	5 648 000
5	15 070 000	19 050 000	546 100	13 270 000	12 740 000	259 700	41 520 000	47 180 000	5 648 000
	Enterprise 3 Pol			Enterprise 2 Pol			Enterprise 1 Pol		
1	18 850 000	59 160 000	26 820 000	930 900	155 300	998	18 690 000	19 450 000	33 080 000
2	28 070 000	81 560 000	26 820 000	1 484 000	420 900	1 202	38 060 000	41 230 000	33 080 000
3	38 530 000	108 400 000	26 820 000	2 329 000	858 900	1 451	65 160 000	70 130 000	33 080 000
4	50 100 000	140 300 000	26 820 000	3 616 000	1 563 000	1 756	103 400 000	108 800 000	33 080 000
5	62 450 000	178 200 000	26 820 000	5 566 000	2 677 000	2 129	157 700 000	161 200 000	33 080 000

Source: formatted by the author using the MathCad software

MAIN RESULTS

As we can see from the calculated data is clear that 5 enterprises will face the problem of the timely repayment of receivables by counterparties. This is evidenced by a significant excess of the amount of receivables over the amount of cash. Among these Enterprise 1 Ukr, Enterprise 3 Ukr, Enterprise 1 Rus, Enterprise 2 Rus, Enterprise 3 Rus, Enterprise 1 Pol, Enterprise 3 Pol. For other companies the value of incoming cash flow is higher than the value of receivables, indicating that effective investment and more profit timely repayment contractors and collect old debts. For such enterprises as Enterprise 1 Rus, Enterprise 2 Rus, Enterprise 3 Rus the incoming flow situation is not critical. It indicates a significant delay in payments by contractors, but the return of a significant portion of cash. However, in relation to Enterprise 1 Ukr and Enterprise 3 Pol incoming cash flows are significantly lower than the current accounts receivable. Further, providing of economic activity on such conditions will threaten enterprises with significant loss of liquidity, solvency and possible bankruptcy. Of course, considering these figures is not possible to give definitive characteristics of activity of the enterprises in the future, but adopting such a model may evaluate risks and, where necessary, make adjustments to monetary policy, which will allow bettering manage a portfolio of accounts receivable in order to increase the value of incoming cash flows the goal of ensuring the viability of enterprises.

REFERENCE

Lotka–Volterra equations. (2019). In *Wikipedia*. Retrieved from https://en.wikipedia.org/w/index.php?title=Lotka%E2%80%93Volterra_equations&oldid=896857326

Mathematical model. (2019). In *Wikipedia*. Retrieved from https://en.wikipedia.org/w/index.php?title=Mathematical_model&oldid=896187818

Власова, Н. О. (2014). *Управління оборотними активами на підприємствах роздрібної торгівлі* (ХДУХТ). Харків.

Гринюк, І. (2016). Методичні підходи до визначення сутності оборотного капіталу. *Матеріали II Всеукраїнської науково-практичної інтернет-конференції з міжнародною участю*, *3*, 156–159. Луцьк: РВВ Луцький національний технічний університет.

Завадський, Й. С., Осовська, Т. В., & Юшкевич, О. О. (2006). *Економічний словник*. Київ: Кондор.

Коэффициент ранговой корреляции Кендалла. (n.d.). Retrieved 2 June 2019, from https://math.semestr.ru/corel/kendel.php

Кузнецов, С. В., & Ириков, И. В. (2001). Математическое моделирование задач управления финансовыми потоками. *Электронный Журнал Исследовано в России*, 1442–1464. Retrieved from https://cyberleninka.ru/article/v/matematicheskoe-modelirovanie-zadach-upravleniya-finansovymi-potokami

Чупілко, Т. А., & Чупілко, С. І. (2016). Математична модель оптимізації оборотного капіталу торгового підприємства. *Збірник Наукових Праць Дніпродзержинського Державного Технічного Університету*, (1(28)), 113–117.

Шиндирук, І. П. (2012). Економіко-математичне моделювання та оптимізація структури капіталу підприємств. *Фінанси України*, (2'2012), 111–118.