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ORIGINAL PAPER

DYNAMIC ECONOMIC AND MATHEMATICAL OPERATING MODEL OF FINANCIAL FLOWS OF A COAL PRODUCER

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Abstract. Given the challenging conditions of sanctions and uncertain external economic environment, it is essential for coal producers to project their economic health in the short and long term. This purpose requires to have forecast tools with respect to the development of an enterprise and its future financial flows under various initial conditions and the impact of negative external environment factors. This study aimed to develop a tool for dynamic assessment of financial flows of a coal producer in form of an economic and mathematical operating model. The framing methods for this model are based on the cash flow pattern of an enterprise, including proceeds from the sale of products, receivables, payables and production costs, as well as loan repayments. The model accounts for the time value of money and is dynamic, as it allows to estimate the balance of cash flows for several periods (months, quarters, years) ahead. The dynamic model is based on the assessment of the input financial parameters of a coal producer, the determination of the rules of cash flow management, the calculation of the changes in cash flows for the period concerned and the calculation of the financial parameters of a coal producer at the end of the period under consideration. The model allows to estimate the financial flows of a coal producer for several future periods with different input data. The dynamic model allows to assess the financial condition of a coal producer against the background of the changing financial flow management rules in conditions of uncertainty and Western and US sanctions. The application of the model in planning the performance of coal producers will optimize financial flows and create an effective plan of the enterprises' activities in complex and unstable economic conditions. The proposed model may be further developed to clarify and account for disrupting factors and to computerize dynamic modeling.
Keywords: coal producers, dynamic model, operating financial flows, discounting, dynamic modeling.

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ОРИГИНАЛЬНАЯ СТАТЬЯ

ДИНАМИЧЕСКАЯ ЭКОНОМИКО-МАТЕМАТИЧЕСКАЯ ОПЕРАЦИОННАЯ МОДЕЛЬ ФИНАНСОВЫХ ПОТОКОВ УГЛЕДОБЫВАЮЩЕГО ПРЕДПРИЯТИЯ

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Аннотация. В сложных санкционных условиях и неопределённости внешней экономической среды предприятиям угольной промышленности важно прогнозировать свое экономическое состояние на краткосрочную и долгосрочную перспективу. Для этого необходимы инструменты формирования прогнозов развития предприятия, его будущих финансовых потоков при различных исходных условиях и воздействия негативных факторов внешней среды. Целью исследования явилась разработка инструмента динамической оценки финансовых потоков угледобывающего предприятия в виде экономико-математической операционной модели. Методика построения этой модели базируется на схеме движения денежных потоков предприятия, включающей выручку от продажи продукции, дебиторскую задолженность, кредиторскую задолженность и затраты на производство, а также погашение кредитной задолженности предприятия. Модель учитывает временную стоимость денег, является динамической, поскольку позволяет оценить сальдо денежных потоков на несколько периодов (месяцев, кварталов, лет) вперед. Динамическая модель построена на основе оценки исходных финансовых параметров угледобывающего предприятия, определения правил управления денежными потоками, расчета изменений денежных потоков за анализируемый период и расчета финансовых параметров угледобывающего предприятия на конец исследуемого периода. Модель позволяет оценить финансовые потоки угледобывающего предприятия на несколько периодов вперед при различных исходных данных. Динамическая модель позволяет оценить финансовое состояние угледобывающего предприятия при изменении правил управления финансовыми потоками в условиях неопределенности и санкционных воздействий стран Запада и США. Применение модели при планировании деятельности угледобывающих предприятий позволит оптимизировать финансовые потоки и сформировать эффективный план деятельности предприятия в сложных и нестабильных экономических условиях. Дальнейшее развитие предложенной модели возможно в направлении уточнения и учета дестабилизирующих факторов и компьютеризации динамического моделирования.
Ключевые слова: предприятия угольной отрасли, динамическая модель, операционные финансовые потоки, дисконтирование, динамическое моделирование

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Introduction

Financial activity statistical models do not allow predicting the development of the coal mining company's activities in the short and long term; they do not have high accuracy and have a limited range of objectives to be addressed. Dynamic models, although based on retrospective statistical data, allow us to address these objectives. Dynamic models describe the processes of system (its main parameters) change and development over time. They constitute a simplified theoretical structure (model) compared to the original one, formally describing with the help of mathematical relations the state dynamics of the object of study under given conditions, rules for changing the parameters of the system being studied, restrictions, and assumptions. The simplified character of the models should not be considered as a disadvantage.

Any system being studied is characterized by a set of elements it consists of that can change their characteristics over time. However, in the dynamic economic and mathematical model being considered, the system structure is constant.

The main study method of this paper is an integrated approach to short-term and long-term forecasting of the financial standing of a coal mining company, which consisted in a comprehensive account of external factors affecting the coal mining company's operations and assessing the degree of their influence on changes in the company's financial performance. The selected set of indicators for evaluating the company's activities takes into account all the financial flows of the company over time. A systematic approach to the model development was applied in its construction by taking into account the initial state of the company, the current and projected indicators of the refinancing rate, inflation, the amount of bank penalties and other characteristics of the external environment in which the coal mining company operates. The validity of the findings of this study is confirmed by the use of previously tested mathematical apparatus, using data from the company's official statistics. Structural analysis of the model made it possible to determine the initial parameters, restrictive and control parameters, which choice, when applying the model, leads to effective management decisions [1].

Results and Discussion

In order to develop an economic and mathematical operating model, we present a coal mining company's or its subsidiary's cash flow generalized scheme in the form shown in *Fig. 1* [2]. The purpose of dynamic modeling is to ensure the sustainable development of a coal mining company in unstable business environment.

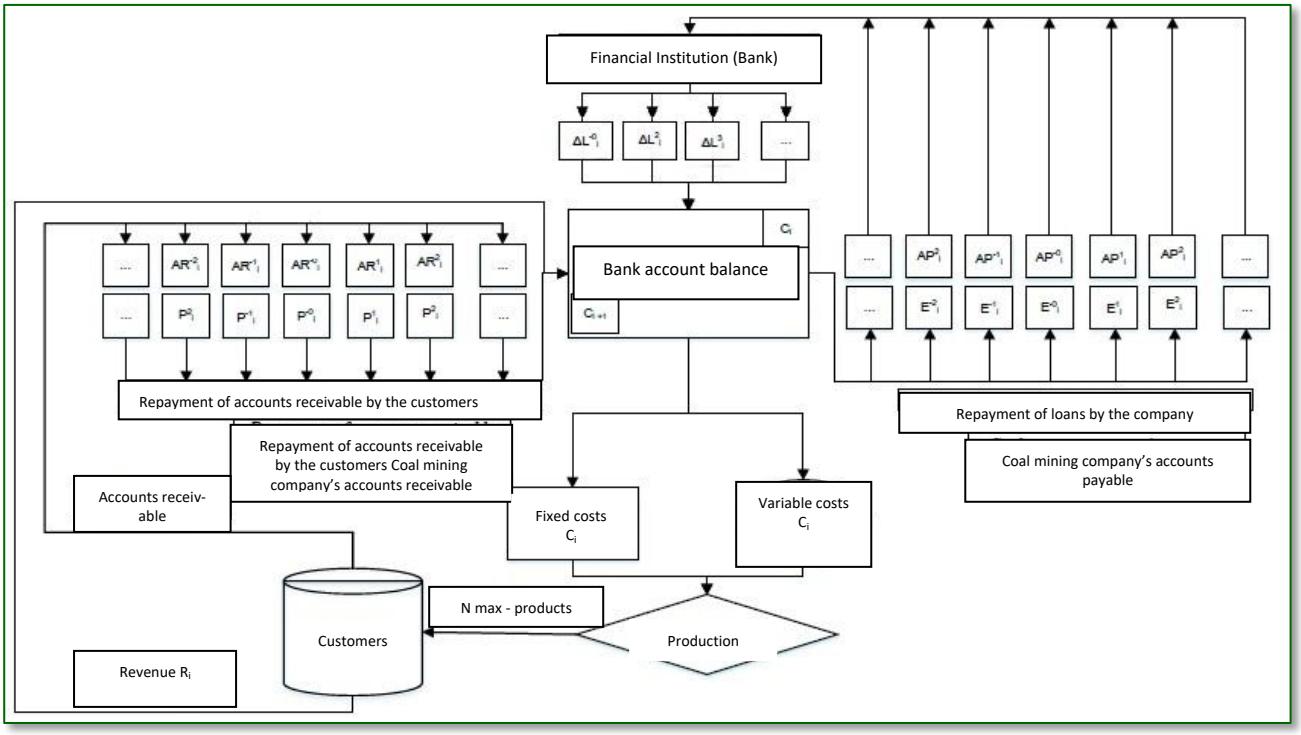

Fig. 1. **General Scheme of Dynamic Economic-Mathematical Operational Model of Financial Flows of an Enterprise** / *Рис. 1.* **Общая схема динамической экономико-математической операционной модели финансовых потоков угледобывающего предприятия**

Source: compiled by the authors based on [2, 3] / *Источник:* составлено авторами на основе [2, 3]

Let's define the initial conditions for the company's financial flow dynamic economic and mathematical model.

Let's assume that at the beginning of the i-th year the company is characterized by the following indicators:

- Cash balance in the company's bank accounts is the opening balance B_i , the balance of I+1 year and the closing balance B_{i+t} after period t.

Accounts receivable to the coal mining company, in view of its various maturities:

$$\ldots AR^{-3}_i, AR^{-2}_i, AR^{-1}_i, AR_i, AR^{1}_i, AR^{2}_i, AR^{3}_i \ldots, \quad (1)$$

where AR^{t}_i is the amount of accounts receivable with a maturity of t years at the beginning of the i-th year. (If t is negative, it means that the accounts receivable are overdue).

- Accounts payable by a coal mining company to banks:

$$\ldots AP^{-3}_i, AP^{-2}_i, AP^{-1}_i, AP_i, AP^{1}_i, AP^{2}_i, AP^{3}_i \ldots, \quad (2)$$

where APti is the amount of accounts payable with a maturity of t years at the beginning of the i-th year. (If t is negative, it means that the accounts payable are overdue).

Let's represent these arrays of numbers in the form of a matrix of the states of account receivable $||AR^{l}_i||$ and accounts payable $||AP^{l}_i||$, in which the same designations are adopted; i.e., i is the number of the year, t is the maturity.

External influences on the system are the following [3]:

- loans AP^1_i received in i-th year with maturity date in i+1, i+2, . . . ,(i+t), . . . year;
- financing (investment) of the coal mining company from various (external: budget and/or internal: parent company) sources in the amount of R_i, in the i-th year;
- production output by the coal mining company N_I in the i-th year.

The following can act as control parameters of the coal mining company:

1) Proportions when using funds from the company's bank account for the following types of expenses:

- fixed production costs W_i;
- variable production costs V_i;
- accounts payable expenses E^1_i existing at the beginning of the year with the t-th maturity (t =. . . -3, -2, -1, 0, 1, 2, 3 . . .).

2) Proportions of the revenue distribution (R_i) received in the i-th year, for the following purposes:

- granting a grace period for t years to individual customers with a corresponding increase in accounts receivable;
- increase in funds in the coal mining company's bank account.

For this purpose, profit (the difference between revenue and costs) does not participate in the movement of the coal mining company's financial flows, as well as the total accounts payable and total accounts receivable. These integral indicators are used to assess the company's business activity, but they do not directly participate in the formation of financial flows. They participate in this process indirectly, influencing the control parameters, i.e. the overall financial policy.

In order to establish dependencies between financial flows at the beginning of the i-th and (i+1)-th year, it is required to use three concepts:

- discounting (refinancing rate, loan interest);
- inflation (deflation);
- penalties.

Discount factor $k=(1+r)^t$ is a multiplier that takes into account the increase in debt depending on the maturity date. The loan AP^t_i, which was received for t years, is subject to repayment in (i+l) year in the amount of

$AP^0_{i+1}=AP^t_i (1+r)^t$ with a constant discount factor r.

If r varies by years, then the loan AP^t_i, which was received for t years, is subject to repayment in (i+l) year in the amount determined by the following formula:

$$AP^0_{i+1}=AP^t_i * \prod_{j=i+t}^{j=i+t}(1 + r_i), \quad (3)$$

The inflation factor reflects the change in the price of money in the global market. Commodity price in the domestic market is defined as the ratio of the price of this commodity in the global market (in currency units) to the price of a monetary unit in the global market (in currency units)

pu=1 unit (currency unit)/1 Russian ruble (currency unit).

If the monetary unit price has fallen by 1 %, then all prices for any commodities will increase by 1 %.

The ratio of the price of a monetary unit of a given year to the price of the previous year is called the inflation factor F_{inf}, which is calculated by the following formula:

$$F_{inf}=1+R_{inf}/100, \quad (4)$$

where R_{inf} is the inflation rate.

In order to discount all monetary amounts (accounts payable and accounts receivable balances) to one year, it is required to use the following formulas:

$$AP^t_i=AP_i * (F_{inf})^{-1}, \quad (5)$$

$$AR^t_i=AR_i * (F_{inf})^{-1/}, \quad (6)$$

Deflation factor, by definition, is the inverse of the inflation factor:

$$F_{def}=(F_{inf})^{-1}, \quad (7)$$

If $F_{inf}>1$ and t>1, then $AP^t_i<A^P_i$

If t<1, then $AP^t_i>A^P_i$

Any amount held in a bank account when $F_{inf}>1$ depreciates much faster, the larger the value of the period t.

The inflation and deflation factors are used to compare the company's performance indicators (profitability, accounts payable and accounts receivable, etc.) in different years. Although they do not affect the balances of bank accounts, they must be taken into account when making forecasts of company financing, profits, pricing and when discounting them to one year.

Penalty is a fine for an overdue loan.

The equations of transition from the company's cash balance of the i-th year to the balance of i+1 year (closing balance) can be presented as follows:

$$B_{i+1}=B_i(1+r_i)+B_i+\sum_1^{Tmax}\Delta L_i^t+\sum_{-Tmax1}^{Tmax}P_i^t - \sum_{-Tmax1}^{Tmax}P_i^t+\beta_i-(B_i+n_i V_i), \quad (8)$$

where B_i is the company's account cash balance at the beginning of the i-th year; ΔAP_i^t is loans received in the i-th year with a maturity of "t" years; $\sum_1^{Tmax}\Delta L_i^t$ is the amount of loans with different maturities; F_i is financing (investments) in the i-th year; $\sum_{-Tmax1}^{Tmax}P_i^t$ is repayment of accounts receivable for various years; $\sum_{-Tmax1}^{Tmax}P_i^t$ is repayment of accounts payable for various years; T_{max} is a maximum loan term; β_i is a coefficient that determines the share of revenue that goes to the company's accounts; $(C_i+n_i V_i)$ is production development costs; C_i is fixed costs that do not depend on the production output; V_i is variable costs; $R_i=pu_i P_i$ is revenue from the sale of products in the i-th year; pu, is a price per unit of product; $N_{ij}<N^*$ is a number of products produced in the i-th year; N* is the maximum quantity of products determined by the coal mining company's production capabilities; P_i is funds spent on loan repaymentb$(1+r_i,)$ is a discount factor in the i-th year; r_i is a bank loan interest.

Moreover, there are the following obvious relationships between the parameters of the dynamic economic and mathematical model:

$$\beta_i+\sum_{-Mmax}^{M\,max}\gamma_i^t=1, \quad (9)$$

where γ^t_i is the share of revenue provided to the company's customers in the form of a loan for t years.

Thus, the revenue went either to the company's accounts, or to the debtors' accounts with different maturities.

Of course, all these proceeds and expenses are carried out quarterly, monthly, weekly, etc. For the sake of simplicity, we believe that they are carried out once at the end of the year (or once a month, but for this, "i" will need to be understood as the number of the month on the Julian (') timescale. The Julian scale is the number of time units (hours, days, weeks, etc.) counted from a certain reference point and independent of the number of days in a month (in a year, in a century).

$$AP^t_{i+1}=AP^{t+1}_i(1+pnlt)-E^t_i, \quad (10)$$

for negative t (t/<0)

(pnlt is a penalty for overdue payment).

$$AP^t_{i+1}=AP^{t+1}_i+\Delta AP^t_i+A\,AP! - E^t_i \text{ for } t>0, \quad (11)$$

The presented ratios describe the fact that accounts payable in (i+1) year with a maturity of t years is equal to that in (i+1) year with a maturity of (t+1) year (since the year has already passed) plus loans taken for t years in i-th year ΔAP^t_i (in addition to the previously taken ones) minus payments on account of debt repayment (i+l+t)-th of the year [4].

Similarly, the following formula is also true:

$$AR^{t}_{i=1}=AR^{t+1}{}_{i}(1+pnlt)-P^{t}_{i}, \quad (12)$$

for negative t, and

$$AR^{t}_{i=1}=AR^{t+1}{}_{i}+\Delta AR^{t}_{i}-P^{t}_{i}, \quad (13)$$

for positive t.

$$B_{i+1}=\delta_i B_{i},, \quad (14)$$

$$(C_i+v_i N_i)=\varepsilon_i B_{i},, \quad (15)$$

$$E^{t}_{i} = \chi^{t}_{i} B_{i}., \quad (16)$$

Besides, $\delta_i+\varepsilon_i+\sum_{i=-Mmax}^{Mmax}\chi_i^t=1$

where δ_i is the share of savings remaining on the company's account as of the beginning of the (i+1)-th year; e_i is the share of savings allocated for production purposes; χ^{t}_{i} is the share of savings allocated for repayment of accounts payable.

The profit P_i will be determined by the following formula:

$$P_i =F_i-(C_i+v_iN_i)=(pu_i-V_i) N_i-C_i, \quad (17)$$

Let's consider the algorithm for implementing a dynamic economic and mathematical model on a specific example of Mining and Processing plant No. 1 (MPP No. 1).

The financial flows of a coal mining company depend both on financial transactions and on the modern methods of organizing the process of mining and processing coal products used at the company. The introduction of digital technologies [5], logistics dispatching [6], as well as the preferences of the coal mining region administration have a positive effect on increasing the revenues and profits of the coal mining company [7]. The use of digital platforms on which the coal mining company and its customers are interacted contributes to the reduction of the coal mining company's transaction costs.

The input indicators of CC Kolmar LLC — coal mining and processing company (MPP No. 1) presented in *Table 1* [8]. In order to ensure the company's trade secrets, the values of the parameters are conditional and are given to reveal the meaning of the dynamic model functioning.

Table 1 / Таблица 1

Company's Input Indicators at the Beginning of the i–Year / Исходное состояние предприятия на начало i –года

No.	Indicator / Показатель	Period / Период	Designation / Обозначение	Value / Величина	UoM / Единица измерения
1	Current account balances	beginning of the current $_i$ year	B_i	20	RUB million
2	Total accounts receivable			9	RUB million
	Overdue accounts receivable	for the year before last t^{-2}	$AR^{-2}{}_{i}$	-1.1	RUB million
		for the last year t^{-1}	$AR^{-1}{}_{i}$	-1.1	RUB million
	Scheduled accounts receivable	for the current year t^0	AR_i	2.1	RUB million
		for the next year t^1	$AR^{1}{}_{i}$	3.2	RUB million
		for the following year t^2	$AR^{2}{}_{i}$	3.1	RUB million
3	Total accounts payable			7.5	RUB million
	Overdue accounts payable	for the year before last t^{-2}	$AP^{-2}{}_{i}$	1.6	RUB million
		for the last year t^{-1}	$AP^{-1}{}_{i}$	1.1	RUB million
	Outstanding payables	for the current year t^0	AP_i	2.1	RUB million
		for the next year t^1	$AP^{1}{}_{i}$	2	RUB million
		for the following year t^2	$AP^{2}{}_{i}$	2.4	RUB million
4	Fixed costs	for the current year t^0	C_i	5	RUB million
5	Variable costs	for the current year t^0	0.2x50	10	RUB million
6	Financing (investments of the head office)	for the current year t^0	R_i	10	RUB million
7	Accounts payable	for the next year t^1	ΔAP_i^1	2.1	RUB million
		for the following year t^2	ΔAP_i^2	1.6	RUB million
		for the third subsequent year t^3	ΔAP_i^3	1	RUB million
8	Repaid accounts receivable	for all the years ^{0}	$\sum_{-Tmax1}^{Tmax} P_i^t$	5	RUB million
9	Repaid accounts payable	for all the years	$\sum_{-Tmax1}^{Tmax} E_i^t$	5	RUB million
10	Penalty	for all the years	ϑ	0.2/20	unit/%
11	Discount	for all the years	r	0.15/15	unit/%
12	Inflation	for all the years	k_{inf}	0.1/10	unit/%
15	Production output	for the current year t^0	W	50	RUB million
16	Price	for the current year t^0	pu_i	0.4	RUB million
17	Revenue	for the current year t^0	$W=pu_i N_i$	10	RUB million
18	Share of variable costs from production output	for the current year t^0	v_i	0.2	unit
19	Share of the increase in accounts receivable due to penalties	for the current year t^0	ϑ	0.2	unit

Source: calculated by the authors based on [5, 6] */ Источник:* рассчитано авторами по данным [5, 6]

Let's define the rules for the distribution of the coal mining company's financial flows:

1. The received revenue is sent in equal shares to increase the cash (balance) (50%) and to advance (credit) the customers (50%). The latter amount is divided equally into an advance with a one-year maturity (25%) and an advance with a two-year maturity (25%).

2. Annually, RUB5 million of accounts receivable should be received from the customers' accounts and sent to the production company's accounts in ascending order t.

3. RUB5 million accounts payable are repaid annually.

4. RUB5 million are allocated for the development of production at the expense of fixed costs and RUB10 million at the expense of variable costs (V=0.2x50).

5. The order of repayment of accounts receivable and accounts payable: as t (t) increases= -2, -1, 0, 1, 2).

It is required to move from the characteristics of the financial standing in the current year to the same characteristics of the next year and subsequent years (*Table 2*).

Table 2 / Таблица 2

Change in the Company's Financial Standing for the Current i–Year / Изменение состояния предприятия за текущий i –год

No.	Indicator / Показатель	Period / Период	Designation / Обозначение	Value / Величина	UoM / Единица измерения
1	Current account balances	beginning of the current $_i$ year	B_i	20	RUB million
2	Settlement account replenishment	for the current year t^0	*0.5 W*	5	RUB million
3	Increase in accounts receivable due to penalties	for the previous year t^0	$\Delta AR_i^{-2} = 9\ AR^2{}_i$=1*0.2	0.2	RUB million
		for the next year t^1	$\Delta AR_i^1 = 9\ AR^1{}_i$=1*0.2	0.2	RUB million
4	Increase in accounts receivable due to advance payments at a discount r	for the next year t^0	$\Delta AR_i^1 = 0.25\ W^1{}_i$ =0.25*10*1.15	2.88	RUB million
		for the following year t^0	$\Delta AR_i^2 = 0.25\ W^1{}_i$ =0.25*10*$(1.15)^2$	3.4	RUB million
5	Reduction of accounts receivable due to debt repayment	for all the years	$\sum_{-Tmax1}^{Tmax} P_i^t$	5.1	RUB million
		for the following year t^{-2}	$P^{-2}{}_0$=1+0.2	1.2	RUB million
		for the following year t^{-1}	$P^{-1}{}_0$=1+0.2	1.1	RUB million
		for the current year t^0	$P^0{}_0$=2	2	RUB million
		for the following year t^1	$P^1{}_0$=5–(1.2+1.2+2)	0.6	RUB million
		for the following year t^2	$P^2{}_0$	0	RUB million
6	Increase in accounts payable due to penalties (9=0.2)	for the previous year t^{-2}	$\Delta AP_i^{-2} = 9\ AR^2{}_i$=1.5*0.2	0.3	RUB million
		for the previous year t^{-1}	$\Delta AP_i^{-1} = 9\ AR^2{}_i$=1.0*0.2	0.2	RUB million
7	Increase in accounts payable due to advance payments at a discount r	for the next year t^1	$\Delta AP_i^1 = 2 * 1.15$ =2.3	2.3	RUB million
		for the following year t^2	$\Delta AP_i^2 = 1.0 * (1.15)^2$	2	RUB million
		for the following year t^3	$\Delta AP_i^3 = 1.0 * (1.15)^3$	1.5	RUB million
8	Reduction of accounts payable due to RUB5 million allocated for these purposes	for the previous year t^{-2}	$E^{-2}{}_i$=outstanding payables + penalty=1.5+0.3=1.8	1.8	RUB million
		for the previous year t^{-1}	$E^{-1}{}_i$=outstanding payables + penalty=1.0+0.2=1.2	1.2	RUB million
		for the current year t^-	$E^0{}_i$=outstanding payables=2	2	RUB million

Source: calculated by the authors based on [5, 6] */ Источник:* рассчитано авторами по данным [5, 6]

Knowing the coal mining company's input financial indicators at the beginning of the current year and their change during the year or at the beginning of the next year, it is possible to estimate the company's input financial indicators at the end of the current i–year (vector of the company's financial standing forecast in a year). The results of such estimation are presented *in Table 3*.

Table 3 / Таблица 3

Company's Financial Indicators at the End of the Current i–Year (Vector of the Company's Financial Standing Forecast in a Year) / Параметры состояния предприятия на конец текущего i –года (вектор прогнозного состояния предприятия через год)

No.	Indicator / Показатель	Period / Период	Designation / Обозначение	Value / Величина	UoM / Единица измерения
1	Accounts receivable[1]	for the year before last t^{-2}	$AR^{-2}{}_i$	0	RUB million
		for the last year t^{-1}	$AR^{-1}{}_1$	0	RUB million
		at the end of the current year with a 1-year maturity	$AR^{-0}{}_{i+1}$=$AR^{-2}{}_i$+$AR^{-1}{}_i$-$P^1{}_i$ =3+2.88–0.6=5.28	5.28	RUB million
2	Scheduled accounts receivable	for the current year t^0	AR_i	2.1	RUB million
		for the next year t^1	$AR^1{}_i$	3.1	RUB million
		for the following year t^2	$AR^2{}_i$	3.2	RUB million
3	Accounts payable in of the subsequent period (year)	for the year before last t^{-2}	$AP^{-2}{}_{i+1}$	0	RUB million
		for the last year t^{-1}	$AP^{-1+1}{}_i$	0	RUB million
		for the current year t^0	$AP^0{}_{i+1}$=$AP^1{}_i$+$\Delta AP^1{}_i$ =2+2.3=4.3	4.2	RUB million
		for the next year t^1	$AP^1{}_{i+1}$=$AP^2{}_i$+$\Delta AP^2{}_i$ =2.5+2.0=4.5	4.6	RUB million
		for the following year t^2	$AP^2{}_{i+1}$	1.4	RUB million
4	Current account balances	beginning of next year	B_{i+1}	17.5	RUB million
		beginning of the next year in the prices of the previous year	B_{i+1}*0.9	15.7	RUB million

Source: calculated by the authors based on [5, 6] */ Источник:* рассчитано авторами по данным [5, 6]

[1]Overdue accounts receivable at the end of the year with a 1-year maturity consists of accounts receivable of the previous year with a 2-year maturity, loans granted to customers in the current year with a 1-year maturity, taking into account discounting minus payment in the current year to repay the debt with a 1-year maturity

The company's account balance (settlement account balance) at the beginning of next year is calculated according to the following formula:

$$B_{i+1}=B_i\,(1+r_i)+R_i+\sum_{1}^{Tmax}\Delta K_i^t+\sum_{-Tmax1}^{Tmax}P_i^t-\sum_{-Tmax1}^{Tmax}E_i^t+\beta_i-(B_i+n_iV_i)=$$
$$20\text{-}1.15\text{+}1\text{+}0.5\ 10\text{+}4.5\text{+}5\text{-}5\text{-}5\text{-}10=17.5, \quad (18)$$

It consists of the balance at the beginning of the year, taking into account discounting, financing or investment funds, replenishment of the coal mining company's accounts at the expense of revenue and newly received loans, repayment of accounts receivable minus repayment of accounts payable and production development costs.

The cash balance of RUB17.5 million at the beginning of next year in the prices of the current year is calculated according to the following formula:

$$B_{i+1}=B_i*(1-_{kinf})=\text{RUB17.5m}*0.9=\text{RUB15.7m}$$

Profit in the current year is amounted to:

$$P_i=R_i-(C_i+v_iN_i)=10\text{-}5\text{-}10=\text{-RUB5m}$$

That is, the company is unprofitable. It is operable at the expense of budget proceeds of RUB1 million and at the expense of additional loans of RUB4.5 million.

The company's profitability can be increased by increasing the order and reducing the cost.

The considered numerical example shows the role of:

- penalties for overdue loans;
- loan interest for the loan granted;
- deflator, as a means of bringing financial indicators in different years to a comparable form.

Dynamic economic and mathematical models make it possible to make effective management decisions and form the right management policy by taking into account the entire set of the coal mining company's indicators.

The advantages of system dynamics modeling are shown in *Fig. 2*.

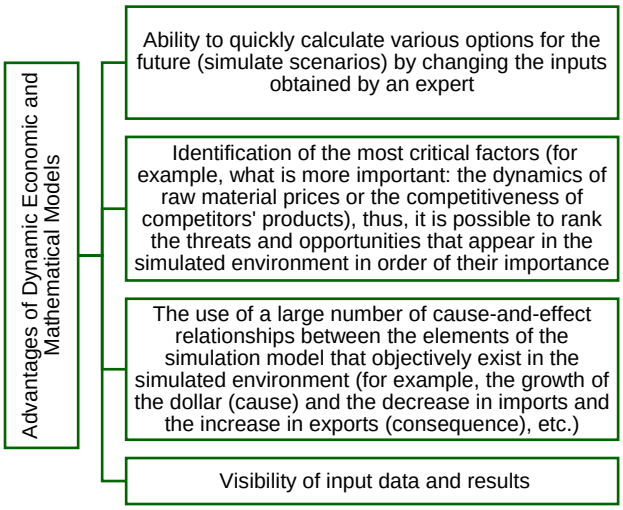

Fig. 2. **Advantages of Dynamic Economic and Mathematical Models** / *Рис. 2.* **Преимущества динамических экономико-математических моделей**

Source: compiled by the authors / *Источник:* составлено авторами

It is advisable to implement dynamic models on computers. This will allow electronic calculations to be carried out for various source data and thereby actually test the model operation.

The algorithm of computer implementation of the dynamic economic and mathematical model is shown in *Fig. 3.*

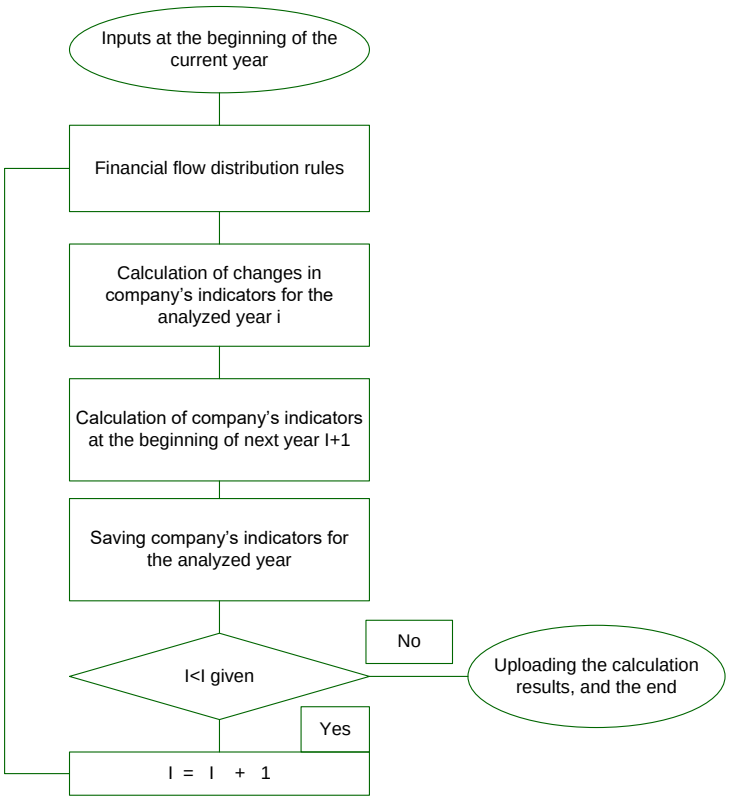

Fig. 3. **Algorithm of Dynamic Economic and Mathematical Model Computer Implementation** / *Рис. 3.* **Алгоритм компьютерной реализации работы динамической экономико-математической модели**

Source: compiled by the authors based / *Источник:* составлено авторами

Undoubtedly, the computer implementation of an economic and mathematical model creates an image of the system being studied, which is different from the real one. Nevertheless, computer modeling of dynamic mathematical and economic systems has undoubted advantages, which are presented in *Fig. 4*.

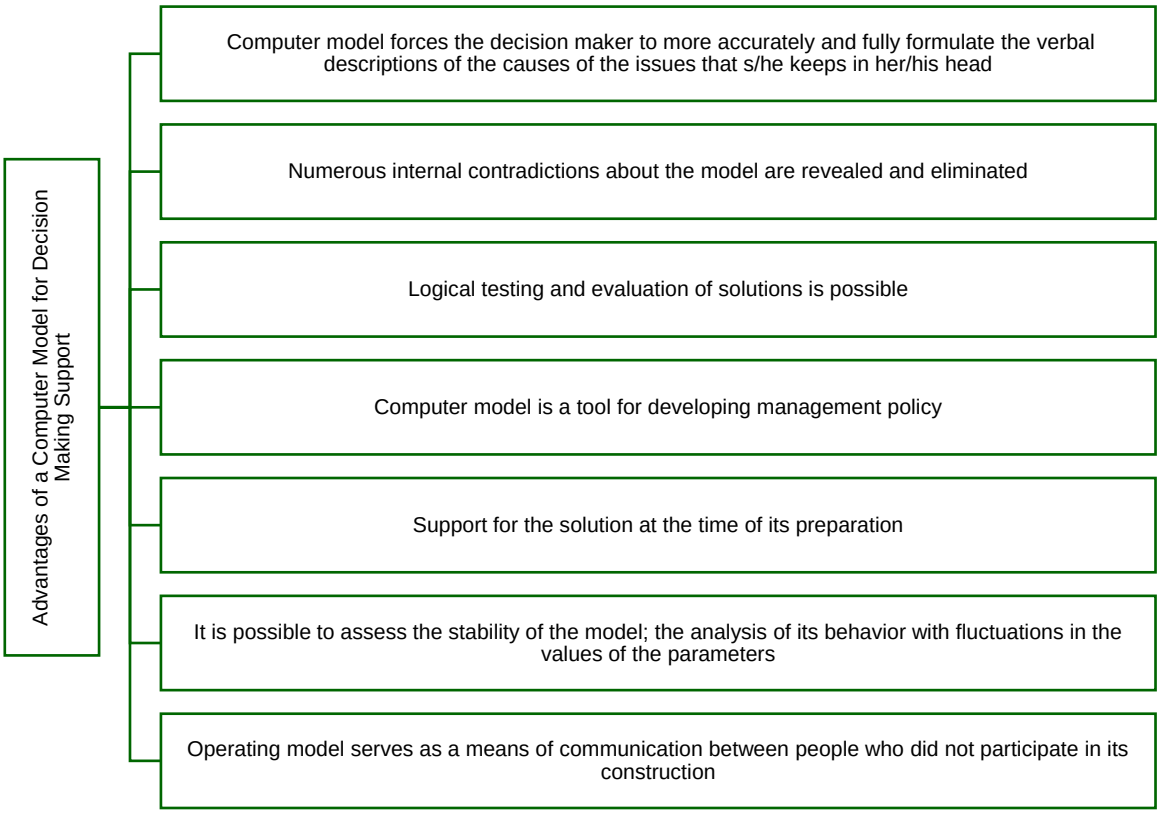

Fig. 4. **Main Advantages of Computer Modeling** / *Рис. 4.* **Основные преимущества компьютерного моделирования**

Source: compiled by the authors */ Источник:* составлено авторами

Digital technologies are being actively introduced into all spheres of our life, predictive analytics is gaining popularity. Therefore, computer modeling is certainly a modern and relevant tool for supporting managerial decisions on the effective management of coal mining companies.

Conclusion

It is vital for each coal mining company to monitor its financial standing in the conditions of a turbulent external environment, characterized today by long-term station pressure on the activities of Russian companies. Statistical methods for the company's financial standing forecasting do not allow obtaining correct results of changes in the company's financial flows. Dynamic models are more accurate in obtaining short- and long-term forecasts of the economic system development.

The designed coal mining company's financial flow dynamic economic and mathematical operational model is distinguished by taking into account the peculiarities of coal mining companies, which consist in taking into account environmental factors affecting the functioning of coal mining companies, a sharp decline in coal production, an increase in the cost and labor intensity of the process of mining and processing coal products, deterioration of mining and geological conditions of working with coal seams, the implementation of structural transformations related to the closure of unprofitable mines. The influence of these factors is reflected in the coal mining company's financial flows. The proposed dynamic model of the company's financial flows allows in the short and long term estimating the company's financial standing, identifying factors leading to an increase or decrease in the coal mining company's profitability. Identification of the detected negative or positive trends in the coal mining companies' activities will allow timely detection of the symptoms of the crisis in unstable external economic environment of the company, estimating the possible consequences of risk events, developing an appropriate behavior strategy in advance and timely taking proactive measures to prevent them.

Authors' Contribution

The authors have made an equal contribution to the research: collection and analysis of the material; definition of goals and objectives, research methods; formulation and scientific substantiation of conclusions, registration of key research results in the form of an article.

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