

## APPLICATION OF ECONOMIC MATHEMATICAL MODELS TO BANKING

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**Abstract:** *In a modern market economy, there is a need to increase the competitiveness of enterprises. This requires enterprises to optimally manage their financial resources. Based on this optimal control, the need arises for the effective use of mathematical models. This will be the basis for ensuring optimal operation and growth of the enterprise's income in the face of uncertainty. The article analyzes the uncertainty between the banking system and their customers using the total probability and Bayesian formulas based on statistical data.*

**Keywords:** *financial resources, mathematical modeling, competitiveness, absolute probability, Bayes formula, uncertainty conditions, criteria.*

In the current market economy, the competitiveness of the financial position of enterprises is often based on the effective management of financial resources. Improving such management is done on the basis of statistical data and economic mathematical models.

When we analyze the banking system, there are a lot of uncertainties between the bank and the customers. One of these uncertainties is the credit line of the banking system, in which some customers do not fulfill their loan agreements. To solve such problems, it is necessary to use economic mathematical models based on statistical data.

In this paper, the probability of probability theory and the uncertainty between the banking system and their customers, using Bayes formulas, are analyzed on the basis of statistical data

The main task of the banking system is to identify reliable enterprises that are subject to the terms of the contract in order to ensure optimal operation and revenue growth in the face of uncertainty.

The construction of a mathematical model of an economic system is based on modeling, which consists of 3 stages:

- 1) the laws of change of the economic system are defined and the mathematical model is created;
- 2) the method of solving the mathematical model is determined;
- 3) Based on the results of the mathematical model, the economic system is analyzed and recommended for optimal management.

We will apply the full formula of probability and the Bayes formula to banking.

*For example. Three  $K_1$ ,  $K_2$ ,  $K_3$  businesses accordingly \$216000, \$360000, \$450000 received a loan from the bank on the condition of repayment for a period of 3 years. The scheme of monthly payment of these funds to the banks is given as follows.*

### **$K_1$ the scheme of repayment of the loan received by the enterprise to the bank**

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№	date	Balance of principal debt	Principal debt	Interest payment	Total payment
	15.12.2018				
1	10.01.2019	216 000,00	6 000,00	3 385	9 385
2	10.02.2019	210 000,00	6 000,00	3 924	9 924
3	10.03.2019	204 000,00	6 000,00	3 443	9 443
4	10.04.2019	198 000,00	6 000,00	3 700	
5	10.05.2019	192 000,00	6 000,00	3 472	9 472
6	10.06.2019	186 000,00	6 000,00	3 475	9 475
7	10.07.2019	180 000,00	6 000,00	3 255	9 255
8	10.08.2019	174 000,00	6 000,00	3 251	9 251
9	10.09.2019	168 000,00	6 000,00	3 139	
10	10.10.2019	162 000,00	6 000,00	2 929	8 929
11	10.11.2019	156 000,00	6 000,00	2 915	8 915
12	10.12.2019	150 000,00	6 000,00	2 712	8 712
13	10.01.2020	144 000,00	6 000,00	2 691	8 691
14	10.02.2020	138 000,00	6 000,00	2 579	8 579
15	10.03.2020	132 000,00	6 000,00	2 307	8 307
16	10.04.2020	126 000,00	6 000,00	2 354	8 354
17	10.05.2020	120 000,00	6 000,00	2 170	8 170
18	10.06.2020	114 000,00	6 000,00	2 130	8 130
19	10.07.2020	108 000,00	6 000,00	1 953	7 953
20	10.08.2020	102 000,00	6 000,00	1 906	7 906
21	10.09.2020	96 000,00	6 000,00	1 794	7 794
22	10.10.2020	90 000,00	6 000,00	1 627	7 627
23	10.11.2020	84 000,00	6 000,00	1 570	7 570
24	10.12.2020	78 000,00	6 000,00	1 410	7 410
25	10.01.2021	72 000,00	6 000,00	1 345	7 345
26	10.02.2021	66 000,00	6 000,00	1 233	7 233
27	10.03.2021	60 000,00	6 000,00	1 013	7 013
28	10.04.2021	54 000,00	6 000,00	1 009	7 009
29	10.05.2021	48 000,00	6 000,00	868	6 868
30	10.06.2021	42 000,00	6 000,00	785	6 785
31	10.07.2021	36 000,00	6 000,00	651	6 651
32	10.08.2021	30 000,00	6 000,00	561	6 561
33	10.09.2021	24 000,00	6 000,00	448	6 448
34	10.10.2021	18 000,00	6 000,00	325	6 325
35	10.11.2021	12 000,00	6 000,00	224	6 224
36	10.12.2021	6 000,00	6 000,00	108	6 108
	<b>Total:</b>		<b>216 000,00</b>	<b>72 661</b>	<b>269 822</b>
	<b>On a contractual basis</b>		<b>216 000,00</b>	<b>72 661</b>	<b>288 661</b>

**K<sub>2</sub> the scheme of repayment of the loan received by the enterprise to the bank**

№	date	Balance of principal debt	Principal debt	Interest payment	Total payment
	15.12.2018				
1	10.01.2019	360 000,00	10 000,00	5 642	15 642
2	10.02.2019	350 000,00	10 000,00	6 540	16 540
3	10.03.2019	340 000,00	10 000,00	5 738	
4	10.04.2019	330 000,00	10 000,00	6 166	16 166
5	10.05.2019	320 000,00	10 000,00	5 786	15 786
6	10.06.2019	310 000,00	10 000,00	5 792	
7	10.07.2019	300 000,00	10 000,00	5 425	15 425
8	10.08.2019	290 000,00	10 000,00	5 419	15 419
9	10.09.2019	280 000,00	10 000,00	5 232	15 232
10	10.10.2019	270 000,00	10 000,00	4 882	14 882
11	10.11.2019	260 000,00	10 000,00	4 858	
12	10.12.2019	250 000,00	10 000,00	4 521	14 521
13	10.01.2020	240 000,00	10 000,00	4 484	14 484
14	10.02.2020	230 000,00	10 000,00	4 298	14 298
15	10.03.2020	220 000,00	10 000,00	3 845	13 845
16	10.04.2020	210 000,00	10 000,00	3 924	13 924
17	10.05.2020	200 000,00	10 000,00	3 615	13 615
18	10.06.2020	190 000,00	10 000,00	3 550	13 550
19	10.07.2020	180 000,00	10 000,00	3 255	
20	10.08.2020	170 000,00	10 000,00	3 176	13 176
21	10.09.2020	160 000,00	10 000,00	2 991	12 991
22	10.10.2020	150 000,00	10 000,00	2 712	12 712
23	10.11.2020	140 000,00	10 000,00	2 616	12 616
24	10.12.2020	130 000,00	10 000,00	2 351	12 351
25	10.01.2021	120 000,00	10 000,00	2 242	12 242
26	10.02.2021	110 000,00	10 000,00	2 055	
27	10.03.2021	100 000,00	10 000,00	1 688	11 688
28	10.04.2021	90 000,00	10 000,00	1 682	11 682
29	10.05.2021	80 000,00	10 000,00	1 447	11 447
30	10.06.2021	70 000,00	10 000,00	1 307	11 307
31	10.07.2021	60 000,00	10 000,00	1 084	11 084
32	10.08.2021	50 000,00	10 000,00	934	10 934
33	10.09.2021	40 000,00	10 000,00	747	10 747
34	10.10.2021	30 000,00	10 000,00	542	10 542
35	10.11.2021	20 000,00	10 000,00	375	10 375

36	10.12.2021	10 000,00	10 000,00	181	10 181
	<b>Total:</b>		<b>360 000,00</b>	<b>121 102</b>	<b>409404</b>
	<b>On a contractual basis</b>		<b>360 000,00</b>	<b>121 102</b>	<b>481 102</b>

**K3 the scheme of repayment of the loan received by the enterprise to the bank**

№	date	Balance of principal debt	Principal debt	Interest payment	Total payment
	15.12.2018				
1	10.01.2019	450000	12500	7052	19552
2	10.02.2019	437500	12500	6856	19356
3	10.03.2019	425000	12500	6660	19160
4	10.04.2019	412500	12500	6464	18964
5	10.05.2019	400000	12500	6269	18769
6	10.06.2019	387500	12500	6073	18573
7	10.07.2019	375000	12500	5877	18377
8	10.08.2019	362500	12500	5681	18181
9	10.09.2019	350000	12500	5485	17985
10	10.10.2019	337500	12500	5289	17789
11	10.11.2019	325000	12500	5093	17593
12	10.12.2019	312500	12500	4897	17397
13	10.01.2020	300000	12500	4701	17201
14	10.02.2020	287500	12500	4505	17005
15	10.03.2020	275000	12500	4309	16809
16	10.04.2020	262500	12500	4113	16613
17	10.05.2020	250000	12500	3918	16418
18	10.06.2020	237500	12500	3722	16222
19	10.07.2020	225000	12500	3526	16026
20	10.08.2020	212500	12500	3330	15830
21	10.09.2020	200000	12500	3134	15634
22	10.10.2020	187500	12500	2938	15438
23	10.11.2020	175000	12500	2742	15242
24	10.12.2020	162500	12500	2547	15047
25	10.01.2021	150000	12500	2351	14851
26	10.02.2021	137500	12500	2155	14655
27	10.03.2021	125000	12500	1959	14459
28	10.04.2021	112500	12500	1763	14263
29	10.05.2021	100000	12500	1567	14067
30	10.06.2021	87500	12500	1371	13871

31	10.07.2021	75000	12500	1175	13675
32	10.08.2021	62500	12500	979	13479
33	10.09.2021	50000	12500	784	13284
34	10.10.2021	37500	12500	588	13088
35	10.11.2021	25000	12500	392	
36	10.12.2021	12500	12500	196	12696
	<b>Total:</b>		<b>450000</b>	<b>130461</b>	<b>567569</b>
	<b>On a contractual basis</b>		<b>450000</b>	<b>130461</b>	<b>580461</b>

Using statistics, the bank should be required to identify non-performing loans.

Solve. Using the above, the bank distributed its credit resources as follows: 21 percent of the loan  $K_1$  to the enterprise, 35% of the loan was allocated to the  $K_2$  enterprise, and 44% of the loan was allocated to the  $K_3$  enterprise. Using the tables, the bank determined that the probabilities of non-repayment of loans of enterprises  $K_1$ ,  $K_2$ ,  $K_3$  were 0.065, 0.15, 0.022, respectively. For borrowers, the probabilities of the following hypotheses are included, where  $N_1 - K_1$  is the loan received by the enterprise,  $N_2 - K_2$  is the loan received by the enterprise,  $N_3 - K_3$  is the loan received by the enterprise. This problem is solved using the Bayes formula [1,2]:

$$P_A(H_i) = \frac{P(H_i)P_{H_i}(A)}{P(H_1)P_{H_1}(A) + P(H_2)P_{H_2}(A) + \dots + P(H_n)P_{H_n}(A)} \quad (i = \overline{1, n}) \quad (1)$$

with,  $A$  – is an accident and the loan is non-refundable;

$P(H_1) = 0,21$ ;  $P(H_2) = 0,35$ ;  $P(H_3) = 0,44$  –  $H_1, H_2, H_3$  probabilities of occurrence of hypotheses;

$P_{H_1}(A) = 0,065$ ;  $P_{H_2}(A) = 0,15$ ;  $P_{H_3}(A) = 0,022$  –  $H_1, H_2, H_3$  conditional probabilities of event  $A$  occurring after the hypotheses have occurred.

(1) The formula for this problem is written as follows:

$$P_A(H_i) = \frac{P(H_i)P_{H_i}(A)}{P(H_1)P_{H_1}(A) + P(H_2)P_{H_2}(A) + P(H_3)P_{H_3}(A)} \quad (i = \overline{1, 3}) \quad (2)$$

From this we can determine from formulas (2) that enterprises cannot repay loans:

$$P_A(H_1) = \frac{0,21 \cdot 0,065}{0,21 \cdot 0,065 + 0,35 \cdot 0,15 + 0,44 \cdot 0,022} = 0,18$$

$$P_A(H_2) = \frac{0,35 \cdot 0,15}{0,21 \cdot 0,065 + 0,35 \cdot 0,15 + 0,44 \cdot 0,022} = 0,692$$

$$P_A(H_3) = \frac{0,44 \cdot 0,022}{0,21 \cdot 0,065 + 0,35 \cdot 0,15 + 0,44 \cdot 0,022} = 0,128$$

The results of this calculation show that the highest probability of non-repayment of loans is the  $K_2$  enterprise, which is equal to 0.692.

This means that the bank will not lend to  $K_2$ .

In conclusion, it can be said that the main task of banking professionals is the optimal distribution of loans. Therefore, in order to remain competitive in a market economy, enterprises are required to optimally manage their financial sectors using mathematical models.

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