ISSN: 2278-3369
International Journal of Advances in Management and Economics
Available online at www.managementjournal.info

RESEARCH ARTICLE

Estimating Credit Scoring for Individuals

Maria Dimitriu*[1], Razvan Constantin Caracota[2] and Maria-Ramona Dinu[3]

[1] *Academy of Economic Studies, Bucharest, Romania.*

[2] *Alpha Bank, Bucharest, Romania.*

[3] *Politehnica University of Bucharest.*

Corresponding Author: Email:** ***dimitriumaria1@gmail.com

Abstract

The present paper presents a scoring model for individuals who require an application for funding through a bank loan [3], [4], [8-10]. We were taken into account 28 criteria for calculating the total score of customer and we have determined the degree of indebtedness based on National Bank of Romania regulations [1], [12]. We have estimated the probability of default using logistic regression. Following analysis and simulations on a sample of 80 applicants, of which 42 are already accepted for credit, there were established five risk classes (I, II, III, IV, V) and indebtedness as a percentage of income eligible. We determined the regression coefficients, using a solver in Excel and the data entry (factors) were: Indebtedness determined by income and loan amount; Number of products held in the bank; Number of dependent persons; Time worked in last job (in months).

Keywords: *Bank loan, Banking system,Credit risk management, Logistic regression, Scoring.*

Introduction

The experience of developed countries underlines the need to develop portfolios of information on all bank customers and a database for information processing as a main way to strengthen the bank's position in its relations with customers, regardless of their size, and as a weapon for prevention and avoidance of credit risk [2], [5] [6]. The present paper presents a scoring model for individuals who require an application for funding through a bank loan.

The scoring model for individuals who apply for funding through a bank loan is taking into account 28 criteria for calculating the total score of customer. The degree of indebtedness has been determined based on National Bank of Romania regulations [12]. We are taken into account 28 criteria for calculating the total score of customer and we have determined the degree of indebtedness based on National Bank of Romania regulations. The main conditioning imposed by the National Bank of Romania, under Regulations No. 3/2007, are as follows:

Net income eligible for credits is determined by deducting from the income of potential customers the following: Cost of living Payment commitments other than the current monthly rate of loan requested;

Maximum degree of indebtedness may be: 70% for banks that send information satisfactory to the Credit Bureau (this information relates to the positive behavior of a loan); 65% for banks not yet satisfactory information transmitted to the Credit Bureau;Maximum grade debt must take account of: Risk profile of customers (scoring data).

Payment Behavior of Customers

Following market research banking regulations, credit history and current situation of financial markets there have been established 28 criteria for a clear score of customer. These may reveal:

- Requesting personal data: marital status (married persons receive the maximum score), number of family members, the last level of education completed, since when he or she lives at the present address and as the owner, tenant, live with parents etc.

- Data on employment: the scope of activity, the total number of employees, job applicant, position, age at current employment and total employment. Those working in the public sector receive scoring points, they have more stable jobs and employing companies can enter the default of payment more difficult.

- Possibility of contact via phone or mobile – the fact that the client can be contacted through a telephone is still important for credit institutions.
- Number of dependents - People with children are better placed than those without, and according to statistics they are more responsible.
- Other properties - car, lands - to receive an additional scoring.

Criteria like age, income, occupational position held or loans taken to pay arrears in the past or pending orders are placed by banks on a risk matrix. The matrix is a computer program in which the applicant data are recorded and following the application procedures, the client is given a certain score (scoring). The higher the score, the better the chances of receiving funding approval.

Other important factors to be taken into account: its own contribution to the investment, potential litigation with third parties, age (preferably 24-45 years), secondary and higher education, stable income over 1000 RON [12] and banking history.

History includes both banking relationship with the bank on which credit is sought together with other banks if the applicant has to repay any previous loans. Basically, if the potential customer has had credits before and the statements reported to the credit bureau show large arrears or possible execution, even if they last long periods of time (even 2 years), lending decision is taken individually, case by case by the Committee based on recommendations of branches, without the system intervention; the system usually calculates the arrears of last year. Most banks add additional points to score if the person requesting the credit has or has taken, at one time, a loan from that bank. As further data scoring analysis can take into account the co-debtors. They are assessed in a similar scoring system and, after that, they are given the quality of internal or external co-debtor. The main features of these are summarized below:

- Internal co-debtor

A borrower's family member or other person who

- Lives and households, together with the debtor.
- Whose income is taken into account in determining repayment capacity.
- Sign the credit agreement as co-debtor.

- Is accepted for all types of loans
  - The maximum allowed internal cosigners is 4.
  - The wife is considered a domestic cosigner.
- External co-debtor
  - Is a person who is not a family member and does not live with the borrower and debtor, but:
    - his income is taken into account in determining repayment ability
    - signed credit agreement as co-debtor
    - is only supporting loans secured by real estate

Maximum number of external co-debtors is 4. If the applicant is applying for a loan with a co-debtor, then, he has to respect the following rules:

- Internal and external co-debtors are treated as independent families even if they live with the applicant. If the spouse has the status of internal co-debtor, he/she is treated as the debtor's family.

- Minimum monthly shopping's co-debtor is calculated using the same model as for the applicant.

- The liabilities of applicant and/or co-debtor's family are declared and considered.

Scoring model developed contains the range of points in the interval [-2,5]. In the table below (Table 1) are presented in detail all the criteria for a score.

Table 1: Criteria

Criteria	Score
Credit type	Total = 14,00
Real Estate	5
Car & Leasing	5
Personal loans	4
Destination	Total = 14
home purchase	5
car purchase	5
purchase durable goods	4
Currency	Total = 9
LEI / RON	5
Euro	4

Repayment term	Total = 15
20-35 years	1
10-20 years	2
5 10ani	3
1-5 years	4
<1 year	5
Amount (Euro)	Total = 15
> 100,000	5
50001-100000	4
10001-50000	3
5001-10000	2
501-5000	1
<500	0
Its contribution to investment	Total = 7
> 50%	5
25% -50%	2
<25%	0
Income (RON)	Total = 11
> 2000	5
1001-2000	4
700-1000	2
500-700	1
250-500	0
<250	-1
Applicant's potential litigation with third parties	Total = - 6
civil	-2
on claims and restitution	-1
on ownership, use, usufruct, superficies and servitude	-2
property of any kind	-1
not applicable	0
Marital status	Total = 9
married	4
divorced	2
widower	2
single	1
Age	Total = 12
> 65	-1
45-65	3
35-44	5
25-34	4
18-24	1
The applicant home situation	Total = 6
house / villa	3
apartment	2
parents house	1
rent	0
Contact: fixed or mobile phone	Total = 11
telephone	3
mobile phone	2
both	4
email address	2
none	0
Age at current address	Total = 8
> 5 years	4
3-5 years	3
1-3 years	1
<1 year	0

Number of dependents	Total = 10
0 pers.	4
1 pers.	3
2 pers.	2
3 pers.	1
> 4 pers.	0
Last level of education completed	Total = 16
doctorate	4
master degree	3
postgraduate	3
faculty	3
high school	2
vocational school	1
secondary schools	0
Company type (number of employees)	Total = 15
> 250 employees	5
150-250 employees	4
50-149 employees	3
20-49 employees	2
10-19 employees	1
<10 employees	0
Company employing capital	Total = 17
state	5
private	4
novel	4
foreign	4
Age at current job	Total = 11
> 5 years	5
2-5 years	3
1-2 years	1
<1 year	0
retired (to)	2
Age at previous employment	Total = 9
> 5 years	5
2-5 years	3
1-2 years	1
<1 year	0
Profession	Total = 17
skilled labor	1
engineer	3
economist	2
health professional	3
military framework	3
servant	2
lawyer, judge	3
Position occupied by the applicant in the company	Total = 12
management (top)	5
management (executive)	4
means	2
bottom	1
Food vouchers	Total = 2
yes	2
not	0
Banking products	Total = 14
deposit account	5
current account	4
credit	3
card	2

Other properties	Total = 8
villa / house	3
apartment	2
land	2
Car	1
Other liabilities of the applicant and their type	Total = - 5
borrowings (financial liabilities)	-2
tax debt	-2
social debt	-1
Credit history	Total = 1
term credit products reimbursed	3
outstanding term credit products	-2
Indebtedness of the applicant family	Total = 12
<10% of net income	5
10% -20% of net income	4
21% -30% of net income	2
> 30% of net income	1
Mother bank branches around the residence of the applicant	Total = 2
there is a branch	2
no branch	0

As a result of scoring analysis (total score accumulated), the applicant is assigned a risk class, with an appropriate level of debt. If the total score is less than 80 points the applicant is rejected. Following analysis and simulations on a sample of 80 applicants, of which 42 are already accepted for credit, there were established five risk classes (I, II, III, IV, V) and indebtedness as a percentage of income eligible.
These were summarized as follows (Table 2):

Table 2: Risk classes

Score		Risk class	High leverage
Minimum	Maximum		
80,00	82,00	E	50,50%
83,00	85,00	D	56,00%
86,00	88,00	C	59,50%
89,00	92,00	B	63,00%
> 93,00		A	65,00%

The rules establishing the income to which the indebtedness is

- At the net income can be added value meal vouchers and permanent increases or bonuses.
- From the remaining amount is subtracted the minimum consumption basket, which depends on the number of dependents, which is also lessen with permanent payment obligations (like child support) and the actual net income results.
- To the actual net income is applied the degree of indebtedness resulting maximum monthly rate that can be borne by the customer.

According to the National Institute of Statistics the minimum consumption basket is 291 RON and it includes:

Money expenditure of which.

- Buying food and drink consumed;
- Buying non-food;
- Payment services;
- Investment expenditure;
- Production costs;
- Taxes, contributions, levies, duties.

The value of consumption of agricultural products from own resources. Total expenditures were divided by regions of development, so you can enter correction factors eligible net income as follows:

- North - East – 0,8
- South - East – 0,9
- South - Muntenia – 0,9
- South - West Oltenia – 0,8
- West – 1,1
- North - West – 1,05
- Center – 1,0
- Bucharest - Ilfov -1,1

The table below presents a simulation for an applicant whose income is 1.500 RON and has two dependent persons:

Table 3: Simulation

Monthly net income	1500	RON
Number of persons	2	–
Food vouchers	174	RON
Increases	0	RON
Raw	0	RON
Euro Currency	4,2664	RON
Minimum consumption basket	291	RON
Obligations	0	RON
Minimum consumption basket total	582	RON
Actual net income	1092	RON

The next step is to calculate the eligible net income corresponding to each risk category:

Table 4: Eligible net income

Category risk	Eligible net income (RON)
I	709,80
II	687,96
III	649,74
IV	611,52
V	551,46

If the score resulted in the first part of the evaluation was within the third class of risk, then the final amount of eligible net income is 649,74 RON. The maximum amount of debt calculated is adjusted with a coefficient determined by customer's payment behavior:

- **1** if the client currently has or had in the last year to pay the remaining obligations within 60 days (standard).
-
- **0,75** if the customer currently has or had in the last year to pay the remaining obligations between 61 and 90 days (adjusted).

- **0** if the client currently has or had in the past year, the remaining liabilities of more than 91 days (rejected). For the second case the coefficient of **0,75** results (Table 5)

Table 5: Behavior of the customer's payment

	Coefficient
60 days	1
61 - 90 days	0,75
> 90 days	0
0,75	
Category risk	Net income eligible (RON)
I	491,40
II	476,28
III	449,82
IV	423,36
V	381,78

Techniques Used in Credit Scoring: Logistic Regression [7], [11]

General term scoring function:

$$Scor = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n \quad (1)$$

where

- x_i -Representative factors influencing the probability of default;
- b_i are coefficients to be determined by the k factors.

If we consider a logistic regression *logit* type, the probability of default can be written:

$$\log it(p_1) = \log \frac{p_1}{1-p_1}$$
$$\vdots$$
$$\log it(p_1 + p_2 + \ldots + p_k) = \log \frac{p_1 + p_2 + \ldots + p_k}{1-(p_1 + p_2 + \ldots + p_k)}, p \in [0,1] \quad (2)$$

where

$$p = \frac{1}{1+\exp(-(b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n)} \quad (3)$$

or

$$\Pr ob(default) = \frac{1}{1+\exp(-(b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n)} \quad (4)$$

$$\Pr ob(no\_default) = 1 - \frac{1}{1+\exp(-(b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n)} \quad (5)$$

In this paper we determined the regression coefficients, using a solver in Excel and the data entry(factors) were:

- Indebtedness determined by income and loan amount.
- Number of products held in the bank.

- Number of dependent persons.

- Time worked in last job (in months).

By running the program, according to initial values, we obtain values and their standard error (Table 6).

Table 6 : Estimates coefficient

Variable	Estimated	SE
Intercept	19,3926	12,66393
0,3	4,402288	18,3828
2	2,491115	3,194806
3,9	–1,68023	0,988841
3	–3,28492	3,475287

In the first column is passed *Variable* value of each vector data for identifying the position of each factor considered and the *estimated* coefficients and *SE* are shown the corresponding error.

The estimated linear probability models to calculate the maximum *PseudoR*^{2} was introduced by researcher McFadden. It is calculated as one minus the ratio of estimated log likelihood $(\ln L)$ and a constant $(\ln L_0)$. Log-likelihood probability function is given by the last iteration of the Newton procedure, already available.

$$PseudoR^2 = 1 - \frac{\ln L_{Model}}{\ln L_{Intercept}} \qquad (6)$$

Table 7: Pseudo R squared

Number of observations	40
Number of X Variables	5
Mean of Dep. Var.	0,2
$\ln L$	–2,96218
Iterations	13
$PseudoR^2$	0,85201

In addition to the above values, the program displays: total number of iterations, the average distribution, standard deviation (Table 8).

Table 8: Standard deviation (SD)

X Variable	Mean	SD
Intercept	1	0
0.3	0,28775	0,114163
2	1875	0,991955
3.9	36	48,10245
3	2075	0,729858

The values obtained show that the probability of default for customers accepted for funding is under 1% and, moreover, is almost zero for about 50% of them (Table 9).

For example, on the fifth position is a debtor who is borrowing 28.760 Euros and has two banking products under development. He earns a net income of 4.900 Ron, has a seniority of 15 years and 9 months. He is married, with two dependent people, domiciled in Bucharest, he owns one apartment, a car and a ground. The result for him was a very low default risk, 2,15E–130. A default of 0,999739 % has resulted for a customer who has requested a loan of 3.090 Euros, with a net income of 1.340 RON, married, with two dependent persons, domiciled in Bucharest, the apartment owner, but his present working age was only six months.

Table 9: Probability of default

NO. CRTs	Default probability [%]	NO. CRTs	Default probability [%]
1	0,999907467	22	1,89 E-39
2	3,37 E-43	23	1,64 E-23
3	5,28 E-07	24	6,66 E-05
4	0,047108703	25	0,4956928
5	2,15 E-130	26	0,9997393
6	4,82 E-40	27	0,9552393
7	0,999149117	28	0,1666696
8	0,999999029	29	0,0033175
9	0,006972549	30	0,1049248
10	2,01 E-12	31	0,0002167
11	7,01 E-06	32	3,16 E-11
12	1,22 E-150	33	8,61 E-07
13	3,07 E-56	34	0,9985376
14	0,981748913	35	0,1012779
15	1,67 E-05	36	2,53 E-06
16	1,23 E-47	37	2,85 E-10
17	1,05 E-38	38	0,0162717
18	5,86 E-99	39	0,0086912
19	0,062038063	40	0,0379582
20	0,99988719	41	1,16 E-06
21	0,014464404		

Determining the category of financial performance in lending

The category of financial performance for individuals is based on default risk class determined in accordance with the Credit Standards Individuals approved by the National Bank of Romania [12] and information about sources of income status, as follows:

- In case when at the time of classification the individual customer receives credit only for real estate investments (Table 10)

Table 10: Category of financial performance-real estate investments

Category of financial performance	For crediting	For restructuring loans
A	Customers with default risk classes I and II	–

B	Customers with default risk classes III and IV	Customers in the category of financial performance A with at least a restructured bank credit agreement, with no decrease in family income.
C	Customers with default risk class V	Clients with at least a restructured bank credit agreement, for which the bank has information on lower revenues by up to 50% of the value considered in granting credit.
D	n / a	Clients with at least a restructured bank credit agreement, for which the bank has information on reducing revenue by more than 50% of the value considered in granting credit.
E	n / a	Clients with at least a restructured credit agreement to which the bank granted a grace period to pay the total monthly debt.

In case when at the time of classification the individual customer receives only a consumer loan (Table 11)

Table 11:Category of financial performance- consumer loan

Category of financial performance	Crediting	Restructuring loans
A	Customers with default risk classes I and II	
B	Customers with default risk classes III and IV	Customers in the category of financial performance A with at least a restructured bank credit agreement, with no decrease in family income.
C	Customers with default risk class V	Clients with at least a restructured bank credit agreement, for which the bank has information on lower revenues by up to 50% of the value considered in granting credit.
D	n / a	Clients with at least a restructured bank credit agreement, for which the bank has information on reducing revenue by more than 50% of the value considered in granting credit.
E	n / a	Clients with at least a restructured credit agreement to which the bank granted a grace period to pay the total monthly debt.

- In case when at the time of classification the individual customer benefits of both credit for real estate investment and consumer (Table 12)

Table 12: Category of financial performance- real estate investment and consumer loans

Category of financial performance	Crediting	Restructuring loans
A	Table 1	
B	Table 1	Customers in the category of financial performance A with at least a restructured bank credit agreement, with no decrease in family income.
C	Table 1	Clients with at least a restructured bank credit agreement, for which the bank has information on lower revenues by up to 50% of the value considered in granting credit.
D	n / a	Clients with at least a restructured bank credit agreement, for which the bank has information on reducing revenue by more than 50% of the value considered in granting credit.
E	n/a	Clients with at least a restructured credit agreement to which the bank granted a grace period to pay the total monthly debt.

In case of credit restructuring belonging to borrowers who do not have a decrease in family income, the category of financial performance will be a downgrade from the existing grade at the date of restructuring.

ISSN: 2278-3369
International Journal of Advances in Management and Economics
Available online at www.managementjournal.info

RESEARCH ARTICLE

Table 13: Default risk class on credit for real estate investment

Default risk class on credit for real estate investment	**I**	**II**	**III**	**IV**	**V**
Default risk class on consumer loans	Category of financial performance of customer				
I	A	A	B	B	C
II	A	A	B	B	C
III	A	A	B	B	C
IV	A	B	B	B	C
V	B	B	B	B	C

References

1. Basno C, Dardac N, Floricel C (1994) Monedă, credit, bănci, Editura Didactică şi Pedagogică, Bucureşti.
2. Danielsson J, Jorgensen BN, De Vries CG (2002) Incentives for effective risk management. J. Banking & Finance, Elsevier 26 (7):1407-25.
3. Drake LM, Holmes MJ (1995) Adverse selection and the market for
4. consumer credit. Applied Financial Economics 5: 161-167.

4. Finance and Leasing Association (2000), London–Guide to credit scoring.

5. Grunert J, Norden L, Weber M (2005) The role of non-financial factors in internal credit ratings. J. Banking & Finance, Elsevier 29(2):509-31.

6. Hakenes H (2004) Banks as delegated risk managers. J. Banking & Finance, Elsevier, 28(10):2399-426.

7. Löffler G, Posch PN (2007) Credit risk modeling using Excel and VBA, John Wiley & Sons.

8. Lyn T (2009) Consumer Credit Models: Pricing, Profit and Portfolios, Oxford University Press, USA.

9. Lyn T, Edelman DB, Crook JN (2004) Readings in Credit Scoring: Foundations, Developments and Aims, Oxford University Press, USA.

10. Lyn T, Edelman DB, Crook JN (2002) Credit scoring and its application, Society for Industrial and Applied Mathematics, Philadelphia, PA, USA.

11. Mays, Credit risk modeling (1998) Chicago Glenlake Publishing.

12. www.bnr.ro