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CREDIT RATIONING AS A RESULT OF OPTIMIZING THE LOAN PORTFOLIO UNDER THE PRUDENT ATTITUDE TO RISK

This paper examines the credit rationing problems and the principal reasons which generate it. The paper develops the conceptual framework for the study of the credit market equilibrium under the conditions of neutral risk attitude of lender to study of the formation mechanisms of optimal loan portfolio under the conditions of prudent risk attitude of lender. The paper argues that information asymmetry is not the main reason for credit rationing. On the basis of the optimization of the constructed model it was found that the key cause of credit rationing is an attempt to optimize loan portfolio by the lender with prudent attitude to risk.
Keywords: credit rationing; risk; loan portfolio; information asymmetry.

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КРЕДИТНЕ РАЦІОНУВАННЯ ЯК РЕЗУЛЬТАТ ОПТИМІЗАЦІЇ КРЕДИТНОГО ПОРТФЕЛЯ ЗА УМОВИ ОБЕРЕЖНОГО СТАВЛЕННЯ ДО РИЗИКУ

У статті розглянуто проблеми кредитного раціонування та основні причини, що його породжують. Розвинуто концептуальну основу переорієнтації з дослідження рівноваги кредитного ринку за умови нейтрального ставлення кредиторів до ризику на дослідження механізмів формування оптимального кредитного портфеля за умови обережного ставлення кредитора до ризику. На основі оптимізації побудованої моделі було встановлено, що основною причиною раціонування кредиту є намагання кредитора, що обережно ставиться до ризику, оптимізувати кредитний портфель.
Ключові слова: кредитне раціонування; ризик; кредитний портфель; інформаційна асиметрія.
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КРЕДИТНОЕ РАЦИОНИРОВАНИЕ КАК РЕЗУЛЬТАТ ОПТИМИЗАЦИИ КРЕДИТНОГО ПОРТФЕЛЯ ПРИ ОСТОРОЖНОМ ОТНОШЕНИЮ К РИСКУ

В статье рассмотрены проблемы кредитного рационирования и основные причины, его порождающие. Статья развивает концептуальную основу переориентации по исследованию равновесия кредитного рынка при условии нейтрального отношения кредиторов к риску для исследования механизмов формирования оптимального кредитного портфеля при условии осторожного отношения кредитора к риску. На основе оптимизации построенной модели было установлено, что основной причиной рационирования кредита является попытка кредитора, который осторожно относится к риску, оптимизировать кредитный портфель.
Ключевые слова: кредитное рационирование; риск; кредитный портфель; информационная асимметрия.

Introduction. Access to credit plays a crucial role in the development of agriculture. This is caused by the seasonal gap between investment and output sales and the continuity of the reproduction process. Credit is required to finance working capital

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and investment in fixed capital. It is an important instrument for smoothing the process of reproduction in the context where revenues from sales or incomes typically experience large seasonal fluctuations. However, it can be a problematic issue to obtain loans by farms due to credit rationing, the essence of which is that an agricultural enterprise cannot get credit or does not get a sufficient one, even if it is willing to pay higher interest rates. They can be considered as a fair price that takes into account the inherent risks.

Latest research and publications analysis. The asymmetric information problem is one of the basic theoretical approaches that attempt to explain credit rationing. This approach builds on earlier papers by D. Jaffee and T. Russell (1976) and J. Stiglitz and A. Weiss (1981). They explain credit rationing as a rational response to adverse selection problems (Stiglitz and Weiss, 1981) and as a moral hazard problem (Jaffee and Russell, 1976; Piketty, 1997) attributed to asymmetric information problem between lenders and borrowers. H. Bester (1985) and A. Besanko and A. Thakor (1987) explain credit market under asymmetric information conditions. A comprehensive recent treatment of credit market under asymmetric information conditions is provided by X. Freixas and J. Rochet (1997) and R. Bebczuk (2003) and S. Cosci (1993).

The problem of credit rationing in agriculture under asymmetric information conditions is also addressed by T. Jappelli (1990), A. Diagne and M. Zeller (2001), J. Foltz (2003), M. Petrick (2003), K. Janda (2006) etc.

M. Petrick (2003) gave an overview of various methods for measuring and provides an empirical analyses of credit rationing as employed in literature. K. Janda (2006) researched from the theoretical point of view how different tools of government's credit support may decrease the inefficiencies caused by credit rationing of agriculture under asymmetric information conditions. T. Jappelli (1990) and A. Diagne and M. Zeller (2001) showed that credit rationing has a negative impact on agriculture's economic performance. J. Foltz (2003) showed what possible implications of credit rationing can be for farms: a farm is unable to optimally allocate resources in a short term (the profit-liquidity effect) and has to refrain from long-term investments in land and equipment since it cannot spread its expenditures over time (investment demand effect).

However, studies so far have not paid sufficient attention to the problem of lender's attitude to risk, which is generally considered under the assumption that lenders have the neutral attitude to risk. From this perspective, we have made an attempt to examine credit rationing from the position of the lender's prudent attitude to risk. Hence, the purpose of this paper is to develop a conceptual framework focusing on the main reasons of credit rationing.

Material and methods. Despite the fact that credit rationing has been an important research topic for a long period of time, the question of the main reasons for its causes has remained important. Understanding the causes for credit rationing in practice depends on several determinants. Theoretically, the conceptual issues of credit rationing in many respects depend on the key principles or methodological fundamentals that are assumed to provide the basis for credit rationing in the conceptual study.

From this point of view if we consider the application of the credit rationing problem at the level of some sector such as agriculture, it is necessary to clearly define the principles used:

- Credit is not a standardized product; the study of supply and demand market mechanism is important for formation of the equilibrium price (interest rate).

- Interest rates are set according to the results of individual agreements (in negotiations) between a borrower and a lender on the basis of many factors. The range of interest rates for the enterprises of specific industry can be quite significant in a separate point of time.

- Assuming the concept of compromise between risk and profitability (risk and return trade-off concept), the relationship between the level of profitability of individual credit transactions and the level of risk is directly proportional.

- Lenders have prudent attitude to risk (researchers during the study problems of credit rationing are using mainly the condition that the lender has a neutral attitude to risk, which does not always correspond to reality).

- A measure of the lender risk is the variance of return of the loan portfolio, which is assumed by the traditional approach of decision theory and risk assessment (Damodaran, 2008; Knight, 2005), as well as by the approach of one of the founders of portfolio theory (Markowitz, 1959).

The goal of the paper. The above mentioned principles from the study of the credit market equilibrium under conditions of neutral risk attitude of lender are used to study the formation mechanisms of optimal loan portfolio under the conditions of prudent risk attitude of lender. Thus, the study formulates the following hypothesis: a major cause of credit rationing is an attempt by the lender with prudent risk attitude to optimize loan portfolio. Therefore, it is assumed that:

- information asymmetry should be considered as a factor that limits the possibility of loan portfolio optimizations and, as a consequence, leads to a decrease in credit rationing;

- growth of interest rates at the credit market is not a prerequisite of credit rationing, but growth of interest rates is a factor that limits the ability of credit portfolio optimization that leads to a decrease in amount of credit rationing.

The set hypothesis is tested using the hypothetical data.

Results and discussion. Confirmation of the validity of the proposed hypothesis can be obtained using the model of loan portfolio, which is constructed based on the above defined basic principles and has the following main characteristics:

First, all borrowers are enterprises of a single industry, i.e., farms.

Second, it is considered that the consolidated lender and the so-called single loan means that borrowers can obtain one conventional currency for a period of the one-year from the terms of repayment of all principal and interest rate payments at maturity.

Third, all loans granted are not collateralized, and commitments (interest rate and repayment principals) depend entirely on the results of implementation of the projects by the borrowers financed by the loan. To simplify the model, this stipulates that all projects of borrowers are 100% financed by a loan.

Fourth, all projects of borrowers that require loan financing are divided into several groups, each of which is characterized by specific results. Some of them have

anticipated value (mathematical expectation) and variance of the internal rate of return (*IRR*).

Fifth, it is assumed that the results of the borrowers' projects depend on the scenarios assumptions of the environment in which these projects are implemented. 5 scenarios are considered: pessimistic, moderately pessimistic, moderate, moderately optimistic and optimistic. The 5 scenarios and the probability of scenario performance are defined on the basis of hypothetical data.

Table 1 presents a hypothetical example of outcomes distribution for each of the 5 scenarios under the assumption of distribution of the probability of scenario.

Table 1. **The results of the borrowers' projects appraisal using the hypothetical data,** *authors' calculations*

Scenario	Probability of scenario	The internal rate of return (IRR), %					
		1 group	2 group	3 group	4 group	5 group	6 group
Pessimistic	0.15	2.5	-0.5	-6.5	-11.5	-20.0	-30.0
Moderately pessimistic	0.25	2.0	7.5	9.0	10.0	10.0	7.5
Moderate	0.4	0.5	9.5	19.5	23.5	30.0	36.0
Moderately optimistic	0.15	0.0	20.0	27.5	34.0	40.0	47.5
Optimistic	0.05	-1.5	28.0	36.0	44.5	50.0	72.0

Sixth, because all the borrowers are agricultural enterprises of the same industry, the above scenarios are considered common (cross-cutting) for all groups of projects and determine the value of mathematical expectation and variance of *IRR* for each group. The results of calculations by equations (1) and (2) are shown in the columns from 1 to 3 in Table 2:

$$E(IRR) = \sum_{i=1}^{n} IRR_i \times \Pr(IRR_i); \qquad (1)$$

$$\sigma^2{}_{IRR} = \sum_{i=1}^{n} \left(IRR_i - E(IRR)\right)^2 \times \Pr(IRR_i), \qquad (2)$$

where *E(IRR)* is the mathematical expectation (anticipated value) of a discrete random variable IRR of the borrower' project; $\sigma^2{}_{IRR}$ is the variance of a discrete random variable *IRR*; *n* is the number of possible values of a discrete random variable *IRR*. It is assumed that the number of possible scenarios of the enabling environment in which projects are implemented by borrowers is 5; Pr(*IRR$_i$*) is the probability of obtaining each of the possible values of *IRR* for each possible scenario.

Seventh, the parameters of credit demand for certain projects' groups in the situation of a single loan can be simultaneously viewed as relative indicators that characterize the structure of credit demand and the structure of non-rationing loan portfolio (Column 4 Table 2).

Eighth, possible effective interest rate on the loan is set for each group of projects and meets expectations value of *IRR*, adjusted for the effect of tax savings for the borrower as a result of financial costs. This provides the condition that the borrower does not agree to a loan if the cost of funds exceeds the expectation value of *IRR*. It is known that the cost of borrowing should take into account the effect of tax savings that occurs due to financial costs of the borrower. The results using the hypothetical data according to equation (3) are presented in Column 5, Table 2:

$$r = \frac{E(IRR)}{(1-Tax)}, \qquad (3)$$

where r is the possible effective interest rate on the loan; $E(IRR)$ is the expectation of project's *IRR* of particular group; *Tax* is the average income tax for borrowers.

Table 2. **Parameters of the loan portfolio model under the condition of absent information asymmetry using the hypothetical data from Table 1,** *authors' calculations*

Group of borrowers' projects	Expectation of projects' IRR, %	The standard deviation of projects' IRR, %	Demand for credit, in standard monetary unit	Possible effective interest rate on the loan, %
1	2	3	4	5
1	1.0	1.07	0.05	1.22
2	10.0	7.03	0.07	12.20
3	15.0	11.49	0.18	18.29
4	17.5	15.23	0.35	21.54
5	20.0	20.25	0.25	24.39
6	22.5	27.55	0.10	27.44
Total	x	x	1.00	x

Note: the level of taxation of income by borrowers is at 18%.

Ninth, the results of credit operation for the lender (Table 3) are not identical to the results of the borrowers' projects, but depend on them in the case of adverse enabling environment scenarios for which *IRR* is lower than expectation. If there are implemented scenarios for which *IRR* is higher than the expectation, the result for the lender is the difference between the amount of earned interest rate on the loan and operating expenses, and income tax for the lender. To simplify the model results there are considered credit operation without losses associated with the creation of required reserves:

$$N = \begin{cases} (IRR_i - c) \times (1-Tax), & IRR_i \leq 0 \\ IRR_i - c \times (1-Tax), 0 < IRR_i < E(IRR) \\ (r-c) \times (1-Tax), & IRR_i \geq E(IRR) \end{cases}, \qquad (4)$$

where N is the result of credit that belongs to a particular group or net operating profit less adjusted taxes, in the case of a single loan that can simultaneously be regarded as a relative measure of profitability of credit transactions; c is operating costs of lender associated with the implementation of credit transaction.

Table 3. **The results for the lender in the case of no information asymmetry,** *authors' calculations*

Indicator	Probability of scenario	Projects					
		1 group	2 group	3 group	4 group	5 group	6 group
1	2	3	4	5	6	7	8
1. The results for the lender:							
Pessimistic	0.15	0.002	-0.012	-0.062	-0.103	-0.172	-0.254
Moderately pessimistic	0.25	0.002	0.067	0.082	0.092	0.092	0.067
Moderate	0.4	-0.003	0.087	0.142	0.167	0.192	0.217
Moderately optimistic	0.15	-0.008	0.092	0.142	0.167	0.192	0.217
Optimistic	0.05	-0.021	0.092	0.142	0.167	0.192	0.217
2. Expectation	x	-0.003	0.068	0.096	0.108	0.112	0.109
3. Standard deviation	x	0.005	0.035	0.071	0.094	0.127	0.165

Note: the current level of lender's costs is considered as a permanent at 1%. The numbers in the case of a single loan can be considered both as absolute in standard monetary units, and as a relative.

Tenth, information asymmetry for the lender manifests itself to uncertainty about the borrower on loan commitments. This lender's uncertainty can be eliminated only partially using available tools such as better screening and assessment of business plans of the borrower.

Eleventh, the need to deal with lender's uncertainty in the case of information asymmetry causes additional operating costs for the lender, comparing to the situation in the absence of information asymmetry.

Twelfth, the hypothetical results of lender performance in the information asymmetry are evaluated under the principle of prudent attitude to risk. This assumes that into account are taken the worst of possible project outcomes of borrowers. This is that part of the loan portfolio, which is burdened by uncertainty or the share of loans for which is considered to be impossible to determine the creditworthiness of borrowers. More specifically, this is the share of loans allocated in a separate group with its own expectation and variance IRR.

Thirteenth, the variance of return for lender's loan portfolio is calculated based on the values of the covariance of returns (results for lender) for certain groups of borrowers' projects, which involves calculating the covariance matrix:

$$\sigma^2 = \sum_{i=1}^{k} X_i^2 \sigma_i^2 + 2\sum_{i=1}^{k-1}\sum_{j=i+1}^{k} X_i X_j \sigma_{ij}, \tag{5}$$

where σ^2 is the variance of return of loan portfolio; σ_i^2 is the variance of return of lending projects of specific group; k is the number of groups of projects; X is the share in loans to finance projects of individual groups in the loan portfolio; σ_{ij}^2 is the covariance of returns of lending projects of two separate groups.

Equation (5) in matrix form can be written as follows:

$$\sigma^2 = XYX^T, \tag{6}$$

where X is the row vector for share in loans to finance projects of individual groups in loan portfolio; Y is covariance matrix, (i, j)-th element is equal to σ_{ij}. This matrix is symmetric in its diagonal. It represents the variance of return of lending projects of specific group; X^T is the transposed row vector X.

Fourteenth, as mentioned above, the model of loan portfolio is a quadratic programming model. The model could be optimized by using a generalized reduced gradient method which possible provides through Excel "Search solutions" (Solver) (Moore, 2001).

Fifteenth, it is possible to use 3 alternative criteria for the optimization of loan portfolio by:

- Maximizing of the choice function of customers with careful attitude to risk. This is the simplest type of linear functions, but only in the situation with the absence of information asymmetry. However, this criterion is rarely used to study the impact of information asymmetry.

- Minimizing the variance of return of the loan portfolio under the condition of restriction on the minimum level of return.

- Maximizing the return of the loan portfolio under the condition of the restriction on the maximum value of the variance of return.

The last two of the following criteria optimization are similar to those used by H. Markowitz (1959) in the process of solving problems of optimization of investment portfolios.

As a result of optimizing simulated loan portfolio, the following conclusions regarding the amount of credit rationing can be derived:

First, if we apply the criterion of minimization of the variance of the return on the loan portfolio (σ^2) under condition of the restriction on the minimum level of its return (y_{min}), then we can get 3 possible solutions and implications:

- As in the absence of information asymmetry, and if it exists, then the value of σ^2 optimized credit portfolio increases with increasing y_{min}, whilst there is also increasing proportion, which is matching the needs of creditors. Thus strengthening of the optimization restrictions (growth in y_{min}), *ceteris paribus,* leads to a decrease in credit rationing, as illustrated in Figure 1.
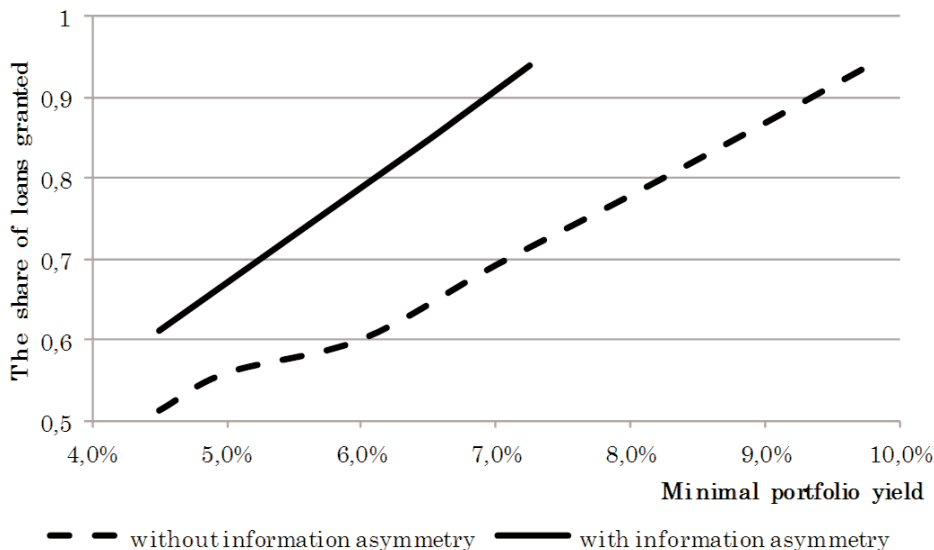
Figure 1. Dependence of loan granting on the minimum value of return of the loan portfolio, defined as limitations in the optimization process, *authors' calculations*

- In the case of the information asymmetry lender has less capacity to minimize σ^2, since the application of the principle of prudent attitude to risk leads to underestimation in the assessment of the expected return of loan portfolio and, consequently, this increased restrictions on the optimization. The same value of y_{min} stipulates that the result of the optimization in the case of the absence of information asymmetry is lower than in the case of σ^2 with information asymmetry. It follows that in the case of information asymmetry the optimized credit portfolio will be rationed less than a similar portfolio in the absence of information asymmetry.

- Finding the optimal solution for the model of loan portfolio is only possible if y_{min} does not significantly exceed the value of return of loan portfolio, which is not

optimized. This is satisfying all the needs of borrowers, which does not involve credit rationing. In the case of information asymmetry it holds that the threshold value is less than in the case of its absence when assuming the equivalence needs of borrowers in both cases.

Second, if the criterion of maximizing the return of the loan portfolio (y) is applied under the condition of the restriction on the maximum value of its variance (σ^2_{min}), then similar results are observed as in the case of first optimization of loan portfolio. In the case of information asymmetry optimized credit portfolio will be less rationed than a similar portfolio in the absence of the information asymmetry. Difference between the first and the second optimization is that with the increase σ^2_{min}, *ceteris paribus,* the return of the optimized portfolio will increase to a certain value. This value is higher for the absence of information asymmetry situation than the situation that information asymmetry is present.

The model of loan portfolio under the condition of prudent attitude to risk, constructed above, in general confirmed the properties of the set hypothesis. Thereby, the main cause of credit rationing is an attempt of the lender with prudent risk attitude to optimize loan portfolio.

Conclusions. The article has made an attempt to develop a conceptual framework to explain the causes of credit rationing. The existing studies into the relationship of credit rationing often do not pay enough attention to the problem of the lender's attitude to risk and is generally considered that lenders have a neutral attitude to it. This paper further develops the conceptual framework on the main reasons of credit rationing and the role of information asymmetry. The paper has employed the optimization model using the hypothetical data to test the set hypothesis. It was found that the main cause of credit rationing is an attempt by the lender with prudent attitude to risk to optimize the loan portfolio. This main finding provides a basis for developing of more effective ways of monitoring and management to eliminate the negative effects of credit rationing on the level of a discrete industry.

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