ISSN 1392-1142
TAIKOMOJI EKONOMIKA:
SISTEMINIAI TYRIMAI: 2008.2/1

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Fuzzy sets theory adoption for credit risk assessment in leasing sector

Straipsnyje pateikiami sprendimai kredito rizikos vertinimo lizingo sektoriuje efektyvumui didinti. Suformuotas kredito rizikos vertinimo lizingo sektoriuje, naudojant neapibrėžtų aibių teoriją, modelis, palengvinantis lizingo gavėjo kredito rizikos įvertinimą.

Raktiniai žodžiai: kredito rizika, lizingas, neapibrėžtos aibės.

In this article the decisions for credit risk assessment efficiency improvement in leasing sector are presented. The model of credit risk assessment in leasing sector using fuzzy sets is formed to make the assessment of lessee's credit risk easier.

Keywords: credit risk, leasing, fuzzy sets.

JEL Classifications: G32/G21/C65

Introduction

The use of leasing as one of company's financing sources is based on preference that company's income is guaranteed by usage of asset regardless of the property rights (Beuselinck, 2000). This presumption characterizes the conception of leasing, where the possibility to use asset to generate income avoiding non-recurring big investment is accented.

Leasing, as one of lending forms, is sensitive to credit risk, which characterizes the uncertainty the lessor encounter in case of threat of possible lessee's default. Credit risk in leasing sector is treated as smaller than in commercial banks sector but this doesn't presume the possibility to avoid credit risk assessment and management in leasing. This is especially important in the context of expanding range of leasing objects, which conditions the need to accept higher level of risk as the results of competition growth in leasing sector.

In the context of accented necessity to assess credit risk in making any type of financial transactions, it is important to pay attention at the fact that usage of credit risk models, that are common in commercial banks' sector, is not the best choice for leasing companies. Those models require more time and financial

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inputs than it is necessary for credit risk assessment in leasing sector, because leasing conditions lower credit risk probability and average loss size than commercial banks. This conditions the presumption that leasing sector must be interested in specific credit risk assessment models that are adopted for leasing product and allows simplifying credit risk assessment procedures while keeping the acceptable level of assessment reliability. The specifics of leasing, as one of lending products, was analyzed by various authors (Bauselinck, 2000; Biagi, 1999; Caouette, Altman, Narayanan, 1998; Schmit, 2007; Chen, 2001; Sing, Tang, 2004; Crouhy, 2000; Danys, Milašauskas, 2000; Gallardo, 1997; Bessis, 1998; Dainauskienė, 1996; Mayes, Nicholas, 1988; Metawa, 1995, etc.) but only small part of them (Caouette, Altman, Narayanan, 1998; Schmit, 2007; Chen, 2001; Sing, Tang, 2004; Metawa, 1995) tried to conceptualize credit risk specifics in leasing sector. In most cases those tries are limited by determination of main leasing sector's peculiarities (Danys, Milašauskas, 2000; Mayes, Nicholas, 1988; Caouette, Altman, Narayanan, 1998) and only in rear cases (Schmit, 2007; Chen, 2001; Sing, Tang, 2004; Metawa, 1995) the concrete decisions for credit risk assessment optimization in leasing sector were presented. Such situation accents the relevance of this article: various authors' presented peculiarities of leasing in the context of credit risk area require the generalization and concrete decisions for credit risk assessment. This problem is attempted to be solved in the article by presenting conceptual model of credit risk assessment in leasing sector.

The object of research is credit risk assessment in leasing sector.

The objective of research is to form the model of credit risk management in leasing sector using fuzzy sets theory.

The methods of research are as follows: systemic, logical and comparative analysis of scientific literature, fuzzy sets theory, breakeven point analysis.

Researches of credit risk assessment relevancy and methods in leasing sector by M. Schmit (2007), T.F. Sing and W. L. Tang (2004), Y. C. Chen (2001), C. Beuselinck (2000), J. Gallardo (1997), A. Danis and T. Milašauskas (2000), K. Giesecke (2004) and S. A. Metawa (1995) are analyzed in this article. In the base of those researches the model of credit risk assessment in leasing sector using fuzzy sets theory is formed.

The presumptions for fuzzy sets theory adoption for credit risk assessment in leasing sector

Credit risk assessment in leasing sector is based on credit risk assessment models, which are adopted for banking sector. M. Schmit (2007a), T.F. Sing and W.L. Tang (2004), A. Danys and T. Milašauskas (2000), S.A. Metawa (1995), J.C.Duke (2004) and others agree with the statement that credit risk analysis in leasing sector is basically analogous to credit risk that appears in crediting, but abovementioned authors accent that there are some specific factors in leasing sector, which condition specific nuance in leasing product's credit risk management. If credit risk in leasing is assessed by using common banks' credit risk models, there exists the menace that peculiarities of leasing remains unappreciated. More thorough analysis of credit risk specificity in leasing sector is presented by A. Cvilikas, P. Baršauskas and T. Šarapovas (2007), where it is given

the validation of statement that credit risk assessment in leasing sector can be treated as specific procedure because of those two main peculiarities (in comparison with commercial banks' credit risk):

- Property rights in leasing agreement remain in disposition of lessor.
- The existence of front-end fee, which performs the role of additional financial guarantee.

In the assessment of credit risk in leasing sector it is worth to pay attention at the specifics of credit risk. Credit risk in leasing sector is mostly connected with non-receiving of estimated inflow, because the risk of possible asset loss is minimized by keeping property right of leased asset.

The analysis of credit risk specifics in leasing sector allows stating that before making the leasing agreement lessor is interested to assess the possibility to guarantee lessee's payoff that is defined in agreement. This means the need to analyze lessee's positive and negative financial flows and to measure the difference between those flows. Leasing agreement in most cases is a long-term agreement (lasts more than one year) and this conditions the need to forecast lessee's future financial flows and their changes not just in case of leasing, but also in the context of changing market and macroeconomic situation. In this case qualitative analysis of lessee's performance changes is necessary, which is the foreground for lessee's credit risk assessment. In leasing, just like in banking sector, the main aspect of credit risk assessment process is analysis of risk generating factors that can be maid by using two methods (Vaškelaitis, 2003):

- Qualitative analysis, which purpose is to define market conditions under which the risk appears. In general qualitative analysis is the determination of possible risk areas and definition of all possible risk factors.
- Quantitative analysis, which goal is to assess risk volume in numbers. This task is considered to be very difficult because of limited possibilities to generate accurate measure of various risk areas. The quantitative assessment of risk requires high level knowledge, special software and experience.

The comparison of qualitative and quantitative analysis characteristics is presented in table 1. The main difference between those two methods of analysis is the impact of assessor's individual characteristics on final results: in case of qualitative analysis the competence and priorities of assessor may have big (in some cases even crucial) impact on credit risk assessment; in case of quantitative analysis, as P. Em-

Table 1

Differences of qualitative and quantitative risk analysis (CFO Research Services, 2004)

	Qualitative analysis	Quantitative analysis
Methodology	On the base of credit managers' knowledge, experience and priorities the weighted functions is formed, which generates numerical assessment of credit risk	Statistical analysis of potential debtor's financial data and performance results, which generates numerical assessment of credit risk
Information sources	Internal and external data, which are chosen in discretion of creditor, usually taking in mind experts' advices	Primary data of financial statements and additional performance results, which are processed by adopting for further analysis
Assessor's priorities	Used by assessors, who prefer automated and standardized decisions	Is used by assessors, who prefer new scientifically based decision making models.

brechts (2000) states, assessor's individuality may affect only primary stage of data collection, but is not significant in final assessment of credit risk.

The determined peculiarities of qualitative and quantitative analysis methods adoption allow stating that reliable risk analysis results may be guaranteed only by using thorough information about lessee's financial state and its development tendencies, which are assessed in qualitative and quantitative form. In such case it is necessary to obtain the information processing by using high-quality technical methods, which allow assessment of potential lessee's risk level. In leasing sector it is important to ensure that information collection and processing should guarantee not only accurate results but also low time, financial and labor resources, which are imminent in credit risk assessment in commercial banks' sector. This conditions additional requirements for credit risk assessment in leasing sector.

In the assessment of lessee's risk level most often the financial state (asset usage, performance volume, turnover, liquidity, etc.) of lessee is analyzed with the purpose to define most possible development perspectives in case of lending the asset (Fraser, Gup, Kolari, 1996). The lessee's performance forecasting-based risk management is related to some uncertainty, which is conditioned by limited possibilities to assess accurate lessee's development perspective, narrow assessor's competence (assessor as the expert of lessee's performance area is rather exception than usual practice) and other factors.

The instability that exists in assessment of debtor's reliability is closely related to uncertainty of debtor's performance forecasting. For this reason lender is unable to predict exact changes in factors that may influence debtor's performance and ability to apply the undertakings. Also, it is important to mention the limited ability to assess the intensity of influence of separate factor on debtor's performance and financial state.

This kind of fuzziness, as Y. C. Chen (2001) states, limits the possibility to evaluate the scale of credit risk, because the variance of every factor's assessment is omitted. For this reason usual quantitative credit risk valuation models can be used with some reservation, keeping in mind that they include only one scenario of debtor's performance development.

The more complicated credit risk models may include several scenarios of lessee's financial state development, but even in this case limited possibilities to assess the variance of presumptive lessee's financial state development tendencies remains.

The possibility of valuation fuzziness conditions the need to use unusual quantitative assessment for those factors, which can't be treated as absolutely reliable (Gottwald, 2005). To minimize the risk of uncertainty in the process of forecasting that is necessary in lessee's credit risk assessment, Y. C. Chen (2001) recommends using *fuzzy sets theory*, which creates possibility to reduce the uncertainty that exists in qualitative credit risk assessment because of assessor's subjectivity or lack of competence. Fuzzy sets allow assessment of risk factor in forecasting procedures, that is more useful then the need of accurate valuation of forecasting boundaries exists.

The originator of fuzzy sets theory is considered to be L. A. Zadeh (1965) who presented this theory for solving problems where strictly defined numerical parameters do not exist. Fuzzy sets theory, also

known as fuzzy numbers theory, is treated as modeling language with the purpose to generalize situations where indefinite expressions and parameters dominate. Fuzzy set is treated as special subset of real numbers, where the possible boundaries of value's deviance are concretized, depending on value's reliability and nature of usage (Gottwald, 2005):

$$A = (\alpha X; X; \beta X) \quad (1)$$

where,

A – fuzzy set,

X – most likely value of fuzzy set A,

α and β – coefficients that define bottom and top deviance from most likely value.

J. Čiburienė and D. Pabijanskas (2004) present expert comparison between real and fuzzy sets (table 2). Authors accent the possibility of fuzzy sets to assess the risk of value variation that is very important in business indicators assessment, which in most cases are calculated using approximate values (i.e. assessment of fixed or variable cost per unit).

S. Gottwald (2005) accents the possibility of fuzzy sets theory to convert linguistic rating scale to quantitative expression. It is an important advantage of fuzzy sets usage in credit risk assessment process, because fuzzy sets create possibility to incorporate expert rating in quantitative assessment while retaining the uncertainty of expert rating.

The method of fuzzy sets adoption in qualitative assessment is presented in Fig. 1.

The usage of fuzzy sets allows avoiding categorical qualitative assessment that exists then the common binary qualitative-to-quantitative transformation scale is used, i.e. rating scale {very low, low, average, high, very high} is transformed to scale {0, 0.25, 0.5, 0.75, 1} or analogous quantitative scale. In this case the qualitative assessment becomes equal to concrete numeric value that eliminates uncertainty of qualitative assessment in further analysis.

Fuzzy sets theory enables to transform the subjectivity of assessor (uncertainty of assessment) to quantitative scale by using individual set of numeric values for every qualitative assessment. In abovementioned case the assessment of {average} in fuzzy sets theory is transformed to the numeric set {0.25, 0.5, 0.75} where 0.5

Table 2

Comparison of real and fuzzy sets usage in financial analysis

Parameter	Real numbers	Fuzzy numbers
Simplicity of usage	Simple to use	Unusual arithmetic actions, difficult ranking / comparison
Expression of estimated values	Primary information must be processes before expressing	Simple to express
Thoroughness of final value of analyzed parameter	Single value expressed, usually the mean of possible interval, without information about possible variance	Whole interval of values expressed
Possibility to present financial assessment and risk of uncertainty using single indicator	No	Yes
Possibility to use experts' competence in risk assessment comparison of alternatives	No	Yes, but the final assessment of risk is subjective

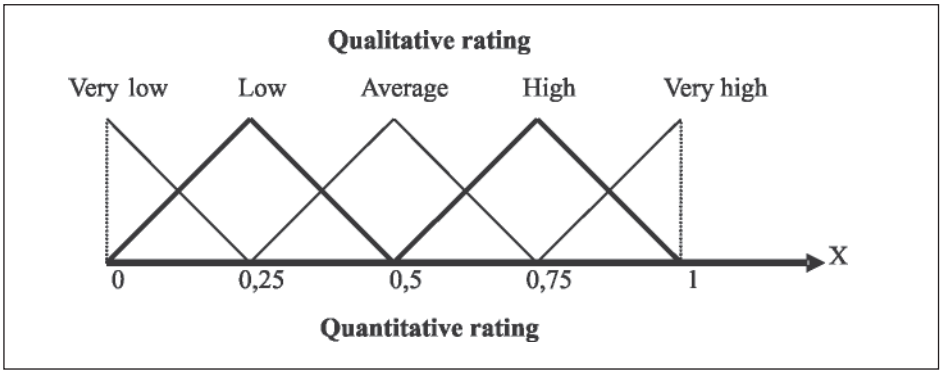

Fig. 1. **Transformation of linguistic scale to fuzzy sets scale (Gottwald, 2005)**

means the choice of assessor and 0.25 and 0.75 are bottom and top boundaries of assessment. In such form the categorical assessment is reduced and the possibility to make further quantitative analysis of risk remains with the option to calculate not just final assessment of lessee's credit risk, but also to define possible variation boundaries.

Fuzzy sets theory as the tool for qualitative and quantitative measurements' integration in united assessment system can be used for credit risk assessment in leasing sector. This allows the possibility to thoroughly assess lessee's credit risk with comparatively low time and labor resources. This statement presumes the relevance of fuzzy sets adoption in credit risk assessment in leasing sector.

Credit risk assessment in leasing using fuzzy sets model's structure

The analysis of M. Schmit (2007) and Y. C. Chen (2001) researches allows stating that the biggest efficiency in credit risk assessment is guaranteed by optimal combination of qualitative and quantitative assessment methods, which creates the possibility not only to determine the tendencies of analyzed object's performance, but also to express those results in numeric expression with the purpose to reduce subjectivity of assessment.

Abovementioned procedures of credit risk assessment in leasing sector can be implemented by using the model of credit risk management in leasing sector using fuzzy sets theory. This model is based on synthesis between fuzzy sets theory and breakeven point model, which include aspects of both qualitative and quantitative credit risk assessment ways. Breakeven point analysis enables fast and accurate assessment of difference between lessee's income and expenditure and this allows determining the possible periodic leasing payment or total sum of leasing agreement. The variables that are used in breakeven point analysis are as follows:

- Lessee's expenses, which are split in two elements: fixed and variable costs.
- Lessee's production / service average price per unit.

The synthesis of fuzzy sets theory and breakeven point analysis was thoroughly analyzed by Y. C. Chen (2001) who pre-

sented decisions for lessee's credit risk level assessment. Credit risk assessment in leasing sector using fuzzy sets theory model presented in this article is based on Y. C. Chen (2001) recommendations for credit risk assessment, which are concretized by defining risk assessment procedure (algorithm with concrete input data necessary for credit risk assessment) and including experts' estimation of lessee's perspective.

Breakeven point shows the minimal sales volume (in units and in value) that is necessary to cover all (variable and fixed) costs (Johnson, 2001):

$$Q_L = \frac{FC}{P-V}; \quad S_L = \frac{FC}{1-\frac{V}{P}} \tag{2}$$

where:

Q_L – breakeven point in production units;

S_L – the value of breakeven point;

FC – fixed cost;

P – average price per unit of product / service;

V – variable cost per unit.

The main problem in breakeven point analysis adoption for company's performance measure usually is miscellaneous assortment of production / services with different measure units that limits the possibility to make accurate calculations of price per unit and cost or unit. To solve this problem the conditional (unified) production units may be used, which neutralizes miscellany.

The surplus of lessee's income in comparison with breakeven point's value shows the success of company's performance and the ability to execute leasing agreement. But in the analysis of estimated lessee's abilities to apply the undertakings it is necessary to forecast future trends of lessee's breakeven point and its relations with income.

Forecasted costs structure (fixed and variable costs), average price of products / services and total income are approximate. For this reason those variables are defined in the form of fuzzy sets that allows to retain the uncertainty of forecasting and enables calculation of credit reliability coefficients, which reflect the risk of lessee's default of leasing agreement.

The algorithm of model of credit risk assessment in leasing sector using fuzzy sets consists of six main stages:

1. Current breakeven point analysis.
2. Future breakeven point analysis.
3. Lessee's utility matrix formation.
4. Changes probability matrix formation.
5. Operating profit estimation.
6. Credit risk assessment.

Graphically the algorithm of model of credit risk assessment in leasing sector using fuzzy sets is presented in Fig. 2. Further in this article every stage of presented model is discussed.

Stage 1. Current breakeven point analysis. Breakeven point analysis is made by using the methodology that was discussed earlier in this article. In most cases lessee's fixed and variable cost can be defined only approximately and for this reason it is purposeful to define those cost as fuzzy sets (Chen, 2001):

$$FC = (\alpha FC; FC; \beta FC) \tag{3}$$

$$V = (\alpha V; V; \beta V)$$

Using the standard arithmetic of fuzzy sets the current breakeven point in terms of money is calculated as fuzzy set:

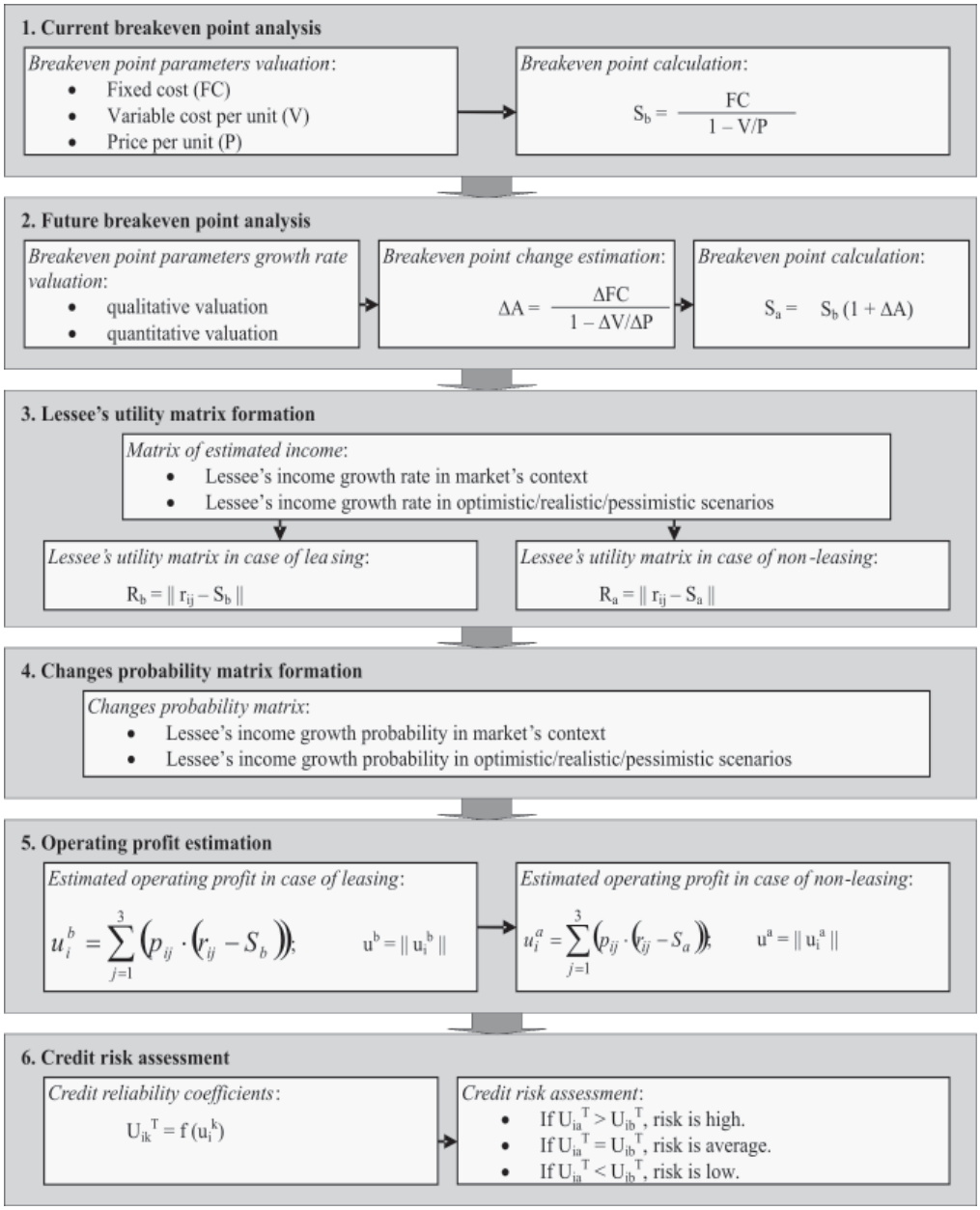

Fig. 2. **Credit risk assessment in leasing using fuzzy sets theory algorithm**

Source: Created by authors in accordance with Y. C. Chen (2003); S.Gottwald (2005).

Lessee's income growth rate in market's context	*Lessee's income growth rate in different scenarios*		
	Optimistic scenario	Realistic scenario	Pessimistic scenario
Faster than market	r_{11}	r_{12}	r_{13}
Average	r_{21}	r_{22}	r_{23}
Slower that market	r_{31}	r_{32}	r_{33}

Fig. 3. **Estimated lessee's income matrix (Chen, 2001)**

$$S_b = (S_b^{ž}; S_b; S_b^{v}) \quad (4)$$

where:

$S_b^{ž}$ and S_b^{v} – calculated bottom and top boundaries of breakeven point.

Stage 2. Future breakeven point analysis. The future breakeven point is measured in two cases: (1) then leasing agreement is made (in case of leasing) and (2) then leasing agreement is refused (in case of non-leasing). Both cases requires assessing of all possible changes in changes in market or macroeconomic situation and in lessee's cost structure, which correlate with the use of leased asset (additional exploitation expenses, changes in efficiency, etc.), if leasing agreement is made.

In he process of future breakeven point calculation the percentage change of breakeven point is assessed using experts' qualitative assessment that is transformed into fuzzy sets using the relation between linguistic and numeric scale, which is presented in Fig. 1. This allows calculating future breakeven point in case of leasing and non-leasing:

$$\Delta A = \frac{\Delta FC}{1 - \Delta V / \Delta P} \quad (5)$$

$$S_a = S_b \times (1 + \Delta A) \quad (6)$$

where:

ΔA – percentage change of breakeven point;

S_b – current breakeven point,

S_a – future breakeven point.

The future breakeven point forecasting can be made by using qualitative experts' assessment, which can be transformed to quantitative scale that is defined as fuzzy set in earlier in this article discussed way:

- Very low change: {0,0,0.25}.
- Low change: {0,0.25,0.5}.
- Average change: {0.25,0.5,0.75}.
- High change: {0.5,0.75,1}.
- Very high change {0.75,1,1}.

Stage 3. Lessee's utility matrix formation. Lessee's utility matrix is the forecasted operating profit (difference between forecasted income and cost) of lessee that is assessed in two dimensions:

- Comparing lessee's income growth rate with market's growth rate.
- Comparing lessee's income growth in optimistic, realistic and pessimistic scenarios.

The assessment of estimated lessee's income, which primary estimation is pre-

sented in qualitative form, is transformed in the form of matrix using fuzzy sets:

$$R' = || r_{ij} || \quad (7)$$

where:

r_{ij} – estimated income, expressed in fuzzy set $\{\alpha r_{ij}, r_{ij}, \beta r_{ij}\}$;

i – lessee's growth rate in context of market growth, expressed in qualitative rating scale {slower than market, average, faster than market};

j – lessee's income growth rate in optimistic, realistic and pessimistic scenarios.

Analogously the estimated lessee's utility matrix is formed. In this matrix the operating profit is presented that is calculated as the difference between estimated income and future breakeven point value. With the purpose to assess the changes, which are directly related with leasing agreement, two lessee's utility matrixes are formed: (1) in case of leasing and (2) in case of non-leasing (Chen, 2001):

$$R_b = || r_{ij} - S_b || ; \quad R_a = || r_{ij} - S_a || \quad (8)$$

The formation of two lessee's utility matrixes is based on the possibility to get different forecasting of lessee's growth rates in case of leasing and in case of non-leasing, because leased asset may impact lessee's performance (cost and income).

Stage 4. Changes probability matrix formation. In finance the practise exists to determine the probability of different income forecasting scenarios. This allows presenting generalized final forecasting of income depending on the probability of every analyzed development scenario (Schmit, 2007a; Giesecke, 2004). In credit risk assessment in leasing by using fuzzy sets model the probability of every lessee's income change scenario is determined by using the form of matrix that is analogous to lessee's utility matrix (Chen, 2001).

$$P = || p_{ij} || \quad (9)$$

where:

p_{ij} – the probability of estimated lessee's income, which can be expressed in basic real or fuzzy number.

In case of probability determination the condition must retain that sum of optimistic, realistic and pessimistic scenarios probabilities must be equal 1:

$$\sum_{j=1}^{n} p_{ij} = 1 \quad (10)$$

The forecast of lessee's income should be performed by experts by using survey form or personal interview. The assessment can be made in 1 to 5 scale (when 5 means the biggest probability) for every scenario (optimistic, realistic and pessimistic). Such scale allows clear comparison of experts' opinions, but requires recalculation of final results using this formula:

$$p_i = \frac{h_i}{\sum_i h_i} \quad (11)$$

where:

p_i – probability of i scenario;

h_i – i scenario probability's expert assessment (in 1 to 5 points scale).

The usage of such expert assessment method is based on the fact that the sum of optimistic, realistic and pessimistic scenarios probabilities must be equal 1 (because the most likely value is calculated as weighted mean of all scenarios). Besides, recalculation of experts' assessments in relative scale allows retaining the original relation of experts assessment differences between scenarios.

Table 3

Qualitative measurement of credit reliability coefficients

Lessee's income growth rate in market context	Credit reliability coefficients		Qualitative credit risk assessment
	In case of leasing	In case of non-leasing	
Faster than market	U_{1b}^{T}	U_{1a}^{T}	Credit risk may be treated as acceptable if $U_{1a}^{T} \le U_{1b}^{T}$, because lessee's perspectives in market are positive.
Average	U_{2b}^{T}	U_{2a}^{T}	Credit risk is acceptable only in case $U_{2a}^{T} < U_{2b}^{T}$, because lessee's growth rate is only average; in this case it is useful to assess market's growth rates additionally.
Slower than market	U_{3b}^{T}	U_{3a}^{T}	Most attention must be paid to lessee's growth. Even in case of $U_{3a}^{T} < U_{3b}^{T}$ acceptable risk level is not guaranteed, because lessee may be an outsider in the market without positive growth perspectives.

Stage 5. Operating profit estimation. After the estimated income and their probability assessment the matrixes of operating profit in case of leasing and in case of non-leasing can be made. Operating profit matrix is formed as the sum of product of estimated operating profit and profit's scenario probability (Chen, 2001):

$$u^{b} = || u_i^{b} ||; \quad u_i^{b} = \sum_{j=1}^{3} \left(p_{ij} \cdot \left(r_{ij} - S_b \right) \right) \tag{12}$$

$$u^{a} = || u_i^{a} ||; \quad u_i^{a} = \sum_{j=1}^{3} \left(p_{ij} \cdot \left(r_{ij} - S_a \right) \right) \tag{13}$$

where:

u_i^{b} and u_i^{a} – estimated (average) lessee's operating profit respectively in case leasing and in case of non-leasing in the prism of lessee's growth rate market's context.

Stage 6. Credit risk assessment. After the assessment of estimated operating profit is made it is possible to calculate credit reliability coefficients in case of leasing and non-leasing. Those coefficients are calculated using this formula (Chen, 2001):

$$U_{ik}^{T} = \frac{1}{2} \cdot \left(\frac{Z_i - x_1}{x_2 - x_1 - Q_i + Z_i} + 1 - \frac{x_2 - Y_i}{x_2 - x_1 + Q_i - Y_i} \right) \tag{14}$$

where:

i – lessee's income growth rate in market context, expressed in qualitative rating scale;

x_1 = min (Y_a; Y_b);

x_2 = max (Z_a; Z_b);

when u_i^{b} = (Y_b; Q_i; Z_b); u_i^{a} = (Y_a; Q_a; Z_a).

The qualitative assessment of calculated credit reliability coefficients is presented in table 3. S.A.Metawa (1995) and M.Schmit (2002, 2007) studies allows stating that the level of credit risk should be measured and the decision for leasing should be made by comparing relation between credit reliability coefficients in case of leasing and in case of non-leasing through the prism of lessees' growth rate in the context of market growth. Firstly it is important to define lessee's creditability change in case of leasing agreement is made:

- If $U_{ib}^{T} < U_{ia}^{T}$, risk is high.
- If $U_{ib}^{T} = U_{ia}^{T}$, risk is average.
- If $U_{ib}^{T} > U_{ia}^{T}$, risk is low.

In the assessment of lessees' growth rate in the contexts of market growth it must be determined if lessee is one of leaders or one of outsiders in current market. In first case credit risk is considered to be lower because of positive lessee's perspectives in market.

The model of credit risk assessment in leasing sector by using fuzzy sets can be used as the tool for lessor's credit risk management. The usage of credit reliability coefficients creates the ability to identify lessor's credit risk level, which can be expressed in the form of weighted average of proportions leasing agreement's credit reliability coefficients in case of leasing and in case of non-leasing:

$$U^T = \sum_{j=1}^{n} g_j \cdot \frac{U_{ja}^T}{U_{jb}^T} \qquad (15)$$

where:

U^T – lessee's credit risk;

j – number of lessor's leasing agreements;

g_j – j leasing agreement's weight in lessor's leasing portfolio;

U_{ia}^T/U_{ib}^T – proportion of j leasing agreement's credit reliability coefficient in case of leasing and in case of non-leasing.

This method for lessors' credit risk management and assessment is efficient only when model of credit risk assessment in leasing sector by using fuzzy sets is used for all lessees' credit risk assessment.

The main advantage of presented model of credit risk assessment in leasing sector by using fuzzy sets is the ability to include the uncertainty of estimated variables (this is important in risk assessment) and the simplicity of the model (expert's assessment can be maid by lessor's employees; the transformation of expert's assessment to fuzzy sets retains the uncertainty of assessment and reduces level of subjectivity). The main disadvantage of presented model is the need of systemic use in lessor's credit risk assessment process because final coefficients of credit reliability can be judge only in comparison with other results of the same model.

Also it is important to mention that presented model for credit risk assessment in leasing sector can be used only when the ability to use computers exists. The simplicity of model can be realized only then suitable software is used which allows automate the calculations. This doesn't mean the need for specific expensive software: to implement this model standard spread sheets can be used, because model has clear input variables and clear final output results with the ability to transform final results to qualitative assessment scale.

The resume of this article can made that the model of credit risk assessment in leasing sector by using fuzzy sets is suitable for potential lessee's credit risk assessment and also can be used as a tool for lessor's credit risk management.

Conclusions

1. The analysis of advantages and disadvantages of credit risk assessment using qualitative and quantitative analysis in leasing sector the recommendation is made to adopt fuzzy sets theory for credit risk assessment. The main advantages of this model, which allows improvement of credit risk assessment in leasing sector, are as follows: (1) the combination of qualitative and quantitative analysis by using the method of linguistic scale transformation to fuzzy sets scale; (2) the minimum need of expert's assessed information, which

means time and cost efficiency; (3) the assessment of approximate variables with concretization of top and bottom boundaries of variation; (4) the ability to use model as a tool lessor's credit risk management.

2. The model of credit risk assessment in leasing sector by using fuzzy sets allows determination of potential lessee's reliability in case of leasing agreement's commitments. The reliability is defined by comparing lessee's income and breakeven point's value and its estimated change depending on the decision to make or not to make leasing agreement. The use of this model is purposeful only in case the calculations are automated by using software.

3. The model of credit risk assessment in leasing sector by using fuzzy sets is suitable for lessee's credit risk assessment and lessor's credit risk management. But efficient and accurate assessment of credit risk can be made only then presented model is used systemically for all current or potential lessees.

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Straipsnis įteiktas: 2008 05 13
Parengtas publikuoti: 2008 06 01

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NEAPIBRĖŽTŲ AIBIŲ TEORIJOS TAIKYMAS KREDITO RIZIKOS LIZINGO SEKTORIUJE VERTINIMUI

S a n t r a u k a

Kredito rizika finansinio pobūdžio literatūroje traktuojama kaip svarbiausia rizikos rūšis, galinti turėti lemiamą reikšmę priimant daugelį sprendimų finansiniame sektoriuje. Ši savybė galioja ir lizingo sektoriui, tačiau šiuo atveju tikslinga atsižvelgti į tai, kad lizingo paslauga, apimanti nuomos, kaip turto naudojimo neturint jo nuosavybės teisės, ir išorinio finansavimo veiksnių kompleksą, sąlygoja kredito rizikos vertinimo specifiką. Tai sukuria prielaidą formuoti lizingo sektoriui pritaikytus kredito rizikos vertinimo modelius, kurie pasižymėtų palyginti nedideliu vertinimui reikalingų išteklių imlumu ir lizingo sektoriui priimtinu vertinimo patikimumu.

Tyrimo tikslas – suformuoti kredito rizikos vertinimo lizingo sektoriuje tobulinimo, naudojant neapibrėžtų aibių teoriją, modelį.

Atlikta užsienio ir Lietuvos autorių publikacijų lizingo srityje analizė leidžia teigti, kad daugelyje publikacijų yra tik identifikuojamos kredito rizikos lizingo sektoriuje savybės, tačiau tik retais atvejais siekiama pateikti sprendimus kredito rizikos vertinimo lizingo sektoriuje efektyvumo didinimui. Įvertinus tokį esamų kredito rizikos vertinimo lizingo sektoriuje tyrimų ribotumą, daroma išvada, kad lizingo sektoriui yra aktuali kredito rizikos vertinimo efektyvumo didinimo problema, kurios sprendimas turėtų būti nukreiptas į kredito rizikos vertinimo išteklių poreikio mažinimą, išlaikant lizingo teikėjams priimtiną kredito rizikos vertinimo patikimumą.

Vienas iš sprendimų, leidžiančių įgyvendinti kredito rizikos vertinimo paprastumą ir tikslumą lizingo sektoriuje, yra neapibrėžtų aibių teorijos naudojimas kredito rizikos vertinimui. Neapibrėžtų aibių teorijos suteikiama galimybė sujungti kiekybinio ir kokybinio kredito rizikos vertinimo rezultatus, apimančius esamos lizingo gavėjo būklės bei jos kitimo tendencijų vertinimą, įgalina suformuoti galutinį kiekybiškai išreikštą kredito rizikos įvertinimą, kuris gali būti traktuojamas kaip vadybinė priemonė priimant lizingo paslaugos teikimo sprendimą.

Vertinant skolininko rizikos lygį, dažniausiai analizuojama skolininko finansinė būklė, siekiant nustatyti tikėtinas jos kitimo perspektyvas kreditavimo atveju. Toks rizikos vertinimas, pagrįstas skolininko veiklos ateities tendencijų numatymu, susijęs su tam tikru neapibrėžtumu, kurį sąlygoja ribotos tendencijų įvertinimo galimybės, vertintojo kompetencija ir subjektyvumas bei kiti veiksniai. Neapibrėžtų aibių teorija sudaro galimybę sumažinti kokybinio vertinimo metu egzistuojantį neapibrėžtumą bei tuo pačiu leidžia išvengti kokybinio vertinimo kategoriškumo, kuris egzistuoja naudojant įprastą binarinę kokybinio vertinimo transformavimo į kiekybinę išraišką metodiką.

Kredito rizikos vertinimo lizingo sektoriuje ypatumus leidžia suderinti neapibrėžtų aibių teorijos kredito rizikos vertinimui modelis, pagrįstas neapibrėžtų aibių teorijos ir lūžio taško analizės sinteze, apimančia kiekybinius ir kokybinius kredito rizikos vertinimo aspektus. Neapibrėžtų aibių teorijos kredito rizikos vertinimui modelio algoritmą sudaro 6 pagrindiniai etapai: 1) esamo lūžio taško analizė; 2) būsimo lūžio taško analizė; 3) kliento naudos matrica; 4) pokyčių tikimybės matrica; 5) laukiamas veiklos pelnas; 6) kredito rizikos nustatymas.

Neapibrėžtų aibių teorijos kredito rizikos vertinimui modelis yra orientuotas į kredito rizikos vertinimo lizingo sektoriuje efektyvumo didinimą, mažinant rizikos vertinimui reikalingus išteklius, apribojant kompetencijos trūkumo ir subjektyvumo įtaką vertinimui bei išlaikant vertintojui priimtiną rezultatų patikimumo lygį.