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MODELING THE RISK FACTORS FORMATION IN APPRAISAL MODEL USING FUZZY SETS

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Abstract

The paper sets and solves the problem of application the tools of fuzzy sets theory to appraisal using income approach. On the basis of developed conception the mechanism to adjust the values that compensate risk factors in discounting ratio was offered. The problem of adjustment of the risk compensation level that accounts for risk's significance was set and solved. In particular, quantitative estimates of discount rates for different risks were grounded. Influence of different risks on the aggregate discount rate was estimated. For the conditions of Ukrainian economy the maximum reasonable values of risk factors has been defined. Using the example of suppliers' diversification particular values of risk compensation for each distinguished state and possible number of suppliers has been calculated. Correspondence between the number of suppliers and diversification level in terms of fuzzy sets that enables more precise and accurate determination of discount rate is proposed.

Keywords: income approach, membership function, economic objects appraisal, risk factors, discounting ratio.

INTRODUCTION

The need to appraise business arises practically every time transformations take place, i.e.: sales and purchase, IPOs, mergers and acquisitions, and many other cases. As market relations develop the need for business appraisal raises as well. The need for appraisal arises while investing, crediting, insurance, taxable base calculation etc. Business appraisal is highly demanded for grounding and choosing the ways of enterprise restructuring. The process of business appraisal reveals available approaches to enterprise's management, defines which one is providing the maximum expected efficiency, and hence leads to the highest market price. The latter is often considered as the main goal of owners and respectively the main task of managers in firm's development in market economy. Problem of appraisal keeps urgency at different phases of enterprise development. Since any enterprise can be considered as long-term asset that generates incomes and has particular investment attractiveness, its current value may provoke interest of many people as owners and management as state institutions.

It is a common to use the income approach in enterprise appraisal. This is due to many investors in fact do not invest buildings, equipment and other tangible and intangible assets but future incomes that are capable not only cover initial investments but gain some profit multiplying in this way the investor's capital. In this case quality and duration of expected future income flows are significantly important for investment decision. Of course, the expected income amount depends on majority of factors called the risk that have probabilistic nature, may influence efficiency of investments and require to be accounted in decision making.

Appraisal based on income approach as good as possible accounts for the main goal of enterprise activity which is profit generation. From this position it is the most preferable for business appraisal as it describes perspectives and future expectations of enterprise development. Moreover, this approach accounts for functional and moral depreciations of the evaluated objects as well as market and risk influence by means of discount rate.

Discounted Cash Flow (DCF) method makes it possible to take into account the risks related with expected incomes gaining. Quantitative measure of corresponding risks compensation is the key feature of DCF method. The concept proposed here enables adjustment of the risk factors values and their representation in discount rate calculation. Thus it allows specifying the level of risk compensation depending on its significance. For specific categories of risks it is possible to make more precise compensations adjustments using tools of fuzzy sets theory.

THE PROBLEM

One of the main problems that arise during business appraisal using income approach is the discount rate determination. Correctly determined discount rate guaranties high accuracy and provides adequacy of the business functioning valuation being held under condition of market economy. One of the mostly widespread methods for determining the discount rate is the cumulative one. Although this method accounts for compensation of different risks in order to increase adequacy of estimates of risk factors fuzzy sets are applicable.

In this paper, we'll consider certain special methods that are used by appraisers to define market or some other kinds of business values. These methods are called appraisal methods. Use of each appraisal method implies prior analysis of certain information base and appropriate computing algorithm. All appraisal methods enable to define business value and can be treated as market methods as all of them are accounting for market conditions, market investment expectations, market risks or possible market reactions that are taking place at the moment or going to take place in respond to purchase contracts related to the object being appraised.

Kosorukova (2005) states that the income approach is inherently underlain by expectation principle. It means that the value of appraised object is determined by expected future incomes of its owner. Thus income approach implies that potential buyers consider the attractiveness of appraised object with respect to possible income that can be generated in the future, so it is treated as investment.

So, as it is stated by Ronova & Kuzmina (2008) the logic of income approach of enterprise appraisal fits the investor's behavior in the best way. Indeed, business appraisal based on income approach implies that potential buyer (investor) is ready to pay (invest) now not more than he is expecting to gain as income in the future. As present value and future one are definitely not the same values what we need is to make them comparative. Kosorukova, I.V. (2005) considers the method of discounted cash flows as the universal one that makes it possible to determine present value of future cash flows. Moreover, cash flows may be random, irregular and highly risky. Discounting is estimating present value of future cash flows using a discount rate. From the economic point of view, the discount rate is considered as an interest rate on invested capital required by investor.

Modern financial and economic theory provides many methodologies and approaches to discount rate calculations as well as explanations of economic essence of it. Some of them are discussed in Gryaznova & Fedotova (2001), Lebed et al. (2003), Kozyrev & Makarov (2003). But nevertheless problem that explores the discount rate structure and methods that determine impact of each element on it stays actual and quite important for the appraisal process. Importance of the problem mentioned above is conditioned by the fact that discount rate is the key factor determining the value of appraised business. Precisely and correctly chosen discount rate guaranties not only highly precise but adequate estimated value of an appraised object. It provides correspondence of estimated business value and market development conditions as well.

Mathematically discount rate for DCF method is determined as follows:

$$d = d_0 + \sum_{i=1}^{n} d_i \qquad (1)$$

Where: d_0 - base interest rate (discount rate);

$\sum_{i=1}^{n} d_i$ – aggregate risk premium.

In this case the cumulative method of discount rate construction is applied. This method is widely used while economic objects' appraisal. Let's explore precisely process of discount rate construction based on this method. In foreign appraisal practice, for example Frank C. Evans, David M. Bishop (2001), the base interest rate or discount rate is assumed to be equal to interest rate of so called risk free assets. Usually it is long term government bonds with maturity date over 10 years. This is due to government bonds are considered to be free of default risk as government can always issue extra money to meet its obligations. These considerations are not applicable for current Ukraine economics conditions. In fact issuing extra money under conditions of not freely convertible Ukrainian hrivna and parallel existence of US dollar and Euro as store of value leads to decrease of the real value of hrivna while the nominal value stays the same. This situation in fact means that either government does not fully meet its obligations (at least in amount the real value has decreased) or there is another asset that has less risk (in this case it is foreign currency whose store of value increased with respect to domestic one). In any case in economy with high inflation risks and not freely convertible currency interest rate of long term government bonds fails to be adequate measure of base interest rate.

So, we need to find another measure of base interest rate. Let's consider properties of the measure. First of all "risk free" means that we have high guarantees that this amount of income will be earned. Ones, as it was shown above, no guarantees are available in long term we have to revise the process of income gaining respectively to time. In other words as the base discount rate it's reasonable to use interest rate of alternative assets that are easily accessible and require minimum attention or management of investor i.e. assets that has high liquidity.High liquidity enables to stay up to date with the highly unsteady economic condition. Accounting for conditions of Ukrainian economy it is proposed to take interest rate on short term or demand deposits as the base discount rate.

The second part of discount rate is the risk premium. The risk premium is calculated as a sum of different risks appropriate to the business or economic object being appraised.

Main problem of this approach is to find grounded quantitative estimates of different risks. Another problem is defining the degree of influence of each and particular risk on the aggregate discount rate. Without solving these problems we can't guarantee that discount rate we get corresponds to real economy development conditions and adequately depicts the state of object appraised. Prior to valuing different risks the maximum possible value that all risk factors can get has to be defined. For this purposes we'll use the difference between the largest reasonable interest rate, for example on unsecured loans, and risk free interest rate. This difference will define the upper limit of aggregate risk premium that is corresponds with the riskiest asset and thus cannot be exceeded. So, the further task is to distribute this aggregate risk premium amongst different risk factors.

For the conditions of Ukrainian economy as the largest reasonable interest rate we propose to take the interest rate of overdraft. The interest rate on overdraft is chosen because of the considerations that in this case bank has the most uncertainty as to time and guaranties of return. As Internationalfinancialleague (Access:http://finliga.com/banks/overdraft.php) states the average interest rate set by Ukrainian banks on overdraft is 25%.

Accordingly to International financial league (Access: http://finliga.com/banks/overdraft.php) the average interest rate on short term deposits is 9%. So, the aggregate risk premium that has to be distributed amongst different risks is 16%. While distributing aggregate risk premium we'll define the size of changing for each risk factor. Also we will account for respective importance of each factor. Vitvitskyi (2006) has offered to use pairwise comparisons for this purpose. Pairwise comparisons enable as well to define significance of each risk factor. This paper also proposes the list of factors taken into consideration while decomposing the aggregate risk premium.

Using this list and described above assumptions we can calculate adjusted values of risk factors accounted for their significance. In this way adjusted values of risk factors will equate the production of sensitivity of each factor in terms of shares of units and maximum reasonable value of each factor. The resulting value can be explained as the maximum reasonable value of each corresponding risk factor with respect to their significance. Mathematically this can be written as following:

$$d_i^* = d_\Delta * k_i \qquad (2)$$

where d_i^* is adjusted values of risk factors accounted for their significance;

d_Δ is the aggregate value of maximum reasonable values of risk factors;

k_i is significance of each and particular risk factor.

Using factors list and their significance values proposed by Vitvitskyi (2006) and aggregate risk premium of 16% grounded above the following adjusted values of risk factors can be retrieved (see table 1).

Table 1. Adjusted risk factors

№	Factor name	Significance	Adjusted maximal reasonable value, %
1	Increase of owned capital	0,096	1,536
2	Assets turnover	0,107	1,712
3	Variation of sales	0,094	1,504
4	Profitability of operating activity	0,099	1,584
5	Product market diversification	0,099	1,584
6	Suppliers diversification	0,05	0,8
7	Accumulated depreciation	0,058	0,928
8	Total Debt to Equity ratio	0,055	0,88
9	Working capital financed by equity to total assets ratio	0,047	0,752
10	Quick ratio	0,058	0,928
11	Operatingleverage	0,058	0,928
12	Price elasticity of products by materials price	0,041	0,656
13	Financialleverage	0,047	0,752
14	Products diversification	0,041	0,656
15	Fixed assets dynamics	0,05	0,8
TOTAL		1	16%

It is important to emphasis that described method implies variations in the set of included factors thus the table 1 cannot be treated as some sort of fixed standard. This is not critically important for this phase of research as it clears up the procedure of risk factors adjustment but not their list. Accordingly to income approach for economic objects appraisal the next step is to define the degree of compensation of the risk factor. It has to be emphasized that this compensation is determined by variety of factors, i.e. current state of the object appraised, field or branch of economy it is involved in etc.

The very first problem while studying any object is to define principles and methods of quantitative evaluation and measuring for different inherent qualities of it. While evaluating the degree of risk compensation and handling economic state analysis it is quite natural to use the terms of fuzzy sets theory. Let's consider the example of product market or suppliers diversification factor. As it was shown before, adjusted values of risk factors (see table 1) provide us with only maximum reasonable value that cannot be exceeded. While the real compensation value for this factor is distributed among zero and reasonable maximum and depends on the distinguished qualitative state of diversification. Herein we can distinguish such states as non-diversified, poorly diversified, middling diversified or highly diversified. Another problem is to identify quantitative measures for each distinguished qualitative state. Solution of this problem helps as well to obtain more precise estimations for risk factors compensations. Let's examine this procedure using the example of suppliers' diversification. It is quite natural to assume that highly diversified set of suppliers means less risk, while average diversification means average risk and low diversification leads to higher risk. Using fuzzy sets enables to acquire precise qualitative estimates of risk for each number of suppliers.

For this purposes we'll introduce adjective function known in fuzzy sets theory. In terms of examined problem the adjective function answers the following question: at what extent does each and particular number of suppliers is typical for diversified-non-diversified state. It is proposed to use piecewise-linear adjective function particularly triangular, Z-shape and S-shape functions. Triangular adjective function allows to depict such properties of fuzzy sets that can characterize uncertainties of the following types: "approximately equal", "is average", "belongs to interval", "similar to", "looks like" etc. Z-shape and S-shape function in its turn are used to depict such properties of fuzzy sets that characterize uncertainty of type: "small amount", "small value", "little amount", "low cost", "low price level", "low interest rate" and many others. The common for all of situations described above is possible weak demonstration of a particular qualitative property that requires using fuzzy sets.

While fuzzy sets implementation it is required to obtain appropriate parameters for adjective functions. Methodologically estimation of Z-shape, S-shape or triangular adjective functions parameters is not critically different. Thus, we'll consider the simplest linear functions that nevertheless capable to demonstrate the use of fuzzy set methodology for suppliers' diversification problem.

First of all we have to define the number of distinguished diversification levels. For our purposes four levels are distinguished. In particular, there are "not diversified", "weakly diversified", "averagely diversified" and "highly diversified". Taking into account these levels we'll assign the values of risk compensation factors. As one can see from table 1 maximal reasonable value of risk compensation factor for suppliers' diversification is 0,8%. This value is corresponds to "not diversified" state. It is quite natural to assume that "highly diversified" state leads to 0% value of risk compensation factor and other "intermediate" states can be valued proportionally i.e. "weakly diversified" – 0,533%, "averagely diversified" – 0,267%.

The next task being resolved is to set correspondence between the number of suppliers and diversification level. For example let's assume the following correspondence scale: "not diversified" – no or one supplier; "weakly diversified"– 2 suppliers, "averagely diversified"– 5 suppliers, "highly diversified"– 15 suppliers. It has to be noted, that precise value of suppliers number is not critically important and following approach is applicable for any initially determined number of suppliers for each distinguished state.

Leonenkov (2005) and Altunin & Semukhin (2000) propose to use following general form of triangular adjective function:

$$f_{\Delta}(x,a,b,c)=\begin{cases} 0, & x \le a \\ \frac{x-a}{b-a}, & a < x < b \\ 1, & x = b \\ \frac{c-x}{c-b}, & b < x < c \\ 0, & c \le x \end{cases} \quad (3)$$

where *a, b, c* are particular quantitative parameters that take real ordered values: $a \le b \le c$. Values *a* and *c* define the base of appropriate triangle, and parameter *b* — its altitude. Using this approach the following matrix can be derived (table 2):

Table 2. Matrix of adjective function and risk compensation values

Diversification level \ Number of suppliers	1	2	5	15	Risk compensation, %
Not diversified	1	0,93	0,71	0	$RC_{ND} =$ 0,8
Weakly diversified	0	1	0,77	0	$RC_{WD} =$ 0,533
Averagely diversified	0	0,33	1	0	$RC_{AD} =$ 0,267
Highly diversified	0	0,07	0,29	1	$RC_{HD} =$ 0
Total	**1**	**2,33**	**2,77**	**1**	

Each element of table 2 demonstrates membership of different amount of suppliers, in particular 1, 2, 5 or 15 in each and particular distinguished states of diversification level. As one can see unit values are assigned to so called, "pure characteristics" of each state. Using the same considerations any other number of suppliers of diversification levels can be described.

To calculate particular values of adjective functions (in table 2) the following membership functions has been used:

- For not diversified state - linear *Z*-shape function:

$$f_{ND}(x)=\begin{cases} 1, & x\le 1 \\ \dfrac{15-x}{15-1}, & 1<x<15 \\ 0, & 15\le x \end{cases} \quad (4)$$

- For weakly diversified state – triangular function:

$$f_{WD}(x)=\begin{cases} 0, & x\le 1 \\ \dfrac{x-1}{2-1}, & 1<x<2 \\ 1, & x=2 \\ \dfrac{15-x}{15-2}, & 2<x<15 \\ 0, & 15\le x \end{cases}$$

- For averagely diversified state – triangular function:

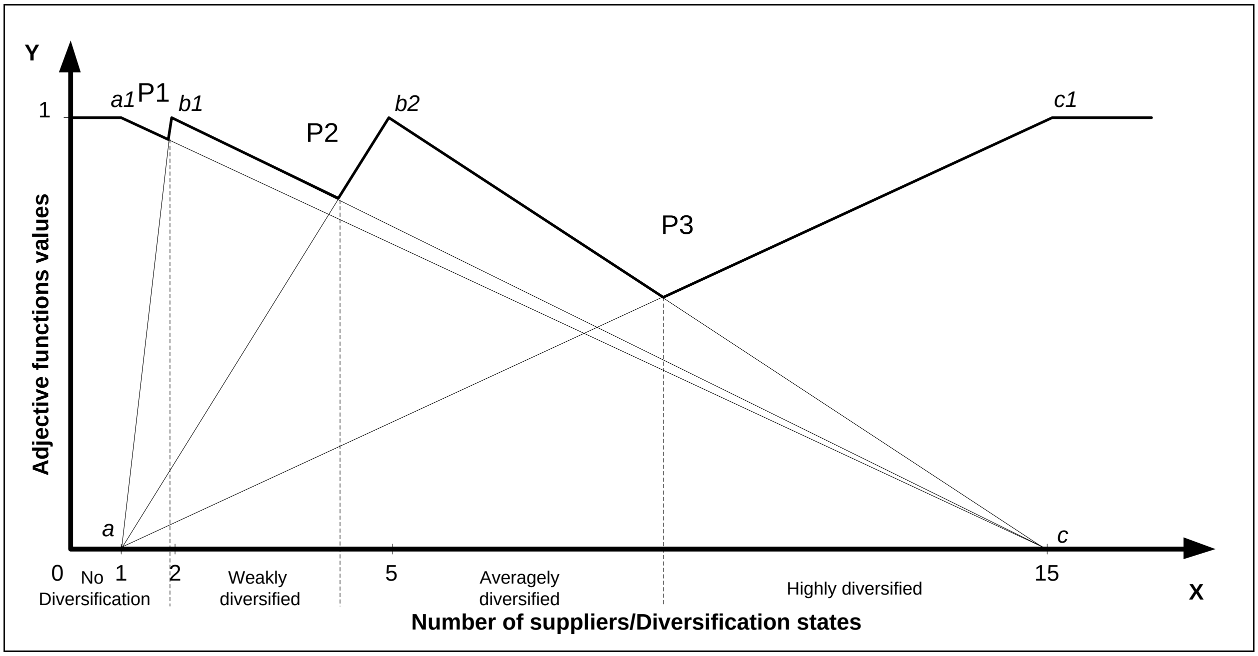
$$f_{AD}(x)=\begin{cases} 0, & x\le 1 \\ \dfrac{x-1}{5-1}, & 1<x<5 \\ 1, & x=5 \\ \dfrac{15-x}{15-5}, & 5<x<15 \\ 0, & 15\le x \end{cases}$$

- For highly diversified state – *S*-shape function:

$$f_{HD}(x)=\begin{cases} 0, & x\le 1 \\ \dfrac{x-1}{15-1}, & 1<x<15 \\ 1, & 15\le x \end{cases} \quad (5)$$

Simultaneous effects of all adjective functions are illustrated at fig. 1 below.

Figure 1. Adjective functions of Diversification states with respect to numbers of suppliers



As one can see from fig. 1*a1c*line is the descending part of adjective function $f_{ND}(x)$ that corresponds to not diversified state, line *ac1*is ascending part of adjective function $f_{HD}(x)$ that corresponds to highly diversified state. Weakly and averagely diversified states are depicted by triangles *ab1c* and *ab2c* respectively. An intersection point of two adjective functions that correspond to adjacent states depicts the point where these two states are equivalent and can be treated as transferring point from one state to another. So, any number of suppliers to the left of point P1 corresponds to domination area of not diversified state while any numbers of suppliers between points P1 and P2 are in domination area of weakly diversified state. Similar considerations lead to measures of averagely and highly diversified states as well.

In order to find risk compensation values for each possible number of suppliers assume that risk compensation values for each distinguished state, i.e. values RC_{ND}, RC_{WD}, RC_{AD} and RC_{HD} from table 2 participate in an adjusted value of risk compensation factor proportionally to values of their adjective functions.

So, the adjusted value of risk compensation factor $d^*(x)$ can be calculated as follows:

$$d^*(x) = \frac{RC_{ND} f_{ND}(x) + RC_{WD} f_{WD}(x) + RC_{AD} f_{AD}(x) + RC_{HD} f_{HD}(x)}{f_{ND}(x) + f_{WD}(x) + f_{AD}(x) + f_{HD}(x)} \quad (4)$$

For example, if number of suppliers is five, then risk compensation of diversification factor is:

$$d^*(5) = \frac{0,8*0,71+0,533*0,77+0,267}{0,71+0,77+1+0,29} = \frac{1,245}{2,77} = 0,45\%$$

CONCLUSIONS

The paper proposes approach for adjustment of risk compensation factors based on the fuzzy sets theory. Using fuzzy sets enables better understanding of how different quantitative values of different indicators influence qualitative interpretations of possible states of appraised objects. Offered procedure for adjustment of risk compensation factors helps to account for all distinguished qualitative states and thus increase accuracy of risk factors compensation values.

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