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Consideration of Risk Factors in Corporate Property Portfolio Management

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Abstract: The article is devoted to the topical issue of optimization and harmonization of the formation of the corporate property portfolio. The method of managing the corporate property portfolio in order to reduce the level of risk was optimized in the research, based on differentiated and portfolio approaches: the differentiated approach is used when considering corporate property as a set of individual elements that determine self-management; the portfolio one is used under the condition of combining corporate property in the management portfolio. The article also takes into account the applied model of fuzzy sets related to the identification of the level of profitability of the corporate property portfolio and its risk. It was determined that the fuzzy sets methodology has an advantage in the conditions of instability of financial markets and optimizes the search for attractive corporate property for investment. The article substantiates the use of the fuzzy set approach to assess corporate investment decisions as the most effective in terms of risk and uncertainty.

Keywords: portfolio risk; corporate property; property package; fuzzy analysis model; risk minimization; production chain

1. Introduction

The increase in the scale and complexity of corporations' activity is becoming an agent to the enhancement of the requirements for the quality of risk management in the course of property package formation. The decisions, which are made by the governing bodies either individually or collectively and aim to achieve a particular goal of the corporation, are the foundation of any management activity. The absence, insufficiency, or inaccuracy of the necessary information is the main cause of occurrence of risk situations, under the conditions of which the managerial decisions are made. The use of the portfolio type of corporate property management to minimize risks is gaining an increasingly strong foothold, which results from the dynamic development of production technologies and the formation of property packages within a framework of the production chains. Under these challenging conditions, the corporations, which are involved in the development,

introduction, and provision of portfolio support for the property packages and non-admission of risks, give a considerable amount of attention to the question of setting analytical and methodological foundations for managerial decision-making within all organizational levels.

The research objective resided in the methodological and organizational need for managing the portfolio corporate risks, based on a fuzzy analysis model for all types of property packages, which means the minimum financial and organizational losses for a corporation in the course of building an efficient structure of the controlled property.

The importance of the study is that the optimal allocation of assets in the portfolio is a key issue for asset managers. To build a diversified portfolio, one should consider investing in both risky and risk-free corporate assets, taking into account the degree of risk.

The importance of the research topic is determined by the need to increase the efficiency of the formation of a portfolio of corporate assets. In addition, over time there is a need to review the portfolio, as a result of which some assets are sold and others are bought. This rebalancing involves certain costs, depending on the risk factors that help to take into account fuzzy market analysis models. Although the G. Markowitz method is an unsurpassed approach to determining the optimal asset allocation in a portfolio, it also has disadvantages such as concentration and instability. Therefore, it is advisable to consider alternative methods of diversification, which include the fuzzy risk analysis methodology.

We believe that the formation of a quality portfolio of property objects for the corporation is under the pressure of uncertainty in the distribution of profitability with a fairly large sample of property, which is typical of modern market conditions, which in turn depend on many factors that cannot be accurately taken into account. The law of distribution in this case is constantly transformed with the arrival of new information on the market. Therefore, such studies form an applied basis for creating an optimal investment bank of corporate property based on the model of forming a portfolio of securities of property objects and building the efficiency boundary in accordance with the G. Markowitz model.

2. Materials and Methods

Our research methodology grounds on the comprehensive approach to corporate risk management, which is determined as the process thanks to which the corporate bodies evaluate, control, run, finance, and conduct the monitoring of all possible risks to maximize the cost of the corporate property during the short- and long-term periods. Among the most important components in the framework of the risk management theory and practice are the estimating, monitoring, and prediction methods as well as information support for risk management, which are spectrally represented in the research papers by Dionne and Garand (2003); Liebenberg and Hoyt (2003); Kleffner et al. (2003) and Durmanov et al. (2019).

Holmstrom and Kaplan (2003); Kiel and Nicholson (2002) and Rosenberg and Schuermann (2006) stated that the activity, related to risk management within the corporate environment, comprises the following main phases: risk revealing, its assessment, the choice of the method and risk management tools, prevention, control, risk financing, and evaluation of results.

Such researchers as Blessy and Taddesse (2014); Hoyt and Liebenberg (2009) and (Cakici et al. 2019) gave a complex idea about the division of risks into the following groups: (1) hazard risks, such as the loss of property; (2) financial risks—include potential losses, occurring because of the changes in the financial markets, including the changes in the interest rates, currency rates, raw material prices, liquidity, and credit risks for corporations; (3) operational risks—cover various situations of the main production activity of the corporation, for example, consumer satisfaction, product development, trademark protection, corporate leadership, information technologies, fraudulent activities in management, information risks, etc.; (4) strategic risks—include such factors as excellence, customer's preference, technological innovations, regulatory (normative) and political barriers.

Mehran and Mollineaux (2012) and Smith and Stulz (1985) considered that the general principle of risk management resides in the fact that after the corporation achieves a strategic goal, all risks are

reviewed from the standpoint of the systematic analysis. The risk is addressed as a potential source of profit, not just as a phenomenon, which must be minimized or removed.

As noted by Kumar and Zattoni (2019) modern systems of corporate ownership include (a) low accuracy of input operational information (the presence of this type of uncertainty causes inaccuracy in setting variables in models, initial, and boundary conditions); (b) inaccuracy of models of corporate property control objects, which arises because of an incorrectly carried out decomposition of the task of formation of a package. Thus, scientists note the need for fuzzy control in corporate governance through the use of algorithms based on the mathematical apparatus of fuzzy set theory.

The paper by (Sobel and Reding 2004) states that the apparatus of fuzzy sets allows the processing of formalized qualitative information, and the results of processing can be presented in mathematical form. The advantages of the methodology of expert systems will allow preserving the experience of forming corporate ownership packages, as well as to accumulate and systematize it.

Within a framework of any cluster of property units, the process of management takes place at several levels, depending on the weight of problems. In this regard, both every individual flow and corporate activity, in general, can be considered from different points of view. To put it in other words, we state that it is possible to use one of the approaches to manage the property cluster, depending on the way of consideration of any cluster of the corporation. In particular, the authors propose the use of the following approaches. (1) Differentiated—used when considering a cluster as a set of separate elements that require independent management. It can be used, for example, at the top management level to manage objects of corporate property; (2) Portfolio—used under the condition of consolidation of individual elements into so-called management portfolios; one should clarify that this association takes place upon the approved criteria algorithm.

3. Results

3.1. Leading Approaches to the Building of the Corporate Property Packages

In the methodological format, the corporation justifies its decision to choose the optimal portfolio solely by the expected profitability and standard deviation. This means that the corporation estimates the expected profitability and standard deviation of each portfolio and then chooses the best one based on the ratio of the two parameters. Intuition plays a decisive role. The main provisions of the portfolio investment methodology are formulated in the following way (Ballou and Heitger 2005; Sobel and Reding 2004; Stoll 2014; Polac 2019): (1) an effective set contains those portfolios that simultaneously provide the maximum expected profitability at a fixed level of risk and minimum risk at a given level of expected profitability; (2) the corporation chooses the optimal portfolio from the portfolios that make up the effective set; (3) the optimal portfolio of property objects is identified with the point of contact of the indifference curves with the effective plurality; (4) the general risk of property objects consists of market risk and own risk; and (5) diversification leads to averaging market risk.

As far as we know, a big number of participants are involved in the production process of corporate associations. Usually, these participants are entities controlled by corporations. Let us call these controlled enterprises—a cluster of the corporation.

The content of the differentiated approach grounds on the consideration of any element of the corporate property cluster as an independent management object, which is a structural component of the cluster as a system. One should mention that, in the framework of a differentiated approach, it somewhat reminds of consumer segmentation and is widely used in marketing. Let us consider the content of the basic principles of the differentiated approach:

1. The Pareto principle. The idea of this principle, regarding the cluster theory, resides in the fact that only 20% of the total number of the control objects of the corporation is the economic foundation (80%) of this cluster. Thus, the concentration of attention and management efforts (i.e., 80% of management activity) on the most important elements of the corporate activity (20% of the property units) is the key to effective management activity at any level of

management of the corporation, which makes it possible to act with minimal losses and obtain the maximum effect (Stoll 2014; Chehabeddine and Tvaronavičienė 2020).

2. The principle of the importance of the management object. It can be presented through the following rule: the amount of time, allocated for solving a problem, should be adequate to the problem, while the level of the leader to the level of the problem. The determination of the proportion of working time, as well as the level of solving this problem, can be carried out through the use of the criterion of the importance of the problem (Vogiazas 2015). The criteria of the importance of a problem (object of management) are formed as sets of values of the corresponding estimates. In the article, we propose the use of two criteria:

   (1) A relative criterion, which makes it possible to compare the level of criticality of the objects in pairs and choose the priority one for generating a control action;
   (2) An absolute criterion, which makes it possible to rank all objects upon their importance.

Let us consider the algorithm of building the relative criterion (Panfilo 2019):

1. A cluster falls into management objects mo_j (j = 1, ..., n), where j is the number of controlled objects.
2. After that, one determines the set of indicators for the evaluation of the importance of an object, which can be represented by a decisive nonempty set D, the elements of which are the properties of the object of the importance d_i (i = 1, ..., m), where i is the number of important properties. As indicators, characterizing the importance of an object, one should use the main financial and economic indicators of the corporate activity.
3. Each of the elements of d_i is provided with a level of importance (weight p_i). After that, they are ranked by the level of importance.
4. Each controllable object of the infinity of properties is given an importance value v_{ij}.
5. After that, one builds a fuzzy set D_j for each controlled object. Herewith:

$$D_j = \frac{\mu_{ij} D(d_i)}{d_i} \tag{1}$$

where $\mu_{ij} D(d_i)$ is an importance function, showing the grade of the importance of this property for a particular object of management:

$$\mu_{ij} D_j(d_i) = p_i \times v_{ij} \tag{2}$$

6. For all D_j, one determines the height $[\sup \mu_{ij} D(d)]$, in other words, the biggest value of all acquired indicators of the importance function:

$$[\sup \mu_{ij} D(d)] = \max \mu_{ij} D_j(d_i) \tag{3}$$

7. All values of a function of importance are normalized:

$$\mu^{l}{}_{ij} D_j(d_i) = \frac{\mu_{ij} D_j(d_i)}{\sup \mu D(d)} \tag{4}$$

herewith:

$$\mu^{l}{}_{ij} D_j(d_i) = D_k \tag{5}$$

where D_k is the function of the importance of the normalized fuzzy set.

8. The objects of management are ranked through the comparison of the normalized importance functions. Herewith, one can mention that the D_j indicator is more important than the D_k indicator under the following condition:

$$N[\mu^{l}_{ij} D_j(d_i)] > \mu^{l}_{ik} D_k(d_i)] > N[\mu^{l}_{ij} D_j(d_i) < \mu^{l}_{ik} D_k(d_i)] \tag{6}$$

where $N\,[\mu_{ij}^{I} D_j(d_i)] > \mu_{ik}^{I} D_k(d_i)]$ is the number of pairs of functions of importance, in which normalized values of these functions of the set D_j are bigger than the corresponding values of the importance function of the D_k set; $N\,[\mu_{ij}^{I} D_j(d_i) < \mu_{ik}^{I} D_k(d_i)]$ is the number of pairs of functions of importance, in which the normalized values of these functions of the set D_j are smaller than the corresponding of the importance function of the D_k set.

Under the reverse condition, i.e.,

$$N\,[\mu_{ij}^{I} D_j(d_i)] > \mu_{ik}^{I} D_k(d_i)] < N\,[\mu_{ij}^{I} D_j(d_i) < \mu_{ik}^{I} D_k(d_i)] \quad (7)$$

one can state that that D_k is more important than D_j. If both of them have equal N values, then the objects are of equal importance (Ballou and Heitger 2005).

The held paired comparisons serve as the basis for the appearance of the ordered set of management objects. Following the Pareto principle, such a set makes it possible to determine the most important objects for the generation of management actions.

We introduce the necessary definitions: (1) corporate ownership is a set of real estate, property rights, works and services, information and technology, intangible assets, and other parts of the national wealth, the right to use, own, and dispose of which belongs to a particular corporation; (2) the package of corporate property includes real estate (buildings, land, etc.), movable property (securities), cash, debts, receivables, information, intellectual property, and other results of intellectual activity of corporate units.

Property units, which build the cluster, are interconnected via the economic links, and the problem of the unit cluster corporate management resides in the determination of the way of building these links in the most efficient way. Herewith, each controlled enterprise that is part of the cluster can be considered as the object of this cluster.

In addition to the differentiated approach, the corporation can use the portfolio approach of property management, which is carried out based on the portfolio strategy. The main objective of the portfolio strategy of the corporation is the formation of a set of property portfolios, each of which is a diversified set of different elements (Figure 1).

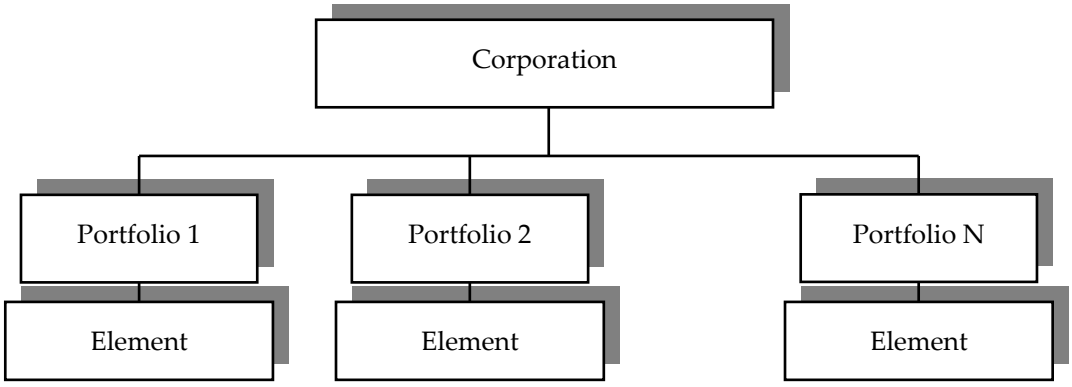

Figure 1. Property portfolios of the corporation.

When the costs, which are invested, are distributed between different types of investments, one can observe risk reduction. The diversification reduces the risk as the low-level income might come from one element of the portfolio, which will be compensated by high-level income from another property object (Bromiley et al. 2015). To ensure the most efficient distribution of elements, one can use the portfolio diversification methodology. This situation can be classified as uncertainty in the corporate property portfolio management.

In Markowitz's formulation, the problem of choosing the optimal portfolio comes down to choosing an effective set of property portfolios, or the so-called efficiency boundary. If a corporation has n securities available, each with its own expected profitability E(ri), where i = 1, 2, ..., n, then

there is only one combination of securities in the portfolio, which minimizes the portfolio risk of property objects for each given value of the expected portfolio return (Belaid et al. 2018). Figure 2 shows that no matter what value of the expected profitability is determined by the investor (for example, E(rm)), always by sorting the weights of securities of the portfolio, it is possible to find a portfolio at which the level of risk reaches a minimum value (Figure 2, point M).

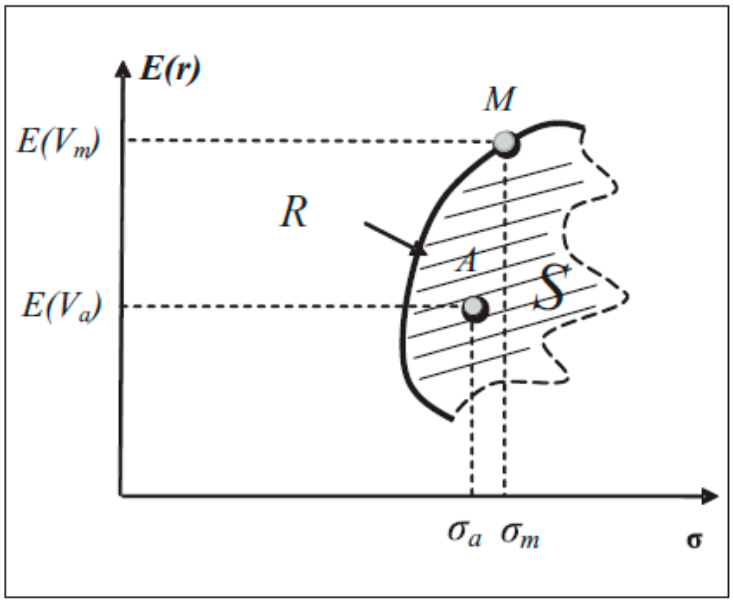

Figure 2. Ratio of portfolio return level and risks.

The expected profitability of a security in the Markowitz model is calculated as the mathematical expectation of its returns in the previous period of time, the risk is calculated as the standard deviation of these returns, and the covariance is calculated using the formula:

$$\sigma_{ij} = V_{ij} \times \sigma_i \times \sigma_j \tag{8}$$

where V_{ij} is the coefficient of pairwise linear correlation between the profitability of two assets.

Two important conclusions can be drawn: firstly, if the correlation coefficients between the returns on assets in different portfolios are constant, then when the ratio of securities in the portfolio changes, the portfolio risk also changes; secondly, for any portfolio, as the correlation coefficient of securities decreases, the portfolio risk also decreases (Stulz 2014). The set of portfolios that minimize the level of risk at each value of the expected profitability forms a hook called the efficiency limit; in Figure 2, this is line *R*. As can be seen from this figure, when moving along the boundary up-to-right, the values of $E(r_i)$ and σ increase, and when moving down-to-left, they decrease.

The investor's task in the Markowitz model is reduced to the following: from a set of portfolios with the expected rate of return $E(r_p)$, it is necessary to find one that would provide the minimum level of risk. In other words, the corporation's task can be reduced to solving such a system:

$$\begin{cases} E(r_p) = \sum_{i=1}^{n} x_i [E(r_t)] \to \max; \\ \sigma_p = \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_{ij} x_i x_j} \to \min; \\ \sum_{i=1}^{n} x_i = 1; \\ x_i \geq 0. \end{cases} \tag{9}$$

An effective portfolio is a portfolio that provides the minimum risk at a given value of *E(r)* or the maximum return at a given level of risk.

3.2. Portfolio Property Management

The fuzzy sets are one of the tools of future uncertainty accounting. In particular, if the corporation owns several businesses (property units), it faces the need for managing a business portfolio. Let us consider the ways to solve this task using the fuzzy sets (Carpenter 2000).

There are several models of portfolio management. At the same time, considering the specificity of corporate management, we suggest taking a classical model as a basis—the Markowitz model of portfolio management (Froot et al. 1993). Its essence is as follows. Let us assume that the businesses' portfolio of the corporation contains the N number of business directions (BD), each of which is characterized by the following five parameters:

- The initial cost W_{i0} of acquisition or setting of business before its transference in the portfolio;
- The number of participants n_i in the business direction;
- The initial investments S_{i0} in the given portfolio segment, under the condition that:

$$S_{i0} = W_{i0} \times n_i; \tag{10}$$

- Expected profitability of the business direction r_i;
- The standard deviation of income σ_i from the average income of a corporation.

The conditions given above demonstrate that the random value of the market price of business (including the payment of dividends) has a normal distribution with the parameters $(W_{i0} \times (1 + ri), \sigma_i)$.

The portfolio is characterized by:

- The total amount of portfolio investment at a specific point of time $t - S_t$;
- The share price distribution of businesses in the portfolio $\{x_i\}$, and for the initial portfolio the following procedure is true:

for the initial period:

$$x_{i0} = \frac{S_{i0}}{S_0} \tag{11}$$

$$\sum_{i=1}^{N} x_{i0} = 1 \tag{12}$$

for the current period:

$$x_{it} = \frac{S_{it}}{S_t} \tag{13}$$

$$\sum_{i=1}^{N} x_{it} = 1 \tag{14}$$

- The correlation matrix $\{\rho_{ij}\}$, the coefficients of which characterize the relationship between the profitability of the *i*- and *j*-business directions.

The coefficient value ρ_{ij} is calculated upon the formula of the pair correlation coefficient:

$$\rho_{ij} = \frac{n\sum_i r_i r_j - \sum_i r_i \sum_j r_j}{\sqrt{\left[n\sum_i r_i^2 - \left(\sum_i r_i\right)^2\right]\left[n\sum_j r_j^2 - \left(\sum_j r_j\right)^2\right]}} \tag{15}$$

If $\rho_{ij} = -1$, it means a complete negative correlation; if $\rho_{ij} = +1$, there is a complete positive correlation (functional dependence). The formula $\rho_{ij} = +1$ is always true as business always correlates positively with itself.

Thus, the portfolio is defined as a system of statistically related random variables with normal distribution laws (Lingel and Sheedy 2012). Then, based on the theory of random variables, we can make a conclusion that the expected return on the portfolio at a certain point of time r_t is calculated upon the formula:

$$r_t = \sum_{i=1}^{N} x_{it} r_{it} \tag{16}$$

The standard deviation of the portfolio (the distribution of returns from average corporate figures) S, characterizing the degree of the risk of the portfolio, is determined by the formula:

$$\sigma = \sqrt{\sum_{i=1}^{N} \sum_{j=1}^{N} x_i x_j \rho_{ij} \sigma_i \sigma_j} \tag{17}$$

The task of managing this portfolio has the following description: to determine the vector $\{x_{it}\}$, maximizing the target function r_t appearing as (16) at a given limit on the risk level S, which is assessed upon the formula:

$$\{x_{opt}\} = \{x\} \mid r \longrightarrow max,\ S = const. \tag{18}$$

The authors think it important to mention that the approach of Markowitz on the choice of portfolio considers under the notion of risk not the risk of making investments but the degree of fluctuation in the expected profitability upon the property portfolio, both in the direction of the decrease and increase. One can effortlessly move from the task, having the form of (18) to the task, having as the limit not a fixed standard deviation but the likelihood that the portfolio profit will reach a lower level than it was predetermined.

The approach of Markowitz has gained the most prevalence in portfolio management practices. Nevertheless, we think it has a number of model assumptions that are poorly correlated with the reality of the described object—the global or national market. We mean the weakness of the hypothesis about the statistical character of random processes (Nocco and Stulz 2006). The classical expectation theory states the statistical character of random events in conditions, characterized by the statistical homogeneity of sample events. The organization observed ten years ago and the same organization at the present are two different objects of study (Rogers 2002). The market setting of the organization changes, thereby causing the change of the market position: it could expand the market in terms of the types of its products or do the opposite and reduce the level of sales. Thus, the risk of losses upon a particular business direction falls or increases, but the reason behind these fluctuations is external. It has neither direct relation to the organization nor inherent to it. Thus, when studying the business direction, one can speak neither of statistical homogeneity nor the statistical character of the random process of the business profitability. In addition, it is impossible to speak of the statistical probability of one or another event, related to a random amount of revenue from a specific type of business, in the classic sense of the term "probability".

If one deals with subjective probability, then the introduction of this probability should precede by special justifications (the study of the informational content of context of the certificates about the object under study, expert surveys, etc.). When the subjective assessment of the probability is held by a single expert, the risk of subjectivity and the faulty forecast increases significantly. In fact, when using subjective probability, the expert refuses from his individual understanding of the probability and attaches to the concept of his individual subjective expectations, which can be significantly intertwined by the qualification, concerning the history of fluctuations in income upon the given type of business. In the case of the change of the market orientations, this foregoing history stops to be demonstrative; the object under the study "goes bad" (Seville and Teyssier 2017).

If the random processes of income from the business direction have no statistical character, then there are no statistical relationships between these random processes. When the correlation

coefficients ρ_{ij} are set by constants, the known character of the cause-and-effect relationship between the incomes of two business directions is assumed once and for all.

Things do not go easy under the market conditions, and only one market expert cannot provide a precise description of the character of this cause-and-effect relationship, only with a varying degree of approximation.

We think that those comments on the Markowitz approach, make us, considering the peculiarities of the corporation, make some allowances if not in the approach itself, then in the initial assumptions upon the model. Having removed the assumption about the statistical nature of the random processes, we propose turning to an alternative way of information uncertainty accounting, concerning the future state of the market per business, included in the portfolio (Robin and Stephen 2006). In such a case, we think, it is advisable to apply a fuzzy-multiple approach.

Considering that business income is, in many ways, accidental, its exact value in the future is unknown, and the description of the probability for such a fluke will not be correct, then, as a description of business profitability, it is appropriate to use the triangular fuzzy numbers to set a model of the expert conclusion of the following type. If the profitability of the business is equal to $\bar{r}$ and sits within the estimated range $[r_1, r_2]$, in such a case, one should refuse the use of the determination of the probability of the profitability, cut off the hardly probable random results on both sides of the expected value $\bar{r}$ (the probability of such results under the normal distribution does not equal to zero), and form a calculation corridor one expects the level of profitability of the business (Cakici et al. 2019). At the same time, under $\bar{r}$, one should consider the most expected or average value of the profit in the calculation corridor.

The membership function of the fuzzy number has the triangular form if the degree of reasonable certainty, related to the profitability, equals to zero beyond the framework of the calculation corridor of profitability values, while the maximum of this certainty, which equals to one, is reached at the point $\bar{r}$. The expert is convinced that $\bar{r}$ will clearly fall into any of the calculation profitability corridors, no matter how much the boundaries of that corridor change.

The way of description of the expected profitability in the form of a fuzzy number automatically eliminates all problems related to the consideration of the relationship between the risk and the size of the property portfolio. If the profitability of a certain business is a triangular fuzzy number, while the portfolio profitability is a linear combination of the components' profitability, then the resulting form of the portfolio profitability can be expressed in the following way.

Let us assume that $\bar{r} = (r_{1i}, \overline{r_i}, r_{2i})$ is the profitability of the i-business, a triangular fuzzy number. Then the portfolio profitability will be also represented by a triangular fuzzy number:

$$\bar{r} = \left(r_{\min} = \sum_{i=1}^{N} x_i r_{1i}, \ \bar{r} = \sum_{i=1}^{N} x_i \bar{r}, \ r_{\max} = \sum_{i=1}^{N} x_i r_{2i} \right) \quad (19)$$

The conclusion that a linear combination of triangular fuzzy numbers is a triangular fuzzy number is a well-known result of the fuzzy set theory.

Let us make some assumptions for the assessment of the portfolio risk. Let us assume that $r^* = const$ is a critical value of portfolio profitability. If the actual value of the profitability r will be below r*, then the portfolio management strategy is developed with mistakes. Herewith, in the assumption that the indicator of the economic effect of business is a triangular fuzzy number, we will calculate the level of risk of losses of a particular business upon the formulas:

$$\beta = \begin{cases} 0, & then \quad r^* < r_{\min} \quad ; \\ R \times \left[1 + \frac{1-\alpha}{\alpha} \times \ln(1-\alpha)\right], & then \quad r_{\min} \le r^* < \bar{r} \quad ; \\ 1 - (1-R) \times \left[1 + \frac{1-\alpha}{\alpha} \times \ln(1-\alpha)\right], & then \quad \bar{r} \le r^* < r_{\max} \quad ; \\ 1, & then \quad r^* \ge r_{\max} \quad ; \end{cases} \tag{20}$$

$$R = \begin{cases} \left[\frac{r^* - r_{\min}}{r_{\max} - r_{\min}}\right], & then \quad r^* < r_{\max} \quad ; \\ 1, & then \quad r^* \ge r_{\max} \quad ; \end{cases} \tag{21}$$

$$\alpha = \begin{cases} 0, & then \quad r^* < r_{\min} \quad ; \\ \left[\frac{r^* - r_{\min}}{\bar{r} - r_{\min}}\right], & then \quad r_{\min} \le r^* < \bar{r} \quad ; \\ 1, & then \quad r^* = \bar{r} \quad ; \\ \left[\frac{r_{\max} - r^*}{r_{\max} - \bar{r}}\right], & then \quad \bar{r} < r^* < r_{\max} \quad ; \\ 0, & then \quad r^* \ge r_{\max} \quad . \end{cases} \tag{22}$$

For management purposes, it is advisable to fix $\bar{r} = const$—the required level of the expected portfolio profitability. While manipulating the vector $\{x_i\}$, we can draw the investment risk to a minimum. This task has the following written form:

$$\{x_{opt}\} = \{x\} \mid \longrightarrow min, r = \bar{r}. \tag{23}$$

This model is a double task of the nonlinear programming to the task in the following form:

$$\{x_{opt}\} = \{x\} \mid r \longrightarrow max, \quad = const. \tag{24}$$

This model is similar to the one of (18), but the risk factor (a linear restriction in the form of equality) is not the standard deviation of the portfolio but the degree of risk of business losses or the ineffectiveness of the choice of business.

3.3. Portfolio Risk Management on the Base of a Fuzzy Model of Analysis

In accordance with the main principles of portfolio risk management based on a fuzzy model, determined above, it is possible to analyze the application of this approach to a specific case study.

The business portfolio of the corporation covers two directions (BD1 and BD2) with the following parameters: the profitability—% and 12%, thus, the calculated corridors BD1 and BD2 are [7.2%, 8.8%] and [9.6%, 12.4%] accordingly. The share of BD1 in the portfolio varies from 0% to 50%, and the share of BD2 from 50% to 100%, respectively (Kumar and Zattoni 2019). The critical value of the portfolio profitability is $r^* = 11\%$. The results of the loss risk assessment upon the business directions, under the condition of redistribution of their shares in the framework of the portfolio, are presented in Table 1.

The dependence "risk-expected profitability" for the portfolio is presented in Figure 3, while the dependence of the degree of risk on the share of the low-income businesses in the portfolio is given in Figure 4.

Table 1. The determination of the risk of a two-segment portfolio with the marginal rate r^* = 11% per annum.

№	BD_1 Share	BD_2 Share	Expected Portfolio Profitability, %	Lower Profit Limit, %	Upper Profit Limit, %	Degree of Risk
1	0.0	1.0	12.0	9.6	14.4	0.109
2	0.1	0.9	11.6	9.4	13.8	0.190
3	0.2	0.8	11.2	9.1	13.3	0.339
4	0.3	0.7	10.8	8.9	12.7	0.670
5	0.4	0.6	10.4	8.6	12.2	0.854
6	0.5	0.5	10.0	8.4	11.6	0.959

It is clear that with the growth of the low-income business share in the portfolio, despite the fact that the calculating corridor BD1 is narrower than the calculating corridor BD2, the expected profit of the portfolio decreases, and respectively, the risk of losses and the ineffectiveness of the choice of the portfolio increase.

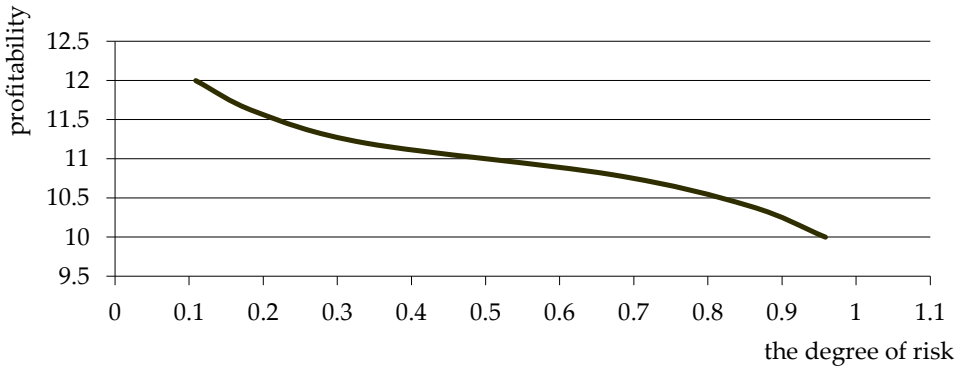

Figure 3. The dependence "risk-expected profitability".

If one fixes the limits of the expected profitability of the portfolio in the risk management task at a level of, for example, 11.2%, then the minimum risk of such a portfolio will be 34%. This minimum is reached when the share BD1 is 20%. Thus, under the condition of the risk fixation at 19%, the maximum profitability is reached when the BD1 share in the portfolio reaches 10%.

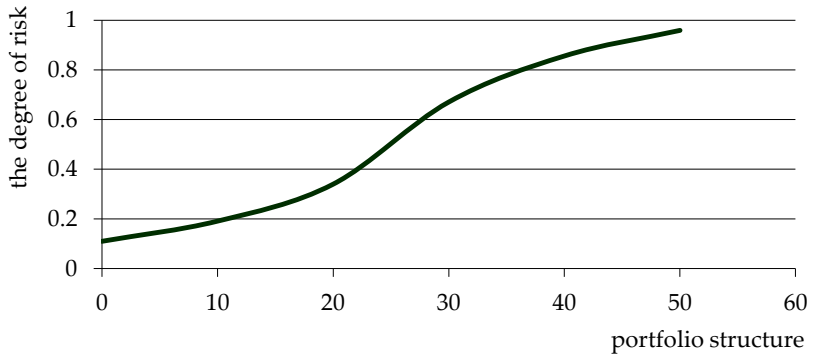

Figure 4. Dependence "portfolio structure-the extent of risk".

The considered example for the simplification of the situation intentionally excludes the assumptions about the reliability of the business, i.e., the risk factor for failure of servicing the credit and debit debts.

Example of application of the method: the initial data for the assessment of the securities portfolio, formed of five blocks of shares of corporate property, are given in Table 2.

Table 2. Expected profitability and standard deviation of the profitability of corporate property packages at the boundaries of the membership function.

Parameters	Package 1	Package 2	Package 3	Package 4	Package 5
$E(R_i)$	–0.05	–0.072	–0.056	–0.061	–0.0009
$E(R_p)$	0.029877	0.034	0.0333	0.029	0.000
R, probabilistic model	0.00688	0.00099	0.00099	0.00199	0.0029
σ_{ij}	0.024	0.02877	0.02877	0.02432	0.026668
6, probabilistic model	0.049	0.0455	0.04602	0.03988	0.036799

The values of weights obtained as a result of using fuzzy sets give a more attractive value of profitability and risk for the owner-company than the probabilistic model. The above values are presented in Table 3.

Table 3. Results of using the fuzzy set model and the probabilistic model for the formation of an optimal portfolio of corporate property objects.

Parameter	Fuzzy Model	Probabilistic Model
Portfolio return	0.059933	0.003945456
Portfolio risk	0.000498	0.00089243245
Maximum ratio “return-risk”	112.2333	4.763454326

Although the optimal portfolio, which is characterized by the inclusion of more corporate property, has a lower return, the risk is significantly reduced, which increases the efficiency of a particular corporate structure by almost two times. The reduction of risks in the presented model is the result of ensuring the neutralization of financial risks of the corporation on the basis of the strategy of avoiding losses in the formation of the portfolio of property and financial decisions based on comparative analysis of financial and mathematical models of alternative scenarios.

We should note that the trend toward the establishment of similar structures is caused by many factors, among which is the desire to bring into action the economic effect of large-scale production, the positive synergetic effect of unification of independent and relatively independent entities in the framework of developed structures, the advantages of competitiveness, the decrease of the final costs for products through the use of internal commercial and self-supported accountability, and the decrease of taxes at an expense of internal business volume. The global experience demonstrates that the most realistic way, leading to the establishment of competitive commercial structures, is the concentration of the capital and production capabilities, their integration upon the vertical technological principle, or the establishment and development of network structures. The vertical integration improves the efficiency of production at an expense of reduction of transaction expenses and reduction of conduit for the intermediary manufactured products.

4. Discussion

The use of fuzzy sets for the accounting of the initial uncertainty, concerning income from businesses, is a perspective direction of analysis of business efficiency in the course of building the diversification strategy. The use of this approach allows corporate management to avoid the necessity of setting the forecasts of the probability, based on the changing informational foundation, when the behavior of businesses and risks, under the conditions of the market uncertainty, is not characterized by statistical random processes. It is enough to make an assumption about the

calculation corridor, in the lines of which the expected future income fluctuates upon the business direction. Considering these simple assumptions, it is usually possible to assess the degree of risk of the ineffectiveness of the choice of business and implement measures on risk minimization.

One of the important competitive advantages of the corporation in the market is the fast response to all changes, which affect both the competitors and legislative state bodies. The risk factors are changing. They get more complicated. Moreover, they demonstrate new features. The risks acquire a multifactorial character; they become cross-subjective and possess complex internal relations.

5. Conclusions

Methodologies for forming a portfolio of corporate property were studied. In order to minimize risks, it is necessary to select those methodological tools with certain characteristics that allow building a profitable and low-risk portfolio.

The authors of the scientific paper optimized the methodology of portfolio management of the corporate property units to reduce the level of risks, based on the differentiated and portfolio approaches: the differentiated approach is used to consider corporate property as a set of separate components, which become the agent for independent management; the portfolio approach is used under the condition of unification of the corporate property units into management portfolios. It was determined that the increase in requirements for the system of corporate management is observed at all levels. The need for risk management has become evident for corporations. The design of the organizational system of risk management in the area of corporate property management includes, for the most efficient implementation of this function, the identification of analytical support of the package formation processes and the reduction of a general risk level in the management system of the block.

Using proven methods of portfolio theory to practice, one can determine the expected return on the portfolio of corporate property at some point or predict the profitability of the decision to change and supplement the portfolio within the projected risks identified by the fuzzy set model. The tools obtained describe the relationship between the profitability and the potential of the portfolio of the corporate property within the portfolio. It was proved that the diversification of the portfolio of corporate property on the basis of fuzzy sets requires compliance with its optimal structure and risk horizons. Excessive diversification of the corporate portfolio can reduce the efficiency of its maintenance and increase financial risks. It was determined that the limitation of the spectrum of diversification may result in dependence on specific risk groups. The spectrum of diversification is influenced by the characteristics of corporate property and the purposes of its use. The main task of forming a corporate portfolio of property is to ensure the effective distribution of risks between the objects themselves in order to maximize profits.

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