MODEL OF INVESTMENT DECISION-MAKING IN A SMALL INDUSTRIAL ENTERPRISE

ELENA VETROVA, SOFIYA DOROSHENKO, NIKITA TIHOMIROV, GALIYA KHAKIMOVA, LASHA KAKAVA

ABSTRACT

The need for the development of small enterprises in Russia, set against the background of stagnation in this segment of the economy in recent years, makes studying the problem of the investment attractiveness of this market segment relevant when it comes to finding opportunities and prospects for the development of this sector. Given this fact, the purpose of this study is the construction of a model for investment decision making based on a small industrial enterprise. The study uses methods and models of financing, the evaluation of investment attractiveness as well as modelling. We propose and develop a conceptual model for investment decision making, taking into account the choice of the financing option, the method for assessing the effectiveness of investments and the decision support system in the context of the specifics of a small industrial enterprise. This is the novelty of our study. The research is given in the context of analysing linguistic variables of risk assessment and fuzzy parameters of the main indicators of the project, and is supplemented by some elements of scenario analysis.

Key words
Model of investment decision making, small enterprise, industry, risk management.

Introduction

The need for the development of small enterprises in Russia, set against the background of stagnation in this segment in recent years, makes studying the problem of investment attractiveness relevant to finding opportunities and prospects for the development of small businesses. Small enterprises are more flexible because they are less formalised. Large companies are bureaucratic, and their activities are highly regulated by the state, as in the case of Russia. Furthermore, when there is a change in the market situation, it is difficult for a large company to respond quickly as it takes time to coordinate with various structures inside and outside the company. A small business can quickly change its strategy. Being more flexible and adaptive to changes, this segment of the market plays a key role in the development of a market economy. Therefore it is reasonable to show the paths to investment decision making for small enterprises in industry, with undeniable potential on the Russian market.
We have identified declining trends in foreign direct investment (FDI), both in terms of incoming and outgoing flows (Figure 1). The share of Russian FDI in the global investment market is low (Figure 2), and the share of small enterprises is less than 20%.

At the same time, there is an increase in international trade, which means the absence of a link between investment policy and performance. Mineral resources (export) and high-tech goods (import) dominate in terms of the sectoral structure of Russia’s foreign trade (United Nations, 2019).
Thus, the importance of changing the policy for making investment decisions aimed at increasing investment attractiveness in general, and for small industrial enterprises in particular, is being updated. One should add that our research was conducted in the context of regional specificities and is oriented not only to Russian firms, but also to foreign investors. A small enterprise can develop independently, be integrated into networks of global companies or follow other options for growth. Project financing may also be interesting for regional and local government authorities. In addition, production has features which should be taken into account from an environmental perspective when assessing the investment attractiveness of projects. In other words, these factors are the base criteria for the selection of methods of valuation of investment projects, financing methods and investment decision making. Thus, the purpose of this research paper is to construct a model of investment decision making based on a small industrial enterprise. The most complicated part is to optimise the portfolio, given the constantly changing conditions under which the project is implemented. The influence of external and internal factors is always a consideration, inasmuch as decisions are made in conditions of uncertainty. When investment projects are chosen, determined data is substituted for probable data, both expert and statistical methods are used and the risk premium is considered, so the uncertainty factor is taken into account.

We assume that expressing expert assessments through fuzzy numbers reduces the drawbacks of average weighted values of project input parameters, which may result in considerably shifted point estimates of efficiency and risk indicators. In some situations, the theory of probabilities is ineffective due to the lack or imprecision of data. In such cases, the fuzzy set theory should be used. According to the fuzzy set theory which was determined by Zadeh (1965), experts may give a specific mathematical sense to the results of expert assessment, then qualitative expert estimates can be transferred into quantitative ones (Krutikov et al., 2017). Another positive aspect is to use the scenario approach in fuzzy sets: an expert commission suggests several case scenarios, namely a pessimistic one, an optimistic one and the expected one. The information obtained as a result can be combined as a fuzzy triangular number for each project, and compared so that the best projects are chosen.

The construction of the model starts from the presentation of the expected result of modelling. The results of modelling should include: methods of valuation of investment attractiveness; methods of financing of investment projects and investment decision support systems. Therefore, we used various theories and methods in the subject fields. In that case, because of the specifics of the object and the uncertainty of the external environment of its functioning, we consider it to be expedient to use a combination of methods in a unified system.

The paper is structured as follows: the relevance of the research is explained in the introduction, which is then followed by the objectives of the study. Existing developments on the topic at hand are identified in the literature review. Two hypotheses are formulated based on the literature review and subsequently proven. The following are the results of the study, i.e. a model for making investment decisions and a model for assessing project risks. The main conclusions are formulated and the prospects for future research are explained in the conclusion section.
1. Literature review

The development of small business is the basis of economic development for every country. The sources of this development include factors of production, investment and innovation. This study focuses on the importance of investment. One should, however, remember that investments in small industrial businesses are highly risky, which escalates in a competitive environment. Under these conditions, new approaches to making investment decisions are needed.

Making an effective investment decision determines the success of the implementation of the strategy of any enterprise. This may be decisive for the functioning of a small enterprise, since its investment portfolio is less diversified than in a large company. Investment management theory considers various methods of substantiation of investment projects (Ross et al., 2002), but does not focus on the various interests of participants in this process. In our opinion, these differences determine the variety of decision-making criteria and methods that can be used. This updates the construction of an investment decision-making model. We agree that a multi-criteria approach to decision making should be used (Puška et al., 2018); at the same time, it should be combined with standard methods for substantiating investment projects. In the scientific literature, models for making investment decisions are most often identified with models for evaluating investment projects. However, participants in these models may have not only different interests, but also different appetites for risk. This is even more relevant for small enterprises, since their investment attractiveness is subject to a high degree of uncertainty, not least in Russia. Therefore, we conducted an audit of the methods for undertaking investment projects and assessing their risks to include them in the investment decision-making model, and took into account the peculiarities of making investment decisions for a small enterprise.

There are traditional methods of investment decision-making: the method of net present value (NPV) and the accompanying method of calculating the internal rate of return (IRR), the method of calculating the payback period (PB) and others. More modern methods of investment decision-making are: methods of economic value added (EVA), multicriteria methods, fuzzy set theory and others besides. In this paper, we prove that the feasibility of using alternative investment solutions for a variety of methods for assessing investment projects and methods for their financing is the subject of the fuzzy set theory (Zadeh, 1965, 1975; Chernov, 1999; Chernov et al., 2010).

Appropriate and efficient techniques are required for the risk analysis of any project. There are a number of techniques available in the literature, which have their own advantages, disadvantages and limitations. Selection of a particular risk assessment technique depends on various factors such as the cost of using the method, adaptability to the organisation’s requirements, the level of risk, size and structure of an organisation, consistency, complexity, usability, validity and credibility of the method (Sharma and Goyal, 2015). We believe that multi-criteria analysis methods are more objective when it comes to making investment decisions. Many researchers have made a certain contribution to the use and development of multicriteria analysis for selecting projects as a whole, or for a specific industry. For example, Mohanty (1992) used the TOPSIS method for solving the project-choice issue. He also
used the analytic network process (ANP) for choosing projects (Mohanty et al., 2005). Triantaphyllou (2000) applied the analytic hierarchy process (AHP) method for choosing an information system project, and Mahmoodzadeh et al. (2007) applied the AHP and TOPSIS methods for choosing projects. One should add that investment projects for industry were selected using multi-criteria analysis, and industrial investment projects were evaluated and selected using the AHP method (Vaidya and Kumar, 2006), whilst AHP and fuzzy TOPSIS were used to select projects in oil development (Amiri, 2010).

The further development of multicriteria methods is associated with the specifics of the investment strategy. The AHP method for choosing between a current and a new project was used by Manteghi and Haddadpour (2012). The application of AHP and ANP allowed researchers to develop a model that helps investors to choose suitable projects (Aragonés-Beltrán et al., 2014). Later the MCDM methods were applied for the selection of projects based on the values of AHP and TOPSIS (Pangri, 2015). In addition, Bollinger and Pictet (2008) used multicriteria decision analysis as the basis for integrating inputs from policy and technology in a structured way in environmental projects. We did not, however, find a model for investment decisions by small enterprises, with the exception of proposals for investment solutions for small businesses made by Puska et al., (2018).

In modern conditions, however, we observe the complication of investment projects and the conditions for their selection. Therefore, the use of individual methods does not make it possible to make objective decisions. In addition, it is difficult to make an optimal decision, since the optimisation problem is associated with a number of limitations. However, it is possible to make a better decision than others. However, it is possible to use a complex method, either creating their own or on the basis of combining different methods. And it is necessary to choose the investment project that gives the best results in comparison to others.

Fuzzy set theory is a branch of modern mathematics which was introduced by Zadeh (1965) to model the vagueness intrinsic to the human cognitive process. It is suitable for handling undefined and complex problems due to the partial and imprecise information available for decision making. Fuzzy sets are able to incorporate information described in linguistic terms. Furthermore, a fuzzy decision algorithm was proposed by Karsak and Tolga (2001). It is built on the application of the fuzzy analytic network process along with fuzzy cost analysis for selecting R&D projects and solving the problem of the option’s qualitative attributes. A fuzzy inference enhanced VC-DRSA model was developed for technical analysis of the investment (Shen and Tzeng, 2015). It is worth adding that Russian scientists also contributed to the development of the theory of investment decision making using the theory of fuzzy sets (especially Altunin and Semukhin, 2002; Gavrilenko, 2013).

Despite the existence of many literature sources, the multi-criteria fuzzy logic algorithm is a new instrument, functioning as a decision-making tool based on scientific acquisition criteria of assets, with which the optimal combination of the cost of assets purchased and their economic performance is assured (Boloş et al., 2019). In addition, there are some rules which can be used in applying fuzzy sets to optimise a project portfolio. When the fuzzy set theory is applied to the assessment of investment projects, it is necessary to decide on the algorithm of actions and the methodology of assessment. For example, when the membership function is determined, the
accuracy of knowledge of a complicated phenomenon is defined by estimating the grade of membership of a variable in the fuzzy set. An element can belong to a set within a range of 0 to 1 with a larger or smaller degree of reliance.

A membership function expresses the subjective assessment of an expert via fuzzy numbers. A fuzzy number with a triangular membership function is understood as a triangular fuzzy number (a1, a2, a3). A trapezoidal membership function is applied too. In cases when data changes and the values of indicators are fuzzy or unreliable, the fuzzy set theory should be used (Gavrilenko, 2013).

Linguistic variables are introduced in order to assess projects. They are designated not in a numerical format, but in words, for example: low, medium, high. The number of terms in a set must contain a scale which defines the entire spectrum of indicator conditions; 5-11 terms are usually singled out so differentiated assessments can be obtained.

Furthermore, the linguistic variables determined by experts can be represented graphically in the form of fuzzy sets; the consistency function is defined for each variable, i.e. the value of consistency is determined for each element of a linguistic variable (Pererva et al., 2019).

The consistency functions of term values are written as sets of ordered pairs: the value of the basic variable is put along the axis OX and the consistency function values are put along axis OY. When investment projects are analysed, there is a problem concerning the number of indicators chosen for analysis: the estimates of each of them are unambiguous, hard to compare and require additional information. There are two types of linguistic information: weighted, when the degree of importance of a variable in a full set is determined, and not weighted, when there is merely a list of linguistic variables. In this case, the weighted information is more preferable, even if there is an expert commission to choose the best from a wide range of assessments. The opinions of experts can be contradictory to each other, so they are aggregated to obtain a single resolution. The concordance coefficient must be assessed as well.

In conclusion, one may state that the reviewed publications on the fuzzy set theory used for building an investment project portfolio and assessing project risks prove that the topic is very popular. It is a multidimensional construct and authors analyse it from different perspectives.

2. Methodology

The study aims to test the two hypotheses that define the basis for building a model for making investment decisions in small enterprises in industry. These hypotheses are:

Hypothesis 1: The model of investment decision making includes three main components: methods for evaluating investment efficiency, financing methods and an information support system.

Hypothesis 2. In order to manage the risk, it is necessary to increase the investment attractiveness of projects and their effectiveness and ensure timely adjustment

The existing methods of investment decision making do not contradict, but rather complement, each other, and consequently can be used as part of the integral methodology. Therefore, we consider the expediency of using the basic method of net present value (NPV) and the accompanying method of calculating the internal rate of return (IRR), the method of calculating the payback period (PB) and others in combination with methods of economic value added (EVA) and fuzzy sets
(Bendeković, 2008; Balashov et al., 2014; Brusov et al., 2014; Ross et al., 2002; Rogova et al., 2011). In turn, the main methods of financing are: self-financing, corporatisation, loan financing, leasing, and venture financing (Balashov et al., 2014; Brusov et al., 2014; Rogova et al., 2011). We suppose that the usage of the proposed methods and combinations thereof should become the basis for forming alternative design options for investment.

The creation of a single structured system for monitoring data on each of the possible methods for making investment decisions in the context of macro- and meso-factors of the external environment has been considered for information support pertaining to investment decisions (Vetrova and Vashchillo, 2017). Such a support system should include information, ways of collecting and processing it in the context of the country’s social and economic development, regions, municipalities, sectoral and regional complexes, and enterprises. In these conditions it is advisable to use the methodology of architecture (Zachman, 1997).

In order to form alternative options for investment projects, we propose to use a methodology based on the fuzzy set theory (Zadeh, 1975; Chernov, 1999; Chernov et al., 2010). To this end, a matrix is drawn up where the evaluation criteria is placed along the X-axis, financing methods are placed along the Y-axis, and methods for evaluating investment projects are along the Z-axis. The linguistic description of the listed sets was carried out by means of an expert method. The evaluation of the alternative by the criterion $x_i$ is multivalued and is characterised by the membership function of $X$ taking values on the set $(0 - 1)$ i.e. the fact that an element belongs to a fuzzy set is determined from 0 (certainly does not belong) to 1 (certainly belongs). The number of financing methods $Y$ proposed by experts for evaluation amounted to 5, and the number of methods of evaluation of $Z – 5$. A variety of options can be made of these three sets, that can themselves be considered alternative options.

The system of support for the adoption of investment decisions which we have proposed should include information, as well as ways of collecting and processing it in the context of the country’s social and economic development, regions, municipalities, sectoral and regional complexes, and enterprises. The main advantage of such a system is a single, structured, generalised view of the real, quantifiable indicators that determine the choice of the method of making an investment decision.

The direction of further research will be related to the modelling of options for making investment decisions with the justification of the conditions and criteria for their adoption for implementation.

3. Construction of the model and Discussion

In order to design an investment decision-making model that we identified with three main components: a unit of methods for evaluating investment efficiency, a block of financing methods, and an information support system for making an investment decision, it is necessary to take into account the following: participants in the investment decision-making process; complex information resources, such as regulatory legal documents formed at various levels (regional and sectoral strategies, programs, projects, methodological materials and so on); peculiarities of decision making by Russian and foreign investors; and the possibility of adjusting investment decisions on the agreement of all participants in the investment process. When constructing the model, we took into account the possibility of combining various methods of financing (Ross et al., 2002; Balashov, 2014; Brusov et al., 2014;
Rogova, 2011) and making investment decisions, both traditional and specific (Puška et al., 2018; Zadeh, 1975; Chernov, 1999; Chernov et al., 2010); identified the location of information support (Zachman, 1997; Vetrova and Vashchillo, 2017); and identified the object and subject of decision making.

A conceptual model for making an investment decision is presented in Figure 3.

Figure 3. Model of financial decision making

Since a small enterprise is considered to be a business entity, and investments are considered in the industry, we clarified the specifics of all the elements of the investment decision-making process, taking the specifics of the subject, object and subject matter into account. The investment decision is the result of an integrated assessment of the investment object in terms of the methods of financing and the results of the investment assessment, the opportunities and risks associated with it, and the investment decision support system, taking all participants in the investment activity into account.

Participants in the decision-making process of small industrial enterprises are: 1) owners and investors, both Russian and foreign; 2) the Management Board of the company; 3) partners, including resource providers, as well as large companies, in which small business chains can be built; 4) regional and/or local government authorities interested in developing the territory; and 5) experts who specialise in matters pertaining to investment activity and the specificity of industry production.

The process of standard investment decision making consists of stages; its content is determined by the specifics of the
object and subject. The standard stages are: evaluation of the investment case; formulation, initial assessment and selection of investment proposals; analysis and decision making; project implementation and monitoring; and post-investment control. In the last three phases, the defining role is played by the business environment in the territory, including in terms of infrastructure.

We have left the basic principles of investment decisions and specifically added the following: accounting for all the most significant consequences of project implementation (economic, environmental, social, etc.); accounting for the availability of various project participants, the discrepancy between their interests and the different estimates of the cost of capital, which is expressed by individual values of the discount rate; multi-stage evaluation at the stages of substantiation of capital investments, development of feasibility studies, selection of a financing scheme, monitoring, etc.; accounting inflation and risk factors, as well as the possibility of using it in the implementation of multiple currencies for the development of the project; and accounting for the working capital requirement for the new project.

Since the problem of the investment attractiveness of small enterprises in the industry is being investigated for this business segment in order to attract not only domestic but also foreign investors into the industry, the investment attractiveness of small enterprises in the polymer industry in Russia should be considered, taking into account the regional specifics of the current or future location of the enterprise in the industry. At the initial stage of the formation of the algorithm for making an investment decision, the investor requires a structured data system in the context of regions with the possibility of comparison with the purpose of assessing the feasibility of investments, both at the stage of forming a new enterprise and investing in the operating business.

All projects go through a structuring procedure in the form of a hierarchy in accordance with expert opinion, the estimation of NPV indicators and risks using the fuzzy set theory and the selection of alternatives.

The creation of a single structured system for monitoring data on each of the possible decision-making methods and methods for evaluating the effectiveness of investment projects in the context of macro- and external factors form a database on socio-economic development, economic indicators, sectoral and regional complexes, and monitoring from various sources: federal statistical reporting agencies, departments, offices and enterprises (Khasanshin, 2011).

Technologically, this stage may be based on the concept of the Data Warehouse (Vetrova and Vashchillo, 2017), which will ensure greater efficiency in decision making by the investor, regardless of the level of his awareness of the region at the initial stage of investment project evaluation. The main advantage of this system is a single, structured, generalised representation of real, quantifiable indicators or structured fuzzy sets that determine the choice of the investment decision-making method.

We propose that a project portfolio should be optimised by analysing fuzzy parameters of risk, which will also allow us to assess the risk level of the projects in the portfolio. To do so, we chose two main areas: NPV and risks. Figure 4 shows a scheme for building an investment project portfolio by using an apparatus of fuzzy sets.
Building an investment project portfolio based on the fuzzy set theory has several advantages, such as versatility, flexibility and a wide range of estimates. The fuzzy set theory apparatus implies significant preliminary work at the stage of identifying and analysing risk factors, which contributes to a more exact assessment of risk, the accumulation of a risk database and a prospective assessment of risk factors in dynamics. The drawbacks include complications in the perception of this theory and difficulties in the interpretation of results.

A risk criterion depends not only on the assessment, but also on the weight of the criterion, and the degree of importance in the complex assessment of project risk. Combining the risk assessment and NPV analysis helps us to determine the best composition of projects in a portfolio. The other considerable advantage of this method is the opportunity to compare qualitatively different elements of a system with various units of measurement.

Is it always reasonable to use fuzzy sets when a project portfolio is being built? In our opinion, the efficiency of approaches based on probable, fuzzy set and expert assessments depends on a specific project, its characteristics, externalities, and the level and nature of risk. With growing risk, probable descriptions are not as efficient as expert ones; if they are combined with the fuzzy set theory, a larger number of factors can be embraced. The undoubted advantage of the fuzzy set theory as applied to project assessment is the capacity to compare qualitatively different indicators and parameters with various units of measurement.

When a set of investment projects is considered at an enterprise, it is difficult to choose qualitative indicators and to compare and select from the presented alternatives. Net present value is most commonly used to judge the efficiency of a project. The integrated value of a project is hard to define as a whole, but at the same time every project is a single scheme, and individual suggestions cannot be used. It is necessary to determine the main parameters for analysing and choosing a project, whereby the decision will be taken to build a portfolio. Therefore, projects are chosen if they can be implemented with the available amount of initial capital investment.
and ensure the maximum amount of net present value.

For those projects that have been selected for analysis, investment expenditures and the total amount of available investment funds are determined. It is suggested that, in order to do so, the fuzzy set theory, scenario approach and risk assessment should be combined. Calculations are made separately for every project. Both general risks (such as underfunding and strategic risks) and specific risks inherent to a particular project are determined. It is preferable that the selection of economic indicators should be the same for all projects. Most commonly, NPV, IRR and – in rare cases – payback period are used.

As a result, focusing on the trend of the net present value to a maximum (Pererva et al., 2019; Ptuskin, 2003) is suggested. It is shown as a problem of selection from n investment projects, in the form of a fuzzy model. The task model is expressed as a function of the total (integral) NPV tending towards a maximum result:

$$c(x) = \sum_{i=1}^{n} NPV_i \quad \rightarrow \quad \text{max}$$

The following conditions must be met to achieve this variant:

$$\sum_{i=1}^{n} a_i x_i \leq b, \quad x_i = 0$$

in case a project is excluded from the investment portfolio, and $$x_i = 1$$, if an investment project is selected for the portfolio; $$n$$ is the number of projects, $$b > 0$$, $$a_i > 0$$, $$NPV_i > 0$$, $$\sum_{i=1}^{n} a_i > b$$, $$i = 1, \ldots, n$$.

For further analysis, $$x_i$$ is assigned a value of either 0 or 1 so that the function $$c(x)$$ achieves a maximum value, and consequently the conditions of our task are satisfied. All values of the indicators selected in a given interval are expressed as fuzzy numbers.

If the decision is made to estimate NPV separately by items, to evaluate every cash flow, which is part of the NPV indicator, then all the expected flows should be chosen for evaluation and consideration – sales revenues in period $$t$$, variable and fixed costs in period $$t$$, investment in period $$t$$, taxes and other payments, etc.

When the fuzzy set theory is used, project scenario analysis must be considered, which implies analysing and evaluating three variants of project development: optimistic, pessimistic and probable, with the calculation of three values of NPV: $$NPV_p$$ – for the pessimistic variant, $$NPV_o$$ – for the optimistic variant, and $$NPV_b$$ – for the probable variant (Pererva et al., 2019).

Consequently, let us express the selected parameters by means of fuzzy triangular numbers $$(NPV_i(l, t)p, NPV_i(l, t)o, NPV_i(l, t)b)$$ for $$l = 1, 2, \ldots, 6$$.

The membership functions of these fuzzy numbers are expressed by intervals whose boundaries are set by optimistic and pessimistic assessments and by vertexes with peak values of the membership functions, determined by probable assessments. These assessments are approximate, so it can be assumed that triangular membership functions are quite suitable for describing uncertainty and for all necessary operations with fuzzy numbers. The only risk which is not considered is project risk. To assess the risks, we use the second column of Figure 4.

The algorithm of assessing the risk inherent in an investment project is described as follows:

- identify the risks of an investment project and set all variables for each of them in linguistic form;
- determine the importance and probability of every risk factor and associated loss;
- choose the most dangerous risks for the previous item and determine
the indicator of the project risk as a weighted average for every risk factor given the possible loss;
- determine the degree of convergence of the investment project risk variable with each term of the pre-set linguistic risk variable;
- choose an investment project.

Risk analysis begins with an expert determining a set of linguistic terms: types of risks for projects, probability of a risk, importance of a risk, and the size of the loss in case a risk occurs. The following are chosen as risk variables: insignificant, very low, low, medium to low, medium, medium to high, high, very high and critical (Ajzin and Livshic, 2006; Chen et al., 2006). All types of risks are classified and divided into groups, corresponding to the forecast NPV defining cash flows: for example, risk of sales revenue reduction, risk of prime costs growth, etc. The meaning of terms is pre-set by fuzzy numbers defined on the interval from 0 to 1 and triangular membership functions.

### Table 1. Defining a linguistic risk variable (example)

<table>
<thead>
<tr>
<th>No.</th>
<th>Term</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insignificant</td>
<td>(0.0; 0.0; 0.0; 0.0; 0.0; 1.0)</td>
</tr>
<tr>
<td>2</td>
<td>Very low</td>
<td>(0.0; 0.0; 0.02; 0.05; 0.07; 1.0)</td>
</tr>
<tr>
<td>3</td>
<td>Low</td>
<td>(0.04; 0.1; 0.18; 0.23; 0.34; 1.0)</td>
</tr>
<tr>
<td>4</td>
<td>Medium to low</td>
<td>(0.17; 0.22; 0.36; 0.42; 0.55; 1.0)</td>
</tr>
<tr>
<td>5</td>
<td>Medium</td>
<td>(0.29; 0.34; 0.49; 0.53; 0.69; 1.0)</td>
</tr>
<tr>
<td>6</td>
<td>Medium to high</td>
<td>(0.47; 0.53; 0.78; 0.83; 0.92; 1.0)</td>
</tr>
<tr>
<td>7</td>
<td>High</td>
<td>(0.62; 0.74; 0.82; 0.95; 0.99; 1.0)</td>
</tr>
<tr>
<td>8</td>
<td>Very high</td>
<td>(0.91; 0.94; 1.0; 1.0; 1.0; 1.0)</td>
</tr>
<tr>
<td>9</td>
<td>Critical</td>
<td>(1.0; 1.0; 1.0; 1.0; 1.0; 1.0)</td>
</tr>
</tbody>
</table>

Source: Own elaboration.

At the second stage, experts identify project risks, analysing all their parameters, and define the probability of risk occurrence, possible loss and the importance of the risk for the project using expert statistic techniques. Based on qualitative analysis, an expert must give linguistic terms to variables of probability, importance and loss (Kruglov et al., 2001).

It makes sense for risks to be defined by two directions for innovative projects: the risk of the costs of preparation and creation of a project increasing, and the risk of a project having insufficient cash flows. The higher the risk of a negative change in a parameter, the more the value of the basic variable with a maximum value of the membership function must shift from the amount of cash flow for the probable variant to the amount of cash flow for the pessimistic variant (Ptuskin, 2003).

All chosen risk indicators are calculated as the weighted average of occurrence probability for every risk factor, for which a loss is tangible in the scope of the project (Gracheva and Sekerin, 2009):

$$
R = \frac{\sum_{i=1}^{n} P_i W_i}{\sum_{i=1}^{n} W_i}
$$

As a result, the expert obtains one or both alternative records of the risk variable: \( R = (P(R), W(R)) \) or \( R = (a, b, c, d, wR) \).

At the next stage, the degree of convergence of the obtained risk variable is compared to every linguistic risk term. Provided that the average integration indicator is used in calculations, the degree of convergence must be calculated by the following formula (Gracheva and Sekerin, 2009):

$$
\frac{1}{1 + P(R_{term}) - P(\text{term}_i)} + \frac{W_i}{W_{\text{term}_i}}
$$

### Table 2. Defining the degree of confidence in the probability of risk factors (example)

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Risk probability ( P_i )</th>
<th>Risk importance for project ( w )</th>
<th>Amount of loss ( W_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk 1</td>
<td>Very low</td>
<td>1.0</td>
<td>Low</td>
</tr>
<tr>
<td>Risk 2</td>
<td>High</td>
<td>0.8</td>
<td>Very high</td>
</tr>
<tr>
<td>Risk 3</td>
<td>Medium</td>
<td>0.5</td>
<td>Medium</td>
</tr>
<tr>
<td>Risk 4</td>
<td>Quite high</td>
<td>0.76</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Source: Own elaboration.
As a result of such calculations, there are numbers characterising the degree of convergence of a project risk with each of the pre-set terms. For the following calculations, the highest rank is selected among the ranks obtained. The risk variable will be attributed to the linguistic term with the biggest degree of convergence (Pupkov and Kon’kov, 2003; Bollinger and Pictet, 2008).

The fuzzy $\text{NPVi}$ is within the interval of its values from pessimistic to optimistic. Figure 1 is the maximum degree of the membership function, which corresponds to the pessimistic value of the parameter at a maximum value of the risk level. Correspondingly, with the risk level corresponding to the linguistic variable “practically absent”, the maximum degree of the membership function is obtained by the probable expected value of the $\text{NPV}$ parameter.

To use the optimistic value of the $\text{NPV}$ parameter for such a risk level means to ignore the impact of the risk on the project, since the practical absence of the risk or its insignificantly low impact on the project does not imply that it causes a favourable change in the parameter and does not give any guarantee that this risk will be absent in the future throughout the implementation of the project. As a result, for every project, net present value ($\text{NPV}$) is determined, the value of which is present as a fuzzy number.

In most cases, it is enough to obtain the interval, fuzzy numbers and parameters for comparing investment projects and build a portfolio at this stage, but sometimes it is necessary to obtain the precise value of indicators selected for analysis and transformed in fuzzy numbers. The process by which the precise value of an indicator is obtained is called defuzzification.

In case it is deemed necessary, it is possible to perform the defuzzification procedure and obtain the precise number of the risk by means of the following formula (Gracheva, 2009):

\[
y = \frac{\int_{\text{min}}^{\text{max}} x \varphi(x) dx}{\int_{\text{min}}^{\text{max}} \varphi(x) dx} = \frac{(a_{0} + a_{1} + a_{2} - a_{3} - a_{4} - a_{5})}{3(a_{0} + a_{1} + a_{2} - a_{3} - a_{4} - a_{5})}
\]

The $\text{NPV}$ of the probable variant is used as a basis for shifting, since the risk is manifested in the deviation of the achieved project parameters from their expected value.

All projects go through a structuring procedure in the form of a hierarchy in accordance with expert opinion, the estimation of $\text{NPV}$ indicators and risks using the fuzzy set theory and the selection of alternatives. The scheme is cyclic, since the projects are again structured by importance after selection.

In fact, the entire procedure can be presented graphically as follows (Figure 5).

**Figure 5. Building an investment project portfolio using the fuzzy set apparatus**

![Figure 5](source: Own elaboration)

Building an investment project portfolio based on the fuzzy set theory has several advantages, such as versatility, flexibility and a wide coverage of estimates. The fuzzy set theory apparatus implies significant preliminary work at the stage of identifying and analysing risk factors, which contributes to a more exact assessment of risk, the accumulation of a risk database and the prospective assessment of risk factors in dynamics. The drawbacks include com-
Applications in the perception of this theory and difficulties in the interpretation of results. A risk criterion depends not only on the assessment, but also on the weight of the criterion, as well as the degree of importance in the complex assessment of project risk. Combining risk assessment and NPV analysis helps us to determine the best composition of projects in a portfolio. The other considerable advantage of this method is the opportunity to compare qualitatively different elements of a system with various units of measurement.

Is it always reasonable to use fuzzy sets when a project portfolio is being built? In our opinion, the efficiency of approaches based on probable, fuzzy set and expert assessments depends on a specific project, its characteristics, externalities, and the level and nature of risk. With growing risk, probable descriptions are not as efficient as expert ones; if they are combined with the fuzzy set theory, a larger number of factors can be embraced.

Conclusions
We believe that the existing investment decision-making model is not sufficiently adapted for a small industry enterprise, and we offer a proprietary conceptual model. Therefore, the main objective of the study was to increase the investment attractiveness of a small industrial enterprise to a foreign investor. To prove the first hypothesis, we substantiated the composition of the subsystems of the conceptual model for making investment decisions. Our model includes three main components: a unit of methods for evaluating investment efficiency, a block of financing methods, and an information support system for an investment decision. It is important to achieve consistency amongst the participants in the investment decision. Among the many methods which could be used to achieve our goal, we identified the fuzzy set method and substantiated the possibility of its use.

To prove the second hypothesis, we have chosen methods for substantiating and evaluating investment projects and their risks. We determined the model for evaluating investment projects, taking into account their risks. In this model, various investment decision-making methods are used: namely traditional and modern ones. It is based on the methods of multicriteria analysis, in particular the fuzzy set method, which allows us to take the interests of its participants into account for the evaluation of projects, as well as assessing the risks.

The novelty of our research is the development of a two-step model of the investment decision, taking the characteristics of the risks inherent in the investment projects of small industrial enterprises into account on the basis of the fuzzy set method. To use the approach we have proposed, all participants in making an investment decision need to properly configure the technology of this process. Managerial involvements are required for that, which can bring about resistance. These issues need to be investigated further. The stage of development of the research methodology is completed. The next stage is the adaptation of the methodology to changing environmental conditions, industry, region and the development of a mechanism for its implementation.

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