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# MODELING OF THE OPTIMAL COMPOSITION OF THE ENTERPRISE TECHNICAL DEVELOPMENT PROGRAM

*Об'єктом даного дослідження є програма технічного розвитку підприємства. Дане дослідження присвячене проблемі формування оптимального складу програми технічного розвитку в рамках управління її змістом на базі концепції ціннісного підходу, згідно з якого цінність проекту – це його відповідність цілям розвитку. В основі принципу формування складу програми технічного розвитку – забезпечення максимізації цінності програми з точки зору заданої множини цілей технічного розвитку.*

*Розроблено метод оцінки цінності проектів технічного розвитку, заснований на застосуванні нечітких множин, в результаті якого формуються дві оцінки цінності проекту – внесок проекту в досягнення кожної мети з множини цілей і ступінь даного вкладу. Такий підхід дозволяє врахувати не тільки нечітке значення результатів, а й взяти до уваги в процесах формування програми ступінь «невизначеності» загального результату з точки зору кожної мети.*

*Формалізовано в термінах теорії нечітких множин опис кількісної оцінки ефекту синергізму, що виникає при спільній реалізації проектів в рамках програми, що дозволяє з більшим ступенем достовірності оцінити результат програми.*

*Розроблено модель формування оптимального складу програми технічного розвитку з урахуванням цінності проектів і системного ефекту (синергізму) їх спільної реалізації в рамках програми. Модель передбачає ранжування цілей, яке використовується при встановленні мінімальних меж для ступеня досягнення тієї чи іншої мети, що відповідає реальним процесам відбору проектів на практиці.*

*Використання запропонованого підходу до оцінки вкладу проектів в досягненні цілей, а також моделі оптимізації складу програми дає можливість формувати програму з пропонованої множини проектів. При цьому забезпечується в максимальному ступені досягнення цілей з урахуванням невизначеності як умов реалізації проектів, так і їх результатів.*

*Застосування пропонованої моделі може бути розширено на програми різної спрямованості.*

**Ключові слова:** *програма технічного розвитку, нечіткі множини, цінність проекту, управління змістом.*

## 1. Introduction

Raising the level of technologies and equipment used is an essential element of enterprise development. The importance and priority of technical development depends on the specifics of the enterprise. So, for those areas where technology and technology in production processes or in service delivery processes are not used in significant amounts and their cost is relatively low, technical development has virtually no effect on performance. The priority role in such situations in development processes is assigned to, for example, aspects such as marketing (advertising, product promotion, etc.).

For enterprises which manufacturing processes are carried out on the basis of expensive machinery, equipment and technologies, issues of technical development become priority given the significant influence of technology and the state of technology on cost, productivity and quality of products (services). This, in turn, has a direct impact on the competitiveness of the enterprise. Thus, for many industrial enterprises, the level of technical development practically determines the level of competitiveness, which proves the relevance of considering the issues of technical development in various aspects.

Technical development activities are carried out through appropriate projects and programs that must meet the priority goals of the technical development of the enter-prise. In [1], it is proposed to evaluate technical development projects according to their contribution to the achievement of the set goals, and the use of the theory of fuzzy sets is justified as an apparatus for forming an assessment of this contribution, which is the essence of project value. In this study, this idea of assessing the value of projects extends to the level of technical development programs. This further serves as the basis for shaping the composition of the program as part of scope management, that is, including only those projects that will ensure the achievement of program goals.

## 2. The object of research and its technological audit

*The object of this research* is the program of technical development of the enterprise. As it is known, a program is a series of related projects, the management of which is coordinated to achieve the benefits and degree of control that are not available when managing them separately [2]. The main difference of the program is that it focuses on obtaining business benefits for the company, which is impossible to achieve with the implementation of one project [2]. The following program specifics are described in [3]: a program is a system of projects, and «dropping out» of at least one element leads, as a rule, to the unattainability of the goal of the entire program.

Taking into account the specifics of system properties, it can be argued that each program element (project), on the one hand, influences the achievement of the goal of the entire program, and on the other hand, interacts with the other elements (projects).

In [4] it is established that technical development programs can be formed from interconnected technologically projects as well as from independent projects. Let's assume that in this case there is a program consisting of technologically independent projects.

The main parameters of the program in the context of the solved problem solved are the values of n goal indicators of the technical development of the enterprise. The program is limited by the amount of allocated financial resources.

In the formation of the program, such a system property is taken into account as the synergistic effect [5], which manifests itself in an increase in the total value and cost savings.

The principle of forming the composition of a technical development program is based on ensuring the maximization of the program's value in terms of a given set of technical development goals.

One of the most problematic places is that the goals of technical development (their quantitative characteristics) and the results of projects are uncertain. At the same time, the use of probabilistic methods is not possible due to the lack of, as a rule, the necessary statistics and the confidence that the patterns of the past will in this case be valid for the future. In addition, the synergies effect, which is formed in the programs and affects the final costs and value, requires its evaluation.

### 3. The aim and objectives of research

*The aim of this research* is ensuring the effective scope management of the technical development programs of the enterprise. Based on the aim, the following research objectives are formulated:

1. To develop a method for assessing the value of technical development projects, taking into account the specifics of the information uncertainty on the results of project implementation and in setting goals for the technical development of an enterprise.

2. To formalize the result of the manifestation of the synergy effect in technical development programs.

3. To develop a mathematical model for the formation of the optimal composition of the technical development program, taking into account the value of projects and the system effect (synergies) of their joint implementation within the program.

### 4. Research of existing solutions of the problem

Technical development, and in particular its influence on the formation of the strategic advantages of enterprises, has been considered in many publications, for example, in [6, 7]. Nevertheless, in the scientific literature there is practically no application of the project and program approach to the implementation of technical development. Naturally, the existing development program management programs of various orientations can be applied to one degree or another to technical development programs.

The most important stage in creating a program, like a project, is the define of scope. The scope in [8] is understood as a complex of subprograms, projects, activities, stages,

tasks to be performed to effectively achieve the goals of the program, indicating those responsible for their implementation, deadlines, sources of funds, etc. Formation of the optimal portfolio and program composition is a task which is considered in various studies of the authors, for example in [3, 8]. It should be noted that much more attention is paid to the problem of forming a portfolio of projects and only a fragmentary address to the problem of forming a program for the development of enterprises.

To solve the problem of project portfolio formation, they are mainly used: the approach outlined in [9] (for example, this approach is used for a multipurpose portfolio in the study [10]) and methods based on the use of the theory of fuzzy sets (for example, [11, 12]). The latter approach allows to take into account the specific uncertain nature of the results of project implementation. However, it should be noted that the problem of optimizing the composition of development programs requires its further solution, in particular, in terms of taking into account the appearance of synergies in the joint implementation of projects within the program. Let's note that the authors of [3] propose a subjective approach to taking into account synergies in the formation of a development program based on utility functions that are close in their mathematical essence to the theory of fuzzy sets. These ideas require their development in terms of the description formalization of the synergism emergence.

Also, in most of the existing approaches, economic indicators are used as criteria for the selection of projects and the formation of portfolios and programs, which does not correspond to the current vision of the «value» of projects (according to [13]). The exception is the work [3, 11], which in one form or another takes into account the strategic goals of the enterprise, as well as the study [14], the authors of which propose a procedure for selecting projects based on their relevance to the goals.

According to the concept of compliance of the projects of the program with the goals of technical development adopted in [4] as the basis in this work, an appropriate approach is necessary for its implementation at a formalized level. The paper [1] substantiates the application of the theory of fuzzy sets to assess the values of technical development projects in accordance with the concept outlined in [4].

The mathematical foundations of operations on fuzzy sets are presented in [15, 16]. The procedure for establishing the conformity of fuzzy sets to one or another of the restrictions or criteria in practical problems is presented in [12, 17]. These results can be taken as the basis for the formation of optimization models using fuzzy sets.

The results of the analysis allow to conclude that the development of a formalized approach to the formation of a technical development program is promising, since the existing studies fragmentarily take into account certain aspects characteristic of technical development programs. In particular, the synergy effect, the consistency of the results with a multitude of goals.

### 5. Methods of research

To solve these problems, *the apparatus of the theory of fuzzy sets* was used, the applicability of which under the given conditions is substantiated in [1].

Let *n* technical development goals be singled out, the quantitative characteristic of which $G_i, i = \overline{1, n}$. For simplicity, but without limiting the generality, let's assume that

one indicator is formulated for each goal. At the same time $G_i, i = \overline{1,n}$ are fuzzy sets, which are used to describe the goals. Let's assume that $\mu_{G_i}(x_i), i = \overline{1,n}$ is the membership function corresponding to the set $i$-th goal, $x_i$ – possible values of a fuzzy value characterizing the $i$-th goal. Let's note that a fuzzy description of a goal can be carried out in the form of a fuzzy number or interval, which affects the specificity $\mu_{G_i}(x_i)$. In particular, the questions of the types of membership functions are adequately characterized in [16, 17].

The description of the results of the implementation of technical development projects is also carried out using fuzzy sets. This approach is justified, since the implementation of technical development projects is aimed at the future, and, therefore, it is practically impossible to assess the conditions and results of the implementation of projects with a «clear number».

For a fuzzy description of goals, sets of the so-called «budget constraint» [9] can be used; a triangular form of fuzzy numbers is proposed to describe the results of projects. This kind of fuzzy numbers best matches the results of projects calculated for different scenarios – optimistic, most probable and pessimistic. In particular, the same approach is used in [9, 12] for a fuzzy description of project performance indicators and the results of their implementation.

Thus, the resulting characteristics of projects in the system of technical development goals are given by triangular fuzzy numbers of the form $A = \langle a,b,c \rangle$, and their membership function is of the form [17]:

$$\mu_A(x) = \begin{cases} \dfrac{x-a}{b-a}, & x \in [a,b], \\ \dfrac{x-c}{b-c}, & x \in [b,c], \\ 0, & \text{in other case,} \end{cases} \quad (1)$$

it is observed $a \le b \le c$.

Thus, the results of the project from the standpoint of a specific goal is a triangular fuzzy number $\tilde{\Pi}_j^i$ (a special type of fuzzy set), and the membership function $\mu_{\tilde{\Pi}_j^i}(x_i)$, $i = \overline{1,n}, j = \overline{1,m}$ has the form (1).

So, fuzzy intervals and numbers, in this case, describe both the goals and the corresponding results of project implementation from the point of view of each goal.

## 6. Research results

### 6.1. The procedure for assessing the contribution of projects to the achievement of technical development goals.
The «value» of projects will be understood as their contribution to the achievement of technical development goals (according to the approach [1]). It is necessary to take into account the fact that each project can contribute to the achievement of several goals [4]. Let's suppose that for the formation of the program for consideration m projects of technical development are presented. Let's assume that these projects are not mutually exclusive.

The results of the implementation of these projects in terms of achieving the goals can be characterized by a set of fuzzy values:

$$\langle P_j^1, P_j^2, ..., P_j^n \rangle, j = \overline{1,m},$$

which correspond to the following sets of accessory functions:

$$\langle \mu_{P_j^1}(x_1), \mu_{P_j^2}(x_2), ..., \mu_{P_j^n}(x_n) \rangle, j = \overline{1,m}, \quad (2)$$

describing the results of the implementation of the $j$-th project from the standpoint of each $i$-th goal.

Let's note that some $\mu_{P_j^i}(x_i), i = \overline{1,n}, j = \overline{1,m}$ may be identically equal to 0, which means that such projects do not contribute to the achievement of this goal.

Thus, many goals and many candidate projects for inclusion in the program have been established and characterized.

Fig. 1 reflects the idea of formalization using the theory of fuzzy sets of mutual correspondence between projects and goals.

The «contribution» of the project to the achievement of a specific technical development goal is proposed to be defined by the properties of operations on fuzzy sets – as their intersection, that is, as a fuzzy set, so:

$$\mu_{\tilde{C}_j^i}(x_i) = \mu_{P_j^i}(x_i) \cap \mu_{G_i}(x_i) = \min\left\{\mu_{P_j^i}(x_i), \mu_{G_i}(x_i)\right\},$$
$$i = \overline{1,n}, j = \overline{1,m}, \quad (3)$$

where $\tilde{C}_j^i$ – fuzzy set with the membership function $\mu_{\tilde{C}_j^i}(x_i)$, describing the conformity of the results of the $j$-th project of the $i$-th goal, in this case $\tilde{C}_j^i$ – a fuzzy number of a triangular form.

To move from a fuzzy estimate of the project's contribution to achieving the goal to a numerical estimate, we use the defuzzification procedure.

According to [17], in the theory of fuzzy sets, the defuzzification procedure is similar to finding the position characteristics (expectation, mode, median) of random variables in probability theory. The simplest way to perform the defuzzification procedure is selection of a clear number corresponding to the maximum membership function.

Thus, from a fuzzy value $\tilde{C}_j^i$ – the contribution of the project to achieving the goal – a transition is made to a numerical evaluation of the same contribution $C_j^i$, for example, according to the principle:

$$C_j^i = E_i^*, \ \mu_{\tilde{C}_j^i}(x_i^*) = \sup_{x_i}\{\mu_{\tilde{C}_j^i}(x_i)\}, \quad (4)$$

where $\sup_{x_i}\{\mu_{\tilde{C}_j^i}(x_i)\}$ – the suprenum (in the context of this problem, the maximum) of the membership function of a fuzzy number $\tilde{C}_j^i$.
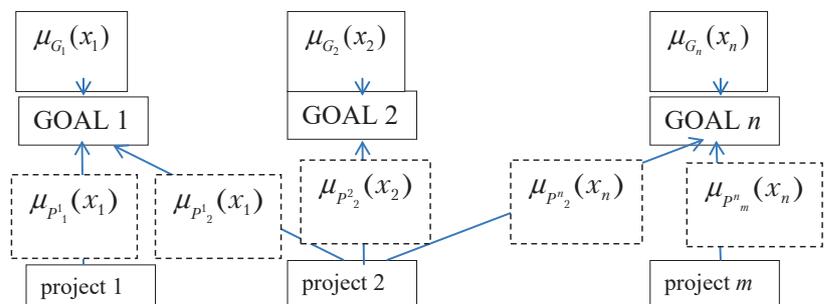


**Fig. 1.** Results of project implementation (example)

Fig. 2 illustrates a graphical interpretation of the definition of a project's contribution to achieving a goal. In this case $\tilde{C}_j^1 = \langle a,b,c \rangle$ characterizes the result of the $j$-th project from the point of view of the considered 1st goal; $\mu_{G_1}(x_1)$ – the membership function of a fuzzy interval that characterizes the first goal. In this example, the selected area of intersection of two fuzzy sets (the goal and the result of the project) has a supernum at the point $x_1^*$, with:

$$\mu_{\tilde{C}_j^1}(x_1^*) = \sup_{x_1}\{\mu_{\tilde{C}_j^1}(x_1)\} = 0.8.$$

Thus, for this example, the numerical value of the project's contribution to the achievement of the goal will be accepted $C_j^1 = x_1^*$, and $\sup_{x_1}\{\mu_{\tilde{C}_j^1}(x_1)\} = 0.8$ – the contribution degree of the project under consideration to the achievement of this goal.
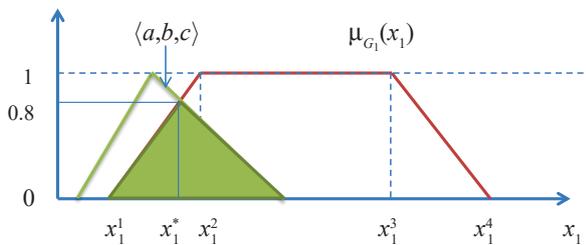


**Fig. 2.** Graphic interpretation of the definition of the project's contribution to achieving the goal

As previously identified, several projects can contribute at the same time to achieving each goal. Let's consider the definition of the joint contribution of projects to the achievement of the goal.

Taking into account the properties of operations over triangular fuzzy numbers, the following [13, 14] holds:

$$\langle a_1,b_1,c_1 \rangle + \langle a_2,b_2,c_2 \rangle = \langle a_1+a_2,b_1+b_2,c_1+c_2 \rangle. \qquad (5)$$

Thus, if $\langle a_1,b_1,c_1 \rangle$ characterizes the result of project 1 from the point of view of the considered goal, and $\langle a_2,b_2,c_2 \rangle$ characterizes the result of project 2 from the point of view of the same goal, then their joint «contribution» to the achievement of this goal is a fuzzy number $\langle a_1+a_2,b_1+b_2,c_1+c_2 \rangle$. Thus, the total results of the implementation of several projects in terms of each goal and the degree of their joint contribution to achieving the goal are determined.

Let $\sum_{j=1}^{m} P_j^i$ – the sum of the $P_j^i$ – results of the implementation of all the projects under consideration from the perspective of the $i$-th goal, $\sum_{j=1}^{m} P_j^i$ – a triangular fuzzy number, which is determined by rule (5), and $\mu_{\sum_{j=1}^{m} P_j^i}(x_i)$ is the membership function of this fuzzy number. Respectively:

– joint contribution of projects to achieve the $i$-th goal:

$$\mu_{\sum_{j=1}^{m} P_j^i}(x_i) \cap \mu_{G_i}(x_i),$$

$$\sup_{E_i}\{\mu_{\sum_{j=1}^{m} P_j^i}(x_i) \cap \mu_{G_i}(x_i)\},$$

is reached at a point $x_i^*$, that is, it is a contribution corresponding to the supernum;

– the degree of this contribution:

$$\sup_{x_i}\{\mu_{\sum_{j=1}^{m} P_j^i}(x_i) \cap \mu_{G_i}(x_i)\}.$$

**6.2. System properties of projects in the framework of technical development programs.** As it is known, synergism is a systemic property, manifested in the strengthening of certain characteristics of the system. The classic manifestation of synergies in the economy is increasing profits by reducing costs. The program is a system in which the conditions for the emergence of synergies are formed, which is characterized in [3, 4]. The implementation of several projects provides synergy, which is manifested in the excess of the value of the implementation of several projects over the sum of their values. This is usually observed in situations where projects complement and contribute to enhancing the properties of each other. Let's express the formation of a synergistic effect in terms of the theory of fuzzy sets, taking into account what was previously defined under the contribution of projects to achieving the goal.

Synergism should be reflected either in an increase (decrease) $x_i^*$, corresponding to the supernum, or/and an increase in the value of the membership function in the suprenum, that is, for such projects $P_j$, $P_k$ it is true:

$$x_i^* > (<)x_i^{**}, \qquad (6)$$

where $x_i^*$ corresponds to $\sup_{x_i}\{\mu_{P^i_j \cup P^i_k}(x_i) \cap \mu_{G_i}(x_i)\}$, that is, the joint contribution of projects to the achievement of the $i$-th goal;

$$x_i^{**} = x_i' + x_i'',$$

where $x_i'$ corresponds to, that $\sup_{x_i}\{\mu_{G_i}(x_i) \cap \mu_{P^i_j}(x_i)\}$, the contribution of the project $P_j$ to the achievement of the $i$-th goal; $x_i''$ corresponds to $\sup_{x_i}\{\mu_{G_i}(x_i) \cap \mu_{P^i_k}(x_i)\}$ – the contribution of the project $P_k$ to the achievement of the $i$-th goal.

In (6) both signs are possible – more/less, which is determined by the essence of the goal indicator. For example, if the investigated goal is prime cost, then synergism will manifest itself in its reduction; if the goal is power, then synergism will manifest itself in its increase.

Another manifestation of synergies at the formal level will be an increase in the degree to which projects contribute to the achievement of a goal when they are jointly implemented:

$$\mu_{\tilde{C}_j^i}(x_i) = \mu_{P^i_j}(x_i) \cap \mu_{G_i}(x_i) = \min\{\mu_{P^i_j}(x_i), \mu_{G_i}(x_i)\},$$
$$i = \overline{1,n}, j = \overline{1,m}. \qquad (7)$$

Thus, the classical mathematical interpretation of synergy, 2+2=5 (or >4), is manifested either in the meaning of the contribution of projects to the achievement of a goal, or in the degree of this contribution.

Taking into account the fact that it is proposed to use fuzzy triangular numbers to describe the results of projects from the point of view of a specific goal, the emergence of synergies in terms of triangular numbers for two projects is described as follows:

$$\langle a_1, b_1, c_1 \rangle + \langle a_2, b_2, c_2 \rangle =$$
$$= \langle a_1 + a_2 + \Delta a, b_1 + b_2 + \Delta b, c_1 + c_2 + \Delta c \rangle, \qquad (8)$$

where $\langle a_1, b_1, c_1 \rangle$ characterizes the result of the project 1 from the point of view of the considered goal; $\langle a_2, b_2, c_2 \rangle$ characterizes the result of project 2 in terms of the same goal; $\langle \Delta a, \Delta b, \Delta c \rangle$ – change the result of the joint implementation of projects under the influence of synergies.

Let's note that synergies, which are manifested in cost reduction, which are also fuzzy values, can be characterized in the same way. Nevertheless, it should be noted that the practical assessment of synergies from the point of view of the result is rather complicated, and it seems more simple to evaluate the synergies, manifested in cost savings (for example, discounts on equipment purchases from one supplier).

**6.3. Mathematical model of the formation of the composition of technical development program.** For the formation of the optimal composition of the technical development program it is proposed to use the mathematical model presented below. Under the optimal composition of the program let's understand such a set of projects from the investigated set, which would ensure the maximization of the achievement of the goals of technical development with given financing constraints.

When forming mathematical models with fuzzy values, two approaches can be used:

– the first is that the model is formed in a «fuzzy» form with its subsequent transformation into a deterministic version;

– the second – the initial «defuzzification» of fuzzy data and the formation of a model already in a deterministic version.

In this research, the second approach is used, since everything stated above, namely, the assessment of project contributions to the achievement of goals, assumed a transition from fuzzy sets to two quantities – the contribution of the project and the degree of this contribution. These characteristics are the main criterion and the main group of constraints of the model.

Let's assign a variable $y_j \in \{0;1\}, j = \overline{1,m}$ to each project under consideration that is «responsible» for selecting a project into the program. The number of program projects can be limited:

$$\sum_{j=1}^{m} y_j \leq K, \qquad (9)$$

where $K$ – the maximum number of program projects.

The selection of projects in the program should be carried out in such a way as to ensure:

$$\sup_{x_i} \left\{ \mu_{\sum_{j=1}^{m} P_j^i \cdot y_j} (x_i) \cap \mu_{G_i}(x_i) \right\} \to 1, i = \overline{1,n}. \qquad (10)$$

The fulfillment of condition (10) reflects the practical achievement of all the set goals of technical development, which is not always possible given the limited resources. In addition, the goals of technical development have a different degree of priority, so let's set for each goal $0 < \alpha_i < 1, i = \overline{1,n}$ – the lower limit of the degree of achievement of goals.

In this case, let's assume that the goals are ranked, that is, $i$ increase, the priority of goals decreases. Let's obtain many restrictions of the following form:

$$\sup_{x_i} \left\{ \mu_{\sum_{j=1}^{m} P_j^i \cdot y_j} (x_i) \cap \mu_{G_i}(x_i) \right\} \geq \alpha_i, i = \overline{1,n}. \qquad (11)$$

Let's note that $\alpha_i, i = \overline{1,n}$ is logical to be set decreasing as $i$ growth, for example, $\alpha_1 = 0.95$, $\alpha_2 = 0.9$, $\alpha_3 = 0.85...$ and so on.

As an optimization criterion, let's use the achievement of the first priority goal, thus, the objective function of the model is:

$$\sup_{x_1} \left\{ \mu_{\sum_{j=1}^{m} P_j^i \cdot y_j} (x_1) \cap \mu_{G_1}(x_1) \right\} \to \max. \qquad (12)$$

Let $R_j, j = \overline{1,m}$ – a fuzzy triangular type describing the costs of a project with a membership function $\mu_{R_j}(z)$ and let $F$ – the program budget, which is also described by a fuzzy set (it is proposed to use the «budget constraint» type [12] with the membership function $\mu_F(z)$). Then the funding limit is:

$$\sup_{z} \left\{ \mu_{\sum_{j=1}^{m} R_j \cdot y_j} (z) \cap \mu_{\overline{F}}(z) \right\} \leq \alpha_F, \qquad (13)$$

which is similar (taking into account the properties of fuzzy sets):

$$\sup_{z} \left\{ \mu_{\sum_{j=1}^{m} R_j \cdot y_j} (z) \cap (1 - \mu_F(z)) \right\} \leq \alpha_F, \qquad (14)$$

where $0 < \alpha_F < 1$ determines the degree of «exit» abroad the established budget; $\mu_{\overline{F}}(z)$ – membership function for $\overline{F}$. Thus, at sufficiently small values $\alpha_F$, the restriction (14) does not allow the total costs of projects $\sum_{j=1}^{m} R_j \cdot y_j$ to belong to an «extrabudgetary» set $\overline{F}$ with a degree of membership greater than $\alpha_F$. Let's note that when evaluating the achievement of goals, such an approach was not used in view of the fact that budget overrun is unacceptable, whereas deviation to one side or the other from the goal indicator is not critical for the program.

Thus, (9)–(12), (14) form a mathematical model that allows to form the composition of the technical development program. This composition meets the requirement of achieving the goals of technical development, taking into account the budget constraints in the face of uncertain information, which can be described by means of the theory of fuzzy sets.

## 7. SWOT analysis of research results

*Strengths.* In comparison with the existing approaches to the formation of the program, the approach proposed in this study takes into account quantitatively the synergy effect formed in the programs, which provides a higher degree of justification for the selection of projects. In addition, the proposed approach provides a two-component quantitative assessment of the comparison of many projects

to the set of technical development goals – the project's contribution to achieving the goal, the degree of this contribution. This allows to take into account not only the fuzzy meaning of the results, but also take into account the «uncertainty» degree of the result in the processes of program formation. Although this study is focused on technical development programs, nevertheless, the results are sufficiently universal and can be applicable (taking into account additional specifics) for the formation of programs of various kinds.

*Weaknesses.* The proposed model does not take into account possible mutual exclusion of projects (this is an assumption declared at the beginning of the study), which requires additional formalization. Also a weak point of research is the lack of consideration of the possible technological interconnection of projects, which makes them mutually complementary in the framework of technical development programs.

*Opportunities.* Using the proposed approach to assessing the contribution of projects to achieving goals, as well as a model for optimizing the composition of the program, it is possible to form a program from a proposed set of projects. At the same time, the achievement of goals is ensured to the maximum extent, taking into account the uncertainty of both the conditions for the implementation of projects and their results.

*Threats.* Any model is based on source information, the quality of which determines the quality of the results of modeling and optimization. Fuzzy sets describing the goals and results of projects are formed on the basis of the synthesis of statistics and expert opinions, which, naturally, determines the risk of operating with unreliable information within the model and, as a result, not a completely reliable result.

## 8. Conclusions

1. A method is developed for assessing the value of technical development projects, which is based on the understanding by the value of projects and programs of their compliance with the set goals. The method is based on the theory of fuzzy sets and as a result of operations on fuzzy sets, two project value assessments are formed – the project's contribution to the achievement of each goal from the set of goals and the degree of this contribution. Such approach, in contrast to the existing ones, makes it possible to take into account to a greater extent the achievement of goals in the subsequent program formation procedures.

2. Description of the quantitative assessment of the synergy effect is formalized that occurs during the joint implementation of projects within the program. This allows a greater confidence degree to evaluate the result of the program.

3. A model is developed for forming the optimal composition of a technical development program, taking into account the value of projects and the systemic effect (synergy) of their joint implementation within the program. The model provides for the ranking of goals, which, unlike the existing approaches, is used when establishing minimum boundaries for the achievement degree of a particular goal, which corresponds to the actual processes of project selection in practice. The application of the proposed model can be extended to programs of various orientations.

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